Technical Report Overview

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Teck

Report: Upper Fording River Westslope Cutthroat Trout Population Assessment and Telemetry Project, Final Report (December 2016)

Overview: This report presents the results of a study of the Westslope Cutthroat Trout population in the Fording River watershed upstream of Josephine Falls, from 2012 to 2017. The purpose of this study was to determine the health, resilience and sustainability of the Westslope Cutthroat Trout population.

This report was prepared for Teck by Westslope Fisheries Ltd.

For More Information
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Upper Fording River Westslope Cutthroat Trout Population Assessment and Telemetry Project

Final Report

Study Period: August 2012 to November 2015

Westslope Fisheries Ltd.
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Westslope Fisheries Ltd.

December 2016

Cover Photo: Mature female Westslope Cutthroat Trout (485 mm fork length, 1,340 g) being released after implantation with a Lotek Radio Tag and application of Floy tag for use in radio telemetry tracking and population estimation, reclaimed Henretta Pit Lake, Fording River Operations, Upper Fording River, August 30, 2012.

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[4]Data has been archived and is considered confidential. Data requests should be referred to Teck Coal Limited, Sparwood Environmental Office, 124B Aspen Drive, Sparwood, BC, V0B 2G0.

Executive Summary

Teck Coal Limited ("Teck") commissioned a multi-year (2012 – 2015) study to understand the current status of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in the Fording River watershed upstream of Josephine Falls. The Upper Fording River Westslope Cutthroat Trout Population Assessment and Telemetry Project (the "Project") was completed by Westslope Fisheries Ltd. in partnership with the Canadian Columbia River Inter-tribal Fisheries Commission (CCRIFC), under the guidance and direction of a Steering Committee that consisted of representatives from Teck, the BC Ministry of Forests, Lands, and Natural Resource Operations, (MFLNRO), the Ktunaxa Nation Council and Simon Fraser University. Fisheries and Oceans Canada (DFO) participated as a Steering Committee member in the study design and implementation phase. The Project was intended to provide supporting data for decision making around land use planning and fisheries management in the upper Fording River watershed.

The overall goal or purpose of this study was to determine whether the upper Fording River watershed Westslope Cutthroat Trout population was healthy, robust and sustainable. Concerns have been raised regarding resource development and recreational use in the area and it was believed that fisheries management decisions related to the Westslope Cutthroat Trout population in the upper Fording River watershed would benefit from a more complete understanding of the status of the population, the current habitat availability and its use.

To address the overall goal of the study, seven key study questions were identified by the Steering Committee, as follows:

1. What is a viable Westslope Cutthroat Trout population?
2. Are the fish healthy (with respect to condition factor)?
3. Is the Westslope Cutthroat Trout population sustainable?
4. Is it one interconnected population or multiple populations (with respect to genetics)?
5. What are the habitats (critical and overall habitat) in the study area?
6. What are the movement patterns and why?
7. What is the distribution of Westslope Cutthroat Trout seasonally, considering life history stage and upstream distribution limits?

Teck operates three surface coal mines within the upper Fording River watershed in southeastern British Columbia: Fording River Operations (FRO), Greenhills Operations (GHO) and Line Creek Operations (LCO). Coal production began in 1971 with a current total combined

production capacity of approximately 17 million metric tonnes of clean coal (Mtcc) annually. In addition to mining, forest harvesting, recreational activities, road, railway, and natural gas pipeline developments also occur in the upper Fording River watershed.

Westslope Cutthroat Trout are the only fish species known to occur in the upper Fording River and its tributaries. Josephine Falls represents a natural barrier to upstream fish movement and this barrier has protected this population from hybridization with non-native Rainbow Trout. As a result, this population is one of a limited group of populations that have been identified as genetically pure, thus making them an important population in the context of Westslope Cutthroat Trout conservation.

The Fording River is a tributary to the Elk River, which is one of seven major streams and their tributaries in the upper Kootenay River watershed that were designated as Class II Classified Waters in 2005. The classified waters licensing system was created to preserve the unique fishing opportunities provided by these waters, which contribute substantially to the province's economy and reputation as a world class fishing destination. In 2010, the Province of British Columbia closed the upper Fording River to angling due to uncertainty regarding the Westslope Cutthroat Trout population status.

Although there are many healthy populations of Westslope Cutthroat Trout in the East Kootenay, Westslope Cutthroat Trout are a blue-listed species (*i.e.,* species of concern; formerly vulnerable) in British Columbia and COSEWIC designated the British Columbia population of Westslope Cutthroat Trout as Special Concern in November 2006. Currently, the federal Species at Risk Act (SARA) lists the British Columbia population of Westslope Cutthroat Trout as Special Concern under Schedule 1 of SARA. If a project is subject to an assessment under the Canadian Environmental Assessment Act, measures must be taken to avoid or lessen any adverse effects of the project on the species. Additionally, fisheries protection and pollution prevention provisions of the Fisheries Act provide protection to this species. DFO in cooperation with the MFLNRO is currently developing a Management Plan for Westslope Cutthroat Trout (British Columbia population).

This study employed a literature review of previous studies within the upper Fording River in combination with field methods including telemetric methods, snorkel mark-recapture, Floy and PIT (Passive Integrated transponder) tag mark-recapture, juvenile densities (representative removal-depletion locations), and habitat mapping (review of high resolution (10 cm) aerial photography and ground-truthing). These methods characterized the fluvial population of Westslope Cutthroat Trout and their habitat within the upper Fording River watershed in terms of abundance, genetic differentiation, mortality rates, condition factors, age class structure, growth rates, life history strategies (home ranges, movement patterns and seasonal distribution by life stage), and habitat (available and critical *e.g.,* over-wintering, rearing, spawning and migration corridors). Results were subsequently used to evaluate population viability and perceived threats to population resilience and sustainability. A synthesis of these results, relating to the specific study questions identified by the Steering Committee, is summarized in Table I immediately following this executive summary.

Habitat utilization was used to infer habitat preferences for the upper Fording River population of Westslope Cutthroat Trout through repeating telemetric use patterns, juvenile densities, and distribution (by life stage). These preferences were examined in relation to habitat mapping results (*i.e.,* habitat availability, or quantity, distribution and quality) and identification of habitat impacts (*i.e.,* habitat losses due to infilling, fragmentation and channel degradation) that could reasonably be expected to impact life history diversity, habitat carrying capacity and population abundance. Finally, results were considered within the context of species preferences and conservation targets from appropriate reference populations (*i.e.,* locally, regionally and range-wide) to identify critical habitats, core population maintenance areas and limiting factors.

To summarize, the upper Fording River population metrics of sub-adult and adult abundance (2,552 to 3,874 fish > 200 mm fork length), habitat availability (57.5 km of mainstem river plus approximately 59 km of tributary habitat), and genetic integrity (pure strain) represent a viable Westslope Cutthroat Trout Population. Population characteristics such as condition factor, growth rates, von Bertalanffy growth model estimates and population age structure, were indicative of a “healthy” population.

The use of telemetric methods has confirmed both resident and migratory life history forms of Westslope Cutthroat Trout within the upper Fording River population. This is a recurring feature for species which have evolved within the dynamic environments of Western North America. The evolutionary history of *Oncorhynchus* spp. (*i.e.,* Pacific salmon, Steelhead, Rainbow and Cutthroat Trout) have many recurring patterns including reproductive homing or site fidelity and the existence of two or more conspecific life history types within a single geographic area. Life history diversity is linked to population resilience through spatial and temporal variation in exposure to disturbance (*i.e.,* risk spreading) and in production of offspring (*i.e.,* bet hedging).

The upper Fording River and similarly investigated upper Kootenay River tributaries (*i.e.,* telemetric studies; Bull, Elk, St. Mary, Wigwam and Flathead rivers) represent these highly variable spatial and temporal Cutthroat Trout environments. These upper Kootenay River tributaries (including the upper Fording River) remain relatively intact within a wilderness setting that contain sufficient geographical area to support substantial numbers of Westslope Cutthroat Trout (*i.e.,* 1,000's), that attain large sizes (*i.e.,* 30 to 50 cm), and retain migratory life histories.

There remain two key statistical uncertainties and four perceived threats to population resilience and sustainability that were identified. The two key statistical uncertainties were:

1. The point estimates for sub-adult and adult (*i.e.,* fish > 200 mm) abundance for the three years appear to be increasing over time but the 95% confidence intervals were wide enough (*i.e.,* overlap among years) that the evidence of an increase in population size among the three years was weak, and
2. The differences between the mortality rate estimates of radio tagged Westslope Cutthroat Trout (*i.e.,* 21% to 32% per year) and those used by the model authors to estimate the amount of stream required to maintain a population (*i.e.,* 10%). Methods may have contributed to elevated mortality through increased susceptibility to predation, potential radio tag failure and delayed mortality due to surgical procedures.

The four identified threats to population sustainability were:

1. Water quality (*i.e.,* both constituents of concern and elevated water temperatures) and water quantity,
2. Loss of tributary habitat through the construction of rock drains (*i.e.,* valley infilling) and inadequate culvert design and placement (*i.e.,* lost connectivity). These impacts are present in some form on all tributaries within the upper Fording River study area except Ewin-Todhunter Creek,
3. Stream channel degradation of Segments S7, S8 and S9 (*i.e.,* mainstem habitat within the FRO property boundary extending from river kilometer (rkm) 51 to rkm 65) represent physical habitat limitations to Westslope Cutthroat Trout production. Habitat assessments documented riparian vegetation loss, channel instability and degraded fish habitat conditions such as excessive width: depth ratios, shallow water depths, limited pool habitat (pool area, pool frequency), limited structural elements in the form of large woody debris (LWD), increased gradient and coarser substrates with decreased substrate diversity. These impacts also contribute to increased water temperatures and increased extent and duration of channel dewatering creating migration barriers and a loss of connectivity, and
4. The possible re-introduction of angling. Given the vulnerability of Westslope Cutthroat Trout in general and the upper Fording River population in particular to angling related

mortality this possibility was a concern given the potential for cumulative impacts within the watershed. The main threats were non-compliance in harvest and vulnerabilities to catch and release post hooking mortality.

The above perceived threats to life history diversity, particularly constraints to the expression of migratory life history forms in a dynamic environment such as the upper Fording River have consistently been identified within the literature as reducing population resilience. Reductions in population resilience increases the risk to population viability (*i.e.,* extirpation) and has consistently been identified as a precursor to precipitous population declines within the Salmonidae family, *Oncorhynchus* spp. and Westslope Cutthroat Trout.

The identification of population level threats represents the first step in ensuring population sustainability. These threats and limiting habitats were identified as opportunities for habitat offsetting (Teck), as well as multi-disciplinary and multi-agency stream rehabilitation and riparian restoration projects for collaborative communities of interest engagement. These opportunities would target limiting habitats within the upper Fording River and known threats to Westslope Cutthroat Trout population sustainability with expectations for increased productive capacity, population resilience and abundance (and hence viability and sustainability). Ongoing initiatives by Teck have already targeted some of the identified threats and are being developed in collaboration with the Elk Valley Fish and Fish Habitat Committee and the Environmental Monitoring Committee (*i.e.,* Regional Fish Habitat Management Plan, Regional Offsetting Strategy, Elk Valley Water Quality Plan, Tributary Evaluation and Management Plan, and the Regional Aquatic Effects Monitoring Program). In 2016, habitat rehabilitation (offsetting) measures were constructed to address some of the identified threats and additional offsetting measures are planned to be constructed over the next five years

Continued population trend monitoring is recommended. This was due to; 1) the statistical uncertainty and perceived threats to population resilience and sustainability that were identified in the current project, and 2) the recommended extension of the population trend monitoring would also function as effectiveness monitoring to ensure management strategies (*i.e.,* habitat mitigation and offsetting strategies) are achieving the desired objective (*i.e.,* a stable or increasing population). This rationale would also apply should additional management actions change (*i.e.,* the current management regulations regarding prohibition on angling).

Two independent trend monitoring programs were recommended to facilitate confidence in the interpretation of population trends. This is an important consideration given the two monitoring programs proposed; 1) continuation of snorkel surveys but utilize the CPUE data (*i.e.,* snorkel counts) rather than mark – recapture estimates for monitoring sub-adult and adult populations, and 2) continuation of estimating fry and juvenile densities within representative locations and meso-habitats. These two trend monitoring programs would complement each other and provide independent confirmation of trends given the concern in the use of CPUE methods (*i.e.,* snorkel counts) and their potential to not meet underlying assumptions that can, at times, be a misleading indicator of abundance when not applied properly. While a relative index can reduce the ability to identify a trend with sufficient power its advantage is that fish are not handled or externally tagged. This was considered a necessary trade-off given the current results that suggest elevated mortality rates through increased susceptibility to predation using the current mark-recapture methods. Similarly, juvenile removal – depletion electrofishing methods typically have high uncertainty when applied to the low densities typically encountered within Westslope Cutthroat Trout populations.

Table I. Summary of the Project study questions, methods and results.

Study Question	Study method(s)	Study Results
1. What is a viable WCT population?	• Literature Review • Population Abundance • Available Habitat • Perceived Threats	From literature, it has been defined that between 470 and 4,600 adults or between 9 and 28 km of stream, depending on model assumptions is required to maintain an isolated population. Given the current population estimate (2,552 – 3,874 fish > 200 mm), available habitat (57.5 km mainstem river plus approx. 59 km tributary habitat), genetic integrity and closure to angling, **the upper Fording River population meets the definition of a viable population.** There remains statistical uncertainty in regard to the population trend and the mortality estimates of radio tagged WCT which were much higher (21-32%) than the model assumptions (10%). Methods may have contributed to elevated mortality rates through increased susceptibility to predation, potential radio tag failure and delayed mortality due to surgical procedures. Four perceived threats (see question 3 below) to population resilience and sustainability were identified and discussed.
2. Are the fish healthy (with respect to condition factor)?	• Visual Exam During Population Monitoring • Condition Factor (*K*)	Based on; 1) visual external (n=1,662) and internal (n=180) examination, 2) relative fish size, and 3) Fulton's condition factor (*K*), mature fish do not exhibit any indication of "stressor" and **appear to be in good condition and robust compared to similar upper Kootenay River populations.** Based on juvenile weight-length relationships there has been no change in condition factor over the last 30 years. Population characteristics such as growth rates, growth model estimates and population age structure were also indicative of a "healthy" population.
3. Is the WCT population sustainable?	• Sub-adult and Adult Population Monitoring • Recruitment and Juvenile Population Monitoring • Perceived Threats	**Population sustainability is attainable given the viability analyses** (*see* Question 1 above)**.** Four perceived threats to population resilience and sustainability were identified; 1) water quality and quantity concerns, 2) loss of tributary habitat through the construction of rock drains (*i.e.,* valley infilling) and inadequate culvert design and placement (*i.e.,* lost connectivity), 3) degraded stream channels, and 4) re-introduction of angling. Although there is still uncertainty regarding the population trend and mortality rates, the long-term sustainability of a resilient, self-sustaining population of Westslope Cutthroat Trout in the upper Fording River should be possible, if not probable, provided the implementation of suitable management strategies (*e.g.,* water quality treatment, water quantity protection, habitat protection and effective habitat offsetting and rehabilitation programs, angling prohibition). Perceived threats and limiting habitats were identified as opportunities for habitat offsetting, as well as multi-disciplinary and multi-agency stream rehabilitation and riparian restoration projects for collaborative communities of interest engagement. Ongoing initiatives by Teck have already targeted some of the identified threats and are being developed in collaboration with the Elk Valley Fish and Fish Habitat Committee and the Environmental Monitoring Committee (*i.e.,* Regional Fish Habitat Management Plan, Regional Offsetting Strategy, Elk Valley Water Quality Plan, Tributary Evaluation and Management Plan, and the Regional Aquatic Effects Monitoring Program). In 2016, habitat rehabilitation (offsetting) measures were constructed to address some of the identified threats and additional offsetting measures are planned over the next five years.

Table I. Concluded.

Study Question	Study method(s)	Study Results
4. One interconnected or multiple populations?	• Literature Review • Radio Telemetry	**The upper Fording River Population is one interconnected population.** No genetic differentiation among samples taken from lower reaches of distant tributaries indicates there is enough ‘mixing’ among fish with connectivity to be managed as one interconnected population. Telemetry data supports the genetics.
5. What are the habitats (critical and overall) in the study area?	• Radio Telemetry • Habitat Mapping • Habitat Characterization	Habitat mapping, telemetric methods (sub-adults and adults), and density information (fry and juveniles) have identified both critical and limiting habitats within the upper Fording River watershed. Over-wintering and tributary habitat was defined as critical based on fish utilization (juvenile densities, telemetric use data, spawning), repeating patterns in the species literature, and was described as limiting based on the habitat availability and the scale of historic habitat loss and lost connectivity. Overlap in habitat use by **migratory and resident life history forms and juveniles centre around three core areas within the upper, middle and lower watershed:** 1) The 6.5 km of stream channel (*i.e.,* portions of FRO onsite river Segments S8 and S9) between Henretta Pit Lake and the multi-plate culvert including the “Clode Flats”, lower Henretta Creek, Henretta Pit Lake, Fish Pond Creek and remnant tributary outflows (Clode Creek, Lake Mountain Creek). This core area supports critical spawning, over-wintering and juvenile rearing habitat. Groundwater influences have been identified; 2) The 7.0 km of river Segment S6 (*i.e.,* “oxbow” pools and groundwater reach) including the side-channel and Chauncey Creek contain critical spawning, over-wintering, and rearing areas. Groundwater influences were identified; and 3) The approximately 6.3 km of stream extending from upper Segment S1 through lower Segment S3 (*i.e.,* GHO area) including Greenhills Creek and Dry Creek.
6. What are the movement patterns and why? 7. What is the distribution of WCT seasonally, considering life history stage and upstream distribution limits?	• Radio Telemetry • Sub-adult and Adult Population Monitoring • Recruitment and Juvenile population Monitoring	Telemetric patterns of mature fish (n=166) and representative juvenile locations (n=19) identify repeating spatial and temporal patterns of over-wintering, spawning and rearing. Habitat mapping, known species habitat requirements and preferences, reference populations and assessments of migration barriers were used to infer habitat use. **Resident and migratory life history forms, reproductive homing and site fidelity were identified. Distribution extends from Josephine Falls (rkm 20.5) to the headwaters between rkm 73.0 and 78.0 (57.5 km of mainstem river habitat).** Habitat loss (valley infill), channel impacts and connectivity (migration barriers) were influencing distribution. Tributary and mainstem habitats were identified as spawning habitat. Tributaries were also identified as high density juvenile rearing habitat. The presence of remnant fragmented populations above barriers was confirmed in Chauncey, Greenhills, Dry, and Kilmarnock Creeks. The average home range was 11.54 km (range 0.7-31.6 km). Return spawning and over-wintering migrations of 60 km (round trip) were documented. Fish movements of 10 km in a 24 hour period were documented. Juvenile (< 141 mm) movements of up to 29.6 km were documented.

Acknowledgements

This study is part of a co-operative initiative funded by Teck. While Westslope Fisheries Ltd. has been retained by Teck to undertake the Project, the study team was a partnership between Westslope Fisheries Ltd. and the Canadian Columbia River Inter-Tribal Fisheries Commission (CCRIFC); with support from Dr. Carl Schwarz (Simon Fraser University) and Ktunaxa Nation Council, Lands and Resources Agency, GIS Services.

The Upper Fording River Westslope Cutthroat Trout Population Assessment and Telemetry Project was implemented under the guidance and direction of the Steering Committee. The Steering Committee consists of representatives from Teck, the Ktunaxa Nation Council, BC Ministry of Forests, Lands, and Natural Resource Operations (MFLNRO), and Simon Fraser University. Fisheries and Oceans Canada (DFO) participated as a Steering Committee member in the study design and implementation phase. The work of the Steering Committee leading up to the implementation of the Project, as well as their ongoing guidance, contribution, and review of the draft report are gratefully acknowledged.

Special thanks are extended to Teck as the funding source and for their striving for a standard of excellence that permitted the results of the Project. Special thanks to Lindsay Watson, Warn Franklin, Karen Halwas, and Glenda Fratton (Teck Project Managers) for their support, advice, and assistance. The many employees of Teck Fording River Operations and Greenhills Operations that facilitated the safe and effective completion of field studies are greatly appreciated.

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1. Introduction

Teck Coal Limited ("Teck") commissioned the Upper Fording River Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) Population Assessment and Telemetry Project (the "Project"), which was a 3.3 year study (40 months) to further understand the current status of Westslope Cutthroat Trout in the upper Fording River watershed upstream of Josephine Falls. This report is the final report and it presents the analysis and interpretation of data collected from August 2012 to November 2015 and builds on the previous interim reports (Cope *et al.* 2013, 2014). The Project has been guided by a Steering Committee comprised of representatives from Teck, the Ktunaxa Nation Council, BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), and Simon Fraser University. Fisheries and Oceans Canada (DFO) participated as a Steering Committee member in the study design and implementation phase.

Teck operates three surface coal mines within the upper Fording River watershed upstream of Josephine Falls: (1) Fording River Operations (FRO), (2) Greenhills Operations (GHO) and (3) Line Creek Operations (LCO). The current permitted boundaries for the three operations are illustrated in Section 2.1 Study Area. The primary product is high-quality, metallurgical coal. The combined annual production capacity of the three mines is approximately 17 million metric tonnes of clean coal (Mtcc).

Production at FRO began in 1971 and the operation (7,005 ha) lies along the Fording River valley with mining on both the east and west sides of the river. GHO was originally opened in 1981; the current operational area (3,066 ha) lies mostly along the height of land between the Fording River and the Elk River to the west. LCO includes activities in the upper Dry Creek watershed, a tributary within the upper Fording River watershed.

In addition to mining, forest harvesting, recreational activities, road, trail, railway, and natural gas pipeline, wells and drill pad developments and exploration related disturbances also occur in the upper Fording River watershed. Concerns have been raised by communities of interests about the lack of information regarding the status of the Westslope Cutthroat Trout population in the upper Fording River watershed. In 2010, the Province of British Columbia closed the upper Fording River to angling due to uncertainty around the population status. The Project was intended to provide supporting data for decision making around land use planning and fisheries management in the upper Fording River watershed.

The following study methods were used as part of the upper Fording River Westslope Cutthroat Trout Population Assessment:

- Evaluation of river discharge and water temperature data;
- Population monitoring;
- Analysis of movement patterns and distribution;
- Habitat mapping and meso-habitat characterization;
- A review of genetic analyses;
- A literature review of population viability studies; and
- A population sustainability analysis.

Note that radio-telemetry was used for population monitoring and in the analysis of movement patterns and distribution.

The results of these study methods were used to answer seven study questions for the upper Fording River:

1. What is a viable Westslope Cutthroat Trout population?
2. Are the fish healthy (with respect to condition factor)?
3. Is the Westslope Cutthroat Trout population sustainable?
4. Is it one interconnected population or multiple populations (with respect to genetics)?
5. What are the habitats (critical and overall) in the study area?
6. What are the fish movement patterns and why?
7. What is the distribution of Westslope Cutthroat Trout, seasonally, considering, life history stage and upstream distribution limits?

The study methods are presented in Section 2 and the results of the study methods are presented in Section 3. A synthesis of the methods (approach), results and discussion for the seven study questions are presented in Section 4. Recommendations for future population monitoring are presented in Section 5.

1.1. Background

Westslope Cutthroat Trout are a key fisheries resource in the Fording River watershed and is the only species known to occur in the upper Fording River watershed upstream of Josephine Falls. Due to the presence of Josephine Falls, which prevents upstream movement of fish protecting this population from hybridization with non-native Rainbow Trout (and competition with non-native species in general), the upper Fording River can be considered an isolated upstream refuge where genetically pure Westslope Cutthroat Trout are present. Carscadden and Rogers (2011) confirmed the upper Fording River population is consistent with the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designation of a genetically pure Westslope Cutthroat Trout population (COSEWIC 2006). Previous studies have identified the upper Fording River Westslope Cutthroat Trout population as one of a limited group to qualify as genetically pure (Rubidge and Taylor 2005, Rubidge *et al*. 2001), thus making them an important population in the context of Westslope Cutthroat Trout conservation.

In 2010, the Province of British Columbia closed the upper Fording River to angling due to uncertainties regarding population status. The following rationale has been quoted directly from the MFLNRO Angling Regulation Variation Order Proposal;

> *"Recent field projects in the section of the Fording River upstream of Josephine Falls have indicated uncharacteristically low densities of Westslope Cutthroat Trout. In August, 2010, experienced personnel assessed a total of 6.6 km of river by snorkeling and angling. Although biologists considered the habitat above average, with the exception of localized high sediment deposits, they observed only 12 trout <300 mm and 14 trout >300 mm in the entire 6.6 km study section. This observable population density of 3.9 trout/km, and larger individuals of 2.2 trout/km is much lower than in Michel Creek, which in 2008 had average densities of 46 adult Cutthroat Trout/km. Both systems are upper tributaries to the Elk River, and are of similar size, but Michel Creek is intensively fished and continues to maintain a relatively high number of trout/km. Anecdotal reports indicate the Fording above Josephine Falls was historically a much better fishery than it is at present. The reasons for the observably depressed state of the population are uncertain, but years of upstream coal/forestry development and/or access and resulting growth or even recruitment overfishing are plausible causes. Expansion of the Fording Coal open pit mine is anticipated in the near future with the expectation the population will not be further compromised, but protection at this*

> *point would be a safeguard to potential future impacts. It is highly likely this particular population is a pure strain of Cutthroat Trout being resident upstream of an impassible falls, warranting additional protection."*

It has been well documented that overharvest in the late 1800s and early 1900s contributed significantly to the decline of native stocks of Westslope Cutthroat Trout throughout their historical range (Cleator *et al.* 2009, Allan 2000). As early as 1905 it was being reported that larger fish were already scarce in the Elk River (Hornady 1909 in Allan 2000). Catchability of Westslope Cutthroat Trout is 2.5 times higher than for non-indigenous salmonids like Brook Trout (Paul *et al.* 2003 *in* Cleator *et al.* 2009). Higher catchability combined with later maturity and slower population growth makes Westslope Cutthroat Trout sensitive to over-exploitation. Over the past 20 years, fishing regulations have become increasingly more restrictive, including closure to harvest. Most populations in the East Kootenay Region do not appear to have suffered any long-term permanent effects as many prominent fish populations have recovered in the last few decades (Pollard 2010, *pers. comm.*, Heidt 2007, Anon. 2006, Allan 2000).

Westslope Cutthroat Trout in the upper Fording River represent the ideal research population as they are isolated from the above confounding factors (*e.g.,* angling, competition from other fish species, hybridization, and potential effects related to agricultural development) that could affect population stability and fish health.

The Fording River is a tributary to the Elk River, which is one of seven major streams (Bull, Elk, Skookumchuck, St. Mary, Upper Kootenay, Wigwam and White Rivers) and their tributaries in the upper Kootenay River watershed that were designated as Class II Classified Waters in 2005 (Anon. 2006). The classified waters licensing system was created to preserve the unique fishing opportunities provided by these waters, which contribute substantially to the province's reputation as a world class fishing destination (Heidt 2007). These seven upper Kootenay River tributaries currently support an intensive, high quality recreational fishery for both pure strain (upper Bull River upstream of Aberfeldie Dam) and varying degrees of hybridized Westslope Cutthroat Trout.

These seven streams within the upper Kootenay River watershed in the Rocky Mountains of southeast British Columbia are recognized as range-wide strongholds for Westslope Cutthroat Trout. It is generally recognized that this is due to the fact that these watersheds are some of the most pristine and diverse landscapes within the species range (Isaak *et al.* 2012, Muhlfeld *et.al.* 2009). As such, Westslope Cutthroat Trout populations in southeast British Columbia have been found to be substantially genetically differentiated (Taylor *et al.* 2003) and contain a diversity of genetic and ecological characteristics of both the migratory and resident populations that have persisted since the last glacial period 14,000 years ago (Cope and Prince 2012, Muhlfeld *et.al.* 2009, Morris and Prince 2004, Baxter and Hagen 2003, Prince and Morris 2003, Shepard *et al.* 1984).

Although there are many healthy populations of Westslope Cutthroat Trout in the East Kootenay, Westslope Cutthroat Trout are a blue-listed species (*i.e.,* species of concern; formerly vulnerable) in British Columbia (CDC 2004) and COSEWIC designated the British Columbia population of Westslope Cutthroat Trout as Special Concern in November 2006 (COSEWIC 2006). Currently, the federal Species at Risk Act (SARA) lists the British Columbia population of Westslope Cutthroat Trout as Special Concern under Schedule 1 of SARA. If a project is subject to an assessment under the Canadian Environmental Assessment Act, measures must be taken to avoid or lessen any adverse effects of the project on the species. Additionally, fisheries protection and pollution prevention provisions of the Fisheries Act provide protection to this species. DFO in cooperation with MFLNRO is currently developing a Management Plan for Westslope Cutthroat Trout (British Columbia population).

Throughout their range, native species of Cutthroat Trout have experienced severe restrictions in their distribution and abundance due to over-harvest, habitat fragmentation, degradation, and the introduction of non-native salmonids that compete, replace or hybridize with native Cutthroat Trout (Shepard *et al.* 2005, 1997, Hilderbrand and Kershner 2000a, Mayhood 1999, Jakober *et al.* 1998, Thurow *et al.* 1997, Woodward *et al.* 1997). In fact, it has been suggested that hybridization with non-native Rainbow Trout is the most important factor responsible for the loss of native Cutthroat Trout (Allendorf and Leary 1988). Non-hybridized populations of Westslope Cutthroat Trout persist in only 10% of their historical range in the United States (Shepard *et al.* 2005) and less than 20% of their range in Canada (COSEWIC 2006). The number of hybridized populations in the upper Kootenay drainage of the East Kootenay dramatically increased from 1986 to 1999 (Rubidge 2003). Consequently, many remaining populations are restricted to small, fragmented, headwater habitats, where the long-term sustainability of these populations is uncertain (Cleator *et al.* 2009, Hilderbrand and Kershner 2000a).

Westslope Cutthroat Trout within the upper Fording River are an above barrier fluvial population. Life history traits and population dynamics of above barrier, fluvial populations of salmonids demonstrate limited downstream displacement and a later spawning period in the spring. These are evolved traits to ensure population persistence and results in differing life history behaviour within the same river or stream above and below a natural barrier. For example, Westslope

Cutthroat Trout eggs collected from individuals above and below a barrier within the same stream were incubated under the same controlled conditions in a laboratory. The above barrier eggs hatched later and when the fry emerged, the above barrier fish orientated into the current (*i.e.,* to migrate upstream). The downstream fry emerged earlier and orientated downstream to the current (*i.e.,* to migrate downstream; *see* Baxter 2004, Northcote 1992, Northcote and Hartman 1988, Elliott 1987 for reviews).

Telemetry data for the Bull River (Cope and Prince 2012) and Elk River (Prince and Morris 2003) support the above barrier literature and illustrate alternate life history strategies when compared to below barrier populations such as the St. Mary River (Morris and Prince 2004) and Wigwam Rivers (Baxter and Hagen 2003). The Elk and Bull River barriers are currently hydro-electric facilities (dams), but these were constructed on existing natural barriers to upstream fish passage (*i.e.,* falls).

Reports of home ranges for Cutthroat Trout vary widely in the literature. Until recently, many regarded Cutthroat Trout as sedentary with home ranges more often than not reported in meters rather than kilometers (Gresswell and Hendricks 2007, Hilderbrand and Kershner 2000b, Brown 1999, Jakober *et al.* 1998, Young 1998). Seemingly contradictory reports often stem from a lack of distinction between sub-species, life history forms, available habitat and infrequent sampling. In those studies showing “resident” behaviors, adult fish are <300 mm in length, water temperatures are warmer, and the subspecies studied is something other than *O. clarkii lewisi*; thus, interstitial spaces available for cover were used by the trout and dynamic ice conditions did not displace fish (Gresswell and Hendricks 2007, Hilderbrand and Kershner 2000b, Young 1998).

In higher elevation watersheds such as those found in the upper Kootenay River watershed, including the upper Fording River, populations where fish attain large size at maturity (*i.e.,* > 300 mm length) and winter conditions are more extreme (*i.e.,* dynamic ice conditions), deep water habitats are required and fish must migrate to reach spatially separated over-wintering and spawning areas (because these habitat features are rarely found in the same locations) (Cleator *et al.* 2009). Westslope Cutthroat Trout telemetry data for upper Kootenay River populations have documented maximum home ranges of between 35 km and 55 km in the Elk and St. Mary Rivers (Morris and Prince 2004, Prince and Morris 2003). Migrations of up to 103 km and 212 km between spawning and over-wintering habitat have been reported for the Wigwam and Flathead River populations (Baxter and Hagen 2003, Shepard *et al.* 1984). Similar home ranges have also been documented within adjacent jurisdictions with similarly intact watersheds (*e.g.,* Salmon River, Idaho, mean home range = 67.4 km, Schoby and Keeley 2011; Blackfoot River, Montana, mean migration to spawning tributary = 31 km, Schmetterling 2001). Recently, (*e.g.,* 2010-11), radio telemetry was used to assess population status and habitat use for the upper Bull River population of Westslope Cutthroat Trout. Home range for individuals within this above barrier population ranged between 0.7 and 27.9 km (Cope and Prince 2012).

Of the above reference populations, the upper Bull River Westslope Cutthroat Trout population has been selected as the most similar to the upper Fording River population for the following reasons:

1. The upper Bull River watershed lies immediately adjacent to the Elk River watershed;
2. Both the upper Fording River and upper Bull River populations are genetically pure populations of Westslope Cutthroat Trout;
3. Both populations occur above naturally occurring barriers (*i.e.,* falls);
4. Habitat availability within the upper Bull River includes 30 km of mainstem river plus several tributaries (note that a second falls 30 km upstream restricts further upstream access for this population) and habitat availability within the upper Fording River includes 57.5 km mainstem river plus several tributaries; and
5. Both populations will have been assessed using similar methods, quality assurance and quality control measures and the same research staff.

However, there was a substantial difference in river size (volume) between the upper Bull River and the upper Fording River (the mean annual discharge of the upper Fording River is approximately 25% that of the upper Bull River). Michel Creek is another tributary to the Elk River of similar size (mean annual discharge) to the upper Fording River that has some fish density information that can be and has been (*i.e.,* MFLNRO rationale for upper Fording River angling closure) used as a reference population.

Although these reference streams are used to place upper Fording River Westslope Cutthroat Trout densities in context, it must be recognized that these populations represent range-wide strongholds for the species. As such, these densities represent the higher end of the “potential” for a productive Westslope Cutthroat Trout population.

Westslope Cutthroat Trout within the upper Fording River have been the subject of several studies since 1975, most of which have been site-specific assessments or monitoring related to coal mining development and potential habitat impacts. Several of the more comprehensive studies within the upper Fording River that were examined for potential as “baseline” or “trend” data include; Lister and Kerr Wood Leidal (1980), Norecol (1983), Fording Coal Limited (1985), Oliver (1999), Amos and Wright (2000), and Wright *et al.* (2001). There was also summary data in reviews by Wood (1978), Berdusco and Wood (1992) and Wood and Berdusco (1999). The approach of using other studies for baseline or trend data has not been successful in the past due to differences in focus, timing and variability of sampling area, combined with the migratory nature of the population (Amos and Wright 2000). A number of previous upper Fording River Westslope Cutthroat Trout assessment studies have noted the apparent migratory nature of this population based on movements inferred from Floy tag distribution data and changes in abundance within specific sites across different seasons within a year (Amos and Wright 2000, Lister and Kerr Wood Leidal 1980, Fording Coal Limited 1985). Regardless, the current study does not assume all segments of the population are migratory and examination of trends between the current study and previous studies was one of several lines of evidence that was explored to determine if the upper Fording River population growth was being limited.

In the context of this Project, water quality was considered important as there was concern that selenium concentrations may be approaching or could approach levels that have the ability to manifest themselves as population level effects for the upper Fording River Westslope Cutthroat Trout (Lemly 2014, Orr *et al.* 2012, Elphick *et al.* 2009, Orr *et al.* 2006). Given that poorly understood fish migratory patterns are confounding interpretation of fish tissue concentrations (Fisher 2013, *pers. comm.*, Orr *et al.* 2012), understanding selenium concentrations and their distribution and how these relate to fish movement patterns and habitat use within the upper Fording River could have important implications for understanding population dynamics and making informed management decisions around habitat mitigation and offsetting works (*i.e.,* in the past or in other literature variously termed habitat mitigation, rehabilitation, restoration, compensation and remediation). Therefore, the Project is primarily in support of substantive on-going work on ecosystem health, namely the Elk Valley Water Quality Plan (EVWQP) and the Regional Aquatic Effects Monitoring Program (REAMP). The goal of the EVWQP (2014) is to stabilize and reverse the increasing trend of selenium, cadmium, nitrate, sulphate and calcite to ensure the ongoing health of the watershed, while at the same time allowing for continued sustainable mining. The goal of the RAEMP, a comprehensive monitoring program, is to assess potential effects in the aquatic environment throughout the Elk River watershed and Koocanusa Reservoir (Windward *et al.* 2014).

Coal mining accelerates the natural release of selenium (Se) and the Elk Valley and the upper Fording River lie within the Kootenay geological formation, an area of naturally seleniferous soils

(Orr *et al.* 2006). This has resulted in long-term increases in water quality constituents of concern, notably selenium, in water downstream of the Elk Valley Coal Mines with concentrations that substantially exceed the Canadian Council of Ministers of the Environment (CCME) Water Quality Guideline (WQG) values for the protection of aquatic life (2 µg/L) and drinking water (10 µg/L) (Windward Environmental *et al.* 2014, Minnow Environmental Inc and PLA 2012, Minnow *et al.* 2011, Chapman *et al.* 2008, Minnow *et al.* 2007).

Recently (2008-2010), water concentrations were evaluated for 78 metal and non-metal variables measured at 13 reference stations, 10 major mine source stations, and 17 receiving environment stations within the Elk River watershed; including the upper Fording River. Chloride, conductivity, hardness, nitrate, sulphate, total dissolved solids, calcium, magnesium, selenium and uranium concentrations were above the background range in at least 50% of samples collected at both source and receiving environment stations and were considered "major mine indicators.", (Minnow Environmental Inc and PLA 2012). The mean 2009 selenium concentration in the Fording River downstream of FRO was 31 µg/L, representing an average increase of 13% per year since 2004 (Minnow *et al.* 2011).

In 2012, the British Columbia Ministry of Environment undertook an independent sampling program within the upper Fording River. The average selenium concentration for these samples was 52.9 µg/L (Fisher 2013, *pers. comm.*, Ministry of Environment Submission to the Environmental Assessment Office (EAO), Teck Coal Limited Line Creek Phase II Project Application).

Most recently, Windward Environmental *et al.* (2014) summarized the surface water quality data for 93 Teck monitoring stations for the 2011- 2013 period. Teck monitoring station GH_FR1 was located just downstream of Greenhills Creek at the downstream edge of the study area. This monitoring station integrates all inputs to the mainstem Fording River from both FRO and GHO (plus future input from LCO via Dry Creek). The median selenium concentration at this site was 40 µg/L representing an average increase of 11%. For all mainstem upper Fording River receiving stations the median range was between 7.9 and 72 µg/L, representing trend increases of between 10 and 43%.

The majority of FRO selenium loading originates from Henretta, Clode, and Kilmarnock Creeks. Swift, Cataract and Greenhills Creeks represent the largest selenium load into the upper Fording River from GHO (Windward Environmental *et al.* 2014). These sources result in high selenium loads within river sections containing notable over-wintering aggregations of Westslope Cutthroat Trout (*see* Section 3.3.1.6.2 Over-wintering). Westslope Cutthroat Trout captured during spawning season within the Fording Oxbow area (*i.e.,* Population Segment S6) and Henretta Pit Lake are known to contain elevated and high selenium bioaccumulation within tissue samples (McDonald 2013, Fisher 2013, *pers. comm.*, Minnow *et al.* 2011).

On the other hand, despite these increasing trends in selenium concentrations in surface water, there has been no discernible increase in fish tissue concentrations reported over time, based on comparison of data collected over four studies since 1996 (Minnow *et al.* 2011). The selenium tissue levels did not increase in benthic invertebrates, bird eggs, or fish muscle samples between 1996 and 2009 (Orr *et al.* 2012) and although elevated do not appear to be adversely impacting the viability and productivity of fish and water bird populations (Minnow *et al.* 2011, Chapman *et al.* 2008). In contrast, Environment Canada sampling (2012-2014) and interpretation of monitoring results provided the alternative opinion that current selenium concentrations in surface water were having an impact on resident fish populations in the Fording and Elk Rivers (Lemly 2014).

Calcite ($CaCO_{3(s)}$) precipitation and deposition is also a potential water quality concern although the calcite precipitation mechanism and the rate of deposition are not fully understood. While calcite precipitation/deposition occurs naturally within the Elk River watershed, it has also been commonly observed downstream of mining activities (*e.g.,* waste rock piles). Interior Reforestation (2010) looked at the effects of calcite deposition on benthic macroinvertebrate communities throughout the Elk River Watershed. The study concluded that “calcite deposition has adversely modified invertebrate communities.” Although the study did not find a significant reduction in overall invertebrate biomass, it did find a significant reduction in the %EPT (*Ephemeroptera* (mayfly), *Plecoptera* (stonefly), and *Trichoptera* (caddisfly)) taxa at both low and moderate-high calcite deposition sites. EPT taxa are important Westslope Cutthroat Trout prey items and the study found EPT taxa replaced by *Ostracoda* which are an unfavourable prey species. The study considers this shift in benthic invertebrate community structure as “a direct reduction in food availability”. Other potential impacts in areas of high calcite deposition include impacts to fish habitat, channel morphology alteration and impacts to riparian vegetation (Interior Reforestation 2011, Interior Reforestation 2012).

Teck initiated a study in 2013 to evaluate the spatial and temporal variability in calcite deposition and evaluate the effects of calcite on biota (Windward *et al.* 2014, Robinson and MacDonald 2014). At present, this study is continuing and in 2015 and 2016 was expanded to include the potential impacts on fish spawning and incubation habitat.

1.2. Study Questions and Definitions

The overall goal or purpose of the Project was to determine whether the upper Fording River watershed Westslope Cutthroat Trout population is healthy, resilient and sustainable. The Project aimed to characterize the upper Fording River Westslope Cutthroat Trout population in terms of abundance estimates, genetic differentiation, population viability and sustainability, condition factors (*i.e.,* age structure, standard weight equations), life history strategies (*i.e.,* distribution, home range, movement patterns and habitat utilization) and habitat (*i.e.,* critical and overall).

Seven study questions and the study methods that were used to answer them (Table 1.2.1), were defined through a series of three workshops held in 2012 by the Steering Committee to address concerns raised by communities of interest, government agencies and First Nations, largely through dialogue regarding resource development in the Upper Fording River watershed.

These workshops followed the Data Quality Objectives (DQO) process based on “Guidance on Systematic Planning Using the Data Quality Objectives Process” (EPA 2006). The DQO process is used to develop performance and acceptance criteria (or data quality objectives) that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.

Through the DQO process, the minimum timeframe for the field data collection efforts was identified to be three years using an adaptive management approach. The adaptive management approach includes annual review and (if necessary) study design modifications as new information becomes available to address unanticipated uncertainties (Hilborn and Walters 1992). This is the same approach recently defined as “feedback loops” in the Aquatic Monitoring Program.

The following subsections describe the seven study questions and explain how they contribute to the overall goal of the study. Note that the specific definitions for study question terminology used in this study (*i.e.,* viability, sustainability, resilience, critical habitat, core area, limiting factors or habitats, fish habitat impact, population or perceived threat) were provided within their respective study question below and were discussed further within the detailed methodology to implement the study design (Section 2).

Table 1.2.1. Overview summary of study questions and study methods derived from the DQO workshops held in 2012. Table adapted from a version provided by S. Swanson, Swanson Environmental Ltd., Fernie, B.C.

	Key Study Question	Evaluation of river discharge and water temperature	Population Monitoring (Juvenile, Sub-adult and Adult)*	Analysis of Movement Patterns and Distribution*	Habitat Mapping and Meso-habitat Charact-erization	Literature Review of Genetics Analyses	Literature Review of Population Viability Studies	Population Sustainability Analysis
1	What is a viable WCT population?						X	
2	Are the fish healthy (with respect to condition factor)?	X	X					
3	Is the WCT population sustainable?	X	X	X	X		X	X
4	One interconnected population or multiple populations?			X		X		
5	What are the habitats (critical and overall) in the study area?	X	X	X	X			
6	What are the movement patterns and why?		X	X				
7	What is the distribution of WCT Seasonally, by life history stage?		X	X				

* Radio-telemetry was used as part of population monitoring and analysis of movement patterns and distribution

1.2.1. Population Viability

1. *What is a viable Westslope Cutthroat Trout population?*

One of the goals of the Project was to assess the status of the upper Fording River Westslope Cutthroat Trout population and to determine its relative "health". Population health can be determined through a variety of measures, including population viability assessment.

> **Population Viability Assessment** (PVA) - is a method of risk assessment frequently used in conservation biology that uses population estimates or models to evaluate the risk of extinction relative to critical management thresholds, threats to life history requirements, demographic stochasticity, genetic variation, environmental variation and catastrophes (DFO 2009, Ackakaya 1998).

Using these methods, population viability is traditionally defined as the probability that a population will go extinct (extirpated) within a given number of years (generations). For example, a 90% probability of persistence for at least 40 generations. Extirpation refers to local extinction of a species in a given geographical area of study though it still exists somewhere.

In the case of the upper Fording River, "viability" must be considered within the context of the population objective, which, for the purposes of this study and for consistency with the assessment end-point being used for Teck development proposals in the area (*e.g.,* Baldy Ridge Extension Project Environmental Assessment, LCO Phase II and FRO Swift), was defined as a self-sustaining and ecologically effective population (this includes the capability to withstand environmental change and accommodating stochastic population processes such as unpredictable events (*e.g.,* several dry summers, floods, or an exceptionally cold winter).

The term used in the study of population dynamics, and in this report, to capture this concept of population stability around a dynamic equilibrium is resilience.

> **Population Resilience** - is a population's capacity to deal with environmental change or disturbance (*e.g.,* natural and anthropomorphic) and recognizes the need to maintain life history, population and habitat characteristics that increase the ability of a population to withstand and recover from disturbances (Waldman *et al.* 2016, Homel *et al.* 2015, Waples *et al.* 2008, Holling 1973).

Reductions in population resilience increases the risk to population viability (*i.e.,* extirpation) and has consistently been identified as a precursor to precipitous population declines within the Salmonidae family, *Oncorhynchus* spp. and Westslope Cutthroat Trout (Waldman *et al.* 2016, Homel *et al.* 2015, AWRT 2013, Cleator *et al.* 2009, Mayhood 2009, Oliver 2009, Waples *et al.*

2008, Rieman and Dunham 2000). Population resilience therefore, is central to the viability of a Westslope Cutthroat Trout population. For the purposes of this report, population resilience was considered in the assessment of population sustainability (as opposed to viability; *see* Section 2.9 Population Sustainability) since it reflects the same end-point defined in the EA process and what the Project Steering Committee referred to as a "robust" population (Cope *et al.* 2013).

1.2.2. Fish Condition

2. Are the fish healthy (with respect to condition factor)?

Indices of condition, or well-being, have often been interpreted and compared using weight – length relationships (Murphy and Willis 1996). In theory, if stressors (*e.g.,* selenium from coal development) were influencing the well-being of fish, this should be evident with lower condition factor for populations within the coal block or its receiving environment. As such, indices of condition provide a means to compare the relative weight – length relationships between the upper Fording River and upper Kootenay River reference populations (Bull River, Cope and Prince 2012, Elk River, Prince and Morris 2003, St. Mary River, Morris and Prince 2004, Wigwam River, Baxter and Hagen 2003). Indices of condition were to be supported by visual examinations of all fish captures for any signs of injury, disease or deformity.

The fish condition work of the Project was designed to opportunistically assess fish health, but was not designed to understand causal relationships. Therefore, the fish condition work of the Project was primarily in support of substantive on-going work on ecosystem health, namely the EVWQP and the RAEMP.

1.2.3. Population Sustainability

3. Is the Westslope Cutthroat Trout population sustainable?

During the Project planning phase the overall goal was defined as determining if the upper Fording River Westslope Cutthroat Trout population was "robust (resilient) and sustainable".

> **Population Sustainability** - can be defined through change in the population over time (*i.e.,* decreasing, stable, increasing) and the intrinsic population growth potential (*i.e.,* productive potential of the habitat and the reproductive potential of the species). In its simplest form, a sustainable fish population can be defined as one that does not decline over time due to natural and anthropomorphic limitations to productivity. As defined above in Question #1, for the purposes of this report, the term population resilience is considered synonymous with robust.

Note that any differences in terminology used in defining a sustainable Westslope Cutthroat Trout population between this report and the environmental assessment process (*i.e.,* Baldy Ridge Extension Project Environmental Assessment, LCO Phase II and FRO Swift) are meant to define the same endpoint. That is a population that is stable or increasing over time or in the case of the environmental assessment definition a self-sustaining and ecologically effective fish population.

Annual population monitoring data can be used to detect trends (*i.e.,* decreasing, stable, increasing). As the data set grows, the ability to detect trends improves. Initially, only fairly substantial annual differences of population numbers (*e.g.,* approximately 25% or more) will be detectable. After three years it was hoped this would improve to +/- 10%, although the time frame of three years was identified as optimistic and likely to require further trend monitoring using less intensive methods.

Therefore, because it was anticipated that the Project timeframe (3.3 years or 40 months) would limit the ability of trend monitoring alone to define population sustainability, the current assessment also relied on criteria utilized by management agencies that employ Fish Sustainability Indices (Macpherson *et al.* 2014). These criteria include, among others depending on applicability (*i.e.,* introduced species); population abundance and trends (*see* Section 2.4 Population Monitoring), analysis of movement patterns and distribution (*i.e.,* life history diversity, *see* Section 2.5 Analysis of Movement Patterns and Distribution), habitat availability *(see* Section 2.6 Habitat Mapping), genetic integrity (*see* Section 2.7 Population Genetics), and population viability (*see* Section 2.8 Population Viability) (Macpherson *et al.* 2014).

The following methods and corresponding results sections have been structured such that each section builds on the previous sections developing multiple lines of evidence for a balance of probabilities evaluation; particularly as they relate to the final section of population sustainability that includes a discussion of potential population threats and threat mitigation (*i.e.,* population resilience including life history diversity, habitat loss, overharvest, water quality, exotic species, habitat protection needs and availability).

Since an assessment of population sustainability represents a present day snapshot in time of the current status of the upper Fording River Westslope Cutthroat Trout population, it should be reassessed if the severities of population threats change, as new threats appear, or as management actions change.

Population or Perceived Threat – an impact, limiting factor or trend that if not reversed is likely to cause damage or danger such that the population may decrease and population resilience, viability and sustainability may be at risk.

1.2.4. Population Genetics

4. Is it one interconnected population or multiple populations (with respect to genetics)?

Populations of fluvial resident (non-migratory) and fluvial migratory forms of Westslope Cutthroat Trout are intrinsically different and these differences have important population management implications. For example, several small reproductively isolated populations have lower population resilience than one larger connected population. An understanding of gene flow and habitat connectivity (and their correlates of fish movement patterns) provides necessary context regarding population assessment; especially as it relates to population viability, resilience and sustainability.

1.2.5. Habitat

5. What are the habitats (critical and overall habitat) in the study area?

Effective population conservation requires an understanding of habitat availability, identification of critical habitats and their spatial and temporal distribution within a watershed (*i.e.,* migration corridors and timing). Habitat provides the context necessary to complete a population assessment, especially as it relates to the productive potential of the habitat and population abundance (*i.e.,* limitations or “bottlenecks” to abundance), life history strategies (*i.e.,* seasonal distribution and movement patterns by life stage) and their effect on population resilience and sustainability (*i.e.,* habitat characteristics that increase the ability of a population to withstand and recover from disturbance).

The identification of critical habitats and life history strategies will also support decision making regarding development, effective conservation and habitat offsetting in the upper Fording River watershed (*i.e.,* the study area).

For clarity, the following definitions used in the assessment of habitat (critical and overall) and their potential effect on population dynamics are provided. Rather than the area of occupancy definition used for imperiled areas of Westslope Cutthroat Trout distribution (*i.e.,* Alberta, Canada, AWRT 2013), the more refined definition of critical habitat used by SARA and the United States Endangered Species Act (ESA) was considered a more useful tool to identify limiting factors or bottlenecks to productivity.

Critical Habitat - the Canadian Species at Risk Act (SARA) and the United States Endangered Species Act (ESA) definitions were used, "Critical habitat refers to areas that contain habitat features that are essential for the survival and recovery of a listed species and which may require special management considerations or protections."

Limiting Factors or Habitats - are a factor or habitat in short supply that prevents a population from growing any larger (prevents the full expression of life history needs and by definition is critical habitat). Not all critical habitats are necessarily limiting.

Core Population Maintenance Areas (i.e., core areas) - refers to a collection of habitats that are in close proximity, connected, support all life stages within the diversity of habitats present and support both resident and migratory life history types. All habitat including mainstem, side-channels, associated tributaries, and riparian habitat within a core area was considered critical habitat necessary for population maintenance.

Fish Habitat Impact (or Degraded Stream Channel) – a change that results in a loss in productive capacity as defined by DFO as "any change in fish habitat that reduces its capacity to support one or more life processes of fish" (*e.g.,* spawning, nursery, rearing, feeding, overwintering, migration). This report applies the DFO definition of change or impacts as the harmful alteration, disruption or destruction (HADD) of fish habitat, destruction of fish, obstruction of fish passage, and deposit of deleterious substances.

1.2.6. Fish Movement

6. What are the movement patterns and why?

Life history data (*e.g.,* temporal and spatial movement patterns and habitat use) provide the basic foundation for all management, mitigation and habitat compensation programs (*i.e.,* habitat offsetting programs, McPhail 1997). As noted above in Question #5, movement patterns (life history strategies and diversity) provide insight into identifying critical habitats and migration corridors which in turn are necessary for an assessment of sustainability as it relates to the productive potential of the habitat and their effect on population resilience and sustainability. Multiple life history forms (diversity) provide a greater range of opportunities for population persistence in a spatially and temporally variable environment (Homel *et al.* 2015, Waples *et al.* 2008, Prince and Morris 2003).

The identification of movement patterns and life history diversity are especially relevant for Westslope Cutthroat Trout where fragmentation and simplification of the physical habitat are often small in magnitude *(i.e.,* culverts) but replicated many times across the landscape leading to pervasive effects that artificially select against migratory life history forms; often the larger, more fecund fish (Homel *et al.* 2015, Waples *et al.* 2008). While this has resulted in drastic declines of Westslope Cutthroat Trout from its historical range (Cleator *et al.* 2009, COSEWIC 2006, Shepard *et al.* 2005, Liknes and Graham 1988), East Kootenay classified waters populations exist within relatively intact watersheds and retain multiple life history forms within a given population (Morris and Prince 2004, Prince and Morris 2003).

In addition, given that poorly understood fish migratory patterns were confounding interpretation of fish tissue selenium concentrations (Fisher 2013, *pers. comm.*, Orr *et al.* 2012); answers to study questions #6 and #7 in particular will support on-going assessment under the EVWQP and RAEMP of aquatic ecosystem health. Understanding water quality patterns and how these relate to fish movement patterns and habitat use within the upper Fording River could have implications for understanding population dynamics and making informed management decisions around habitat mitigation and offsetting works.

1.2.7. Fish Distribution

7. *What is the distribution of Westslope Cutthroat Trout seasonally, considering life history stage and upstream distribution limits?*

The seasonal distribution (*e.g.,* spawning, summer rearing, over-wintering) of the upper Fording River Westslope Cutthroat Trout population was documented using radio telemetry and population monitoring (*e.g.,* juveniles, sub-adults and adults) over 3.3 years (40 months). Study questions # 5, 6 and 7 were closely linked as fish distribution is generally a function of life history patterns (*e.g.,* movement patterns and seasonal habitat use) that are influenced by the abundance and distribution of critical habitat. Upstream distribution limits were important in determining total available habitat and will enable informed land-use decisions. The combination of movement patterns and seasonal distribution were used to classify the types of life history forms present (*e.g.,* fluvial resident or fluvial migratory).

2. Methods

This section describes the study area, sample locations and the five study methods that were used to answer the seven study questions. This methods section also includes the environmental data collection procedures necessary to document annual variations in river discharge and water temperature as well as outlining the background literature reviews necessary for context regarding population viability and genetics.

Telemetric methods used in this project were supported by 24 years of implementation and interpretation by the principle biologists and field crew within British Columbia watersheds on threatened or endangered populations for a variety of species such as Westslope Cutthroat Trout (Cope and Prince 2012, Morris and Prince 2004, Prince and Morris 2003), Mountain Whitefish (*Prosopium williamsoni*) (Cope and Prince 2012), Bull Trout (*Salvelinus confluentus*) (Prince 2010), Rainbow Trout (*Oncorhynchus mykiss*) (Prince *et al.* 2000), Pacific salmon (Sockeye (*Oncorhynchus nerka*), Hinch *et al.* 1996; Coho (*Oncorhynchus kisutch*), Healey and Prince 1998), White Sturgeon (*Acipenser transmontanus*) (Prince 2004, R.L.&L. Environmental Services Ltd. 1996) and Burbot (*Lota lota*) (Kang *et al.* 2015, Cope 2011).

Similarly, juvenile removal-depletion electrofishing methods for a variety of species including Westslope Cutthroat Trout were supported by over 10 years of implementation and interpretation by the principle biologists (Cope 2008, 2007, 2001, Cope and Morris 2006, Bisset and Cope 2002).

2.1. Study Area

The spatial boundary of the Project was defined as the upper Fording River watershed (including tributaries) above Josephine Falls (Figure 2.1.1). The Fording River is a tributary to the Elk River located within the Regional District of East Kootenay, in southeastern British Columbia. The Fording River drainage basin is located on the west slope of the Rocky Mountains and encompasses an area of approximately 621 km^2 with a mean annual discharge of 7.93 m^3/s (Water Survey Canada, Stn 08NK018, 1970-2010). The river flows 78 km in a southerly direction from its headwaters immediately west of the British Columbia – Alberta boundary and the continental divide to its confluence with the Elk River near Elkford, B.C. Josephine Falls represents a natural fish barrier in a steep-walled canyon and was located at river kilometer (rkm) 20.51. Josephine Falls represents the downstream (southern) limit of the study area approximately 3 km east of Elkford, B.C.

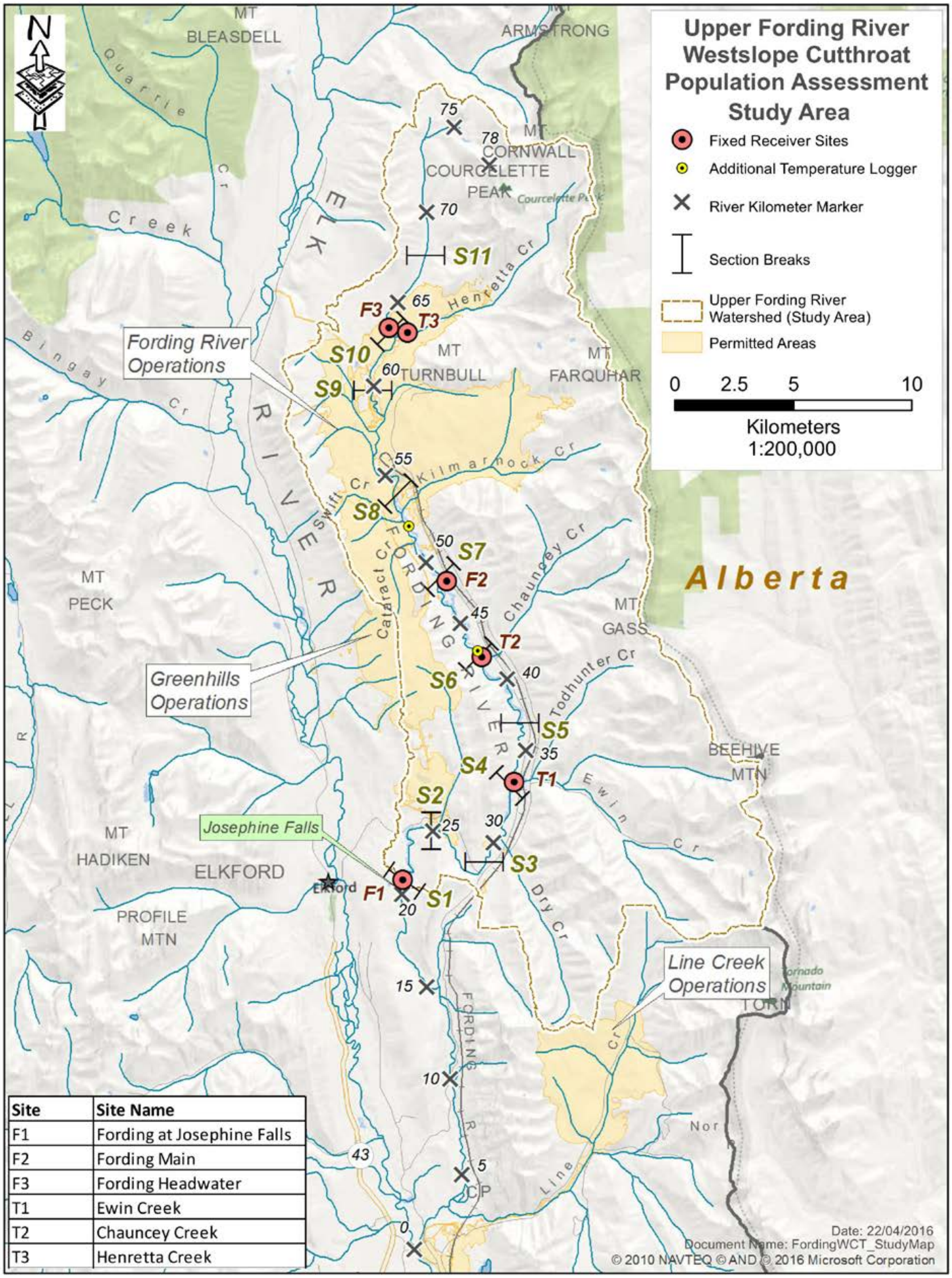


Figure 2.1.1. Upper Fording River study area, river sections and monitoring stations.

The elevation of the study area ranges from 1,400 m at Josephine Falls to 2,740 m at the headwaters (78.0 rkm). For context, the FRO processing plant and dryer were located at 57.0 rkm and 1,650 m elevation. As Josephine Falls represents a natural barrier, the Westslope Cutthroat Trout population of concern was considered a fluvial, headwater population restricted to the approximately 57.5 km portion of the upper Fording River (plus tributaries) between Josephine Falls at 20.5 rkm and the upstream limit of fish distribution in the headwaters somewhere between 73.0 and 78.0 rkm.

The layout of the sampling locations was summarized below and referenced further through subsequent subsections.

Telemetry monitoring includes fixed and mobile receivers for detecting radio signals emitted from fish implanted with radio transmitters. Fixed receivers were placed in permanent streamside locations (*i.e.,* “stations”) to ensure continuous and effective monitoring for detection of movements between river segments or between mainstem and tributary habitats. Figure 2.1.1 illustrates the location of the six fixed receiver stations within the study area. Three stations, F1, F2, and F3, were located on the upper Fording River mainstem to isolate the lower, middle and upper watershed. In general, the stations delineate the lower river that includes an important high sinuosity, low velocity, potential over-wintering area; the middle river section that includes the Fording River Operations (FRO) area; and the upper river above the mine that represents the headwaters. The lowermost fixed receiver (F1) was located at Josephine Falls, a known barrier to upstream fish passage, to provide an estimate of emigration (over the falls).

Three fixed receiver stations T1, T2, and T3, were located on tributaries to isolate; Ewin, Chauncey, and Henretta Creeks (respectively). Table 2.1.1 provides a summary of the six fixed stations including location by river kilometer.

The upper Fording River mainstem was further sub-divided into 11 population assessment river segments of similar character to facilitate sub-adult and adult population assessment at a finer scale using snorkel methods (Figure 2.1.1; Table 2.1.2). These 11 river segments were also mapped at the meso-habitat scale to document the available habitat and facilitate examination of habitat differences and distribution among river segments (*see* Section 2.6 Habitat Mapping). River “segments” represent “strata” delineated for the randomly stratified approach used for population monitoring. River segments were delineated principally based on the requirement to include enough stream length (lineal river km) to facilitate the recaptures necessary to generate

Table 2.1.1. Upper Fording River fixed receiver and temperature monitoring sites. Mainstem station river kilometers (rkm) were upstream from the confluence with the Elk River. Tributary river kilometers were upstream from the confluence with the Fording River. The study area extends from 20.51 rkm at Josephine Falls to approximately 78.00 rkm (headwaters > 20%). Fording River Operations extend from approximately 51 to 65 rkm.

Receiver Station	River Km	Location	Existing FRO Sample Site (rkm)
F1	20.60	Josephine Falls	
	42.48	S6[a]	
F2	48.60	Downstream FRO	FR2 (54.3 rkm)
	52.00	S7[a]	
F3	63.60	Headwaters	UFR1 (63.6 rkm)
T1	0.25E	Ewin Creek	
T2	0.10C	Chauncey Creek	
T3	0.72H	Henretta Creek	HC1 (0.72H rkm)

a – Note this station was a water temperature monitoring site and does not include a telemetry receiver. All receiver stations also include water temperature monitoring.

Table 2.1.2. Upper Fording River index segments (*i.e.,* strata) used for population monitoring and distribution assessments. River kilometers (rkm) are upstream from the confluence with the Elk River. The study area extends from 20.51 rkm at Josephine Falls to approximately 78.00 rkm (headwaters > 20%). Fording River Operations extend from approximately 51 to 65 rkm.

River Segment	River Km	Length (km)	Location
1	20.51–25.00	4.49	Josephine Falls to GHO
2	25.00-29.00	4.00	GHO to above Fording Bridge
3	29.00-33.16	4.16	Above Fording Br. To Ewin Creek
4	33.16-37.59	4.40	Ewin Cr. To S-bends
5	37.56-41.96	4.40	S-bends to Chauncey Creek
6	41.96-48.96	7.00	Chauncey Cr. to F2 side road
7	48.96-54.00	5.04	F2 side road to Diversion Reach
8	54.00-59.75	5.75	Diversion reach to Turnbull Br.
9	59.75-63.40	3.65	Turnbull Br. to above Henretta
10	63.40-67.75	4.35	Above Henretta
11	67.75-78.00	10.25	Headwaters
		57.49	N = 11

population estimates while restricting the total segment length to a distance that could be snorkeled and traversed on foot within a day. As such, each river segment was not a river "reach" of similar geomorphological characteristics since some segments contain several reaches. Reaches from Ewin Creek upstream to the headwaters were previously delineated (Oliver 1999) and these reach breaks were included within the GIS overlay for reference.

2.2. Study Period

The Project was a 3.3 year study (40 months) over four years (2012 – 2015) that included three replicate fish tagging periods (sub-adults and adults 2012, 2013, 2014; Juveniles 2013, 2014, 2015). The life history (telemetry), habitat mapping and population monitoring field work were completed August 2012 to October 2015. Table 2.1.3 provides a visual summary of the data collection timelines for the five study methods through the project time period.

Table 2.1.3. Data collection timelines for the five study methods designed to answer the seven study questions.

	2012	2013	2014	2015
Radio Telemetry and Population Monitoring	Tagging + snorkel surveys each year (subadult and adult)		Ongoing Tracking	
Recruitment and Juvenile Population Monitoring		Recruitment assessments		
Habitat Mapping (availability)	Using 2012 air photographs			Ground-truthing
Meso-Habitat Characterization	Ongoing seasonally and by life stage			
Water Quality		Existing data sources		

2.3. Evaluation of River Discharge and Water Temperature Data

Radio tagged sub-adult and adult Westslope Cutthroat Trout were tracked over 40 months (Aug 2012 to Nov 2015) to examine life history strategies over a range of environmental conditions. Water flow or discharge and water temperature were of particular interest as the daily, seasonal and annual variation in river discharge and water temperature are known influences on seasonal distribution and habitat utilization of Westslope Cutthroat Trout. As a result, there is a body of literature that define water temperature guidelines for Westslope Cutthroat Trout life history functions such as spawning and rearing (Pollard 2010 *pers. comm*., Bear *et al*. 2007, Oliver and Fidler 2001, Ford *et al.* 1995, Behnke and Zarn 1976). As such, the interpretation of telemetry movement data relies on an understanding of the hydraulic and thermal regime within which the species and population under study occupy. Therefore, documentation of mean daily and daily minimum and maximum discharge and water temperature were being completed as part of this telemetry study and population assessment.

The annual thermograph and hydrograph data are presented at the start of Section 3 (Results) and the seasonal pattern and specific values defined in guidelines are subsequently used in following sections in the interpretation of seasonal movement and distribution data.

2.3.1. River Discharge

The primary hydrometric data that was utilized for this study was collected by the Water Survey of Canada (WSC) on the Fording River at the mouth (Station No. 08NK018). This station has been in continuous operation since 1970 and this data was also summarized to provide comparisons of study conditions within the range of recorded conditions.

2.3.2. Water Temperature

Water temperatures were recorded at each fixed receiver location (n=6) with two Tidbit V2TM loggers (replicates) to document mainstem and tributary temperature variation (Table 2.1.1; Figure 2.1.1). Additional temperature loggers were also placed at 42.48 rkm in river Segment S6 immediately upstream of Chauncey Creek and at 52.00 rkm in Segment S7 immediately downstream of Kilmarnock Creek. The S6 location represented the aggregations of over-wintering Westslope Cutthroat Trout. The S7 location represented the lower mine site and high spot water temperatures. Temperatures were recorded every 15 minutes and summarized to provide hourly and daily means. Temperature loggers were installed August 20-22, 2012 with the exception of river Segment S6 (October 25, 2012) and Segment S7 (September 30, 2014).

All temperature loggers were placed immediately above the river bottom using a concrete landscape block with a 9" central opening that was used both as an anchor and as a housing to protect and shade the Tidbit loggers. The concrete block was attached to an anchor tree using 1/4" wire cable and cable clamps. The cable was attached to the concrete block by wrapping through the block twice and securing using cable clamps. The tidbits were then attached to the cable on the inside of the concrete block using cable ties. The concrete block housing was then deployed in pool habitat within a shaded location. Water depths varied between 1.0 m and 3.0 m depending on the stream size and location but were selected to represent maximum depths available. All thermistors were deployed in flowing water with no thermal stratification.

Temperature data was downloaded from the Tidbit loggers on a seasonal schedule as follows; 1) late October to capture summer water temperatures before freeze-up and loggers may become inaccessible due to winter ice conditions, 2) late April-early May to capture winter temperatures before freshet conditions, and 3) July-August post freshet. The loggers were checked to ensure the data was logged; the status light was flashing "o.k." to indicate the logger was functioning properly and a water temperature was taken using a hand-held thermometer and cross-referenced to the data logger at that time stamp for quality assurance. Radio receiver stations were serviced on a three week schedule and temperature loggers were checked at that time to ensure they remained in flowing water and were functioning properly.

2.4. Population Monitoring

Population monitoring of the upper Fording River Westslope Cutthroat Trout was examined through two methods: 1) annual sub-adult and adult population estimates generated through snorkel survey mark – recapture methods, and 2) annual recruitment (fry) and juvenile density estimates using removal – depletion electrofishing methods.

2.4.1. Sub-adult and Adult Population Monitoring

In this study, radio telemetry and Floy tags were used as tools for both population estimation and life history study for the sub-adult and adult life stages (*i.e.,* fish > 200 mm fork length). Since radio telemetry fish could be individually and independently confirmed within a given river segment, these fish were also used to calibrate observer efficiency (*e.g.,* snorkel counts) of batch marks (*i.e.,* Floy tagged fish with no radio tag) to generate annual population estimates using snorkel survey mark – recapture methods (Schwarz *et al.* 2013). These mark recapture methods were replicated for three years (2012, 2013 and 2014).

2.4.1.1.Fish Capture and Tagging

In order to attach radio (telemetry) and Floy (mark-recapture) tags, sub-adult and adult Westslope Cutthroat Trout were captured in August and September 2012, 2013, and 2014 when water temperatures were predominantly less than 14.0 ^{o}C. There were three days that exceeded the temperature guideline (August 27, 28, 2012, August 11, 2014) in river Segments S7 and S8.

Fly-fishing was used exclusively as the capture method to help reduce post-release mortality (Schill and Scarpella 1997, Schill 1996, Schisler and Bergersen 1996). Fish were captured using professional anglers experienced with radio telemetry projects and their specialized handling techniques designed to minimize potential hook and capture trauma (Cope and Prince 2012, Prince 2010, Morris and Prince 2004, Prince and Morris 2003).

Annual capture targets were for a combined mark density of approximately four fish per km over the 57.5 km mainstem Fording River for a total of 232 radio and Floy tagged fish. This resulted in the following targets or objectives for each tag type:

1. 60 Westslope Cutthroat Trout (> 200 g or approximately 230 mm fork length) implanted with radio tags (Lotek Wireless, Newmarket, Ont., Canada) and applied with a unique coloured Floy tag (Floy Tag, Seattle, WA, USA) for external identification, and
2. An additional 172 Westslope Cutthroat Trout > 200 mm fork length applied with Floy tags (alternate colour than radio tagged fish) for snorkel mark – recapture population estimation.

Beginning in August 2013 (Year 2) all incidental captures of juveniles (at this point arbitrarily defined as fish between 60 and 200 mm) were PIT tagged (Biomark HPT8 134.2 PIT Tag, Biomark, Boise, Idaho) and sampled to augment the juvenile assessment component of the Project (*see* Section 2.4.2 Recruitment and Juvenile Population Monitoring).

Captured fish were allowed to recover their oxygen deficit (created during capture) in an instream fish sleeve for 30 minutes prior to being anaesthetized and processed. Fish were anaesthetized in a 40 L bath of river water containing 2.0 ml clove oil yielding bath concentrations of 50 ppm. Clove oil is a safe, inexpensive, and effective anaesthetic suitable for invasive procedures in the field (Prince and Powell 2000, Peake 1998, Anderson *et al.* 1997). The lowest effective dose of clove oil is recommended as time to recovery of equilibrium and fear response in salmonids has been shown to increase exponentially with exposure time (Keene *et al.* 1998). Because of its low solubility in water, the clove oil was first dissolved in 10-ml of ethanol (95%) before being added to the river water. Times to anaesthesia, surgery, and recovery were recorded for quality assurance.

The five stages of anaesthesia referred to in this investigation are: level one, partial loss of equilibrium with normal swimming motion; level two, total loss of equilibrium with normal swimming motion; level three, partial loss of swimming motion; level four, total loss of swimming motion and weak opercula motion; level five, no opercula motion (Yoshikawa *et al.* 1988). For surgical procedures level four anaesthesia was required to ensure immobility.

Once anaesthetized to a stage four level, fish were weighed (g), measured (fork length mm), examined externally for any signs of deformity or injury, Floy tagged, and then (if selected for radio tag implantation) placed on their dorsum in a V-shaped surgical table and partially submerged in a water bath to ensure the head and gills were in contact with oxygenated water. All Floy tagged fish were externally assessed for maturity status. Fish selected for radio tag implantation were also assessed internally for sex and maturity status. All radio tagged fish were photographed and any deformities encountered were photo-documented.

2.4.1.1.1.Radio-Tags

Radio tagged fish were limited to 200 g or approximately 230 mm or larger to ensure the radio tag weight did not exceed 2% of the body weight; a general standard for behavioural fish telemetry studies (Winter 1983). Radio tags (frequency 150.210 MHz) were Lotek MST-930 tags (Lotek Wireless, Newmarket, Ont., Canada) 9.5 mm x 28 mm that weigh 4.0 g (weight in air) and have a warranty life of 390 days (typical battery life 488 days at a 10 sec. burst rate). Radio tags were individually coded (codes 11-70 in 2012, 72-132 in 2013 and 133-193 in 2014) so that individual fish could be identified in all receiver logs and the mobile relocation records. All radio tagged fish were also Floy tagged for visual identification.

Following the general anaesthesia and measurement protocol as described in the previous section, transmitter implantation methods were as follows. A small incision (2.0 cm) was made approximately 1.0 cm from the mid-ventral line and anterior to the pelvic fins. Gonadal development and any sign of deformity were examined internally with an otoscope to confirm reproductive status and visual signs of fish health. An equine intravenous catheter (1.7 X 133 mm) was inserted through the incision to a point 5-10 mm posterior and slightly caudal to the origin of the pelvic fins (Adams *et al.* 1998). The antenna wire was inserted through the catheter and the transmitter into the body cavity. The catheter was then pulled through the body wall and the transmitter gently pulled back to the pelvic girdle to prevent the transmitter from resting directly on the incision, which can increase the likelihood of tissue encapsulation and transmitter expulsion. The incision was then closed using independent and permanent monofilament sutures (4/0 Ethicon). Once the fish regained equilibrium and swimming ability, they were transferred to an instream sleeve and allowed 30 minutes to fully recover (*i.e.,* attainment of fear response) before release.

Radio tags were applied in a randomly stratified manner to ensure distribution across the study area. A tag density of one radio tagged fish per river kilometer was selected based on previous experience (Cope and Prince 2012, Prince 2010, Morris and Prince 2004, Prince and Morris 2003). Therefore, for each river segment (n=11, Figure 2.1.1), the number of radio tags deployed was determined by the length of the segment. Within a given river segment, the radio tags were randomly applied. Given the estimate of approximately 57.5 km of mainstem river habitat, the target density resulted in an annual sample size of 60 radio tags.

There was also technical rationale for limiting the sample size to 60 radio tags per year based on the trade-off between increased sample size and decreasing detection probabilities due to frequency saturation (*e.g.,* when a number of tags are located within the same meso-habitat unit causing interference) and the necessary use of multiple code sets and frequencies. The sample size selected maximizes the use of a single frequency with 10% reserve capacity (n=200 maximum coded tags per frequency). The use of a single frequency was considered vitally important to ensure tag detection by fixed receivers and helicopter. The tag burst rate was doubled from five seconds to ten seconds to extend battery life. This resulted in a guaranteed tag lifespan of 390 days (typical lifespan 488 days) for a tag size capable of tagging fish as small as 200 g. Fixed stations contain two antennae (one upstream, one downstream) to determine the direction of movement and this results in a 20 second monitoring cycle. Each additional frequency would double again the effective monitoring cycle (*e.g.,* 40 seconds for two frequencies). An increased monitoring cycle results in an increased risk of “missing” tagged fish as they move past the fixed monitoring station, particularly during times of decreased detection efficiency (*e.g.,* freshet flows, multiple tags in one location). These issues are amplified for helicopter tracking methods where the airspeed was approximately 15 - 20 knots.

2.4.1.1.2.Floy Tags

All radio tagged fish were also Floy tagged with a unique colour (green in 2012, pink in 2013, lime 2014) for visual identification and to differentiate them from Floy tagged fish without radio transmitters (white in 2012, blue in 2013, Orange in 2014). Different colors unique to each year were used to enable snorkelers to identify radio tagged fish as well as the year of tagging. Floy tags were uniquely numbered so that any recaptures could be individually identified. One third (n=78) of the Floy tagged fish were double tagged so that tag loss could be evaluated through recapture events.

2.4.1.2.Sub-Adult and Adult Population Estimates

An annual combined angling capture and snorkel recapture survey was completed in August and September 2012, 2013, and 2014 to estimate the population of Westslope Cutthroat Trout greater than 200 mm in length (the minimum size cut off for tagging). Annual targets were to capture (angling) and mark 232 fish greater than 200 mm fork length (*i.e.,* 4 fish/km). Larger fish (*i.e.,* 230 to 485 mm fork length) had radio tags implanted and a green (2013), pink (2013), or lime (2014) Floy tag attached, and were released; smaller fish (*i.e.,* 200 to 485 mm fork length) had a white (2012), blue (2013) or orange (2014) Floy tag attached and were released.

One week to one month later, the same sections of the river were surveyed using snorkel survey methods and the surveyors recorded the number of fish with coloured Floy tags and no tags. At the same time, members of the team used mobile receivers on the shore to determine how many radio-tagged fish implanted in the year of survey were currently present in the segment of the river being surveyed. Not all segments of the river were surveyed at the same time. Radio and Floy tags from previous years were occasionally sighted, but these were treated as “unmarked” fish in the year of analysis because algae coverage, tag loss, and other problems precludes from knowing how many were still present and available for recapture (*i.e.,* visible) by swimmers.

The capture-recapture snorkel data were then used to calculate population estimates using four models (Pooled Peterson, Stratified Peterson, Hierarchical, and Movement models) for radio tags only, Floy tags only, and all tags combined. A synthesis of these population estimates and their key assumptions were then compared to derive a population estimate for the proportion of the upper Fording River Westslope Cutthroat Trout population greater than 200 mm in length.

2.4.1.2.1.Snorkel Methods

Given suitable watershed conditions, snorkel counts have proven to be a reliable and efficient means of obtaining indices of relative abundance for salmonid populations in British Columbia streams (Korman e*t al.* 2002, Slaney and Martin 1987, Northcote and Wilkie 1963) and for Cutthroat Trout throughout their range including the East Kootenay (Cope and Prince 2012, Baxter 2006a, 2006b, 2005, 2004, Baxter and Hagen 2003, Oliver 1990, Zubick and Fraley 1988, Slaney and Martin 1987, Schill and Griffith 1984). However, it is likely that snorkel counts will be underestimates of true abundance because individuals are routinely missed due to the impacts of visibility, fish behaviour, and stream channel complexity. To address the observer efficiency issue, fish are marked (*i.e.,* Floy tags) within the section of stream for which the estimate will be conducted and the population estimate is generated with associated variability through a mark-recapture calculation. In this study, observer efficiency was further calibrated using the radio tagged fish that were also marked (*i.e.,* Floy tags of a colour unique to the fish with Floy tags only). At the same time as the snorkel survey, independent members of the team used mobile receivers on the shore to determine how many radio-tagged fish implanted in the year of survey were currently present in the segment of the river being surveyed.

The desired precision level for annual population estimates identified through the data quality objectives process was +/- 25%. Previous Westslope Cutthroat Trout mark-recapture estimates employing snorkel counts have demonstrated that marked fish densities of approximately four fish greater than 200 mm fork length per kilometer and an observer efficiency of approximately 50% or better were necessary to achieve desired precision levels (Cope and Prince 2012, Baxter 2006a, 2006b, 2005, 2004). Based on the above, study objectives called for the application of four Floy tagged Westslope Cutthroat Trout greater than 200 mm fork length per kilometer over the 57.5 km of mainstem upper Fording River; for an annual total of 232 Floy tagged sub-adult and adult Westslope Cutthroat Trout greater than 200 mm fork length.

Snorkel surveys were conducted using a team of four observers. Where possible, a snorkeler's lane extends 3-5 metres towards shore, with the offshore observer looking both ways towards the near shore observer. Where the stream width was less than 15 m the snorkel team formed two man teams to cover the distance in a more efficient manner. Frequent stops occur to discuss whether duplication has occurred. Whenever necessary, a habitat unit was re-surveyed if there was uncertainty or obvious discrepancies. Observed fish were identified to species and the target species were identified to 100 mm size class (*e.g.,* 0 – 100 mm, 100 – 200 mm, etc.). At the start of each survey day horizontal Secchi distance was taken from each observer and then averaged.

To date, a total of 12 river or tributary population index strata or "Segments" were established for the study and Table 2.1.2 summarizes these Segments and their extent. Figure 2.1.1 visually represents the location of the segments in the study area. The 12 population segments include 11 mainstem upper Fording River segments plus one tributary segment (Henretta Pit Lake including lower Henretta Creek to the confluence with the upper Fording River).

To further ensure the assumption that all tags were available for recapture (*i.e.,* minimize potential mortality and emigration losses), the annual snorkel surveys were completed immediately following the capture and tagging component. Snorkel surveys were scheduled over a seven day period, with the intent to cover the majority of the 57.5 km length of mainstem upper Fording River that could be safely accessed from the headwaters (river km 78.0) downstream to Josephine Falls (river km 20.5).

The original study intent was to apply Floy and radio tags within all 12 segments for subsequent snorkel enumeration of the entire mainstem upper Fording River and Henretta Creek. The following exceptions were not snorkelled: 1) the uppermost headwater population river segment (S11) representing 11 km of mainstem river above 67.0 rkm; and 2) upper Henretta Creek above Henretta Pit Lake. These two segments were not snorkeled due to the low water volume and small stream size, as well as the absence of tags due to the very low catch-per-unit-effort for fish meeting minimum size requirements.

As well, the lowermost 370 m of river Segment S1 above Josephine Falls was not snorkeled due to obvious safety concerns. The remaining potential fish bearing tributaries (*i.e.,* Chauncey, Ewin, Dry Creeks) were considered but not snorkelled due to the low water volume and small stream size, as well as the absence of tags due to the very low catch-per-unit-effort for fish meeting minimum size requirements.

2.4.1.2.2.Population Estimates

The following population estimation methods were summarized from Schwarz *et al.* (2013), "Integrating batch marks and radio tags to estimate the size of a closed population with a movement model." Population estimates were calculated using the following four models for radio tags only, Floy tags only, and all tags combined. A synthesis of these population estimates and their key assumptions were then compared to derive a population estimate for the upper Fording River Westslope Cutthroat Trout population.

1. Pooled-Petersen Estimates

Pooled Peterson Estimates were computed by pooling the marked-sample, the recovery sample, and the number of recaptures over all sections of the river. The key assumptions of the pooled-Petersen method are;

a) The probability of marking was equal in all sections,

b) The probability of recovery was equal in all sections, and

c) Complete mixing of marked and unmarked fish across all sections.

We use the term "recovered" even though fish were only sighted (*e.g.,* snorkel surveys) not physically handled.

It was unlikely that fish from all sections mix completely across the river (so condition (c) above may not be met), but the assumption of equal marking or equal recovery rates may be approximately satisfied because the effort and methods on all sections was the same. In cases where the probability of marking or recovery was unequal, but not too disparate across sections, the Pooled-Petersen is often approximately unbiased, but the reported standard error is too small (*i.e.,* the estimated abundance looks more precise than it really is and reported confidence intervals are too narrow).

The maximum likelihood estimate was formed as:

$$\hat{N}_{pooled} = \frac{n_1 n_2}{m_2}$$

Where n_1 is the number of fish marked and released in the population, n_2 is the number of fish (marked and unmarked) recovered during the snorkel survey, and m_2 is the number of marked fish recaptured (*i.e.,* sighted during the snorkel survey). An estimate of the number of unmarked fish in the population alive was found the same way by replacing n_2 by u_2 (the number of unmarked fish seen at time 2, the snorkel survey). In cases where the number of recovered fish is small, an adjusted estimate (called the Chapman correction) is often used and this was the estimator used in this report:

$$\hat{N}_{pooled,Chapman} = \frac{(n_1+1)(n_2+1)}{(m_2+1)} - 1$$

The standard error (SE) of this estimate is found as

$$SE\left(\hat{N}_{pooled,Chapman}\right) = \sqrt{\frac{(n_1+1)(n_2+1)(n_1-m_2)(n_2-m_2)}{(m_2+1)^2(m_2+2)}}$$

Three Pooled-Petersen estimates can be formed:

a) An estimate based on radio-tags released and the number of radio-tags only from the year of release seen during the snorkel surveys. Fish with Floy tags from this and previous years are treated as untagged fish and radio tags from previous years are treated as unmarked fish.

b) A second estimate can be obtained by considering recapture of fish tagged with Floy tags only (not radio tagged). Fish with radio tags from this and previous years are treated as untagged fish. Floy tagged fish without radio tags from previous years that are seen during the snorkel survey are also treated as unmarked fish.

c) Pooling Floy tagged fish with and without radio tags. The Floy tagged fish released in each year with and without radio tags are pooled. Fish with and without radio tags from previous years are treated as unmarked fish. This estimate will be about half-way between the two estimates (not unexpectedly) obtained using only radio-tagged fish and only non-radio tagged fish.

2. Stratified Petersen

An alternate estimator computes a separate Petersen estimator for each section of the river and then simply sums the estimates, *i.e.:*

$$\hat{N}_{Stratified} = \sum_{segments} \hat{N}_i$$

with

$$SE\left(\hat{N}_{Stratified}\right) = \sqrt{\sum_{segmemts} SE\left(\hat{N}_i\right)^2}$$

Here the implicit assumption made is that tagged fish do not move from their (pooled) section (which is approximately true).

Unfortunately, this estimator will have poor properties for this project because of the very small sample sizes typically found in each section. Consequently, stratified-Petersen estimators were computed by pooling adjacent sections (*e.g.,* sections 1 and 2 were pooled; sections 3 and 4 were pooled; etc.) which reduces the number of strata from 12 to 6. Note that the addition of one population section was a result of including lower Henretta Creek in addition to the 11 mainstem upper Fording River sections.

A formal statistical test, if a stratified-estimator is needed, can be obtained by looking at the variation in recapture rates among the strata, *i.e.,* by first constructing a contingency table:

	Stratum 1	Stratum 2	…	Stratum *k*
Released	$n_{1,Stratum\ 1}$	$n_{1,Stratum\ 2}$	…	$n_{1,Stratum\ \mathrm{k}}$
Recaptured	$m_{2,Stratum\ 1}$	$m_{2,Stratum\ 2}$	…	$m_{2,Stratum\ 2}$

Then a standard χ^2 test for equal proportions of recaptures is performed.

Again, several estimates can be formed based on the various combinations of tag groups:

a) Based only on fish with radio-tags. As previously, fish with only Floy tags from this and previous years, and fish with radio tags from previous years are treated as untagged fish.

b) Based only on fish with Floy tags. As in previous estimates, fish tagged with radio tags from this and previous years, and fish with Floy tags from previous years are treated as unmarked.

c) Based on fish with radio tags and fish with Floy tags. As previously, fish from previous years are treated as unmarked fish.

3. Hierarchical Stratified Petersen

The pooled-Petersen and stratified-Petersen models are at the two ends of the spectrum of assumptions about the marking and/or recovery rates. The pooled-Petersen assumes that these are equal across all strata while the stratified-Petersen allows for separate rates in all strata with no sharing of information. The hierarchical model is intermediate between the two extremes where a common “average” marking and/or catchability is assumed across all strata, but the individual strata values come from a distribution centered around this average. The variance of this assumed hyper-distribution controls how similar the capture or recovery probabilities are across the strata.

More formally, the model for the observed recaptures in each stratum is:

$$
\begin{aligned}
m_{2i} &\sim Binomial(n_{1i}, p_i) \\
u_{2i} &\sim Binomial(U_{2i}, p_i) \\
p_i &\sim Beta(\alpha, \beta)
\end{aligned}
$$

where the *i* subscript refers to the individual strata. Notice that the p_i, while separate for each stratum, come from a common (beta) distribution with mean $E[p]=\dfrac{\alpha}{\alpha+\beta}$ and variance across the strata of $V[p]=\dfrac{\alpha\beta}{(\alpha+\beta+1)(\alpha+\beta)}$.

This model has the advantage that information is shared among the strata. So information from one stratum that the recovery rate is around (for example) 0.6 is used to inform the model about the likely values of recovery for other strata. This often leads to estimates with improved precision compared to a stratified-Petersen without making the (strong) assumption that the recovery rates are exactly equal in all strata. This Bayesian model was fit using OpenBugs (Lunn *et al.* 2009). The data provide estimates of the individual p_i, U_i, and the parameters of the beta distribution. Three estimates (radio tags only, Floy tags only, radio and Floy tags combined) can once again be constructed as before. Note that when a Bayesian model is fit, the measure of uncertainty is the standard deviation (SD) of the posterior distribution. This measure is analogous to the SE estimated from Maximum Likelihood.

4. Movement Model Combining Radio and Floy Tags.

The previous three methods (based on stratification) all implicitly assumed the fish did not move between strata between the time of marking and the time of recovery (during the snorkel surveys). However, some movement was observed based on the radio tagged fish. It is impossible to know the movement of the fish tagged with just Floy tags, because the snorkel team could not get close enough to read the individual tag numbers.

The radio tags provide information on movement between the sections and this information can be used to impute the movement among the sections. The model for movement will also accommodate “leakage”, *i.e.,* some fish move to other segments between snorkel surveys and so are “missed” during the snorkel surveys.

Because of the sparseness of the data, adjacent segments were again pooled reducing the number of segments from 12 to 6 strata. The data was too sparse for a model with a completely unspecified set of movement probabilities, so the probability of movement was approximated using five parameters: the probability of staying in the reduced segment, moving one segment to the left or right, and moving two segments to the left or right. Leakage was accounted for by moving to a final "dummy" segment with zero chance of recapture. Leakage occurs when the movement of the fish doesn't coincide with the snorkeling. For example, if you snorkel on two days, then some fish that were in segments not snorkeled on day one may move to the segments previously snorkeled on day one and so "disappear". You can imagine this happening due, for example, to "herding" as the snorkelers move through the segments.

A hierarchical model was used for the recovery rates with a common average detection rate for both fish with and without radio-tags, but the recovery rates were allowed to vary among the (reduced) segments around this common average. For example, if the average detection was 50%, a segment could have a detection rate of 45%; another segment could have a detection rate of 57%, but the detection rates must be centered at the mean detection rates and only if the sample sizes were large enough, could they be substantially different. So a raw detection rate of 100% for a segment would be pulled towards the mean detection rate if the number of tags available and recovered was small.

Intuitively, what happens was that the movement data from the radio tags was used to impute the movement of the fish without radio tags but with Floy tags. The number of fish without radio-tags but with Floy tags then available in each reduced segment (along with the radio tags) was used in a Petersen-estimator with the observed number of recoveries and unmarked fish. Estimates of recovery rates borrow information from other segments so that they all vary around a common mean. Bayesian methods must be used to fit this model as it is too complex for standard maximum likelihood estimation. Recall that when a Bayesian model is fit, the measure of uncertainty is the standard deviation (SD) of the posterior distribution. This measure is analogous to the SE estimated from Maximum Likelihood.

The abundance of the upper Fording River population of mature Westslope Cutthroat Trout (fish > 200 mm fork length) was estimated using these methods in 2012, 2013 and 2014 to generate estimates of abundance and trend information (*i.e.,* declining, stable, increasing). Once population estimates were calculated, the upper Fording River Westslope Cutthroat Trout population status was placed in context using reference populations. Abundance and density data have been collected using snorkel methods for a few high priority East Kootenay Westslope Cutthroat Trout streams including the upper Bull River (above barrier, pure strain), Elk River (mainstem), Wigwam River, Michel Creek (Elk River tributary of similar mean annual discharge), St. Mary River, and White River.

2.4.2. Recruitment and Juvenile Population Monitoring

Recruitment is typically the strongest determinant influencing populations (Maceina and Pereira 2007). An understanding of recruitment and juvenile growth rates, survival and densities were required to answer study Question 3 (Is the population sustainable?), Question 7 (What is the distribution of Westslope Cutthroat Trout seasonally, considering life history stage and upstream distribution limits?), and Question 5 (What are the habitats (critical and overall habitat) in the study area?). Recruitment of young fish into catchable, or adult size (*i.e.,* greater than 200 mm fork length) is necessary to sustain any population or fishery. Recruitment failure, due to overfishing, habitat alterations, or abiotic or biotic events can lead to reduced adult abundance (Maceina and Pereira 2007).

Recruitment (fry) and juvenile (fish < 200 mm fork length) population monitoring of the upper Fording River Westslope Cutthroat Trout was examined through density estimates generated using removal – depletion electrofishing methods. The goals for the 2013-2015 recruitment and juvenile population monitoring were defined by the Steering Committee and include:

1. Literature review for existing mark-recapture or density information on Westslope Cutthroat Trout (*e.g.,* growth rates, survival, densities),
2. Fry (0^+) and juvenile (1^+ one year old age class, 2^+ two year old age class) density estimates,
3. Mark-recapture and scale ages to confirm individual growth rates and length-at-age variation, and
4. Collect information on fry presence/absence distribution in all habitats.

Data quality objectives for juvenile population estimates were not defined beyond a proof of concept or feasibility approach given the high variation typical of juvenile estimation methods and the low densities expected.

2.4.2.1.Fish Capture and Tagging

In order to PIT tag juveniles and generate density estimates, fry and juvenile Westslope Cutthroat Trout (fish < 200 mm fork length) were captured mid-September through early October 2013, 2014, and 2015 when water temperatures were greater than 5.0 ^{o}C. Figure 2.4.1 and Table 2.4.1 illustrate and describe the sample locations and their distribution within the

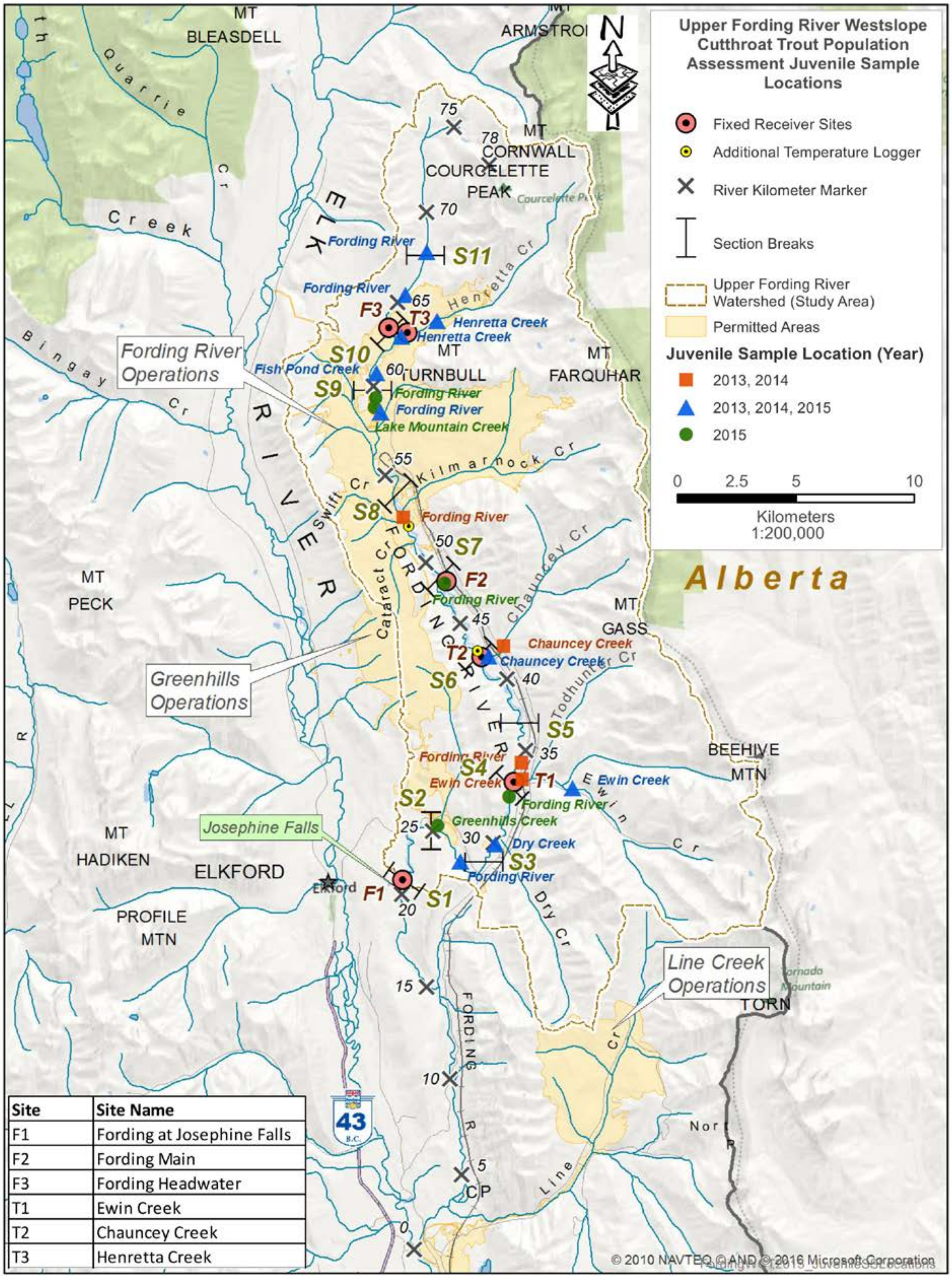


Figure 2.4.1. Upper Fording River Year recruitment and juvenile sample locations (2013 - 2015).

Table 2.4.1. Summary of upper Fording River recruitment and juvenile sample locations 2013 – 2015).

Location	Strata	River Segment	River Km	Sample Years
Fording River	Mainstem Headwaters	11	68.0	2013, 2014, 2015
Fording River	Mainstem Headwaters	10	65.6	2013, 2014, 2015
Fording River	Mid-Mainstem (FRO Onsite)	8b	59.3	2015
Fording River	Mid-Mainstem (FRO Onsite)	8a	58.1	2013, 2014, 2015
Fording River	Mid-Mainstem (FRO Onsite)	7	52.4	2013, 2014
Fording River	Lower Mainstem	6	48.5	2015
Fording River	Lower Mainstem	5	34.4	2013, 2014
Fording River	Lower Mainstem	3	32.5	2015
Fording River	Lower Mainstem	2	27.2	2013, 2014, 2015
Henretta Creek	Lower Tributary	1	0.2	2013, 2014, 2015
Henretta Creek	Upper Tributary	3	2.4	2013, 2014, 2015
Fish Pond Creek	Lower Tributary	1	0.4	2013, 2014, 2015
Lake Mountain Cr.	Lower Tributary	1	0.1	2015
Chauncey Creek	Lower Tributary	1	0.4	2013, 2014, 2015
Chauncey Creek	Upper Tributary	2	1.3	2013, 2014
Ewin Creek	Lower Tributary	1	0.7	2013, 2014
Ewin Creek	Upper Tributary	2	3.3	2013, 2014, 2015
Dry Creek	Lower Tributary	1	0.2	2013, 2014, 2015
Greenhills Creek	Lower Tributary	1	0.3	2015

study area. Locations were selected to represent the available river strata or segments (*i.e.,* reach based methods) to facilitate population estimation, although access considerations (light truck and/or ATV) also factored into the selection process. Five primary strata were delineated for the study design; the lower, onsite and headwater mainstem river segments and both lower and upper tributary sites. In total, nineteen representative juvenile sites were sampled in 2013, 2014 and 2015. Fourteen sites were sampled in 2013 and 2014; fifteen sites were sampled in 2015. In 2013 and 2014 the same 14 sites were replicated; in 2015 10 sites were replicated and 5 new sites were sampled (Table 2.4.1). Site changes in 2015 were designed to test fry and juvenile densities within areas of observed high density spawning.

All sample locations consisted of three meso-habitat units, approximately 100m^2 each that were selected based on professional experience to represent preferred fry and juvenile rearing habitat. Total annual meso-habitat effort was n=42 and approximately 4,200 m^2. Using shore-based electrofishing, the three meso-habitat units in each sample location were sampled using three-pass removal depletion methods. These sampling methods were adapted from Ptolemy *et al.* (2006) and are described in detail below.

Physical site attributes were recorded each year during site layout. Repeat habitat inventories at each site include meso-habitat classification (riffle, cascade, glide, run, pool or side-channel), descriptions of depth-velocity profile at 0.25-0.5 m intervals perpendicular to flow with shorter intervals over high velocity gradients (*i.e.,* a representative transect), riparian vegetation, bed material composition, dominant particle size, D_{max}, D_{90}, large woody debris content, substrate embeddedness, site length, site wetted width, estimated available cover, and maximum depth.

Photographs and UTM coordinates were taken of each site for future reference. Where appropriate, the surveyor also assigned a habitat suitability index per life stage based on expert appraisal (*i.e.,* expert appraisal not HSI curves, Ptolemy *et al.* 2006). These data were captured through the use of three standard data forms plus notes and a site sketch that the surveyor produced. The data forms were; 1) the Field Data Information System (FDIS) Fish Collection Form, 2) the BC MFLNRO Sample Site Habitat Description Form, 3) Level 1 Habitat Survey Data Form, and 4) Hydrometric Survey Data Notes.

As described in Ptolemy *et al.* (2006), wadeable meso-habitat units (*i.e.,* <1.5 m deep) within the selected locations were sampled using three sided shore sites. Where possible full span upstream and downstream stop nets were used (*i.e.,* wetted widths < 8.0 m). Upstream and downstream stop nets were placed perpendicular to the shore and the off-shore side of the site (if required) followed depth and velocity contours to enclose the area between the upstream and downstream stop nets. Sites offering natural physical barriers such as mid-channel bars or braids were preferred since upstream-downstream barriers are easier to install thus requiring less site disturbance prior to sampling. Fry are typically bounded by high velocities close to shore; barrier nets extend well beyond their distribution with the bottom net angled with mid-channel position about 4 m upstream of the shore reference point. This was done to maximize capture of drifting animals by shunting and collection of fry and juveniles near shore. Nets were configured into stable position with guy ropes, bipod stays, and anchors to a distance of up to 8.0 m from shore. The lead line was knitted to the bottom contours with boulders placed as weights along the lead line. Stop nets were 4 mm stretch mesh (square). To prevent immigration during multiple-pass depletion all fish from successive depletions were allowed to recover within fish sleeves or totes placed downstream. Upon completion of sampling fish were released back into the sampled meso-habitat units.

Westslope Cutthroat Trout fry and juveniles were captured using a 3-person crew, a DC backpack electrofishing unit (Smith Root LR24), and three-pass removal depletion methods that requires three successive passes of declining catch for population estimation methods. To increase capture efficiency, the electrofisher was secured on-shore and the anode pole utilizes a catch net and a 20 m anode cord lead. A large 1 m^2 cathode screen was also deployed into the center of the sampled area using a 20 m long lead from the shore-based unit. This facilitates faster, safer and more efficient capture; especially for fry (25-55 mm fork length) from gravel and cobble interstitial spaces. The anode operator works closely with the netters to frequently turn over rocks to hand-recover fish that drift into interstitial spaces; permanent loss of these fish is often a major source of negative bias in population estimates regardless of high capture probabilities (Ptolemy *et al.* 2006). To minimize sample variance an experienced crew was employed and the same crew conducted all sampling events.

At each site, electrofishing was initiated at the downstream net, and consists of a thorough surprise/ambush search in an upstream direction, followed by a systematic sweep back towards the downstream net. Each "catch" (c1, c2, c3) effort involves multiple passes and the same search pattern was replicated in "catch 2". Electrofishing seconds (*i.e.,* time) was monitored and recorded to ensure each successive depletion or "catch" utilizes similar effort. At three-sided shore sites, electrofishing always proceeds from the fast water forming the offshore boundary towards the shore, to avoid chasing larger juveniles into the outside net where they may find a hole and escape from the site.

All fish captured during electrofishing were anaesthetized using the same methods outlined in the sub-adult and adult capture and tagging (*see* Section 2.4.1.1 Fish capture and tagging). All captures were weighed (g), measured (fork length mm), examined externally for any signs of deformity or injury, and all juveniles (fish > 60 mm) were implanted with a Passive Integrated Transponder (PIT) tag (Biomark HPT8 134.2 PIT Tag, Biomark, Boise, Idaho) and sampled for scales (*see* Section 2.4.3.1 Scale Ages). All fish PIT tagged and sampled for scales were restricted to fork lengths of between 60 mm and 230 mm. This size range was expected to encompass the 1 year old through 3 year old juvenile age classes.

Capture, effort (area and electrofishing time for each pass), life history data (length, weight, age) and individual tag identification are input using the MFLNRO Microsoft Excel tool, "Fisheries Data Information Summary System (FDIS)". The Population estimates were calculated using the "Microfish" software package (Van Deventer and Platts 1990). Population estimates and the 95% confidence interval were reported as a standard numerical density (number fish/100 m^2) and biomass (g/100 m^2) by age class, habitat strata and meso-habitat type. Data were then compared to previous data within the upper Fording River and other regional populations.

Provided catch rates allow for density estimates for each age class within individual meso-habitat units (100 m^2), densities would also be examined through the use of an Allen plot.

Plotting raw or observed fish density (FPU) on the Y-axis with paired mean size (g) on the X-axis for all ages derives a scatter plot or Allen Plot named after K.R. Allen (1969). Ptolemy *et al.* (2006) illustrated results as a log-log plot describing an envelope of maximum densities at carrying capacity of local habitats was about 264 g/Unit (steelhead); the envelope was estimated as the 95th percentile biomass. The slope was -1 and implied density was proportionate to the reciprocal of size. Allen suggested that stream salmonids are territorial and that territory size (area or 1/density) increases proportionate to fish size.

All subsequent captures during both the juvenile sampling (September 2014, 2015) as well as the sub-adult and adult angling (August 2014) were scanned for PIT tags for recapture and growth data. Recaptures were used to validate growth rates and age classes as data became available from recaptures. Recapture data was also examined for movement patterns.

2.4.3. Age Class Structure, Growth and Condition

Population age structure forms a cornerstone of fisheries management. The numbers and sizes of fish in a population determine its intrinsic population growth potential and thus, it's' ability to provide recreational and commercial benefits. An understanding of population age structure can be used to more effectively manage populations through means such as altering mortality rates (*i.e.,* length limit regulations, catch and release, angling prohibition).

Methods for estimating age and/or growth of fish in natural populations fall into three general categories; length frequency analysis of fish in identifiable age groups, fish length-at-age by reference to permanent growth records in hard body parts, and recapture of marked individuals whose size at a previous time was known (Busacker *et al.* 1990).

All three methods for estimating age and/or growth of fish were employed in this study and the individual and combined data sets (length-at-age data, growth increment data from capture-recapture data and length frequency data) were used to fit a von Bertalanffy growth model to the upper Fording River population of Westslope Cutthroat Trout (von Bertalanffy 1938). The von Bertalanffy growth model has been shown to conform to the observed growth of many fish species. This model relates growth to the age of the fish as:

$$L(a) = L_{\infty}\left(1 - e^{-K(a-a_0)}\right)$$

where L_{∞} is the maximum length for older fish, K describes how fast the growth reaches the asymptote and a_0 is the "age" at which the fish has 0 length (biologically this has no meaning and is purely a parameter to anchor the curve). The above curve represents an "average" growth curve; individual fish have growth curves that vary around this average curve. All computations were done using R Version 3.2.0 (R Core Team 2015) using the Fisheries Stock Analysis (FSA, Ogle 2015) and Mixtools (Tatiana *et al.* 2009) packages.

Length-at-age (*i.e.,* the size range for each age group or maturity stage) was estimated using one or all of the above methods depending on the life stage. Length frequency analysis was used for fry. Fry or young-of-the-year (*i.e.,* 0^+ years old) is an easily identifiable age group with little or no overlap in length with older age groups. Length-at-age estimates for juveniles (*i.e.,* < 4 years old) were derived from scale ages validated by individual mark-recapture growth. Sub-adults and adults were not estimated apart from identifying the length and estimated age of first maturity based on gonadal maturity assessed during radio tag implantation. Telemetry data illustrating alternate life history strategies between life stages (*i.e.,* sub-adult or adult) was used to validate gonadal maturity assessments *post hoc*. Definitive aging of mature fish (*i.e.,* > 4 years) was problematic due to two factors; 1) the older fish get the more variation there is in length-at-age and thus the more overlap in age groups, and 2) the only reliable aging method (otoliths) is lethal and sacrificing upper Fording River Westslope Cutthroat Trout was not a reasonable option. A literature review for otolith aged Westslope Cutthroat Trout was completed and used to validate age conclusions for mature fish (*i.e.,* > 230 mm or 4 years).

All sources of data (length frequency, scale ages, individual mark-recapture growth rates, literature review) were subsequently used to develop a growth model to explore the age structure of the upper Fording River population of Westslope Cutthroat Trout.

Uncertainty in length-at-age data was owing to emerging evidence regarding the validity of scale age data used for Westslope Cutthroat Trout. Fish scales are shed and replaced at maximum growth patterns (*i.e.,* “ages”) of between four and eight years. This results in maximum scale pattern ages of eight years (or less). Therefore, scale aging is not recommended for any species which has the potential to be older than the scale growth pattern potential (K. Munk *pers. comm.*).

Scale ages have been the predominant aging method for Cutthroat Trout in the literature and maximum ages are typically reported between 6 and 8 years (McPhail 2007, Liknes and Graham 1988, Scott and Crossman 1973). This includes a number of upper Kootenay populations of Westslope Cutthroat Trout (Cope and Prince 2012, Baxter 2004, Morris and Prince 2004, Prince and Morris 2003, Baxter and Hagen 2003).

Otoliths provide an alternate aging structure with greater growth potential than scales and as such, this aging method is preferred for species that can reach ages greater than four to eight years. Unfortunately, the otolith aging method is lethal and therefore not often employed on species such as Westslope Cutthroat Trout that are a species of special concern and are managed to minimize mortalities.

Recently, ages derived from otoliths for the Elk River population (includes upper Fording River samples) have been as high as 12 years (Wilkinson 2009) and 16 years (Minnow Environmental *et al.* 2011, 2007). The age determination lab noted that scales for Westslope Cutthroat Trout aged nine to 16 years by otoliths stopped growing at around age five to six and states, "There is no doubt in my mind that many of these fish are older than their scales show", (Minnow Environmental *et al.* 2007). Robinson (2005) aged Westslope Cutthroat Trout in southwestern Alberta up to ten years old and noted on average, scales under-estimated ages by 1.34 years but varied by as much as six years.

Finally, the under-aging of East Kootenay populations of Westslope Cutthroat Trout using scales has been demonstrated through mark–recapture. In 2004 a 350 mm Westslope Cutthroat Trout was Floy tagged within the upper Bull River (above barrier, pure strain, fluvial population). Six years later (2010), this fish was recaptured within the same reach. This cutthroat had grown 60 mm in the intervening six years (410 mm) and was aged six years using a scale sample. Given the intervening time between captures (six years) and the size at original capture (350 mm) this fish was at least 10 years old. The scale age of six years merely represented the limits of scale growth potential for this species (Cope and Prince 2012). In the upper Bull River scale samples the age determination lab noted that annuli following age two were often very subtle and abbreviated and it was highly likely that under-aging of fish greater than three years occurred (Cope and Prince 2012).

Based on experience and the above literature review, the initial life stages used for study design purposes were fry (0^+ age class or young-of-the year less than 55 mm fork length), juveniles (1^+, 2^+ and 3^+ age classes or fish 56 to 200 mm fork length), and sub-adults and adults (4^+ or greater age classes or fish greater than 200 mm fork length). These initial size categories were evaluated using the above methods that are described in more detail below. The results of these analyses and the estimates for age classes or age groups, estimated age and size of first maturity (*i.e.,* spawning or reproduction) and the growth model are presented in Section 3.2.2 Age Class Structure, Growth and Condition.

2.4.3.1. Scale Ages

Due to the limitations outlined above in scale growth potential, scale aging was limited to Westslope Cutthroat Trout captures between 60 mm and 230 mm fork length. It was expected that fish within this size range should represent the juvenile age classes of 1^+ to 3^+ (one to three year old fish). Scale ages of 1^+ to 3^+ would validate this assumption and document the variation of juvenile length-at-age. If alternative life history forms such as smaller, resident (*i.e.,* non-migratory) headwater populations were present these should be detected as scale ages between 4 and 6 years old and these methods and population age structure assumptions would require review.

Scale samples were taken as a smear from the sides of fish approximately 2-4 scale rows above the lateral line and between the back of the dorsal fin and the insertion of the anal fin. Scale samples were mounted on glass slides and labeled with the site number, date, species (WCT) and fish length. Scales were sent to an experienced age determination lab for analyses (Microtech, Juneau, Alaska).

Multiple scales for each fish were prepared. Hydrated and cleaned scales were mounted onto glass slides. Glass slides were viewed using a stereomicroscope. Scale patterns were studied and then aged. Ages were tentatively recorded and regarded through multiple reviews. Ages were finalized upon last review.

2.4.3.2.Recaptures and Growth rates

One of the goals of the mark-recapture programs (Floy tags for fish > 200 mm fork length, PIT tags for fish < 200 mm) was to collect data on growth rates to further validate length-at-age determination. This data was also used to develop a growth model to explore the age structure of the upper Fording River population of Westslope Cutthroat Trout.

2.4.3.3.Population Age Structure

Provided the capture and tagging programs achieve their capture targets across all years (2012 – 2015), a length frequency distribution with a sample size in excess of 1,400 fish would be available. This distribution would include all age classes from fry through adults and was used for length frequency analysis of fish in identifiable age groups. While length frequency analysis may appear straight forward, it is in fact difficult and works best on the younger age groups (Busacker *et al.* 1990). As fish age their growth rate declines and length-at-age variation (*i.e.,* age class overlap) increases making it increasingly difficult to separate older and older fish.

The length frequency analysis would include validation of fry and juvenile age classes or groups using the scale ages and mark-recapture growth rates. It would also include validation of the estimated length-at-age of first maturity (*i.e.,* adults) determined through assessment of gonadal development during radio tag implantation. Finally, results of the growth model would also be applied where possible.

2.4.3.4. Condition Factor

Indices of condition, or well-being, have often been interpreted and compared in weight – length relationships. In theory, if stressors (*e.g.,* selenium from coal development) were influencing the well-being of fish, this should be evident with lower K for populations within the coal block or its receiving environment.

The Fulton condition factor represents one of the three basic variations of indices of condition for whole fish and takes the form (Murphy and Willis 1996):

$$K = (\text{Weight g}/(\text{fork length}^3\ \text{mm})) * 100{,}000$$

However, comparisons are typically limited to fish of similar lengths and comparison between species is generally not possible (Murphy and Willis 1996). The Fulton condition factor (K) has been reported in previous studies on the upper Fording River population of Westslope Cutthroat Trout (Amos and Wright 2000, Norecol 1983). As such, condition factor was compared over the last 30 years for Westslope Cutthroat Trout of similar lengths within the upper Fording River study area. In addition, the average upper Fording River sub-adult and adult Westslope Cutthroat Trout “size” was compared in terms of mean fish length among upper Kootenay River populations sampled using similar methods and study design (Bull River, Cope and Prince 2012, Elk River, Prince and Morris 2003, St. Mary River, Morris and Prince 2004, Wigwam River, Baxter and Hagen 2003).

All fish captures were anaesthetized and visually examined for any external deformities or injuries. The sub-set of sub-adults and adults (n=180) that were radio tagged were visually examined for any sign of internal deformities using an otoscope. Elevated rates of deformities in captured juveniles and mature fish were not expected given that selenium toxicity is usually associated with teratogenic effects that primarily result in larval mortality as a result of maternal transfer of selenium in eggs (Elphick *et al.* 2009, Orr *et al.* 2006).

2.5. Analysis of Movement Patterns and Distribution

In this section the methods employed to document movement patterns, and distribution of Westslope Cutthroat Trout seasonally, considering life history stage and upstream distribution limits are described. Capture and tagging methods used to enable the determination of movement and distribution patterns were previously described (*see* Section 2.4 Population Monitoring). Different methods were necessary for sub-adults and adults (fish > 200 mm fork length) and juveniles (fish < 200 mm fork length). This was primarily due to size restrictions of radio telemetry methods employed. The minimum size that could be radio tagged due to the 2% rule of underwater telemetry was approximately 230 mm (*i.e.,* 200 g, Winter 1983).

2.5.1. Sub-Adult and Adult (Radio Telemetry Monitoring)

Radio telemetry methods are a commonly used tool in the life history field of study to evaluate fish movement patterns, seasonal distribution and habitat utilization; including Westslope Cutthroat Trout in western North America (Cope and Prince 2012, Schoby and Keeley 2011, Baxter 2006b, Morris and Prince 2004, Prince and Morris 2003, Baxter and Hagen 2003, Schmetterling 2001).

In this study, radio telemetry was used as a tool for both life history study and population estimation (*see* Section 2.4.1 Sub-adult and Adult Population monitoring). Three replicate cohorts (n=60 sub-adult and adult upper Fording River Westslope Cutthroat Trout in 2012, 2013, 2014) were implanted with radio transmitters and each cohort was monitored for approximately 540 days to understand fish movement patterns, seasonal distribution and habitat utilization. A cohort is a term that refers to a group of individuals used in a study who have something in common; in the case of this study, 60 sub-adult and adult Westslope Cutthroat Trout from the upper Fording River in a given year. The study was then replicated (*e.g.,* "repeated") three times (2012, 2013, 2014) resulting in three "cohorts" of fish that were studied (n=180 radio tagged fish in total).

2.5.1.1. Monitoring and Tracking

This section describes how the monitoring and tracking of radio signals emitted from fish implanted with radio transmitters was used to document fish movement behaviour, habitat use, and seasonal distribution of sub-adult and adult fish throughout the study area.

Radio tagged fish were monitored and tracked through the use of fixed receiver stations and mobile (helicopter and ground-based) tracking methods. Fixed receivers were placed in permanent streamside locations (*i.e.,* "stations") to ensure continuous and effective monitoring for detection of fish movements between river segments or between mainstem and tributary habitats.

Mobile tracking moves through the study area in a systematic manner isolating as many of the tagged fish as possible to the strongest possible signal strength (*e.g.,* to meso-habitat unit at a minimum). River kilometer (rkm) and UTM coordinates were recorded at these locations noting the tag number, signal strength, meso-habitat observations, and any other notable comments (*e.g.,* visual confirmation of fish or variable signal strength indicating that the fish was moving around and alive).

2.5.1.1.1.Fixed Station Monitoring

Fixed station monitoring utilizes receivers with data logging capacity on reliable power sources to ensure continuous and effective monitoring for detection of movements between river segments or between mainstem and tributary habitats. Fixed stations were positioned as a "gateway". They do not log fish within a given habitat unit but rather are placed such that any fish logged represent fish moving upstream or downstream. Typically, this was achieved in a gravel-cobble riffle with relatively shallow depths. Ideally the habitat unit remains largely ice-free during winter months; otherwise alternative under-water antennae deployments are necessary (Prince 2010). Direction of movement was validated through the use of two antennae (upstream and downstream) at each fixed receiver (Figure 2.5.1).

Figure 2.5.1 and Table 2.1.1 illustrate and summarize the locations of the six fixed stations within the study area. These locations were selected based on a field reconnaissance, access considerations, and a literature review of previous fisheries assessment reports (Lister and Kerr Wood Leidal 1980, Fording Coal Limited 1985, Oliver 1999, Wright and Amos 2000). Three stations, F1, F2, and F3, were located on the upper Fording River mainstem to isolate the lower, middle and upper watershed. In general, the stations delineate the lower river that includes an important high sinuosity, low velocity, potential over-wintering area; the middle river section that includes the Fording River Operations area (FRO); and the upper river above the surface coal mines that includes the lower water volume, higher gradient headwaters. The lowermost fixed receiver (F1) was located at Josephine Falls, a known barrier to fish passage, to provide an estimate of emigration (over the falls). The three remaining fixed receiver stations (T1, T2, and T3) were installed immediately upstream of the confluence of three tributaries to the Fording (Ewin, Chauncey and Henretta Creeks, respectively).

Figure 2.5.1. Photographs illustrating the streamside fixed receiver set-up on a shallow riffle at Station F2 (rkm 48.6); a) antennae and lockbox; b) Lotek SRX DL1 receiver and power source; c) riffle “gateway” habitat selected to maximize detection probability.

The intent of the fixed stations was to ensure continuous and effective monitoring for detection of movements between river sections or between mainstem and tributary habitats. That way, even if a radio tagged fish went “missing” its location was still known at a gross level based on which fixed receiver stations bound the last recorded position of the fish or alternatively, if the fish was recorded passing a fixed station. Previous experience has demonstrated that a significant proportion of tagged fish can go missing when conducting mobile tracking (Cope and Prince 2012, Prince 2010, Morris and Prince 2004, Prince and Morris 2003), particularly in winter when there was ice cover and fish aggregations in deep pools. Therefore, fixed stations were essential in assisting the tracking crew in isolating a river section to search for “missing” fish. Tributary fixed stations also provide tributary residence time and allow for determination if the tracking frequency was sufficient to document tributary use accurately (*i.e.,* were fish moving in and out of tributaries on a time scale consistent with the tracking schedule?).

Fixed stations utilize Lotek SRX DL1 receivers connected to two four-element directional Yagi antennas to detect and log coded transmitters (frequency 150.210 MHz) in both an upstream and downstream direction (Figure 2.5.1). Whenever possible, detection events and destinations were further confirmed through mobile tracking and re-location to meso-habitat unit. To ensure reliable power sources within remote, wilderness environments, two high capacity 32 cell gel batteries were maintained on a three week station maintenance schedule.

Quality assurance in tag detection at fixed receiver locations was through range testing to define transmitter detection patterns and ensure fish passage past receiver locations was recorded. Once station installation was completed, range testing was conducted to confirm transmitter detection across the wetted channel width and to optimize antennae placement for directional detection upstream and downstream.

Quality assurance in receiver operation was through testing during each station maintenance and download session every three weeks. Before replacing the batteries and again once the batteries were replaced a “live” test tag was used to ensure the receiver was logging the coded transmitters. In this manner, every three weeks, the data log download starts and ends with the logged test tag to ensure the receiver was operating. All receiver data logs were archived and backed up (off-site) in their original raw data format. A master excel spreadsheet was maintained with receiver detections and updated fish locations following each download session.

2.5.1.1.2. Mobile Tracking

Mobile tracking was used to document fish movement behaviour, habitat use, and seasonal distribution of sub-adult and adult fish throughout the study area. Mobile tracking focuses on isolating as many of the tagged fish as possible to the strongest possible signal strength (*e.g.,* to meso-habitat unit at a minimum). River kilometer (rkm) and UTM coordinates were recorded at these locations noting the tag number, signal strength, habitat observations, and any other notable comments (*e.g.,* visual confirmation of fish or variable signal strength indicating that the fish was moving around).

Mobile tracking utilizes a Lotek SRX 400 receiver and a single three-element directional Yagi antenna; except during helicopter surveys where dual four-element directional Yagi antennae were used. Fish were relocated during mobile tracking surveys performed once per month except during the spawning season. During the spawning season mobile tracking surveys were completed weekly (approximately May 15 – July 20). Tracking surveys were completed for the length of the mainstem upper Fording River, including tributaries. Surveys were equally divided between aerial (helicopter) and ground based methods. Ground based surveys were conducted on foot supported by light truck, all-terrain vehicle (ATV) and snowmobile.

Both aerial and ground methods were used each season as these methods complement each other. Aerial methods were essential to search for “missing” fish and ensure complete coverage of the study area including tributaries. Ground methods were essential to “pin-point” or “ground-truth” fish location, meso-habitat characteristics and ensure quality assurance measures confirming fish were alive and healthy. Once a year during the snorkel survey, individual fish were pin-pointed and viewed under water to further confirm fish health and habitat use (Figure 2.5.2). Ground methods within the active mining area also enabled the tracking crew to get into the river bottom and eliminate much of the acoustic interference or “noise” that was generated by industrial activity within this area.

At any given time, there were 60 Westslope Cutthroat Trout implanted with transmitters (codes 11 to 193) using radio frequency 150.210 MHz. To facilitate tracking and data capture, nomenclature used in databases and reporting followed the pattern of species-Code. For example, WCT23 refers to Westslope Cutthroat Trout code 23 on the above frequency.

To facilitate location reporting, Fording River kilometers were delineated from the mainstem centerline distance upstream from the Elk River confluence using GIS and 1:20,000 Terrain Resource Information Management (TRIM) maps.

Figure 2.5.2. Photograph illustrating mobile tracking and visual (snorkel) ground-truthing methods used to document radio tagged fish location and condition.

When tracking, UTM co-ordinates are recorded and using GIS, the co-ordinates were converted to river kilometer. Figure 2.1.1 illustrates the river kilometers for the Fording River. Fish locations were plotted after each tracking session and cross-referenced with station downloads to ensure fish were not being “missed”. Use of a single frequency, upstream and downstream antennae, reliable power sources, frequent maintenance and QA testing combined with appropriate station site selection (shallow water depths, low channel complexity) were key to ensuring movements were not missed.

For the purposes of this study, home range was determined by subtracting a fish’s most upstream location from its most downstream position (Hildebrand and Kershner 2000b).

2.5.2. Fry and Juvenile (Density and Mark-Recapture)

In this study, density trends and PIT tag mark-recapture results were used to evaluate distribution, habitat utilization and movement among representative juvenile sample locations.

2.5.2.1.Distribution and Detection of Movement Patterns

Figure 2.4.1 and Table 2.4.1 illustrate and describe the distribution of the representative juvenile sample locations. Locations were selected to represent the available river strata or segments (*i.e.,* reach based methods) to facilitate population estimation. In total, nineteen representative juvenile sites were sampled in 2013, 2014 and 2015. Fry and juvenile density trends were examined on a number of spatial scales including; 1) location, watershed strata, and meso-habitat type. PIT tag mark-recaptures in years two (2014) and three (2015) were examined for juvenile movement between annual sample sessions.

2.6. Habitat Mapping

In order to document available habitat and its distribution, the mainstem population segments and lower fish bearing reaches of tributaries were mapped at the meso-habitat level through air photo interpretation (2012 imagery). An understanding of the available habitat and its distribution provides necessary context and one of the lines of evidence used for interpretation of fish movements, life history strategies and critical habitat within the upper Fording River watershed. Ground-truthing surveys were completed at two off-site reference locations and three locations within FRO to validate air photo interpretation and to complete a morphological stream channel survey.

To gain a better understanding of the seasonal habitat preferences of sub-adult and adult Westslope Cutthroat Trout (*i.e.,* over-wintering, staging, spawning, summer-rearing), a standard suite of meso-habitat characteristics were documented during capture and tagging (August 2012, 2013, 2014), as well as during mobile ground-based tracking sessions (n=7 per year).

2.6.1. Air Photo Habitat Mapping

The first step in understanding resource selection (*i.e.,* habitat) was to document the resource availability and its distribution. Therefore, in order to understand the aquatic habitats (overall and critical) within the study area the mainstem population segments and lower reaches of fish bearing tributaries were mapped at the meso-habitat level through air photo interpretation. Meso-habitat (Table 2.6.1) represents a discrete area of stream exhibiting relatively similar characteristics typified by a common slope, channel shape and structure (*i.e.,* pool, riffle; Bovee *et al.* 1998). All photo interpretation was completed by habitat specialists with extensive experience working within the upper Fording River.

In September 2012, the length of the mainstem upper Fording River, the lower fish bearing sections of tributaries and the associated riparian area were captured on digital colour images with an image pixel size of 10 cm ground sampling distance. In Year 2 (2013), the aerial photographs were compiled into a composite ortho-photograph watershed display with 10 cm resolution.

Table 2.6.1. Characterization of meso-habitats mapped for the upper Fording River. Width:depth ratio is the quotient of maximum bankfull depth to bankfull width, where the maximum depth is taken at bankfull in the thalweg.

Meso-habitat	Definition
Riffle	Shallow stream feature (shallowest of meso-habitat types) with moderate current velocity, some surface turbulence, relatively high gradient, and convex streambed morphology. Gradients typically range from 0.2 (glide riffle) to 3.6 (steep riffle), with standard riffles in the 0.7 to 2.0% range. For this assessment (based on air photos) we used diagnostics such as turbulent surface, shallow depth (<0.5 m and visible substrates), high width - depth ratio (>100), and location at crossover point of thalweg from left to right stream bank.
Pool	Deep water stream feature (deepest of meso-habitat types). Often water impounded by a channel blockage, partial channel obstruction, or other hydraulic control at the downstream end. Slow velocities with a concave streambed type. Width:depth ratio typically <20. Generally finer (relative) substrate. Lowest gradient of meso-habitat types, typically <0.2%. For this assessment (based on air photos) we used diagnostics such as flat, smooth water surface and deep water depths (typically greater than 1.5 m), and location of feature, typically on the outside bend of the channel.
Run	Relatively deep stream feature with moderate current velocity, moderate turbulence and disturbed surface. Mixture of substrate sizes - gravel, cobble, boulder. Intermediate gradient between riffle and pool (*i.e.,* 0% to 3%). Streambed was longitudinally flat and laterally concave. For this assessment we used diagnostics such as location (transition from a riffle to pool), moderate depth (0.5 to 1.5 m) and non-laminar (turbulent or disturbed) surface. Width:depth ratio typically 10-60.
Glide	Moderately shallow stream channel with laminar flow. Lacks pronounced turbulence, and exhibits flat streambed morphology. Intermediate gradient, usually less than run. Usually finer substrate. Width:depth ratio typically 10-60. For this assessment we used diagnostics such as smooth water surface, shallow (<1.0 m) depth, and location (at the downstream end of a pool typically).
Side-channel	A smaller channel and meso-habitat units of varying depth that is connected to but not part of the main channel. It is not usually mapped due to its inconspicuous nature.
Cascade	Stepped rapids with small pools behind boulders and small waterfalls. Often bedrock or boulder controlled, with gradients greater than 3%. For this assessment, we used diagnostics such as extreme turbulence, high confinement and steep gradient with step-pool sequences. Width:depth ratio in the 20-60 range.

To identify individual meso-habitat units, aerial photographs were reviewed at 1:250 to 1:500 on-screen scale (based on resolution and shading). The upstream and downstream boundaries were marked with a line perpendicular to the water (in most cases) or aligned with the individual feature edge. Null values (a section obscured by shade or other means that prevented interpretation from photos) were included in summaries to prioritize ground-truthing efforts.

Meso-habitat units were delineated using ARCGIS on the 2012 Ortho Photo Base and could be referenced using co-ordinates or river kilometers. Since the 1:20,000 TRIM map water line was often inaccurate (this map line data was based on 1990's imagery), the water centre line was digitized for the mainstem of the Fording River and key tributaries – Henretta, Kilmarnock, Swift, Chauncey, Todhunter, Ewin, and Dry Creeks. This was completed to provide an accurate measurement of habitat unit length and river km measurement (from Josephine falls), to allow for accurate overlay and comparison of other GIS layers (*i.e.,* fish distribution). Unfortunately, this also results in minor discrepancies in river kilometer location depending on which map (centreline) data was used to convert between coordinates and river kilometres. This discrepancy can be avoided by converting fish locations (river kilometres) on the TRIM base into co-ordinates and plotting the co-ordinate output on the 2012 Ortho Photo base.

Meso-habitat mapping also included a standard suite of overview level habitat features derived from two primary sources: 1) Applied River Morphology (Rosgen 1996, 1994); and 2) Fish Habitat Assessment Procedures (Johnston and Slaney 1996). Table 2.6.2 summarizes the stream channel, fish habitat and riparian habitat attributes that were estimated and recorded for each meso-habitat unit. The high resolution photos allowed the habitat specialist to count individual pieces of large woody debris (LWD), wetted and bankfull features, substrate and water depth (to a limited extent), riparian vegetation and disturbance indicators. In some cases, shadows/shading, overhanging vegetation, or stream width limited the habitat assessment specialist from clearly identifying the individual feature. In those situations, comments were provided in the Excel summary form to identify limitations and habitats that required field verification.

Meso-habitat availability was then summarized by river Segment and tributary. Meso-habitat attributes were also summarized by river Segment using the Level 1 FHAP Form diagnostics summary. The Level 1 FHAP diagnostics form was developed by the British Columbia Watershed Restoration Program (WRP) as a tool to identify rehabilitation opportunities within watersheds by identifying potential physical habitat limitations to salmonid production in impacted or impaired river reaches (Johnston and Slaney 1996). Note that regional criteria for habitat conditions do not exist and current WRP diagnostic criteria to evaluate habitat condition were exclusive of Westslope Cutthroat Trout data. Notwithstanding these limitations, these methods have been applied in East Kootenay streams as an overview diagnostics tool for key trout productivity indices (*i.e.,* pool frequency and extent, LWD abundance, cover elements, substrate quality).

Interim attempts were made to apply the Rosgen morphological channel classification system (Rosgen 1996, 1994) using air photograph interpretation data. Mainstem Fording River segments were classified using the Rosgen classification method (Cope *et al.* 2014). These classifications required professional judgement and it was apparent that ground verified data was necessary to accurately complete a morphological stream channel classification.

Table 2.6.2. Overview level fish habitat measurements and features estimated using high resolution (10 cm) ortho-photograph interpretation. For detailed feature definitions refer to Johnston and Slaney (1996).

Feature	Definition
Meso Habitat Type	Riffle, Pool, Run, Glide, Cascade and side-channel *see* Johnston and Slaney (1996) and Table 2.6.1 for definitions.
Bankfull Width (m)	Average width between banks defined by the presence of permanently rooted vegetation (usually trees or shrubs).
Wetted Width (m)	Average width of the water surface.
Length (m)	Distance along the thalweg (deepest part of the channel) from the downstream boundary of the meso-habitat unit to the start (downstream boundary) of the next meso-habitat unit.
Water Depth (shallow, moderate, deep)	Based on estimated visibility at the time of flight. Shallow (0.0–0.5 m), Moderate (0.5-1.5 m), Deep (>1.5 m).
Dominant Substrate[1]	The dominant riverbed material that covers the largest percentage of the area of the meso-habitat unit. Categories were estimated visually from air photos supplemented by memory and on-site photographs.
Sub-dominant Substrate	The riverbed material that covers the second largest percentage of the area of the meso-habitat unit. Categories were estimated visually from air photos supplemented by memory and on-site photographs.
Total Functional LWD tally	Pieces of LWD having a minimum diameter and length of 10 cm and 2 m, respectively. Only LWD with a portion lying within the bankfull channel are tallied as functional LWD that influence channel geomorphology.
Disturbance Indicators[2]	Indicators of recent channel disturbance that may lower salmonid habitat values.
Riparian Vegetation	The dominant riparian vegetation type (unvegetated, grassland, shrub/herb, deciduous, coniferous, mixed deciduous-coniferous) and structural stage (initial colonization, shrub/herb, pole sapling, young forest, mature forest).
Comments	

[1] Substrate categories were sands, silts, clays or fine organic material (< 2 mm diameter), gravels (2 – 64 mm), cobbles (64 – 256 mm), boulder (> 256 mm), bedrock (> 4000 mm) (Johnston and Slaney 1996).

[2] Indicators of recent channel disturbance (from Johnston and Slaney 1996) were extensive areas of scour, extensive areas of unvegetated bar, large, extensive sediment wedges, elevated mid-channel bars, extensive riffle zones, limited pool frequency and extent, multiple channels (braiding), eroding banks, isolated side-channels or backchannels, most LWD parallel to banks, recently formed LWD jams.

Additional features that were estimated from the 2012 ortho-photos for interim morphological channel classification were (Rosgen 1996):

- Width Flood Prone Area was calculated using the mean (n=10) for measurements taken using the GPS tool in each river Segment,
- Entrenchment ratio was calculated by dividing the flood prone area by the bankfull width,

- Valley Length was measured as the straight line distance from the start to the end of a river Segment,
- Segment Gradient was calculated by taking the difference in map elevation (rise) and dividing it by the centreline river distance (run), and
- Segment Channel Sinuosity was calculated by dividing the stream length (m) by the valley length (m).

2.6.2. Ground-Truthing

In 2015, detailed stream channel and fish habitat surveys were completed for five sites in the study area; two off-site or references locations, and three sites within the mine site (FRO). These sites were selected based on the interim results of the Level I FHAP diagnostics summary tool (Cope *et al.* 2014). The two reference sites were in river Segments S2 and S6; segments identified as critical habitat and core areas for population maintenance with an abundance of high quality fish habitat attributes and high utilization by radio tagged Westslope Cutthroat Trout and juveniles (*see* Section 3.3 Movement Patterns and Distribution). The S7, S8, and S9 locations were within the FRO mine site (*i.e.,* onsite) and identified as having poor quality or impaired fish habitat attributes in areas of both low (S7) and high (S8 and S9) utilization by Westslope Cutthroat Trout (*see* Section 3.4 Habitat mapping).

The Rosgen Level II morphological channel classification system was used as the basis for ground-truthing air photo interpretation and providing morphological channel classifications (Rosgen 1996, 1994). The Rosgen classification system employs field survey methods designed to address questions of sediment supply, stream sensitivity to disturbance, potential for natural recovery, channel response to changes in flow regime, and fish potential.

As a very cursory review of Rosgen stream channel types, the “C” channels are usually one of the most productive and abundant for Rocky Mountain trout streams (*e.g.,* riffle-pool channel type; Rosgen 1996). “E” channels are very productive and very stable u-shaped channels that are often associated with old-growth riparian habitats with large stable floodplains. “B” channels are productive trout channels but are more confined and in the upper Fording include bedrock controlled channels (*e.g.,* canyons). The “D” channel represents a braided channel (*e.g.,* multiple channels and bars) with high sediment supply, high bank erosion rates and high width to depth ratios (*e.g.,* unstable channel with frequent changes in channel pattern). D channels have poor fish habitat attributes and corresponding low fisheries productivity.

Following methods described in Rosgen (1996) the following measurement of channel profile, pattern and dimension were completed:

- A longitudinal profile (minimum of 20 channel widths in length or a distance equal to two stream meander wavelengths) of the stream bed following the thalweg of the stream channel including measurement of water surface (slope) and bankfull elevations,
- Stream cross-sections on both a riffle and pool segment (stream bed, thalweg and bankfull elevations),
- Channel pattern (width flood prone area, sinuosity, belt width, meander length and radius of curvature), and
- Modified Wolman pebble count (reach and active channel at a riffle).

At 10 m intervals, following the thalweg of the stream channel, the elevation of the streambed and the water surface was surveyed over the length of the study area. All stream and habitat unit gradients were calculated from differences in water surface elevation. Cross sectional profiles were surveyed at 1 m intervals and extended 5 to 10 m beyond the bankfull width. The elevation of the bankfull channel was also noted at each cross section location and periodically throughout the longitudinal survey. Geomorphic surveys were completed using an auto level (Topcon AT-G7 Auto Level) and standard differential hydrometric survey techniques (Anon. 1998). A differential loop was used to accurately determine benchmark elevations, express error terms and ensure quality control.

Channel bed material characterization employed the modified Wolman method outlined in Rosgen (1996). Briefly, this procedure uses a stratified, systematic sampling method based on the frequency of riffle/pools and step/pools occurring within a channel reach that is approximately 20-30 bankfull channel widths in length (or two meander wavelengths). The modified method adjusts the material sampling locations so that various bed features are sampled on a proportional basis along a given stream reach. In total, 10 transects are established and ten substrate particles are selected at systematic intervals across the bankfull channel width, for a total sample size of 100. To avoid potential bias, the actual particle was selected on the first blind touch, rather than visually selected. The intermediate axis of the particle was measured such that the particle size selected would be retained or pass a standard sieve of fixed opening. The composite particle distribution was used to represent the reach. A second modified Wolman pebble count was completed within the active channel (*i.e.* within the wetted width), at the representative riffle cross-section, to calculate D_{84}. The D_{84} estimate was then used as a roughness coefficient in velocity calculations.

Data were entered in the Reference Reach Spreadsheet Version 2.4 L SI (Mecklenburg 1999) and summarized in the Rosgen Level II Stream Channel Classification Form and the Reference Reach Data Summary Form.

2.6.3. Habitat Characterization

To gain a better understanding of the seasonal habitat preferences of sub-adult and adult Westslope Cutthroat Trout (*i.e.,* over-wintering, spawning, staging, summer-rearing), a standard suite of meso-habitat characteristics were documented during the capture and tagging program (2012, 2013, 2014), as well as during mobile ground-based tracking sessions (7 per year).

During the capture and tagging program (sub-adult and adult summer rearing habitat), all radio tagged fish and their capture locations were photographed and geo-referenced by UTM and rkm. This provides 180 records of summer rearing habitat locations, meso-habitat, and select habitat features (maximum water depth, dominant and sub-dominant substrate, dominant and sub-dominant cover, water temperature) and associated photographs and notes. In years two (2013) and three (2014) Floy tagged fish were also included to increase sample size by approximately 300 fish.

Mobile ground based tracking sessions facilitate “ground-truthing” of radio tagged fish positions to confirm if individual fish were alive. Ground-truthing “pin-points” as many fish locations as possible. This involves isolating individual tagged fish to the strongest possible signal strength (*e.g.,* to meso-habitat unit at a minimum or, when possible, to the exact micro-habitat position within the meso-habitat unit). Once ground-truthed the fish location was geo-referenced by UTM and rkm. Meso-habitat features were photographed and characterized in terms of the meso-habitat features noted above.

Based on the capture and relocation (telemetry) data, seasonal Westslope Cutthroat Trout distribution was illustrated using GIS mapping functions. Movement data, seasonal distribution and life history strategies were interpreted using habitat mapping results (availability and distribution), habitat features characterized during ground-truthing, water temperature and flow data. These results were also compared to other upper Kootenay River populations that have had similar telemetry studies completed (upper Bull, Elk, Flathead, St. Mary, Wigwam Rivers); as well as literature values reported elsewhere (Cope and Prince 2012, Schoby and Keeley 2011, Baxter 2006a, 2006b, 2005, Morris and Prince 2004, Prince and Morris 2003, Baxter and Hagen 2003, Schmetterling 2001, Shepard *et al.* 1984).

It was anticipated that after three years (*i.e.,* three replicate radio tag groups for a total of n=180 radio tagged Westslope Cutthroat Trout), repeating patterns of movement and seasonal distribution could be identified and critical habitats necessary for the completion of life history functions (*e.g.,* spawning, over-wintering, rearing, migration corridors) could be identified. Mortality mechanisms and patterns were identified and discussed.

2.7. Population Genetics

To provide context for the study question "Is it one interconnected population or multiple populations (with respect to genetics)?" a review of existing genetic analyses that have been previously completed for the upper Fording River Westslope Cutthroat Trout population was completed. Carscadden and Rogers (2011) recently examined the upper Fording River population for genetic differentiation to specifically answer this question.

In addition, radio telemetry methods were used to provide supplementary evidence through life history results. Specifically, movements during the spawning season can be utilized to demonstrate whether or not fish from different river segments or tributaries "mix" and provide a mechanism for inter-breeding and gene flow that would prevent genetic differentiation.

2.8. Population Viability

The methodology for assessing the viability of the upper Fording River Westslope Cutthroat Trout population was to complete a literature search for pertinent population viability assessments or analyses (PVA); specifically looking for PVA's for Westslope Cutthroat Trout populations. The intention of the literature search for pertinent population viability assessments or analyses of Westslope Cutthroat Trout was to review Westslope Cutthroat Trout population viability estimates completed elsewhere in order to place current upper Fording River Westslope Cutthroat Trout population estimates in context with regard to evaluating the viability of the upper Fording River WCT population as part of the Study Question 1 discussion. This discussion was then explored in further detail in Question 3 when evaluating if the population was also resilient (*i.e.,* robust) and sustainable.

PVA is a method of risk assessment frequently used in conservation biology that uses population estimates or models to evaluate the risk of extirpation relative to critical management thresholds, threats to life history requirements, demographic stochasticity, genetic variation, environmental variation and catastrophes (DFO 2009, Ackakaya 1998). Extirpation refers to local extinction of a species in a given geographical area of study though it still exists somewhere.

PVA is typically reported as population abundances that can be expected to persist within a defined probability range for a given time frame (Cleator *et al.* 2009, DFO 2009). Another approach to estimating population viability has been to estimate the amount of stream required to maintain a population (Hilderbrand and Kershner 2000a). Intuitively, the importance of these two metrics to population viability can be understood as "larger populations in more productive habitats will be more resilient to anthropomorphic influences than those in smaller, less productive habitats" (MacPherson *et al.* 2014). The underlying model assumptions in regards to acceptable risk (*i.e.,* probability range and time frames), population size and productive habitats or mortality rates are critical to defining appropriate management thresholds and thus viability.

Reductions in population resilience increases the risk to population viability (*i.e.,* extirpation) and has consistently been identified as a precursor to precipitous population declines within the Salmonidae family, *Oncorhynchus* spp. and Westslope Cutthroat Trout (Waldman *et al.* 2016, Homel *et al.* 2015, AWRT 2013, Cleator *et al.* 2009, Mayhood 2009, Oliver 2009, Waples *et al.* 2008, Rieman and Dunham 2000). Population Resilience is a population's capacity to deal with environmental change or disturbance (*e.g.,* natural and anthropomorphic) and recognizes the need to maintain life history, population and habitat characteristics that increase the ability of a population to withstand and recover from disturbances (Waldman *et al.* 2016, Homel *et al.* 2015, Waples *et al.* 2008, Holling 1973). Population resilience therefore, is central to the viability of a Westslope Cutthroat Trout population and in the case of the upper Fording River, reflects the same end-point defined in the EA process and what the Project Steering Committee referred to as a "robust" population (Cope *et al.* 2013). The population objective for the purposes of this study and for consistency with the assessment end-point being used for Teck development proposals in the area (*e.g.,* Baldy Ridge Extension Project Environmental Assessment, LCO Phase II and FRO Swift), was defined as a self-sustaining and ecologically effective population (this includes the capability to withstand environmental change and accommodating stochastic population processes such as unpredictable events (*e.g.,* several dry summers, floods, or an exceptionally cold winter).

To expand upon the intuitive example of viability (*i.e.,* "larger populations in more productive habitats will be more resilient to anthropomorphic influences than those in smaller, less productive habitats"), a common population restoration practice is, "to attain a large numerical target achieved through hatchery stocking of fish with homogeneous life histories, whereas a resilience approach might prioritize a numerically smaller population composed of diverse life histories that can respond to unanticipated changes and make fuller use of habitats within a watershed" (Waldman *et al.* 2016).

2.9. Population Sustainability

Sustainability can be defined through change in the population over time (*i.e.,* decreasing, stable, increasing) and the intrinsic population growth potential (*i.e.,* productive potential of the habitat and the reproductive potential of the species). In its simplest form, a sustainable fish population can be defined as one that does not decline over time due to natural and anthropomorphic limitations to productivity. Assessing a population's sustainability represents a present day snapshot in time of the current status of a population and should be reassessed if the severity of population threats change, as new threats appears, or as management actions change (MacPherson *et al.* 2014).

Annual population monitoring data can be used to detect trends (*i.e.,* decreasing, stable, increasing). As the data set grows, the ability to detect trends improves. Initially, only fairly substantial annual differences of population numbers (*e.g.,* approximately 25% or more) will be detectable. After three years it was hoped this would improve to +/- 10%, although the time frame of three years was identified as optimistic and likely to require further trend monitoring using less intensive methods (*see* Section 2.4 Population Monitoring).

Therefore, since it was anticipated that the Project timeframe (3.3 years or 40 months) would limit the ability of trend monitoring alone to define population sustainability, the current assessment also relied on criteria utilized by management agencies that employ Fish Sustainability Indices (Macpherson *et al.* 2014). These criteria include, among others depending on applicability (*i.e.,* introduced species);

- Population abundance and trends (*see* Section 2.4 Population Monitoring),
- Analysis of movement patterns and distribution (*i.e.,* life history diversity, *see* Section 2.5 Analysis of Movement Patterns and Distribution),
- Habitat availability *(see* Section 2.6 Habitat Mapping),
- Genetic integrity (*see* Section 2.7 Population Genetics), and
- Population viability (*see* Section 2.8 Population Viability).

The preceding methods sections and their corresponding results sections that follow have been structured such that each section builds on the previous sections developing multiple lines of evidence for a balance of probabilities evaluation; particularly as they relate to the final section of population sustainability that includes a discussion of potential population threats and threat mitigation (*i.e.,* population resilience including life history diversity, habitat loss, habitat impacts, limiting habitats, angling, water quality, habitat protection needs and availability).

3. Results

3.1. River Discharge and Water Temperature Data

Patterns and influences in stream discharge and water temperature within the watershed are highlighted in this section and their effects on Westslope Cutthroat Trout habitat, behaviour, movement, and distribution are discussed further in following sections. Streamflow and water temperature play a central role in the aquatic ecosystem because they influence all biological processes including energy flow or productivity, metabolic rates, growth, behaviour and survival of fish populations (Meehan 1991). Streamflow (further modified by valley morphology, basin relief and channel materials) also plays a central role in fluvial processes that determine stream channel morphology and fish habitat (Rosgen 1996).

3.1.1. River Discharge

The upper Fording River discharge is typical for an interior watershed. It has a snow-dominated run-off with peak flows late May through June and minimum flows December through March (Figure 3.1.1). The mean monthly discharge (1970-2011) for August (summer rearing) and February (over-wintering) were 6.49 m^3/s and 1.92 m^3/s, respectively (Water Survey of Canada gauging station, Stn No. 08NK018, 20.5 km downstream at the confluence). During the study period (2012-2015), August mean monthly discharge ranged from 5.24 m^3/s (2015) to 8.73 m^3/s (2013) and February ranged from 1.86 m^3/s (2014) and 3.24 m^3/s (2015).

Figure 3.1.2 illustrates the mean daily discharges for the study period (May 2012 through October 2015) at the Fording River confluence (WSC Stn. No. 08NK018). On the dates June 20 through June 22, 2013 the upper Fording River experienced an extreme flood event. Mean daily discharge peaked at 195 m^3/s and a maximum instantaneous discharge of 277 m^3/s was reported (WSC Stn. No. 08NK018). This flood event was second only to the flood of record in 1995 with a maximum instantaneous discharge of 320 m^3/s. Flood effects are discussed in population monitoring, movement patterns and distribution, and habitat mapping.

The mean annual discharges during the study period were 11.46, 11.29, 9.13 and 7.30 m^3/s in 2012 through 2015, respectively (Figure 3.1.2). Note that the Oct 27 end date for 2015 reflects the end of radio telemetry monitoring and the cut-off date for data collection to facilitate report preparation. Mean annual discharge during the first three years of this study (2012-2014) were above the 41 year (1970-2011) average of 7.95 m^3/s range, 4.04 to 13.4 m^3/s, WSC Stn. No. 08NK018). The 2015 mean annual discharge was on track to being below average.

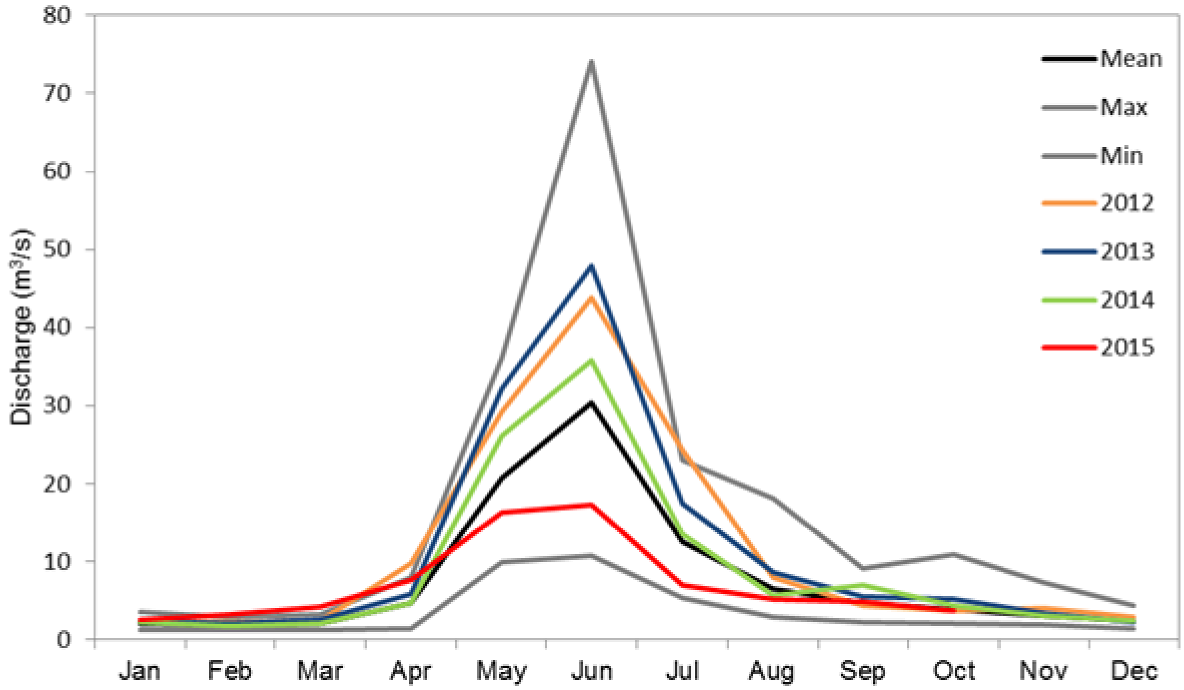


Figure 3.1.1. Mean monthly discharge for the Fording River at the confluence (WSC Stn. 08NK018) for the period 1970–2011 with the current study years (2012-2015) overlain for comparison. Note that 2015 data was preliminary and subject to revision by WSC.

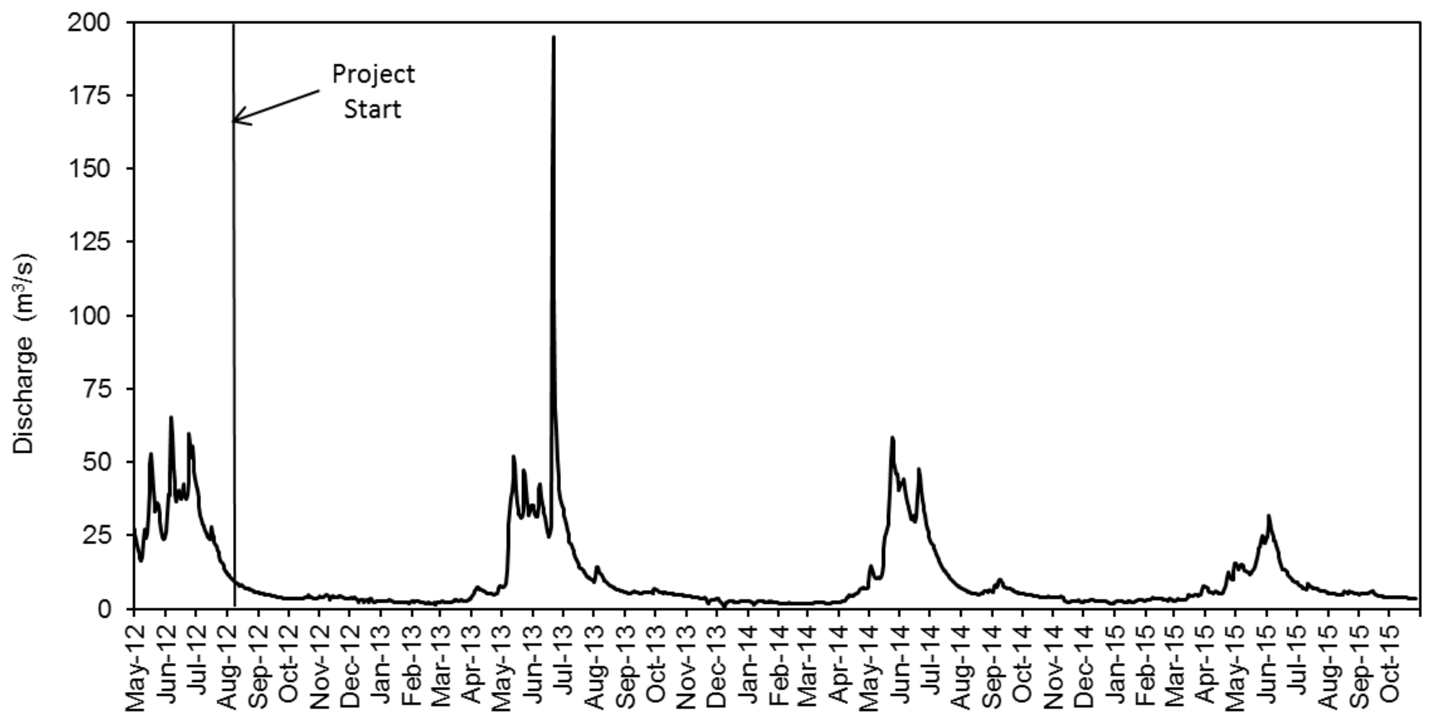


Figure 3.1.2. Fording River mean daily discharge at the confluence for the 2012 through 2015 study period (WSC Stn. 08NK018). Note that 2015 data was preliminary.

Stream discharge or flow, wetted channel width and mean water depth were illustrated to provide context in regards to relative stream "size" (*e.g.,* discharge or flow) among key representative locations used for population assessment. Table 3.1.1 presents the stream discharge estimated at the 19 juvenile sample locations during the late summer season (September 11 to October 3, 2015).

Table 3.1.1. Discharge estimates from the fry and juvenile electrofishing locations (Figure 2.4.1) illustrating relative flows and stream "size" among key study segments within the study area.

Location	Strata	River Segment	River Km	Date	Discharge (m^3/s)	Wetted Width (m)	Mean Depth (m)	Mean Velocity (m^3/s)
Fording River	Mainstem Headwaters	11	68.0	17-Sep-15	0.19	5.3	0.18	0.15
Fording River	Mainstem Headwaters	10	65.6	18-Sep-15	0.17	6.2	0.23	0.09
Fording River	Mid-Mainstem (FRO)	8b	59.3	11-Sep-15	0.85	11.9	0.28	0.25
Fording River	Mid-Mainstem (FRO)	8a	58.1	21-Sep-15	0.63	7.0	0.22	0.29
Fording River	Mid-Mainstem (FRO)	7	52.4	21-Sep-14	0.83[b]	7.5	0.28	0.32
Fording River	Lower Mainstem	6	48.5	23-Sep-15	0.78	8.5	0.32	0.21
Fording River	Lower Mainstem	5	34.4	25-Sep-14	2.30[b]	7.8	0.42	0.46
Fording River	Lower Mainstem	3	32.5	25-Sep-15	0.50[a]	7.8	0.21	0.22
Fording River	Lower Mainstem	2	27.2	29-Sep-15	1.06[a]	10.6	0.37	0.27
Henretta Creek	Lower Tributary	1	0.2	15-Sep-15	0.73	7.5	0.33	0.22
Henretta Creek	Upper Tributary	3	2.4	16-Sep-15	0.59	5.0	0.28	0.28
Fish Pond Creek	Lower Tributary	1	0.4	22-Sep-15	0.21	5.2	0.14	0.19
Lake Mountain Cr.	Lower Tributary	1	0.1	21-Sep-15	0.03	2.4	0.06	0.12
Chauncey Creek	Lower Tributary	1	0.4	19-Sep-15	0.20	3.6	0.24	0.13
Chauncey Creek	Upper Tributary	2	1.3	3-Oct-14	0.23[b]	6.0	0.18	0.16
Ewin-Todd Hunter Cr	Lower Tributary	1	0.7	15-Sep-14	1.06[b]	7.6	0.31	0.31
Ewin Creek	Upper Tributary	2	3.3	20-Sep-15	0.35	5.8	0.21	0.20
Dry Creek	Lower Tributary	1	0.2	24-Sep-15	0.02	3.5	0.11	0.04
Greenhills Creek	Lower Tributary	1	0.3	28-Sep-15	<0.01	1.5	0.18	0.02

[a] - incomplete; multiple channels not all included.
[b] - note not sampled in 2015

Stream discharge ranged from 0.17 to 2.30 m^3/s in the mainstem Fording River and between <0.01 m^3/s and 1.06 m^3/s in tributaries. The corresponding mean daily discharge downstream at the confluence (*i.e.,* rkm 0.00) was 4.36 m^3/s (September 11 to October 3, 2015) and ranged between 3.77 m^3/s and 5.98 m^3/s. With the exception of flows in the lower mainstem of the upper Fording River study area (*i.e.,* downstream of the southern FRO property boundary,

Figure 2.4.1), all locations, including the mainstem Fording River within the FRO mine site were less than 1.0 m^3/s and were indicative of small stream or "tributary" habitat.

Additional context in stream size can be gained through spot discharge estimates collected by Teck within FRO. In lower Segment S8 (South Tailing Pond, Teck Station FR2, 2010-2012, 54.3 rkm) discharge estimates ranged between 1.05 m^3/s and 16.75 m^3/s (Teck, FRO, File data, Jan 2013). These included August flows (summer rearing) of between 1.43 m^3/s and 3.48 m^3/s, and December to March (over-wintering) minimums of between 1.05 m^3/s and 1.39 m^3/s. This represents roughly 35% to 50% of the flows recorded downstream near the confluence with the Elk River. This met expectations based on flow estimation on-site and the location of FR2 within the upper 50% of the watershed.

Ten kilometers upstream near the upstream limit of FRO (Teck Station UFR1, 2010-2012, 63.6 rkm) the discharge ranged between 0.23 m^3/s and 7.67 m^3/s with late summer and winter minimums approximately between 0.23 m^3/s and 1.0 m^3/s.

In all winters (2012/13, 2013/14, 2014/15), the mainstem upper Fording River within the FRO mine site was observed to be dewatered and frozen with no surface flow in two sections of river. The channel typically flowed sub-surface in river Segment S7 immediately below the South Tailings Pond Diversion and intermittently over short sections within river Segments S8 and S9 between Lake Mountain Creek (58.4 rkm) upstream to the confluence with Henretta Creek (62.9 rkm). The latter area (Fording Headwaters-Henretta Pit Lake-Lake Mountain Creek) includes the historical "Clode Flats" area (*see* Figure 3.2.12) and was also an important spawning and over-winter migration corridor (*see* Section 3.3 Movement Patterns and Distribution). These river sections were confirmed to have surface flow during previous site visits from May through November. The December through February observations of dewatered sections were made during helicopter tracking surveys and verified by ground-truthing. The extent of dewatering was not evident due to intermittent flow, snow and ice cover. Dewatering observations confirm a number of studies since mine operations began in 1971 that have reported dewatered and/or frozen sections of river channel within FRO (G. Sword, p*ers. comm.*). Fish kills due to winter conditions (*i.e.,* dewatered) as high as 800 fish have been reported in the past (Lister and Kerr Wood Leidal 1980).

Incidences of channel dewatering are not unique to the Fording River and are also known to occur within the upper reaches of other upper Kootenay River tributaries such as the Wigwam River (Baxter and Hagen 2003, Prince and Cope 2001) and the Elk River (Prince and Morris 2003). Migratory patterns of Westslope Cutthroat Trout documented within the above watersheds, including the upper Fording River, allow persistence (*i.e.,* self-sustaining and ecologically effective populations) despite these intermittent flows.

Density estimates for mature Westslope Cutthroat Trout (fish > 200 mm FL or fish > 300 mm FL) have been collected using similar snorkel methods (*see* Section 2.4 Population Monitoring) for a few priority Westslope Cutthroat Trout streams in the upper Kootenay drainage (Elk mainstem, Elk tributaries (Wigwam River, Michel Creek), St. Mary, White (Middle, East and North Forks) and Bull Rivers). These estimates have been used to place upper Fording River estimates in context regionally. Table 3.1.2 summarizes mean annual and mean monthly discharge to illustrate differences in watershed scale and river size (*e.g.,* discharge or flow) among these population groups used for relative comparison.

Table 3.1.2. Watershed area, mean annual and annual minimum and maximum monthly discharge ($m^{3/}s$) illustrating differences in watershed and river scale.

Population Group	Water-shed Area (km^2)	Station I.D.	Location	Years	Mean Annual Discharge (m^3/s)	Minimum Monthly Mean Discharge (m^3/s)	Maximum Monthly Mean Discharge (m^3/s)
Fording R.	621	08NK018	Fording at Mouth	1970-2011	7.95	1.92	30.50
Michel Cr.	637	08NK020	Below Natal	1970-1996	10.80	1.98	42.60
Upper Wigwam R[1]	n/a	EMS E238242	Bridge above Bighorn	2000-2003	n/a[1]	2.33	33.70
White R.	987	08NF003	Near Canal Flats	1940-1948	12.30	5.20	53.90
Bull River	1,520	08NG002	Near Wardner	1914-2011	32.30	7.19	108
Elk River	3,090	08NK002	At Fernie	1925-2011	46.50	12.40	160
St. Mary R.	2,360	08NG012	At Wycliff	1914-1995	51.20	8.63	210

[1] - station maintained April – November (Prince and Morris 2004).

3.1.2. Water Temperature

Figures 3.1.3a (mainstem Fording River at five locations) and 3.1.3b (Ewin, Chauncey and Henretta Creeks) illustrate the mean daily water temperatures for the eight representative locations within the upper Fording River watershed. Figure 2.1.1 illustrates the location of the monitoring stations. Six of eight stations (75%) in the upper Fording River represent ideal rearing temperatures for Westslope Cutthroat Trout; a species that thrives in cold, clean streams preferring stream temperatures of 7-16 °C (Bear *et al.* 2007, Oliver and Fidler 2001, Ford *et al.* 1995, Behnke and Zarn 1976). One station (Ewin Creek, 12.5%) had water temperatures below recommended guidelines, and one station (Segment S7, 12.5%) had water temperatures above recommended guidelines.

Within the mainstem Fording River, the maximum recorded mean daily water temperatures ranged between 10.99 ^{o}C (S6 Station) and 13.62 ^{o}C (S7 Station). The instantaneous daily maximum temperatures (based on hourly intervals) ranged between 14.53 ^{o}C (F1 Station) and 18.91 ^{o}C (S7 Station). River Segment S7 was the one site with hourly daily maximum temperatures exceeding recommended guidelines for Westslope Cutthroat Trout (7-16 °C). These Segment S7 daily maximum temperatures were within 0.79 °C of the upper incipient lethal temperature for Westslope Cutthroat Trout (19.7 ^{o}C 95% C.I. 19.1 – 20.3 ^{o}C, Bear *et al.* 2005). The upper incipient lethal temperature is a commonly used measure to define the upper boundary to the zone of thermal tolerance above which mortality effects due to temperature can be expected.

Tributary mean daily water temperatures were colder than the mainstem Fording River (Figure 3.1.3b). Maximum mean daily water temperatures range between 7.44 ^{o}C (Ewin Cr.) and 10.35 ^{o}C (Henretta Cr.). Daily maximum temperatures (hourly intervals) range between 9.56 ^{o}C (Ewin Cr.) and 11.69 ^{o}C (Chauncey Cr.). Ewin Creek was at the lower end of the range and its low maximum daily water temperatures rarely meet those considered ideal for Westslope Cutthroat Trout rearing 7-16 °C. Table 3.1.3 provides a comparative summary of the mainstem and tributary temperature profiles illustrated in Figures 3.1.3a and 3.1.3b.

Upper Fording River mean daily water temperatures were consistent with other upper Kootenay River watersheds that support regionally significant fluvial populations of Westslope Cutthroat Trout and recreational fisheries (Table 3.1.4).

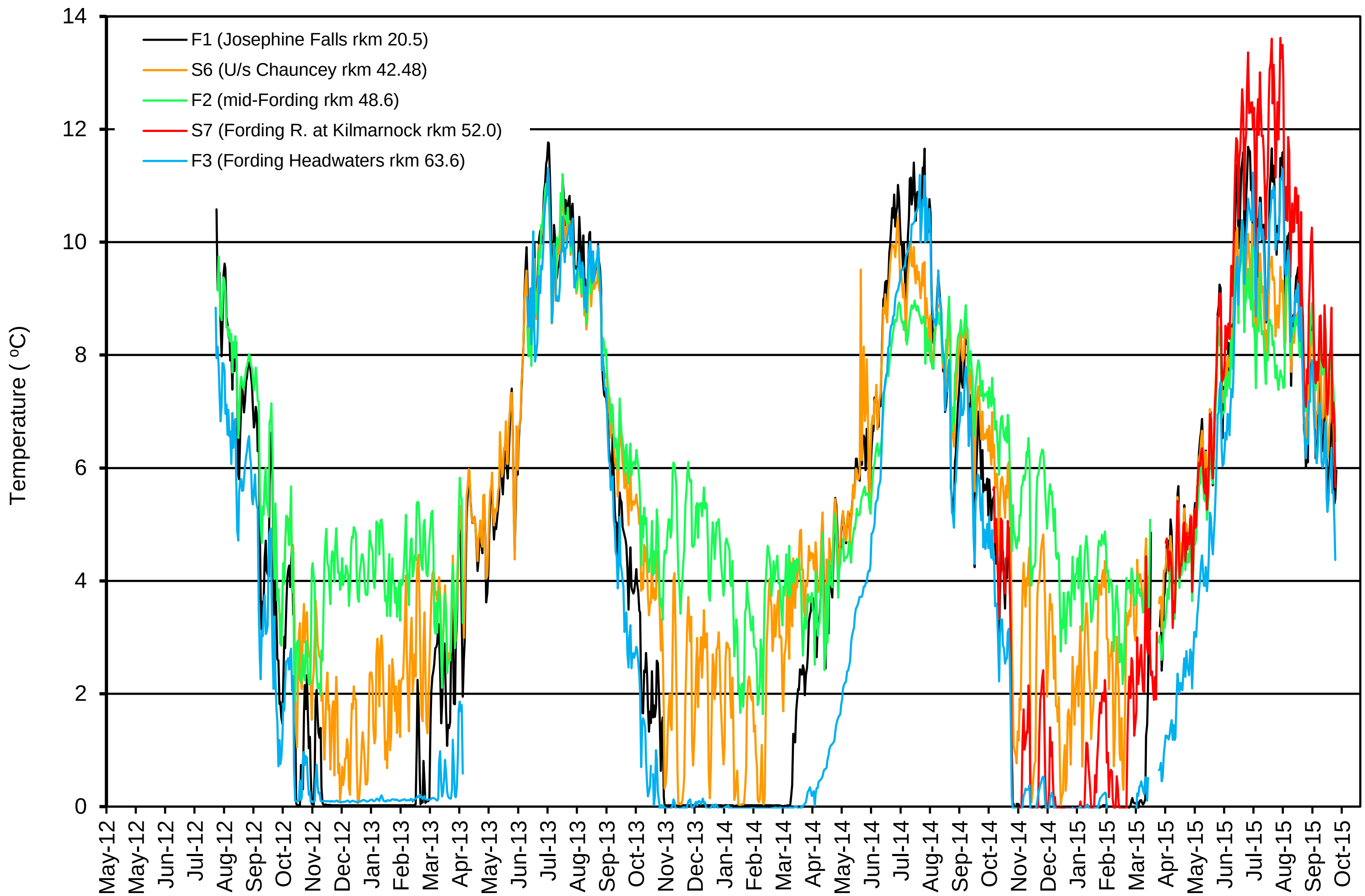


Figure 3.1.3a. Upper Fording River mean daily water temperatures at the five temperature logger stations August 22, 2012 to October 7, 2015.

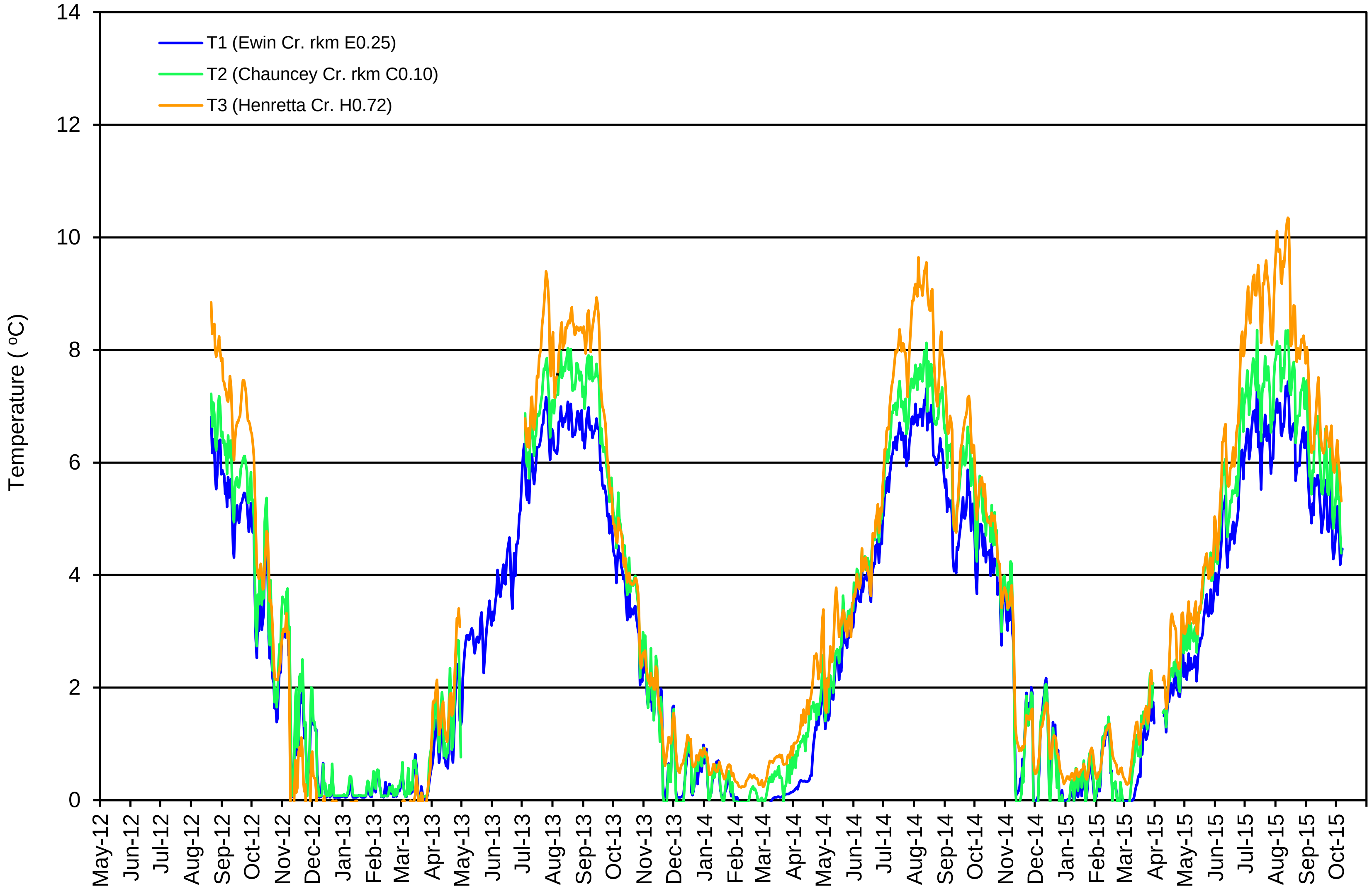


Figure 3.1.3b. Ewin, Chauncey and Henretta Creek mean daily water temperatures at their respective temperature logger stations August 22, 2012 to October 7, 2015.

Table 3.1.3. Comparison of water temperatures for select locations and tributaries of the upper Fording River study area (August 22, 2012 to October 7, 2015).

Watershed Location	River Kilometer (rkm)	Average Mean daily Water Temp (°C)	Min Mean Daily (°C)	Max Mean Daily (°C)	Maximum Water Temp (°C)
Mainstem Fording River					
F1 (Josephine Falls)	20.5	4.17	0.00	11.77	14.53
S6 (u/s Chauncey Cr)	42.5	5.01	0.03	10.99	14.91
F2 (Mid-Fording)	48.6	5.79	1.64	11.20	14.63
S7 (d/s Kilmarnock Cr)	52.0	5.02	0.00	13.62	18.91
F3 (Headwaters)	63.6	3.42	0.00	11.31	15.32
Tributaries					
T1 (Ewin Cr)	33.1	2.87	0.00	7.44	9.56
T2 (Chauncey Cr)	42.0	3.23	0.00	8.35	11.69
T3 (Henretta Cr)	62.9	3.59	0.00	10.35	11.32

Table 3.1.4. Comparison of mean daily water temperatures during the late summer season for select upper Kootenay River watersheds whose Westslope Cutthroat Trout populations have been assessed using radio telemetry.

Watershed	Average Mean Daily Water Temp (°C)	Min Mean Daily (°C)	Max Mean Daily (°C)	Dates
Upper Fording	7.58	4.68	9.75	Aug 22 - Oct 12, 2012
	7.86	4.37	10.45	Aug 22 - Oct 12, 2013
	7.19	4.24	9.43	Aug 22 - Oct 12, 2014
	7.29	5.37	9.55	Aug 22 - Oct 12, 2015
Elk@Elkford	8.04	5.02	9.68	Aug 22 - Oct 03, 2002
Upper Wigwam	7.82	4.45	10.25	Aug 22 – Oct 12, 2003
	7.63	4.29	9.59	Aug 22 - Oct 12, 2002
	7.58	4.8	9.36	Aug 22 - Oct 12, 2001
	7.03	4.4	9.26	Aug 22 - Oct 12, 2000
Upper Bull	9.54	5.62	12.38	Aug 22 - Oct 12, 2011
Upper St. Mary	10.13	9.19	11.02	Aug 22 - Sept 06, 2003

Groundwater Influence

During the onset of early winter conditions (October) water temperatures at the F2 site (48.60 rkm) can be seen to diverge from the lower (F1) and upper (F3) thermistors (Figure 3.1.3a). Both the upper (F3) and lower (F1) watershed temperatures remain at approximately 0 ^{o}C from early November through late March. During this time, the F2 site (located at the upper limit of Segment S6 approximately 3 km downstream of the FRO boundary) remained between 2.0 and 5.0 ^{o}C; confirming the groundwater influence within river Segment S6. An additional temperature logger was placed at the downstream limit of this Westslope Cutthroat Trout over-wintering area at 42.48 rkm on October 25, 2012. The groundwater effect was still evident at the lower S6 site but ambient cooling attenuates the groundwater effect. In contrast, Segment S6 summer water temperatures were cooler than either upstream (F3) or downstream (F1) reaches. Cooler summer and warmer winter water temperatures are identifying features of groundwater upwelling. This river section has been described as the “Segment S6 groundwater segment” and represents the most utilized over-wintering habitat within the upper Fording River study area (*see* Section 3.3 Movement Patterns and Distribution). This Segment also represents the “oxbow pools”, an area of high selenium (Windward *et al.* 2014) and fish captured within this area during spawning season are known to contain elevated and high selenium bioaccumulation within tissue samples (McDonald 2013, Fisher 2013, *pers. comm.*, Minnow *et al.* 2011).

The availability, quality, quantity and distribution of over-wintering habitat is frequently limited for this species and, therefore, often disproportionately important habitat for survival and recovery of Westslope Cutthroat Trout populations in general (Cleator *et al.* 2009). Within the west slope of the Rocky Mountains, the winter period river ice and groundwater dynamics can be influencing fish distribution (Cope and Prince 2012, Prince and Morris 2003, Morris and Prince 2004). During these months, air temperatures range from lows in excess of -25 ^{o}C to highs of over 6.0 ^{o}C. This results in complex and dynamic ice processes including frazil ice formation (ice flows that are transported downstream), anchor ice (submerged ice attached to the river bottom or substrate) and stationary ice cover. These river ice processes, combined with the low volume of water during minimum winter low flows (< 2.0 m^3/s), result in varying degrees of ice formation, channel dewatering and/or freezing and ice dams or jams. Brown *et al.* (2011) provide a recent review of these river ice processes and their influence on the behaviour and survival of stream dwelling salmonids.

The habitat associated with aggregations of over-wintering Westslope Cutthroat Trout described in the literature was typically deep, slow pools, groundwater influx, or both, and an absence of anchor ice (Cope and Prince 2012, Brown *et al.* 2011, Cleator *et al.* 2009, Morris and Prince 2004, Prince and Morris 2003, Brown and Mackay 1995, Brown and Stanislawski 1996, Boag and McCart 1993). River Segment S6 extending from F2 (48.60 rkm) downstream to the Chauncey Creek confluence (41.96 rkm) was dominated by slow, deep pools with groundwater influx. In total, 42% of all radio tagged fish over-wintered within these ground-water influenced pools during the study period (2012-2015). This river Segment (S6) remained ice free as opposed to adjoining river segments that were ice covered and had anchor ice as well as frazil ice and ice jams (S1-S5 downstream and S7-S11 upstream). Clode Pond Exfiltration, Clode Creek and Fish Pond Creek (constructed habitat) also remained largely ice free and spot temperatures suggested these sites (*e.g.,* “Clode Flats” area) were also likely groundwater influenced. There was no indication of groundwater influence for the sites on Henretta, Chauncey or Ewin Creeks.

Thermal Loading

Stream water temperatures in Segment S7 in the lower Fording River mine site (FRO) were routinely elevated 3.0 ^{o}C and increased by as much as 6.2 ^{o}C. Higher water temperatures can be identified in Figure 3.1.3a by the increase in water temperature between inflows into the mine site (F3 Site) and outflows off the mine site (S7 Site). The downstream effect was mitigated by the groundwater inflows immediately downstream (F2 Site) that decreased water temperatures relatively quickly (3.4 km). Although these elevated water temperatures were only documented for the 2015 season, the temperature logger was installed in river Segment S7 in the fall of 2014 based on high spot water temperatures at this location in August 2014 (16.0 ^{o}C).

Figure 3.1.4 illustrates the water temperature data for the five mainstem Fording River sites using the water quality guidelines measure of mean weekly maximum water temperature (Oliver and Fiddler 2001). Mean weekly maximum water temperature is defined as the average of the maximum daily water temperature (hourly intervals recorded) for seven consecutive days. River Segment S7 exceeds water quality guidelines for spawning, incubation and rearing. Although the extent of this effect remains unknown, and a more comprehensive on-site temperature monitoring program was required to quantify possible impacts within Segments S7 through S9, a number of common mechanisms for increasing water temperature were noted. Elevated water temperatures and the likely pathways for this impact are also discussed in Section 3.4 Habitat mapping (*i.e.,* degraded stream channels). Elevated water temperatures and surface mining are most commonly associated with the removal of riparian vegetation (increased solar heating),

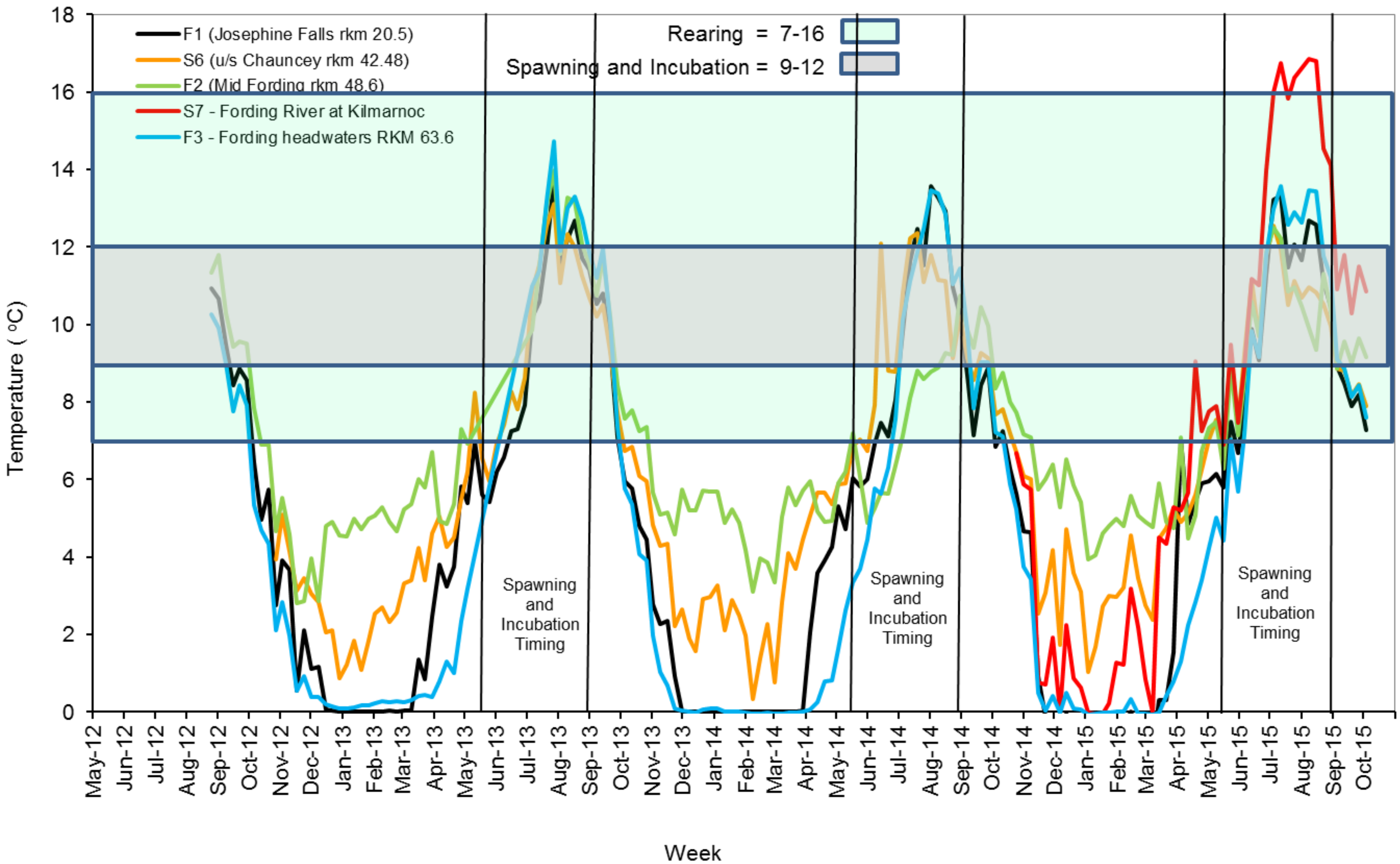


Figure 3.1.4. Mean weekly maximum water temperature for the five mainstem upper Fording River locations in relation to recommended guidelines for Westslope Cutthroat Trout, August 22, 2012 to October 7, 2015.

channel geometry impacts (increased solar heating due to increased width:depth ratios and shallow water depths), settling ponds releasing warmer water, and the loss of cooler headwater tributary inflows from water withdrawals (Nelson *et al.* 1991).

Spawning Temperatures

Recommended water quality guidelines for optimal spawning temperatures for Westslope Cutthroat Trout are 9 – 12 ^{o}C (Oliver and Fidler 2001). More generally, Westslope Cutthroat Trout spawn when temperatures reach approximately 7 – 10 ^{o}C (Scott and Crossman 1973). The Elk and St. Mary River populations have been reported to begin spawning when mean daily water temperatures reach 7.0 ^{o}C (Prince and Morris 2003, Morris and Prince 2004). In the upper Bull River (Cope and prince 2012), spawning related movements were documented between May 25 and July 4 when mean daily water temperatures ranged between 4.0 ^{o}C and 7.8 ^{o}C.

In general, spawning timing within the upper Fording River and its tributaries was estimated between May 20 and July 20 for the 2013, 2014 and 2015 spawning cohorts. These dates were consistent with redd observations from previous studies (Oliver 1999, Amos and Wright 2000, Wright *et al.* 2001).

In 2015, spawning timing in the upper Fording River was estimated to be May 20 to July 3; as documented through observations of spawning (redds) and courtship behaviour (fish on redds). The low snowpack and low precipitation in spring of 2015 provided rare water clarity that permitted the enumeration of redds for the duration of the post-freshet spawning. The first redds were observed in the mainstem Fording River and Greenhills Creek on May 28. The last redds were observed on June 24 (*see* Section 3.3 Movement Patterns and Distribution). In general, spawning activity started once mean daily water temperatures were 5 ^{o}C and daily maximums exceeded 7.0 ^{o}C. Spawning activity ended when mean daily water temperatures were 10.0 ^{o}C and daily maximums approached 14.0 ^{o}C.

Based on the same water temperature criteria (mean daily water temperatures of 5.0 ^{o}C with daily maximums of 7.0 ^{o}C), the 2014 spawning period was estimated to be May 30 to July 12. Water clarity did not generally permit redd enumeration nevertheless, redds were observed in mainstem margin habitats on June 25 and July 3.

Using the same water quality criteria (mean daily water temperatures of 5.0 ^{o}C with daily maximums of 7.0 ^{o}C), the 2013 spawning period was estimated to be June 4 to July 20. Redds were identified within mainstem margin habitat in river Segment S2 and S5 during the helicopter tracking session of June 17. However, river temperatures immediately dropped below 6.0 ^{o}C in response to the heavy precipitation and extreme run-off event of June 20 to June 22. High flows and turbidity persisted into July preventing any further potential spawning or redd observations.

3.2. Population Monitoring

Population monitoring within the upper Fording River study area included annual estimates for the total population of sub-adults and adults and annual estimates for densities of fry and juveniles in 19 representative locations. Based on the minimum size of maturity, sub-adults and adults were considered fish greater than 200 mm fork length. Upper Fording River Westslope Cutthroat Trout less than 200 mm fork length were considered fry or juveniles (*i.e.,* 0 to 3 year olds). This maturity criteria based on the 200 mm cut-off was based on gonad maturity, length frequency analysis, scale ages and mark-recapture growth rates (*see* Section 3.2.2 Age Class Structure, Growth and Condition).

The following summarizes the capture results by life stage, illustrating capture and marking objectives were met. Condition factor, length-at-age data, individual growth data, length-at-maturity data, and population age structure were presented in the subsequent section. This was followed by the population and density estimates.

3.2.1. Capture and Tagging

In total, 1,662 Westslope Cutthroat Trout were captured, measured and 1,049 were tagged using a combination of radio tag, Floy tag and PIT tag (Table 3.2.1). There were 906 fry or juveniles and 756 sub-adults or adults captured. There were 58 recaptures that provided individual growth data. Sub-adults and adults were captured in August 2012, 2013 and 2014, while fry and juveniles were captured in September 2013, 2014, and 2015.

Table 3.2.1. Capture and tagging summary for the Upper Fording River Population Assessment and Telemetry Project (2012-2015).

	Fry and Juveniles (<200 mm)			Adults and Sub-Adults (>200 mm)				
	Captures	PIT Tags	PIT Tag Recaps.	Captures	Floy Tags	Radio Tags	PIT Tags	Floy Tag Recaptures
2012				229	151	60		
2013	140	91		258	166	61	18	14
2014	232	130	19	269	178	60	15	16
2015	534	119	9					
Subtotal	906	340	28	756	495	180	33	30
Grand Total	1662							

3.2.1.1. Adults and Sub-Adults

Angling for sub-adult and adult Westslope Cutthroat Trout (*i.e.,* targeting fish > 200 mm fork length) was completed between August 7 and September 7 each year, for three years (2012, 2013, 2014). Mean daily water temperatures (recorded at the F1 or lowermost river station at Josephine Falls) during capture and tag implantation ranged between 6.1 and 11.7 ^{o}C (Figure 3.1.3a) and spot measurements ranged from 6.0 ^{o}C to 16.0 ^{o}C.

In total, 756 Westslope Cutthroat Trout ranging in size from 134 mm to 485 mm (fork length) and between 33 g and 1,550 g were captured by angling. Upper Fording River fish lengths were within the range reported previously for this population (Amos and Wright 2000), as well as within the species range in general (McPhail 2007, Benke 2002, Scott and Crossman 1976).

In total, 180 Westslope Cutthroat Trout were implanted with a radio tag transmitter and a Floy tag was also applied. An additional 495 fish were tagged with Floy tags. Thirty-three juveniles less than 200 mm fork length were tagged with PIT tags to supplement the recruitment and juvenile sample size and distribution. There were 30 Floy tag recaptures that provided individual growth data. The following table provides a comparative catch and tagging summary for the three tagging years or replicates (Table 3.2.2). The same effort and crew were employed in all three years.

Table 3.2.2. Capture and tagging summary for the three years sub-adult and adult sampling in the upper Fording River.

	2012	2013	2014
Date	Aug 22 - Sept 07	Aug 07 - 27	Aug 05 – 22
Mean Daily W/t (^{o}C)	6.07 - 9.75	9.50 – 11.13	6.99 – 11.66
Spot W/t (^{o}C)	6.0 – 14.5	7.0 – 13.7	7.5 – 16.0
Catch	229	258	269
Mean Length (mm)	289	252	268
Length Range (mm)	160 - 485	149 – 450	134 – 456
Mean Weight (g)	414	277	344
Weight Range (g)	55 -1,550	35 – 1,140	85 – 1,400
Radio Tags Applied	60	61	59
Floy Tags Applied	151	166	178
PIT tags Applied to juveniles		18	15
Recaptures		14	16

3.2.1.1.1.Radio Tag Implantation

There were 180 Radio tags implanted in sub-adult and adult fish ranging from 223 mm to 485 mm fork length (Floy tags unique to each year 2012 Green, 2013 Pink, 2014 Lime were also applied). The corresponding weight ranged from 170 g to 1,400 g. There were 61 males (34%), 95 females (53%) and 24 unidentified sex (13%) tagged. Fish life stage was classified based on gonad development during the internal exam and included; 28 sub-adults (16%), and 152 mature adults (84%). During the internal exam (n=180), all fish less than 233 mm fork length or 170 g were classified as sub-adults (immature gonads). All fish greater than 290 mm fork length or 300 g were classified as mature or maturing (mature, anticipated first spawning event next spring). As such, the size range 230 to 290 mm or 170 to 300 g represents length-at-age maturity variation containing both mature and sub-adult (immature gonads) fish.

Smaller sized mature fish were not restricted to just the headwaters or tributaries. An important distinction as considerable effort was completed to assess the alternative hypothesis that one or more headwater populations may exist with a smaller size-at-maturity and less migratory life history strategy. Table 3.2.3 summarizes the life history characteristics of the three replicate radio tagging cohorts. Life history strategies were examined in further detail in Section 3.3 Movement Patterns and Distribution.

Table 3.2.3. Summary of life history characteristics for the 2012, 2013 and 2014 radio tagged cohorts in the upper Fording River.

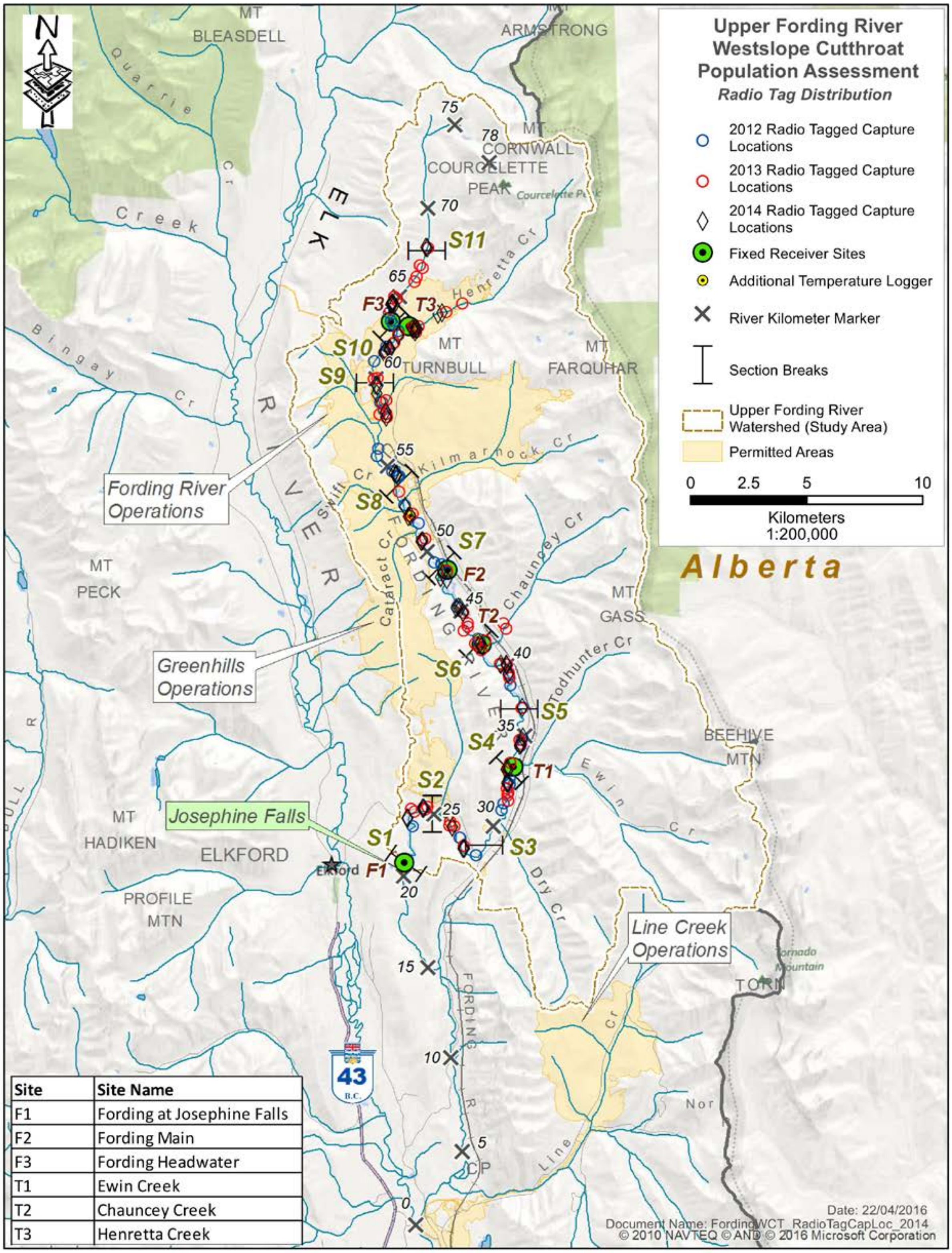
	2012	2013	2014	Total
Radio Tagged (N)	60	61	59	180
Mean Length (mm)	343	302	317	320
Length Range (mm)	234-485	223-450	241-456	223-485
Mean Weight (g)	614	456	599	556
Weight Range (g)	200-1,400	170-1,140	200-1,400	170-1,400
Sex				
Male	21	23	17	61
Female	33	36	26	95
Undetermined	6	2	16	24
Gonad Maturity Status				
Sub-adults	11	12	5	28
Mature	49	49	54	152
Estimated Minimum Length of Maturity (mm)	280 mm	233 mm	250	230-280

The initial distribution of radio tagged Westslope Cutthroat Trout in the study area was achieved for Segments S1 through S10 and lower Henretta Creek (Figure 3.2.1). Tagged fish were distributed between rkm 23.9 and rkm 68.0 of the upper Fording River mainstem. Radio tags were also applied to fish above the Chauncey Creek highway culvert and in Henretta Creek in and above Henretta Pit Lake. Ewin Creek above the highway was angled but no fish were captured.

Surgery implantation procedures met expectations compared to previous Westslope Cutthroat Trout experience and were completed within expected quality control measures of anaesthetic exposure and recovery times (Table 3.2.4). Mean induction and recovery times were 3:58 and 5:40 minutes respectively, and were within the recommended guidelines for invasive procedures (Anderson *et al.* 1997) and exposure to clove oil (Prince and Powell 2000, Peake 1998). Based on previous experience, the mean release time was increased for the Project to include a mandatory minimum 30 minutes in the fish sleeve to reduce the risk of post-surgery mortalities and susceptibility to downstream displacement and predation. In previous studies listed (Table 3.2.4), while this recovery procedure was done, it was done on an informal basis and the time was not always recorded.

Table 3.2.4. Comparative summary of quality assurance parameters for the radio tag implantation procedure for upper Kootenay River Westslope Cutthroat Trout greater than 200 g; average anaesthetic exposure, mean surgery time, recovery to equilibrium, and time to release.

	Upper Fording River (mm:ss)			Bull River	Elk River	St. Mary R.
Exposure Time	2012	2013	2014	(mm:ss)	(mm:ss)	(mm:ss)
Anaesthetic	3:52	3:58	3:35	4:12	4:26	3:10
Surgery	7:01	5:40	6:58	6:52	6:29	6:46
Recovery	6:06	5:22	7:26	7:50	7:08	8:25
Release	48:15	42:17	56:28	19:03	Not Recorded	Not Recorded



Site	Site Name
F1	Fording at Josephine Falls
F2	Fording Main
F3	Fording Headwater
T1	Ewin Creek
T2	Chauncey Creek
T3	Henretta Creek

Figure 3.2.1. Distribution of radio tagged Westslope Cutthroat Trout captured and released in summer 2012, 2013 and 2014, upper Fording River.

Another quality control measure for radio tag implantation was the identification of mortalities within 30 days of tag implantation. These fish were either never relocated or recovered dead within 30 days. Given the short duration at large these fish were not available for recapture (snorkel survey) and there was little or no movement reported. To eliminate this bias, these fish were not included in further analyses.

Regardless of the mechanism of mortality identified (*i.e.,* predation), it was assumed effects of the implantation procedure may have directly or indirectly contributed to the mortality if it occurred within 30 days. There were 15 Westslope Cutthroat Trout implanted with radio tags (n=3 $_{2012}$, n=3 $_{2013}$, n=9 $_{2014}$) that were either; a) recovered mortalities (n=5 or 3%), or b) "missing" fish or assumed mortalities that were never relocated after release (n=10 or 6%). "Missing" fish are typically mortalities that have had the tag or antennae mechanically damaged due to predation (not transmitting) or have been transported into an area with poor signal strength *(i.e.,* in earth den, birds or anglers transport outside of the study area, or buried in silt).

This resulted in a total of 166 (92%) radio tagged Westslope Cutthroat Trout confirmed alive by a combination of movement (telemetry) and visual (snorkel) methods. Note that one recovered radio tag (predation mortality) was recovered within one week and was reused in a second fish and that is why the total at large was 166 rather than 165. These fish were confirmed at large for between 46 and 655 days between August 2012 and November 2015. These fish form the basis for estimating sub-adult and adult population abundance and life history analyses. Of these fish (n=166), 111 or 67% were confirmed alive and at large for at least 312 days.

The observed post implantation mortality rate of 3% met expectations for tag implantation and compares to 3% for the upper Bull River Westslope Cutthroat Trout Project that included the same quality assurance procedures (Cope and Prince 2012). Assuming the ten "missing" fish were a result of procedure mortality resulted in an assumed mortality rate of 9%. The higher incidence (n=7) of missing fish in 2014 was unlikely to be procedural and remains unexplained.

3.2.1.1.2.Floy Tags

An additional 495 Floy tags unique to each year (2012 White, 2013 Blue, 2014 Orange) were applied to sub-adult and adult fish ranging from 171 mm to 485 mm fork length. The corresponding weight ranged from 70 g to 1,550 g. A higher proportion of the Floy tagged fish were represented by smaller sub-adult fish than the radio tagged (plus Floy tag) fish which had a higher proportion represented by larger mature fish (Figure 3.2.2). On average, radio tagged fish weighed twice as much as Floy tagged fish (Table 3.2.5).

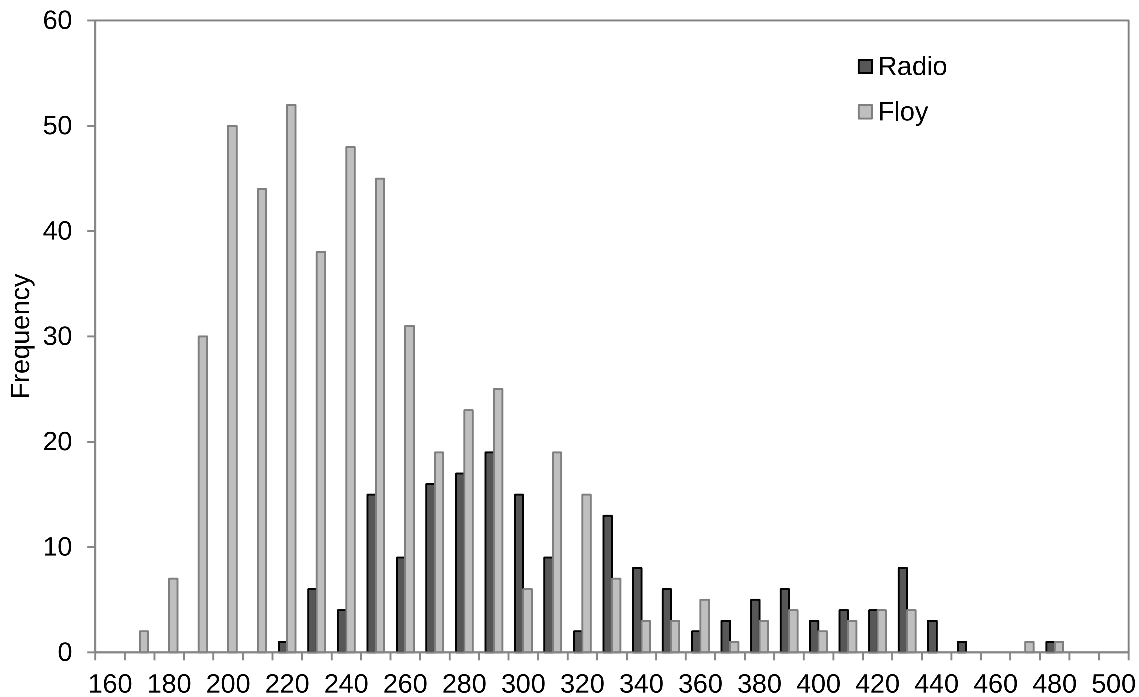


Figure 3.2.2. Length frequency of Floy tagged fish (n=495) and radio tagged fish (n=180) illustrating differences in proportion of smaller sized fish between the marking methods for snorkel mark-recapture.

Table 3.2.5. Comparison of mean size for fish with radio tags and Floy tags.

	2012	2013	2014	Total
Mean Length (mm) and Range				
Floy tagged	279 (180-485)	242 (171-426)	253 (189-378)	257 (171-485)
Radio Tagged	343 (234-485)	302 (223-450)	317 (251-456)	320 (223-485)
Mean Weight (g) and Range				
Floy Tagged	371 (80-1,550)	211 (70-1,050)	262 (85-1,020)	278 (70-1,550)
Radio tagged	614 (200-1,400)	456 (170-1,140)	599 (200-1,400)	556 (170-1,400)
N	151 Floy 60 Radio	166 Floy 60 Radio	178 Floy 60 Radio	485 Floy 180 Radio

These differences were important since they impacted recapture likelihood (*i.e.,* observer (snorkel) efficiency) and population estimates. Dominance hierarchies have been observed in pools with large Westslope Cutthroat Trout occupying the prime habitat within pools (McPhail 2007). Larger fish occupy habitats closer to the surface and the upstream end of pools; smaller fish utilize higher water velocities over coarse substrate, interstices and woody debris for cover (McPhail 2007, Cope 2007, Ptolemy *et al.* 2006, Ford *et al.* 1995). As a result, smaller fish are more difficult to see, thereby biasing population estimates in favour of large, mobile forms. This size related difference was observed in the upper Fording River by the snorkel crew and were reflected in differences in observer efficiencies between the radio (on average larger) and Floy tagged fish (*see* Section 3.2.3 Abundance Estimates).

Differences in the proportion of smaller sized fish between the radio tagged (plus Floy tag) and Floy tagged fish resulted from the discrepancy between:

1. The size category for snorkel surveys (> 200 mm) used to be consistent with reference populations so that results could be compared among these watersheds,
2. The minimum size that could be radio tagged due to the 2% rule (*i.e.,* 200 g or 233 mm, Winter 1983), and
3. Low densities in some river segments necessitated the application of Floy tags to all available captures that met (or nearly so) the minimum size requirements in order to meet the marking target of four fish per river kilometer.

As a result, there were more fish less than 200 g with Floy tags than strict adherence to a random design would have applied. Ideal methods would have been to randomly select captures within each strata or river segment for radio tags so there would be no size bias.

Interpretation of population estimates used a “blended” approach to uncertainty by relying on population estimates of the pooled set of radio tags and Floy tags combined (*see* Section 3.2.3 Abundance Estimates). Note that there were nine undersized fish (between 171 mm and 199 mm) Floy tagged. These fish represent 1% of the total Floy tags applied (n=675). Snorkel observation methods record fish in 100 mm categories and experience suggests these methods are +/- 25 mm depending on experience. Undersized fish fall within the range of observer error and were of such low frequency that the likelihood of introducing bias in resulting estimates was considered negligible.

3.2.1.1.3.PIT Tags

A total of 33 PIT tags were applied to Westslope Cutthroat Trout less than 200 mm fork length during the 2013 and 2014 sub-adult and adult sample sessions (angling). This was done to target the juvenile size class 130 - 200 mm and increase sample size and sample distribution for age class structure, growth and condition (*see* Section 3.2.2 Age Class Structure, Growth and Condition).

3.2.1.2.Recruitment and Juveniles

In total, 906 Westslope Cutthroat Trout between 24 mm and 336 mm were captured in 43 meso-habitat units of approximately 100 m^2 each at nineteen locations (Figure 2.4.1). On average, 4,808 m^2 of habitat was sampled annually (2013, 2014 and 2015) using three pass electrofishing. An additional 33 juveniles were captured by angling (*i.e.,* sub-adults and adult sample program). These fish were included in the PIT tagging and scale aging samples to increase sample size and sample distribution for those objectives. Table 3.2.6 provides a comparative catch and tagging summary for the three years or replicates. Catches of fry and juveniles increased substantially every year. The same effort and crew were employed in all three years.

Table 3.2.6. Capture and tagging summary for the three years fry and juvenile sampling in the upper Fording River (2013-2015).

	2013	2014	2015	Combined
Date	Sep 14 - 29	Sept 16 – Oct 3	Sept 16 – Oct 1	Sep 14 – Oct 3
Mean Daily W/t (^{o}C)	5.0 – 9.7	4.2 – 8.8	5.4 – 8.0	4.2 – 9.7
Spot W/t (^{o}C)	4.5 – 9.0	4.0 – 12.0	4.5 – 10.0	4.0 – 12.0
Spot Conductivity (µs)	242 - 775	212 - 735	290 – 1,770	212 – 1,770
Catch	140	232	534	906
Mean Length (mm)	97.4	107.9	96.5	99.6
Length Range (mm)	28 – 223	24 – 244	25 – 336	24 – 336
Mean Weight (g)	19.2	29.7	15.8	20.1
Weight Range (g)	0.1 – 137.0	0.1 – 217.7	0.1 – 422.8	0.1 – 422.8
PIT tags Applied	91	130	119	340
Angling PIT Tags	18	15	-	33
Recaptures	-	19	9	28

Electrofishing for fry and juvenile Westslope Cutthroat Trout (*i.e.,* targeting fish < 200 mm fork length) was completed between September 14 and October 3 each year. Mean daily water temperatures (recorded at the F1 or lowermost river station at Josephine Falls) during capture and tag implantation ranged between 4.2 and 9.7 ^{o}C (Figure 3.1.3a). Water temperature and conductivity spot measurements ranged between 4.0 ^{o}C and 12.0 ^{o}C and 290 µs and 1,770 µs, respectively.

With the exception of flows in the lower mainstem river portion of the study area (*i.e.,* river Segments S2 to S6 downstream of the southern FRO property boundary, Figure 2.4.1), all locations, including the mainstem Fording River within the FRO mine site were less than 1.0 m^3/s. Flows of 1.0 m^3/s or less were indicative of small stream or "tributary" electrofishing habitat. Stream discharge during fry and juvenile sampling September 14 to October 3 each year ranged from 0.17 to 2.30 m^3/s in the mainstem Fording River and between <0.01 m^3/s and 1.06 m^3/s in tributaries (Table 3.1.1). The corresponding mean daily discharge downstream at the confluence (*i.e.,* rkm 0.00) was 4.36 m^3/s (September 11 to October 3, 2015) and ranged between 3.77 m^3/s and 5.98 m^3/s.

In total, 340 Westslope Cutthroat Trout ranging in size from 62 mm to 231 mm were PIT tagged and 194 of these were aged using scale samples for juvenile length-at-age determination. As expected, these samples predominantly represented 3 age groups or classes encompassing the juveniles (1^+, 2^+) and sub-adults (3^+). There were two 4^+ scale samples (four year old sub-adults) however, both these fish were over 200 mm in length so the result was not unexpected. There were 28 PIT tag recaptures that provided individual growth data used to validate juvenile length-at-age data derived from scale analyses. Length-at-age data, individual growth data, length-at-maturity data, and population age structure were presented in the next section (*see* Section 3.2.2 Age Class Structure, Growth and Condition). Subsequently, the data were pooled in various ways to explore potential temporal and spatial trends in fry and juvenile densities within the upper Fording River (*see* Section 3.2.3 Abundance Estimates).

3.2.2. Age Class Structure, Growth and Condition

This section presents the data from multiple lines of evidence, both from the current study and the literature, to provide estimates of length-at-age for fry and juveniles (mean plus range) as well as length (range) and age of first maturity. All sources of data (length frequency, scale ages, individual mark-recapture growth rates, gonad maturity, literature review) were subsequently used to develop a growth model (von Bertalanffy 1938) to explore the age structure of the upper Fording River population of Westslope Cutthroat Trout.

In total, 1,662 captures were weighed and measured (fork length) and this combined dataset formed the basis for the determination of population age structure (Table 3.2.1). First, the scale age data (n=194) were summarized to document variation in juvenile age classes 1^+, 2^+ and 3^+. The individual growth data collected from mark recapture data (n=28) was then used to validate scale ages (*i.e.,* a one year old PIT tagged fish (1^+) recaptured in year two (2^+) or three (3^+) should have a recapture length consistent with the estimated age class variation). This data was subsequently overlain on the length frequency distribution for all captures (n=1,662). Length frequency analysis consisted of comparing observed modes in length to the means and variation calculated from the scale aged subset. As expected, this method worked well for fry, 1^+, 2^+ and 3^+ age classes but increasing length-at-age variation and age class overlap obscured identification beyond 4^+. Variation in length-at-age or growth rates was due to environmental factors, sexual dimorphism and asymptotic growth typical of most fish species. Gonad maturity and length data were utilized to identify the estimated age and length range of first maturity. The individual growth data collected from mark recapture data (n=24) was then used to estimate growth rates and maximum lifespan for fish greater than 250 mm fork length. Otolith age data from the literature (Wilkinson 2009, Minnow Environmental *et al.* 2007, Robinson 2005) was then used to validate lifespan data calculated from growth rate data.

3.2.2.1.1.Scale Ages

As part of the juvenile population monitoring, 194 captured juveniles were individually tagged (PIT Tagged), measured for length and weight and scale samples collected for length-at-age and growth rate determination. Of these, 192 lengths at age were used to describe the variation in size for juvenile age classes 1^+ (62 – 134 mm), 2^+ (110 – 199 mm) and 3^+ (147 – 231 mm; Table 3.2.7). Due to limitations in scale growth potential, scale aging was limited to fish that could reasonably be expected to be younger than four years old (*i.e.,* < 200 mm fork length). As expected, no scale samples under 200 mm fork length were older than 3 years old. The range of fry (0^+; 24 – 56 mm) or young of the year lengths were identified from the length frequency distribution (*see* Section 3.2.2.1.4 Length frequency).

Table 3.2.7. Length-at-age descriptive statistics for the upper Fording River Westslope Cutthroat Trout juvenile population.

Age Class	N	Mean fork length (mm)	Range fork length (mm)	Mean Weight (g)	Range weight (g)
0^+	258	39	24 - 56	0.6	0.1 – 1.6
1^+	75	89	62 - 134	8.8	2.6 – 40.0
2^+	82	159	110 - 199	50.5	13.4 – 95.0
3^+	33	182	147 - 231	75.4	30.8 – 157.9
4^+	2	218	212 - 224	128.0	117.9 – 138.7

3.2.2.1.2.Recaps and Growth Rates

One of the goals of the Floy tag and PIT tag programs was to collect data on individual growth rates and validate length-at-age determination. There were 28 PIT tag and 30 Floy tag recaptures for a total of 58 individual recaptures. There were 55 recaptures at large for one or two years for which annual growth rates could be calculated. Of these, two outliers were removed and the individual growth for the remaining 53 recaptures was plotted to illustrate Westslope Cutthroat Trout growth variation within the upper Fording River (Figure 3.2.3). As expected fish grow continuously and asymptotically (*e.g.,* growth rate slows as fish mature and approach an upper limit or plateau; von Bertalanffy 1938). This data was used for validation in the growth model and population age structure assumptions.

Within the recapture data, there were 17 PIT tag recaptures for scale aged fish. Thirteen (76%) annual growth increments were within the range predicted by the length-at-age variation for scale ages (Table 3.2.7). Mean annual growth in length by age class was 48.5 mm (1^+), 44.5 mm (2^+), and 30 mm (3^+), Table 3.2.8). The four juvenile recaptures that were smaller than predicted were captured from tributaries (Ewin and Dry Creeks) with lower water temperatures that would be expected to have the lowest growth rates.

Growth rates for mature fish greater than 200 mm fork length were also size dependent (Figure 3.2.3). Fish between 271 mm and 400 mm (n=10) had mean annual growth of 20.9 mm fork length (range 12.5 – 32 mm). Fish greater than 400 mm (n = 14, range 400 – 485 mm) had mean annual growth of 4.8 mm fork length (range 0 – 20 mm). These results confirm ages derived from otoliths for the Elk River population (includes upper Fording River samples) as old as 12 years (Wilkinson 2009) and 16 years (Minnow Environmental *et al.* 2011, 2007).

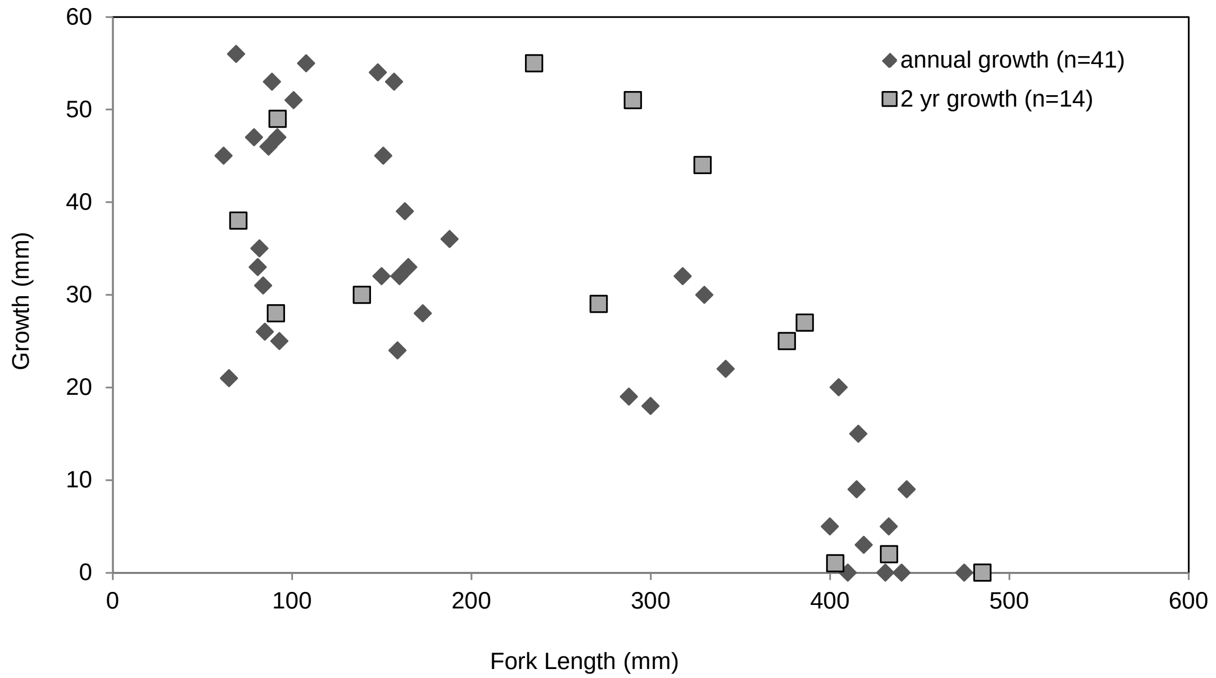


Figure 3.2.3. Individual growth (annual or two year) for Westslope Cutthroat Trout recaptures (Floy and PIT tags combined), upper Fording River 2012-2015.

Table 3.2.8. Summary of annual growth between recapture events for PIT tagged juvenile Westslope Cutthroat Trout aged using scales.

1st Capture (Scale Age)	Length (mm)	2nd Capture (Scale Age + Time)	Length (mm)	Annual Growth (mm)	Mean Annual growth (Age Class)	Notes
1^+	62	2^+	107	45		Dry Cr.
1^+	65	2^+	86	21		Dry Cr.
1^+	69	2^+	125	56		
1^+	79	2^+	126	47		
1^+	85	2^+	111	45		
1^+	92	2^+	139	47		
1^+	92	3^+	141	24.5		Ewin Cr. – 2 year recap
1^+	101	2^+	152	51	48.5	N = 8
2^+	139	4^+	169	15		Ewin Cr. – 2 year recap
2^+	148	3^+	202	54		
2^+	157	3^+	210	53		
2^+	160	3^+	192	32		
2^+	163	3^+	202	39	44.5	N=5
3+	159	4+	183	24		
3+	165	4+	198	33		
3+	173	4+	201	28		
3+	188	4+	224	36	30.0	N=4

Finally, one can estimate the first year's growth as 50 mm based on the mean fry length of 39 mm and the mean length of 89 mm for fish aged 1^+ using scales. The above annual growth estimates were summarized for the various ages and life stages below in Table 3.2.9.

Table 3.2.9. Summary of size or age dependent annual growth rates for Westslope Cutthroat Trout in the upper Fording River.

Age or Maturity Class	N	Mean Length (mm)	Length Range (mm)	N	Mean Annual Growth (mm)	Annual Growth Range (mm)
Fry	258	39	24 - 56	75	50.0	n/a
1+	75	89	62 - 134	8	48.5	21 - 56
2+	82	159	110 - 199	5	44.5	15 – 54
3+	33	182	147 - 231	4	30.0	24 – 36
Adults	10	323	271 – 386	10	20.9	12.5 – 32
Veterans	14	429	400 - 485	14	4.8	0 – 20

This data clearly illustrates a shift in the understanding of Cutthroat Trout length-at-age relative to existing literature. Scale ages have been the predominant aging method for Cutthroat Trout in the literature and maximum ages are typically reported between 6 and 8 years (McPhail 2007, Liknes and Graham 1988, Scott and Crossman 1973). This includes a number of upper Kootenay populations of Westslope Cutthroat Trout (Cope and Prince 2012, Baxter 2004, Morris and Prince 2004, Prince and Morris 2003, Baxter and Hagen 2003).

For example, based on the maximum growth rates observed for fish greater than 270 mm (Table 3.2.8), the largest fish captured (485 mm) in the current study was estimated to be at least 14 years old:

- 250 mm = 5^+ age group
- 250 – 400 mm = 150/32 mm/yr. = 4.7 years
- 400-485 mm = 85/20 mm/yr. = 4.3 years
- Total estimated age = 5 + 4.7 + 4.3 = 14^+ years old

Based on the mean growth rates observed (Table 3.2.9), the same fish would, on average, be 29 years old (5 + 7 + 17). These growth results were not unique to the upper Fording River. In the upper Bull River (above barrier, pure strain Westslope Cutthroat Trout), mark-recapture data documented 60 mm of growth over six years (10 mm/year) for larger mature fish (*e.g.,* 350 mm to 410 mm between 2004 and 2010; Cope and Prince 2012).

One interesting recapture trend of note was that 14 of the 24 (58%) Floy tag recaptures (*i.e.,* mature fish captured angling) were represented by very large fish (> 400 mm fork length). Fish of this size category (> 400 mm) represented only 7% (n=46) of the Floy tagged fish at large (n=675). These recaptures illustrate the vulnerability of the largest sized fish of the population to angling and intuitively makes sense from a bio-energetics perspective. The larger the fish the more energy input required which results in more time spent exposing itself to angling risk through feeding. Anecdotal evidence also supports this coincidental finding as a common complaint from anglers in a heavily fished population is not only the decline in the numbers of fish but also the decline in the number of large sized fish. These results provide supporting evidence for management of fish angling effort and harvest as a means of mitigating impacts to large fish (Anon 2006).

3.2.2.1.3.Length at Maturity

In total, 181 Westslope Cutthroat Trout were internally examined and gonadal maturity was determined. The smallest fish with mature gonads was 233 mm fork length or 170 g. The largest fish with immature gonads (*i.e.,* sub-adult) was 290 mm (excluding one outlier at 315 mm). Therefore, the size range 233 mm to 290 mm represented the overlap between sub-adult and adult life stages and represented variation in minimum size of sexual maturity. There were 68 fish assessed within this size range (233 – 290 mm) and 40% were sub-adults and 60% were adults based on gonad maturity.

In 2013, the sample size of radio tagged fish in this lower size range (*e.g.,* 230 mm to 290 mm), as well as fish within headwater and tributary habitats (Chauncey and Henretta Creeks) was increased to better assess gonadal maturity and the alternative hypothesis that one or more headwater populations may exist with a smaller size-at-maturity and less migratory life history strategy. While it was confirmed the minimum size of sexual maturity was approximately 230 mm, these smaller sized mature fish were not limited to headwaters or tributary habitats. In addition, home range (*e.g.,* migration distance) was not related to size for radio tagged sub-adults or adults within the range 233 to 485 mm fork length (r^2 = 0.001, p = 0.71, n = 111, *see* Section 3.3 Movement patterns and Distribution).

Minimum size of maturity was independently validated by length data collected during egg and sperm collections of upper Fording River Westslope Cutthroat Trout during the 2015 spawning season (Robinson 2015, *pers. comm.*). The smallest sexually mature female was 240 mm and the smallest sexually mature male was 195 mm. Therefore, the minimum length of sexual maturity for the upper Fording River population of Westslope Cutthroat Trout was between 200 mm (males) and 233 mm (females). Based on the length-at-age data the age of first maturity was between 3 and 5 years.

3.2.2.1.4.Length Frequency

Population age structure was first estimated using the combined length frequency distribution of fry and juvenile captures (electrofishing) and sub-adult and adult captures (angling; Figure 3.2.4). There were obvious modes (*i.e.,* age class cohorts) that coincided with the mean length-at-age for age classes 0^+, 1^+, and 2^+. There were also apparent modes that may represent age classes 3^+ through 8^+ based on the mean length-at-age for the 2^+ age class and projecting forward based on the mean growth rates for the accompanying age classes or life stages. However, apparent age class modes beyond 4^+ or 5^+ must be viewed with caution as age classes quickly become obscured by overlap in individual growth rates due to environmental factors, sexual dimorphism and asymptotic growth.

Subsequently, the estimated length-at-age variation for lower size ranges (0^+, 1^+, 2^+, 3^+, 4^+) as well as life history classes of interest (fry, juvenile, sub-adult, adult) were overlain on the length frequency distribution to illustrate the current state of knowledge regarding population age structure of the upper Fording River Westslope Cutthroat Trout (Figure 3.2.4). Estimates of length-at-age or life stage were validated using scale ages at shorter lengths (< 200 mm), individual mark recapture growth rates, gonadal maturity, and recently emerging otolith data.

While the degree of overlap can be debated, it was clear that fry (0^+ or young-of the-year) were less than 58 mm fork length. Juveniles were one and two years old (1^+ or 2^+) and ranged in size between 58 mm and 200 mm. Sub-adults were typically between three (3^+) and five years old (5^+) and ranged in size between 150 and 290 mm. Mature adults reach maturity between three (3^+) and five years old ($^+5$). Mature adults have been aged as old as 16 years using otoliths (Minnow Environmental *et al.* 2011, 2007) and estimates from individual recaptures within the upper Fording River suggests very large fish were at least 14 years old. Female gonadal maturity (*i.e.,* fish will spawn the next spring) was identified in Westslope Cutthroat Trout as small as 233 mm and ranged as large as 485 mm.

These results were consistent with ages as old as 16 years recently estimated using otoliths from the Elk River population (includes upper Fording River samples, Minnow Environmental *et al.* 2011, 2007). This was in contrast to scale ages which have been the predominant aging method for Cutthroat Trout in the literature. Maximum ages were typically reported between 6

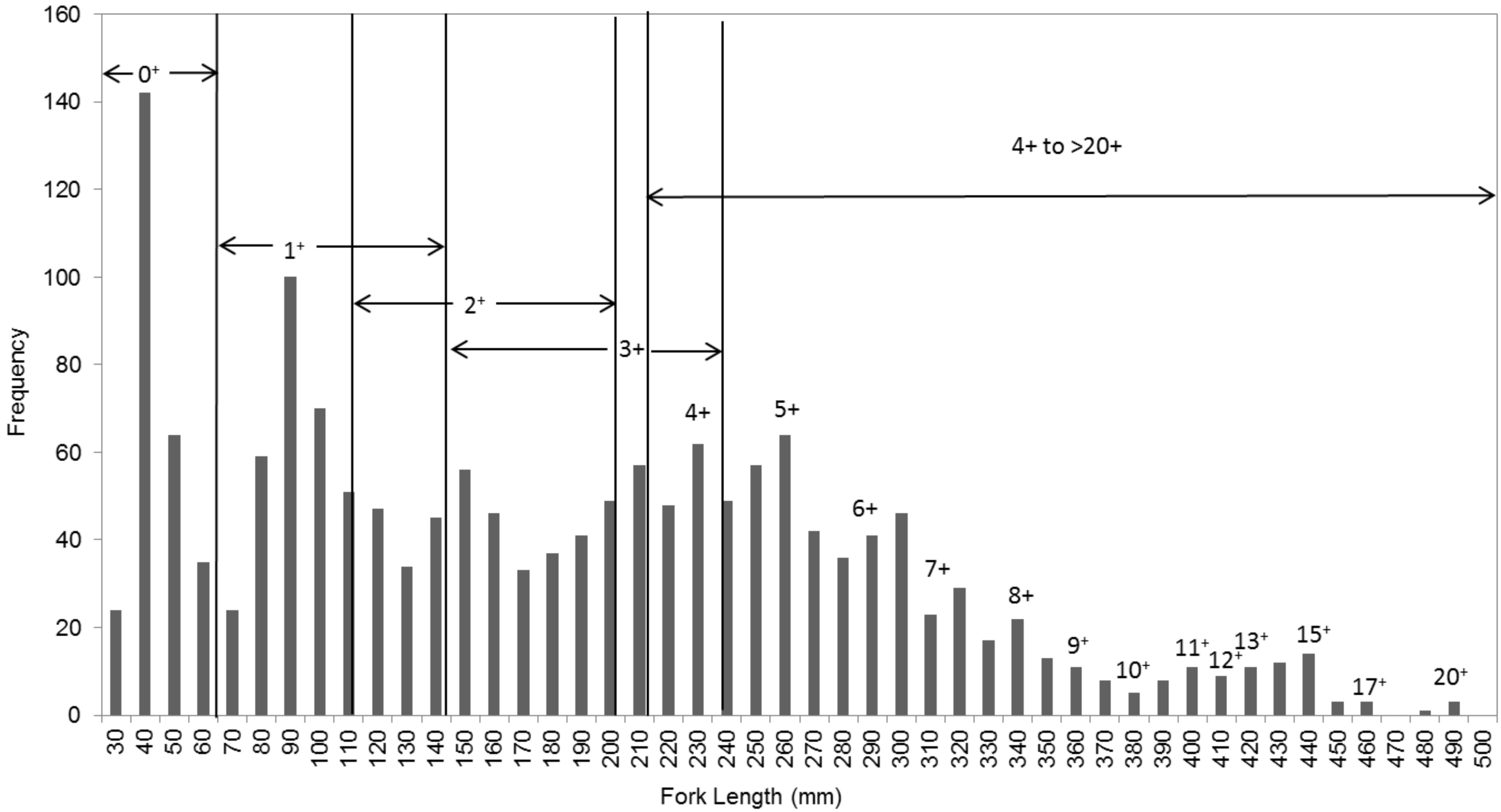


Figure 3.2.4. Length Frequency distribution of captured Westslope Cutthroat Trout (n=1,662) in the upper Fording river 2012 to 2015 with length-at-age variation from scale age validation overlain. Possible modes for age classes 4^{+} to 20^{+} based on the mean growth rate (Table 3.2.9) were also illustrated.

and 8 years (McPhail 2007, Liknes and Graham 1988, Scott and Crossman 1973). This includes a number of upper Kootenay populations (includes Elk River) of Westslope Cutthroat Trout (Cope and Prince 2012, Baxter 2004, Morris and Prince 2004, Prince and Morris 2003, Baxter and Hagen 2003).

3.2.2.1.5.Growth Model

In this section the length-at-age data, growth increment data (recapture) and the length frequency data are used to develop a von Bertalanffy (1938) growth model to estimate the mean length-at-age for the upper Fording River population of Westslope Cutthroat Trout. This model relates growth to the age of the fish as:

$$L(a) = L_\infty\left(1 - e^{-K(a-a_0)}\right)$$

where L_∞ is the maximum length for older fish, K describes how fast the growth reaches the asymptote and a_0 is the "age" at which the fish has 0 length (biologically this has no meaning and is purely a parameter to anchor the curve). The above curve represents an "average" growth curve; individual fish have growth curves that vary around this average curve.

There were three types of data that provided information about the parameters of this model: age-length data; growth increment data from capture-recapture data; and length frequency data. These individual and combined datasets were used to fit the VB growth model. This data was described in more detail in previous sections.

Length-At-Age Data

Ages were available for 192 juveniles *(i.e.,* <4 years old). Because the population is managed to limit mortalities, otoliths were not obtained, and scales were sampled for aging. Once Westslope Cutthroat Trout reach four years of age, there is a great deal of scale regeneration and scale analyses has been proven unreliable. Previous estimates of Westslope Cutthroat Trout maximum lifespan was 6-9 years; however, recent data gathered by the selenium researchers from their otolith analysis on the Elk River population revealed maximum ages of 16 years (Minnow Environmental *et al.* 2007).

A summary of the juvenile length-at-age data was previously illustrated in Table 3.2.7. There were very few fish aged 4^+ or older due to the unreliability of aging older fish (*i.e.*, fish greater than approximately 200 mm fork length).

The VB model can be fit to this data using maximum likelihood as outlined in Eveson *et al.* (2004). Estimates from the fit were shown in Table 3.2.10 and graphed in Figure 3.2.5. While the fitted curve was a reasonable fit to the data for younger ages, it was an unrealistic growth curve in light of the other data sources (*see* below). The 200 mm fork length asymptote was unrealistically too small (many observed fish were larger than 200 mm). The reason for the poor performance was the restriction of the aging data to younger fish 200 mm or less.

Table 3.2.10. Estimates from fitting the von Bertalanffy growth model to length-at-age data alone.

Parameter	Estimate	SE
Linf	200.06	86.66
K	0.98	0.03
a0	0.38	0.01

.

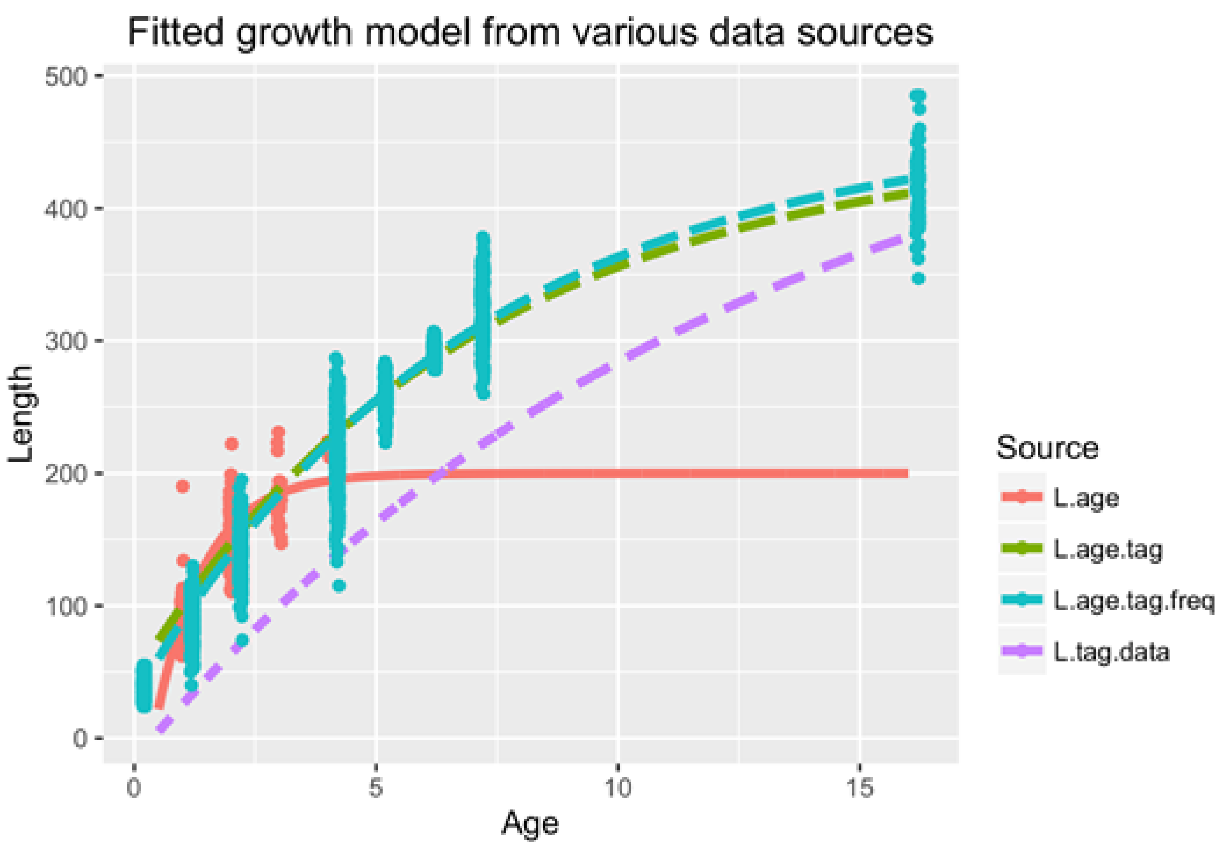


Figure 3.2.5. Fitted growth curves using different sources and combinations of data (age-length data, growth increment data from capture-recapture data, and length frequency data), Upper Fording River captures (2012 – 2015).

Growth Increment (Recapture) Data

A second source of data was from the recapture of tagged fish. There were 55 fish tagged and recaptured one or two years later. The length of the fish was measured at both times. A plot of the data is illustrated in Figure 3.2.6.

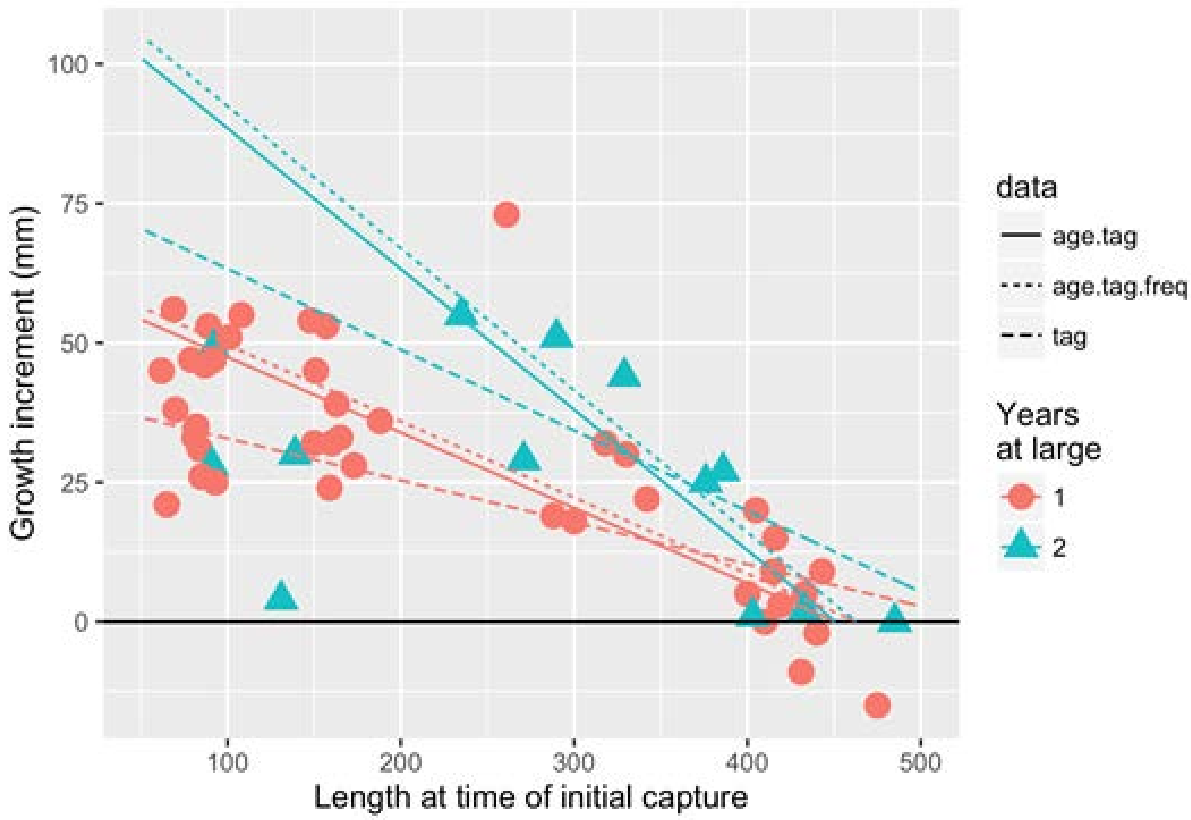


Figure 3.2.6. Plot of growth increment data with estimated increments from fitted model using just the growth increment data (wide dashed line), the combined growth increment and age-length data (solid line), or the three data sets (small dashes). Separate lines are drawn for tags at large one and two years.

There was evidence that the maximum asymptotic length was around 500 mm as upper Fording River Westslope Cutthroat Trout do not appear to increase in length at that point.

There were several methods to estimate the parameters of the VB curve from growth increment data as outlined in Eveson *et al.* (2004). We used the method as outlined in Wang *et al.* (1994) and Somers and Kirkwood (1991) which was an extension of the method of Fabens (1965). Estimates were presented in Table 3.2.11, the resulting growth curve was illustrated in Figure 3.2.5, and the fit to the increment data was shown in Figure 3.2.6. Note that when using growth increment data, it was not possible to estimate the a_0 parameter and the estimated value for a_0 from the age-length fit was used to draw the curve in Figure 3.2.5.

Table 3.2.11. Estimates from fitting the von Bertalanffy growth model to length increment data from recaptures. Note the a_0 parameter cannot be estimated from growth increment data.

Parameter	Estimate	SE[1]
Linf	536.978	0.000
K	0.078	0.000

[1] Standard errors are very small, but not zero.

The fitted lines in Figure 3.2.6 appear to show a maximum length around 500 mm, but there appears to be a slight under fit in the predicted increments for fish around 100 mm in length. The plotted curve in Figure 3.2.5 does not intersect the actual length-at-age data. The actual increment data from the tag-recapture data (Figure 3.2.6) also appears to be contradictory from the mean of the length-at-age data in Table 3.2.7. According to Table 3.2.7, fish of age class 1^+ average about 90 mm in length and, on average, grow to about 160 mm in length at age class 2^+, for an average increment of about 70 mm. Yet, Figure 3.2.6 shows that fish around 90 mm in length only had increments of about 40 mm. This was based on the mark-recapture data previously illustrated in Table 3.2.8. The discrepancy was likely due to small sample bias in the mark-recapture data (n=8 recaptures that were age class 1+ at initial capture).

Combined Length-at-Age and Growth Increment Data

The length-at-age and growth increment data were combined into a single analysis using methods as described in Eveson *et al.* (2004). Basically, a combined likelihood was formed as the product of the likelihood from the two components and standard maximum likelihood methods were used on the combined likelihood.

The parameter estimates from the combined likelihood are shown in Table 3.2.12 and the fitted growth curve was illustrated in Figure 3.2.5. The combined length-at-age and growth increment curve now has an asymptote that was more realistic and consistent with the observed increment data and the length frequency histogram (Figure 3.2.4 and *see* below).

Figure 3.2.6 also illustrates the predicted growth increments based on the two sources of data. The model from the combined data fits the observed data quite well.

Table 3.2.12. Estimates from fitting von Bertalanffy growth model to the combined length-at-age and length increment (recapture) data.

Parameter	Estimate	SE
Linf	450.83	0.001
K	0.15	0.000
t0	-0.72	0.014

Length Frequency Data

The third dataset contains 1,662 measurements for length on fish captured within the upper Fording River study area from 2012 to 2015. This dataset was somewhat problematic because; a) the same fish could be measured in more than one year (fish that were tagged could be identified as recaptures), b) the resulting distribution reflects both the length distribution over the four years, selectivity (combined juvenile electrofishing and sub-adult and adult angling dataset), and differences in recruitment over the years, c) the dataset includes fish that were aged and recaptured so the same fish could be used in multiple datasets, d) there were no distinct peaks or modes in the 200 to 300 mm range; and e) fish in the 400+ mm range were likely a range of ages.

A similar procedure to Eveson *et al.* (2004) was followed. First, a mixture distribution of normal-distributions was fitted to the length frequency distribution. A mixture of 8 components fit the data best and was illustrated in Figure 3.2.7. The estimated means and standard deviation of each component was shown in Table 3.2.13. Based on the length-at-age data (Figure 3.2.5), an imputed age was assigned to each component. An arbitrary age of 16 years was assigned to the last component, but the following results were not sensitive to choices of this arbitrary maximum age between 10 and 16.

Second, a posterior probabilistic assignment was used to classify each fish in the length-distribution to the ages in Table 3.2.12. For example, for a fish with length of about 100 mm (*see* Figure 3.2.7), the posterior probability that this fish belongs to the second component (age 1) was 0.90 and the posterior probability that this fish belongs to the third component (age 2) was 0.10. Consequently about 90% of fish of length 100 mm were assigned to age 1 and 10% to age 2 using a random number generator.

Third, this imputed age-length data (except for age 0 fish) was combined with the other two data sources and a combined maximum likelihood analysis was performed with the final estimates presented in Table 3.2.14 and the final VB model fit was shown in Figure 3.2.5.

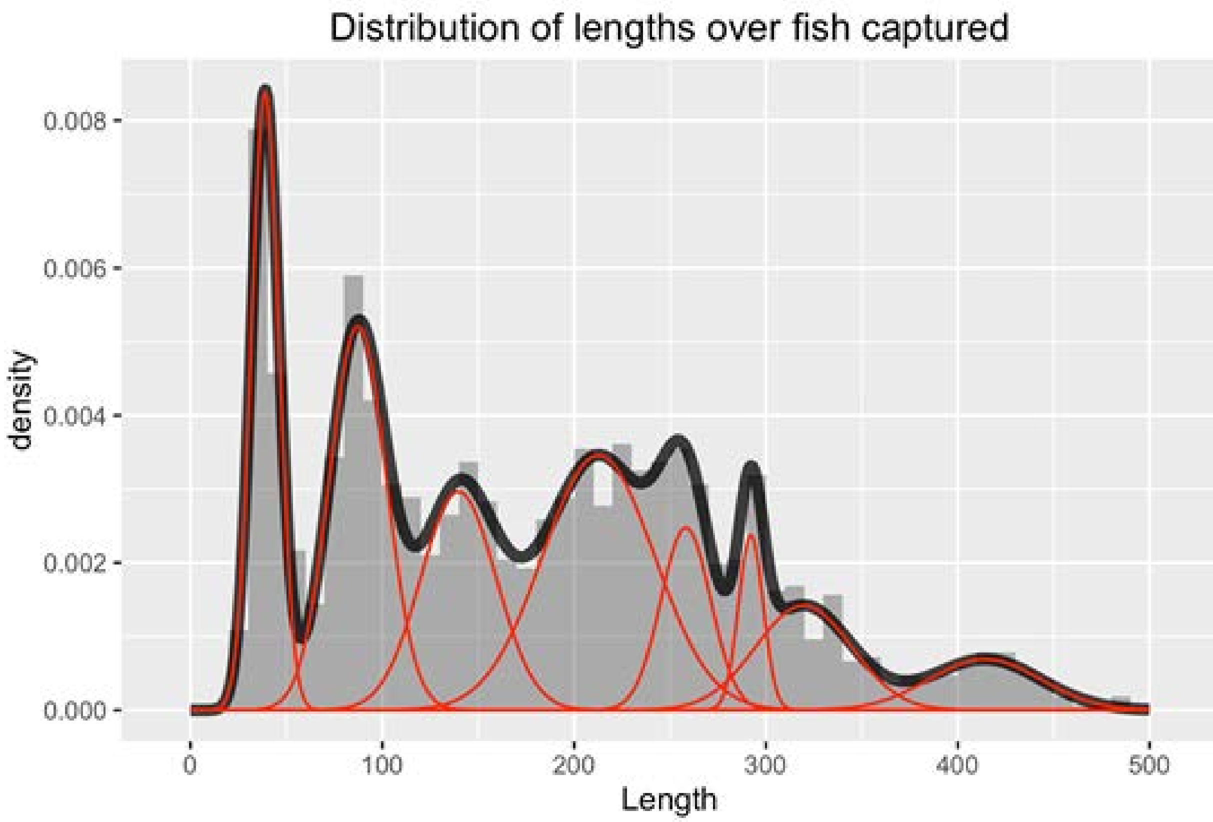


Figure 3.2.7. Length frequency data with density curves of estimated components based on a mixture of normal distributions (red lines) and final estimated density based on combining the densities (black curve).

Table 3.2.13. Estimated mean and standard deviation with imputed age when a mixture of normal distributions is fit to the length frequency distribution (Figure 3.2.7).

Imputed Age	Mean	SD
0	39	7
1	87	15
2	140	20
3	213	29
4	258	13
5	292	6
6	320	25
16	414	29

Table 3.2.14. Estimates from fitting VB model to the combined length-at-age, length increment (recapture), and imputed length frequency data.

Parameter	Estimate	SE
Linf	462.77	19.734
K	0.15	0.000
a0	-0.45	0.001

This final growth model (combined length-at-age, length increment (recapture), and imputed length frequency data) was very similar to that seen from the combined length-at-age and growth increment data. The fit was also not sensitive to imputed maximum ages for the final component between 10 and 16 years.

Von Bertalanffy Model Summary

The final growth model for the upper Fording River Westslope Cutthroat Trout population, based on the three data sources was (Table 3.2.14):

$$L(a) = L_{\infty}\left(1 - e^{-K(a-a_0)}\right) = 463\left(1 - e^{-0.15(a-(-0.45))}\right)$$

This function estimates the approximate mean length-at-age; lengths of individual fish will vary around this mean.

Each of the individual datasets used in this analysis was inadequate for estimating a growth model, but the combined analysis combined the strengths from each dataset. The age-length data set was limited by the lack of data on older age categories. However, the data on ages 1 to 4 years provided good information on the initial part of the growth curve. The growth increment data provided good information on the maximal size of the fish but, because it does not have age information, no information on the relation of age and size of the fish. The length frequency data does not have age data, but was able to be separated into distinguishable components (at least for the first few age classes and the maximal size category).

There were many other models for growth of fish. This model, for example, makes no distinction of growth between the sexes. Given the relatively small datasets and problems in each dataset, other growth models were expected to give similar results.

3.2.2.1.6.Condition Factor

In total, 1,662 Westslope Cutthroat Trout were visually examined between 2012 and 2015. There were 25 fish (1.5%) with observed deformities (shortened operculum) and 30 fish (1.8%) with injuries (worn or inflamed caudal lobe from spawning, injury-predator scars). Shortened opercula were the only observed deformity. There was no trend evident in the incidence of shortened opercula (Table 3.2.15). Shortened opercula occurred predominantly in sub-adults or adults (*i.e.,* fish > 200 mm); 92% of shortened opercula observations occurred during the angling capture sessions that target sub-adult and adult fish.

Table 3.2.15. Frequency of observation of possible deformities (shortened opercula) and injuries in Westslope Cutthroat Trout captures in the upper Fording River, 2012 – 2015.

		2012	2013	2014	2015	Total
Shortened Opercula	Juveniles	-	0	0	2	2
	Adults	2	10	11	-	23
	Total	2 (0.9%)	10 (2.5%)	11 (2.2%)	2 (0.4%)	25 (1.5%)
Injuries	Juveniles	-	0	0	0	0
	Adults	2	10	8	-	20
	Total	2	10	8	0	20
N	Juveniles	-	140	232	534	906
	Adults	229	258	269	-	756
	Total	229	398	501	534	1662

Shortened opercula (gill cover defects) are often described in many fish species and the condition is not uncommon in farmed salmonids although numbers affected are usually low (Branson and Turnbull 2008). Three influences or mechanisms are generally ascribed to this condition; 1) damage to the free edge of the opercula due to trauma, for example, associated with netting can lead to erosion of opercula edges with consequent shortening, 2) egg incubation temperatures have been shown to have an influence on the occurrence in salmonids, and 3) observed stock type bias suggests a possible heritable element to the condition (Branson and Turnbull 2008).

These were considered low incident rates for fish injuries and/or possible deformities based on expectations from similar Westslope Cutthroat Trout studies completed within the upper Kootenay River (Cope and Prince 2012, Morris and Prince 2004, Prince and Morris 2003). The low deformity rate observed in the current study was also consistent with Clode Pond salvage reporting two out of 177 or 1% in 2005 (Interior Reforestation 2006).

Based on the internal visual examinations (n=181) there were zero reported deformities. The primary comment from the internal exam was the robust nature of upper Fording River Westslope Cutthroat Trout that was evidenced by the very thick body wall and white muscle tissue. It was also noted that there was no evidence of angling related injuries such as lost or damaged mouth parts, lost scales, line burns, bruising and infections. In the Elk River telemetry project 40% of captured Westslope Cutthroat Trout were reported to have evidence of angling related injuries (Prince and Morris 2003).

Elevated rates of deformities in mature fish that could be attributed to water selenium concentrations were not expected. Selenium toxicity is usually associated with teratogenic effects that primarily result in larval mortality as a result of maternal transfer of selenium in eggs (Elphick *et al.* 2009, Orr *et al.* 2006). As a result, deformity and mortality occurs in the larval, early life stages and deformed fish were expected to be eliminated from the population long before they reach the mature life stage.

Average upper Fording River sub-adult and adult Westslope Cutthroat Trout “size” compares favourably in terms of mean fish length among upper Kootenay River populations sampled using similar methods and study design (similar minimum size requirements, Table 3.2.16). Based on fork length, the mean size of upper Fording River Westslope Cutthroat Trout was comparable to the upper Bull River (Cope and Prince 2012). Earlier telemetry studies (Elk, St. Mary and Wigwam Rivers) were biased to larger fork lengths due to higher minimum size requirements (450 g versus 200 g) necessary for the larger tag size available at that time (Morris and Prince 2004, Prince and Morris 2003, Baxter and Hagen 2003). Given that the maximum fish size for the upper Fording River was the largest among these populations, it is likely that the mean size of the upper Fording River Westslope Cutthroat Trout would be comparable to the mean sizes for the Elk, St. Mary and Wigwam Rivers under similar sample designs. By any angling standard, Westslope Cutthroat Trout 485 mm and 1,550 g in size would be trophy specimens considering the species rarely exceeds 410-460 mm (Benke 2002). Fish approaching this size have previously been captured within the upper Fording River (Amos and Wright 2000).

Table 3.2.16. Comparative summary of fish "size" (fork length mm - FL) for radio tagged Westslope Cutthroat Trout populations in the upper Kootenay River captured using similar methods and study design.

fork length (mm)	Upper Fording River[1]	Upper Bull River[1,3]	Elk River above Elko[2,4]	St. Mary River[2,5]	Wigwam River[2,6]
Mean	320	330	374	386	393
Min	223	251	325	342	340
Max	485	433	422	430	450
N	180	30	40	40	31

[1] minimum size requirement 200g.
[2] minimum size requirement 450g.
[3] Cope and Prince 2012.
[4] Prince and Morris 2003.
[5] Morris and Prince 2004.
[6] Baxter and Hagen 2003.

Indices of condition, or well-being, have often been interpreted and compared in weight – length relationships. The Fulton condition factor (K) was used for condition comparisons among East Kootenay watersheds and for temporal comparisons within the upper Fording River since it was reported in previous studies on the upper Fording River population of Westslope Cutthroat Trout (Amos and Wright 2000, Norecol 1983).

Table 3.2.17 illustrates a comparative summary of Fulton condition factor for the five upper Kootenay River populations sampled during radio telemetry studies using similar methods. In theory, if stressors (*e.g.,* selenium from coal development) were influencing the well-being of mature fish, this should be evident with lower K for populations within the coal block or its receiving environment. In reality, the opposite appears to be true with the Elk and upper Fording Rivers having the highest mean condition factor. These data were corroborated by fish condition observations noting the robust nature of upper Fording River Westslope Cutthroat Trout.

Table 3.2.18 illustrates the 2013, 2014 and 2015 mean Fulton condition factor for the size range 62 mm – 250 mm was remarkably similar to estimates for 1999 and 1983 (Amos and Wright 2000, Norecol 1983). The largest size class (225-250 mm) from the previous data also had the highest mean condition factor (K = 1.37, Amos and Wright 2000). Based on this data, there has been no change in condition factor over the last 30 years for juvenile, sub-adult or adult fish within the upper Fording River.

Table 3.2.17. Summary of Fulton condition factor (K) for select upper Kootenay River populations of mature Westslope Cutthroat Trout captured using similar methods.

	Upper Fording River (2012)	Upper Fording River (2013)	Upper Fording River (2014)	Upper Bull River (2010)[1]	Elk River (2000-01)[2]	St. Mary River (2001-02)[3]	Wigwam River (2001)[4]
Fulton K							
Average	1.41	1.37	1.52	1.18	1.44	1.28	1.14
Min	1.10	0.77	0.91	0.89	1.17	1.08	0.95
Max	1.80	2.58	2.33	2.14	1.84	1.89	1.40
N	229	244	253	65	40	40	31
fork length							
Average	289	252	268	316	374	386	393
Range	160 - 485	149 - 450	134 - 456	230 - 433	325 - 422	340 - 430	340 - 450

[1] Cope and Prince 2012.
[2] Prince and Morris 2003.
[3] Morris and Prince 2004.
[4] Baxter and Hagen 2003.

Table 3.2.18. Summary of Fulton condition factor (K) for size ranges approximating juvenile size ranges within the upper Fording River for the period 1983 to 2015.

	Upper Fording River[2] (1983)	Upper Fording River[1] (1999)	Upper Fording River (2013)	Upper Fording River (2014)	Upper Fording River (2015)
Fulton K					
Average	1.15	1.18	1.13	1.18	1.07
Min	0.63	0.93	0.96	0.79	0.70
Max	1.63	1.79	1.31	1.65	1.63
N	-	95	103	183	313
fork length					
Average	-	-	120	128	117
Range	-	74 - 250	62 - 223	65 - 244	65 - 260

[1] Amos and Wright 2000.
[2] Norecol 1983.

Condition factors can also be influenced by population density and stream productivity. Higher population densities exert downward pressure on condition factors as more and more fish compete for the same resources (*i.e.,* food). The high condition factors for Elk Valley populations may reflect high nutrient levels within the Elk Valley. It is known that higher nitrate levels are associated with surface mining (including Fording River Operations and the upper Fording River, Minnow Environmental and PLA 2012). In addition, naturally occurring phosphorus sources are known to exist within the Elk Valley. “Wheeler Creek, and to a lesser extent Leach Creek, contain high concentrations of phosphorus. This phosphorus originates from a naturally occurring nutrient source, the subject of extensive exploration in the 1980’s for commercial phosphate production, and is large enough to significantly increase biological production, fish included, in Michel Creek and the Elk River downstream”, (McDonald 2008).

The fish condition results have been made available to the EVWQP and RAEMP project teams to support the on-going assessment of aquatic ecosystem health in the Elk River watershed.

3.2.3. Abundance Estimates

Population monitoring of the upper Fording River Westslope Cutthroat Trout was examined through two methods: 1) annual sub-adult and adult population estimates generated through snorkel survey mark – recapture methods, and 2) annual recruitment (fry) and juvenile density estimates at representative locations using removal – depletion electrofishing methods.

3.2.3.1.Sub-adult and Adult Population Monitoring

Recall that in this study, radio telemetry and Floy tags were used to estimate the size of a closed population with a movement model (Schwarz *et al.* 2013). Since radio telemetry fish could be individually and independently confirmed within a given river segment, these fish were used to calibrate observer efficiency (*e.g.,* snorkel counts) of batch marks (*i.e.,* Floy tagged fish with no radio tag) to generate annual population estimates using snorkel survey mark – recapture methods. The snorkel data were then used to calculate population estimates using four models (Pooled Peterson, Stratified Peterson, Hierarchical, and Movement models). A synthesis of these population estimates and their key assumptions were then compared to derive a population estimate for the proportion of the upper Fording River Westslope Cutthroat Trout population greater than 200 mm in length. These mark recapture methods were replicated for three years (2012, 2013 and 2014). Population estimates were limited to fish greater than 200 mm within the mainstem upper Fording River Segments S1 through S10 and lower Henretta Creek and Henretta Pit Lake (approximately 48 rkm, Figure 2.1.1).

3.2.3.1.1.Population Monitoring (Snorkel Survey)

Table 3.2.19 summarizes the snorkel survey timing and environmental conditions for the three years of sub-adult and adult population monitoring (*i.e.,* fish > 200 mm fork length). As previously identified by Amos and Wright (2000), and confirmed within the current study (*see* Section 3.3 Movement Patterns and Distribution), it was necessary to standardize sample methods as much as possible given the migratory nature of the upper Fording River population of Westslope Cutthroat Trout.

Table 3.2.19. Summary of snorkel survey timing and environmental conditions for the three years of population monitoring (2012-2014) in the upper Fording River.

	2012	2013	2014
Apply Marks	Aug 22 – Sept 7	Aug 7 - 27	Aug 5 - 22
Snorkel Survey	Sept 16 - 22	Sep 4 - 9	Sept 2 - 8
Mean Daily Water Temperature (^{o}C)[1]	7.0 – 7.8	9.4 – 10.2	7.0 – 7.9
Mean Daily Discharge (m^3/s)[2]	3.9 – 4.3	5.2 – 6.0	5.6 – 10.0
Visibility	Excellent	Moderate to Poor	Moderate

[1] As recorded at the F1 (Josephine Falls) Station at the downstream limit of the study area.
[2] As recorded at the Water Survey Canada Station. Note that actual site discharges were estimated to be in the range of 2% to less than 50% of these values (*see* Table 3.1.1).

The proportion of the available habitat within the upper Fording River snorkeled and snorkel counts were summarized in Table 3.2.20. The enumeration included mainstem habitat plus the lower 1.5 km of Henretta Creek, including Henretta Pit Lake. Note that in year one it was determined that the headwater river Segment S11 (9.0 km) was too small and shallow to snorkel. Very low catch rates for fish greater than 200 mm prevented the application of Floy or radio tags within this segment and the effort allocated was redirected to lower Henretta Creek and Henretta Pit Lake; reconstructed habitat that was known to be important over-wintering habitat. There were minor differences in the snorkel effort between years (2012 - 47.62 km (83%), 2013 – 48.37 km (84%), 2014 – 46.62 km (81%)). This was due to grizzly bear encounters in river Segment 6 (2014) and a minor miscommunication in access point the first year (2012). Observer efficiency based on the radio tag validation varied between 39% (2013) and 65% (2012). Recall that initial precision targets were to detect a population change of +/- 25% and observer efficiency varied by up to 40%. This illustrates the necessity of calibrating observer efficiency with known numbers of available marks confirmed independently (*i.e.,* radio tags). This variation occurred despite explicit attempts to standardize sample methods as much as possible (*i.e.,* same crew, timing and environmental conditions).

Also recall that strict adherence to a random study design in relation to the application of radio tags was not met. On average, Floy tagged fish were smaller than the radio tagged fish with the average weight of radio tagged fish being twice that of Floy tagged fish (Table 3.2.5). These differences were important since they impacted recapture likelihood, observer (snorkel) efficiency and population estimates (Table 3.2.20).

Overall lower observer efficiency in years two (2013) and three (2014) were a direct result of decreased visibility. Visibility during the snorkel survey in these years was rated as moderate to poor (6.0 m to 2.0 m) compared to excellent in 2012 (7.0 m to 10.0 m, Table 3.2.19). Impaired visibility was primarily a result of fine sediment and organic material deposited during the June 2013 flood event. Even minor precipitation events re-suspended these materials. In addition, the obvious increase in channel complexity as a result of substantial large woody debris inputs resulted in further observer inefficiencies. Nevertheless, the snorkel enumeration was completed successfully but these factors explain the lower observer efficiencies noted in 2013 and 2014.

Unique Floy tag colours were used in each year to facilitate monitoring of individual tag cohorts for additional population parameters such as survivorship or mortality rates across years. However, snorkel recapture results for Floy tags within the upper Fording River across multiple years illustrate this was not possible due to changes in catchability (*i.e.,* sightability or visibility). Snorkel recaptures of Floy tags applied in the previous year dropped to less than 7% (Table 3.2.20). Angling recaptures of 2012 Floy tags 12 months later in August 2013 revealed algae covering the Floy tags. During the snorkel survey the algae obscured visibility altering (decreasing) the sightability and comparisons across years could not be made (Figure 3.2.8).

Table 3.2.20. Snorkel count data for mainstem river Segments S1 through S11 and lower Henretta Creek, upper Fording River September 2012, 2013 and 2014.

			Snorkel Count						Recaptures					
	Section	Snorkel	2012		2013		2014		2012		2013		2014	
Section	Length (km)	Length (km)	0-200	200-500	0-200	200-500	0-200	200-500	Radio	Floy	Radio	Floy	Radio	Floy
1	4.49	4.12	0	46	0	29	0	22	3	1	2	3	1	2
2	4.00	4.00	81	329	4	51	32	186	1	5	1	4	2	4
3	4.16	4.16	1	37	1	12	0	51	3	1	0	1	2	1
4	4.40	4.40	20	68	75	126	17	143	4	6	3	4	2	8
5	4.40	4.40	5	34	0	1	0	41	1	0	0	0	1	1
6	7.00	7.00	33	160	10	45	4	121	10	10	6	5	2	7
7	5.04	5.04	4	18	148	154	16	39	3	5	2	4	2	5
8	5.75	5.75	1	33	146	167	89	192	7	9	3	8	6	10
9	3.65	3.65	39	82	29	44	101	143	2	3	0	1	2	9
10	4.35	4.35	14	24	15	26	126	77	0	1	2	2	1	4
11	9.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-
H1[a]	1.00	1.00	7	165	1	12	14	19	1	13	0	0	0	0
H2[b]	0.5	0.5	0	0	38	101	15	42	0	0	3	1	2	1
Total	57.74	48.37	205	996	467	768	414	1076	35	54	22+3[c]	33+10[c]	23+12[c]	52+11[c]
			1201		1235		1490		64.8%[d]	35.8%[e]	38.6%[d]	20.1%[e]	39.7%[d]	29.2%[e]

[a] Henretta Creek below Henretta Pit Lake.
[b] Henretta Pit Lake.
[c] Second value is the number of fish with radio tags from previous years seen on the snorkel survey.
[d] Observer Efficiency calculated as the proportion of the current years radio tags confirmed at large at the time of the snorkel survey that were recaptured (*i.e.,* observed).
[e] Proportion of Floy tags applied that were observed (current year only).

Figure 3.2.8. Recapture (white Floy tag) illustrating poor tag visibility after 12 months at large.

3.2.3.1.2.Population Estimates

Statistics used for the three years of population estimates were summarized in Table 3.2.21. Note that in 2012 one radio tagged fish was known to have died before the snorkel survey was undertaken, in 2013 four radio tagged fish were tagged in segments that were not surveyed as part of the snorkel survey (and did not move from the segment where tagged), and in 2014 two radio tagged fish were known to have died before the snorkel survey was undertaken. In all three cases, these fish were not subsequently used in the estimation procedures.

Table 3.2.22 summarizes the population estimates of the four models using radio tags only, Floy tags only and both radio and Floy tag groups combined. The estimates of population size based on the radio tagged fish were about half to one third lower than those based on the fish tagged with Floy tags only. These differences appear to be related to the size differential between fish tagged with radio tags or Floy tags, with larger fish generally being tagged with radio tags and larger fish having a higher detectability by the snorkel teams. Not unexpectedly, the population estimates based on the combined radio tagged and Floy tagged groups were intermediate between the estimates based on each type of tag separately.

Table 3.2.21. Summary of data used for annual population estimation.

	2012	2013	2014
Floy Tag Color for Fish With Radio Tags	Green	Pink	Lime
Radio Tags Applied	60	57[a]	60
Known Deaths Between Application and Snorkel Survey.	-1	0	-2
Net Radio Tags Released and Alive at Time of Snorkel Survey.	59	57	58
Floy Tag Color for Fish Without Radio Tags	White	Blue	Orange
Tags Applied	151	164[b]	178[b]
Fish Without Tags Seen in Snorkel Survey			
200-300 mm	507	485	710
300-400 mm	395	242	325
400+ mm	94	41	41
Fish With Radio Tags Seen in Snorkel Survey	35	22+3[c]	23+12[c]
Fish With Floy Tags Only Seen in Snorkel Survey	54	33+10[d]	52+11[d]

[a] An additional 4 radio tags were deployed in Upper Henretta Creek and Chauncey Creek above the culvert. However these fish did not move from these tagging locations and these segments were not surveyed during the snorkel surveys.
[b] An additional 2 fish were tagged with blue Floy tags in Upper Henretta Creek. It is unknown if these fish remained in these segments, but the count of these fish was ignored in subsequent estimates.
[c] Second value is the number of fish with radio tags applied in previous years that were seen on the snorkel survey. The battery is no longer functional and so these fish are treated as unmarked for the current year.
[d] Second value is the number of tagged fish without radio tags that were tagged in previous years that were seen on the current year snorkel survey. These are treated as unmarked fish for the current year.

Table 3.2.22. Summary of the estimates of population size (fish > 200 mm) with standard error (SE) or standard deviation (SD) from the various models. The first entry in each cell was the 2012 estimate; the second entry was the 2013 estimate and the third entry was the 2014 estimate.

Method	Radio Tagged Fish	Floy Tagged only fish.	Radio and Floy Groups Combined	Key Assumption
Pooled Petersen	1809 (SE 185) 2111 (SE 330) 2889 (SE 440)	3002 (SE 310) 4064 (SE 600) 3969 (SE 442)	2546 (SE 194) 3320 (SE 367) 3969 (SE 442)	Equal Catchability in all Segments
Stratified Petersen[1]	2026 (SE 317) 1842 (SE 262) 2723 (SE 398)	3073 (SE 420) 3422 (SE 466) 3952 (SE 467)	2620 (SE 280) 2901 (SE 306) 3712 (SE 364)	Fish Stay in Segments Where Tagged.
Hierarchical Stratified Petersen[1]	1921 (SD[2] 254) 2354 (SD 582) 2997 (SD 495)	3022 (SD 366) 4309 (SD 928) 4071 (SD 504)	2604 (SD 240) 3227 (SD 422) 3758 (SD 375)	Fish Stay in Segments Where Tagged.
Movement Model[1]	n/a	n/a	2441 (SD 311) 3550 (SD 525) 4059 (SD 609)	Fish With and Without Radio Tags Have the Same Movement Pattern

[1] based on 6 segments.
[2] Note that when a Bayesian model is fit, the measure of uncertainty is the standard deviation (SD) of the posterior distribution. This measure is analogous to the SE estimated from Maximum Likelihood.

Individual model estimates and their key assumptions were reviewed in the following text and subsequently a synthesis of these population estimates was derived into a single population estimate for the upper Fording River Westslope Cutthroat Trout population for trend monitoring.

Pooled Petersen estimates of the population size.

Pooled Petersen estimates were computed by pooling the marked sample, the recovery sample, and the number of recaptures over all segments of the river. The key assumption of the pooled Petersen method was that either:

- The probability of marking was equal in all segments.
- The probability of recovery was equal in all segments.
- Complete mixing of marked and unmarked fish across all segments.

Recall that the term “recovered” is used even if fish were only sighted (*e.g.,* snorkel surveys) and not physically handled.

In all but one case (Floy tag only 2013 to 2014) pooled Petersen estimates increased across all three years (Table 3.2.22). The confidence intervals were sufficiently wide (*i.e.,* they overlap) that the population could be stable or increasing over time. Estimates based on Floy tagged fish were considerably larger than the estimate using the radio-tagged fish which was not too surprising because the detection rate for the fish without radio tags was much lower in all three years. Pooling both tag groups resulted in an estimate that was about half-way between the two estimates (not unexpectedly) obtained using only radio tagged fish and only Floy tagged fish.

Stratified Petersen

An alternate estimator computes a separate Petersen estimator for each segment of the river and then simply sums the estimates. Here the implicit assumption made was that tagged fish do not move from their (pooled) segment (which was approximately true).

These estimates were comparable to the simple pooled Petersen estimates. In all but one case (radio tag only 2012 to 2013) stratified Petersen estimates increased across all three years (Table 3.2.22). Again, not surprisingly, estimates based on Floy tagged fish were considerably larger than the estimates using the radio tagged fish because the detection rate (*i.e.,* sightability or catchability) for the fish without radio tags was much lower in all three years. Combined estimates were again about half-way between the individual stratified estimates based on radio tagged or Floy tagged fish.

A formal statistical test for equality of the recovery (resighting) rates of the fish across the six pooled strata provided evidence of a difference in catchability among segments (Table 3.2.23. For individual stratified estimates based on radio tagged or Floy tagged fish there was evidence in 2012 but not in 2013 or 2014 (but for the latter year, there was some weak evidence). For the combined data set, there was evidence that the recovery (resighting) rates were not equal among the strata in 2012 and 2014, but no evidence of a difference in recovery rates in 2013. Given the similarity in the pooled Petersen and the stratified Petersen estimates, the assumption of equal catchability among the segments was not seriously violated.

Table 3.2.23. Probability summary of contingency table χ^2 test for equal catchability across all segments.

	2012	2013	2014
Radio Tagged Fish	0.009	0.497	0.070
Floy Tagged Fish	0.002	0.306	0.055
Combined	0.010	0.314	0.017

Hierarchical Stratified Peterson

The pooled Petersen and stratified Petersen models were the two ends of the spectrum of assumptions about the marking and/or recovery rates. The pooled Petersen assumes that these were equal across all strata while the stratified Petersen allows for separate rates in all strata with no sharing of information. The hierarchical model was intermediate between the two extremes where a common “average” sightability was assumed across all strata, but the individual strata values come from a distribution centered on this average. The variance of this assumed hyper-distribution controls how similar the capture or recovery probabilities were across the strata. This model has the advantage that information is shared among the strata. So information from one stratum that the recovery rate was around (for example) 0.6 was used to inform the model about the likely values of recovery for other strata. This often leads to estimates with improved precision compared to a stratified Petersen without making the (strong) assumption that the recovery rates were exactly equal in all strata.

These estimates were comparable to the simple pooled Petersen estimates. In all but one case (Floy tag only 2012 to 2013) stratified Petersen estimates increased across all three years (Table 3.2.22). Again, not surprisingly, estimates based on Floy tagged fish were considerably larger than the estimates using the radio tagged fish because the detection rate (*i.e.,* sightability) for the fish without radio tags was much lower in all three years. Combined estimates were again about half-way between the individual stratified estimates based on radio tagged or Floy tagged fish.

The average radio tagged fish recovery (resighting) rates were estimated to be:

- 2012: 0.58 (SD 0.05) with strata recovery rates ranging from 0.54 to 0.64.
- 2013: 0.47 (SD 0.06) with strata recovery rates ranging from 0.22 to 0.52.
- 2014: 0.41 (SD .064) with strata recovery rates ranging from 0.38 to 0.51.

The average Floy tagged fish recovery (resighting) rates were estimated to be:

- 2012: 0.37 (SD .06) with strata recovery rates ranging from 0.31 to 0.47.
- 2013: 0.22 (SD .08) with strata recovery rates ranging from 0.13 to 0.30.
- 2014: 0.30 (SD .04) with strata recovery rates ranging from 0.25 to 0.34.

Not unexpectedly, the estimated individual recovery rates based on Floy tagged fish without radio tags were all smaller than the comparable estimates based on the radio tags.

The average recovery (resighting) rates for the combined pool of tagged fish were:

- 2012: 0.43 (SD 0.06) with strata recovery rates ranging from 0.38 to 0.48.
- 2013: 0.26 (SD 0.07) with strata recovery rates ranging from 0.16 to 0.34.
- 2014: 0.32 (SE 0.04) with strata recovery rates ranging from 0.26 to 0.37.

Not unexpectedly, the estimates from the pooled data were between those from using only the fish with radio tags, or only fish with Floy tags.

Movement Model (Combining Radio and Floy Tag only Groups)

The radio tags provide information on movement between the segments and this information was used to impute the movement of the fish without radio tags among the segments. A summary of the radio tag movements among the reduced set of strata (n=6) in all three years was summarized in Table 3.2.24 illustrating that most fish stayed in their (combined) segments but there was movement, mostly to adjacent strata and tending to move upstream (towards higher river segment numbers).

Not surprisingly the population estimates were very similar to the estimates previously seen based on the combined data (Table 3.2.22). Average recovery (resighting) rate estimates were:

- 2012: 55% and the range of recovery rate were from 52% to 59% over segments.
- 2013: 27% and the range of recovery rate were from 23% to 29% over segments.
- 2014: 34% and the range of recovery rate were from 18% to 46% over segments.

Recovery estimates were closer to the recovery rates of radio tagged fish because the number of fish available with Floy tags but not radio tags in each river segment had to be imputed and so were not given as much weight. Most of the strata had relatively small numbers of tags available and so the raw estimates of catchability were pulled towards the mean.

Table 3.2.24. Radio-tag movements between capture and marking (August 5 – September 7) and recapture (snorkel observations September 2 – 22) for the three replicate years 2012-2014.

A. 2012

Released in combined segments	1-2	3-4	5-6	7-8	9-10	Henretta Pit Lake	Not seen
1-2	5	1	0	0	0	0	2
3-4	0	5	4	0	0	0	1
5-6	0	0	9	0	0	0	2
7-8	0	1	1	14	1	1	0
9-10	0	0	0	0	3	5	1
HP	0	0	0	0	0	4	0

B. 2013

Released in combined segments	1-2	3-4	5-6	7-8	9-10	Henretta Pit Lake	Not seen
1-2	7	0	0	0	0	0	1
3-4	0	5	3	0	0	0	1
5-6	0	1	10	2	0	0	0
7-8	0	1	0	8	1	0	0
9-10	0	0	0	0	8	1	3
HP	0	0	0	0	0	5	0

C. 2014

Released in combined segments	1-2	3-4	5-6	7-8	9-10	Henretta Pit Lake	Not seen
1-2	6	2	0	0	0	0	0
3-4	0	5	2	0	0	0	1
5-6	0	0	9	1	1	0	2
7-8	0	0	0	9	0	0	1
9-10	0	0	0	1	3	6	0
HP	0	0	0	0	0	8	1

The estimated chance of moving among the (reduced) segments was presented in Table 3.2.25. There was evidence that movement was not symmetric with more movement towards higher segments (as seen by the radio tags where more fish were detected to the right (in higher segments) than to the left of the original river segment where released (Table 3.2.24).

Table 3.2.25. Probability of moving one or two segments to the left (negative = downstream) or to the right (positive = upstream) when detected in the snorkel survey or remaining in the river segment of release (0).

Year	-2	-1	0	1	2
2012	0.05	0.06	0.59	0.18	0.12
2013	0.06	0.06	0.66	0.14	0.07
2014	0.03	0.05	0.61	0.20	0.10

Synthesis of Population Estimate Results

The point estimates appear to be increasing over time but the 95% confidence intervals were wide enough (*i.e.,* overlap among years) that the evidence of an increase in population size among the three years was weak. The relative precision in the estimates (*i.e.,* standard error/estimate) was comparable in all three years because the total sample sizes were quite comparable across the three years.

The estimates of population size based on the radio tagged fish were about one half to one third lower than those based on the fish tagged only with Floy tags. These differences appeared to be related to the size differential between fish tagged with radio tags and fish tagged only with Floy tags (Figure 3.2.2 and Table 3.2.5), with larger fish generally being tagged with radio tags and larger fish having a higher detectability by the snorkel teams. Not unexpectedly, the population estimates based on the combined radio tagged and Floy tagged fish were intermediate between the estimates based on each tag group separately. The size of the individual fish was recorded at the time of marking, but not at the time of sighting by the snorkelers, so that a model which used the size of the fish as a covariate for catchability could not be fit to the data.

There was good evidence that recovery rates (sightability) varied among the segments in 2012; there was no evidence of differential catchability among segments in 2013; evidence in 2014 was mixed. It was known that the Pooled Petersen is biased downwards in cases of heterogeneity in catchability, so it was not surprising that the estimates from the pooled Petersen were smaller than corresponding estimates based on the stratified models in 2012, but they were comparable in 2013 and 2014. Similarly, it was known that heterogeneity leads to under reporting of the standard error in the pooled Petersen, so it was again not surprising that the reported standard error for the pooled Petersen was consistently lower than those from the stratified models in 2012 but no consistent pattern occurred in 2013 or 2014.

The estimates from the movement model were very similar to those from the combined radio and Floy tagged Petersen models.

Estimates of the number of fish for other sizes will scale proportionately (*i.e.,* to get estimates for fish > 300 mm just multiply the population estimates in Table 3.2.22 by the fraction of unmarked fish >300 mm compared to the number >200 mm). This implicitly assumes that fish of all sizes move and have equal catchability; which was likely approximately true for fish greater than 200 mm fork length. Home range (*i.e.,* movement) was not related to size for radio tagged sub-adults or adults within the range 233 to 485 mm fork length ($r^2 = 0.001$, $p = 0.71$, $n = 111$, *see* Section 3.3 Movement patterns and Distribution).

Based on the results of the population estimates above, a “blended” approach to uncertainty was adopted that relied on population estimates for the pooled set of radio tags and Floy tags combined. In order to generate a single population estimate for each year, the mean of all four model estimates for the pooled set of radio tags and Floy tags combined (and their 95% confidence intervals) was calculated for each of the three years. Figure 3.2.9 illustrates the four model estimates for the pooled set of radio tags and Floy tags combined as well as the mean annual estimate and their 95% confidence intervals to illustrate the population trend. The point estimates appear to be increasing over time but the 95% confidence intervals were wide enough (*i.e.,* overlap among years) that the evidence of an increase in population size among the three years was weak. The 2015 mean population estimate was 3,874 fish greater than 200 mm fork length. This represented mean annual increases of 27% (2014) and 19% (2015).

The metric most often used for population estimation and comparison within the literature was fish per lineal river kilometer. Using the 2014 mean estimate of 3,874 Westslope Cutthroat Trout greater than 200 mm over the snorkel distance of 46.62 km yields a 2015 density estimate of 83.1 fish/km > 200 mm fork length (mean 95% confidence interval 64.3 – 101.9 fish/km > 200 mm fork length) and 28.2 fish/km > 300 mm fork length (mean 95% confidence interval 21.9 – 34.6 fish/km > 300 mm fork length).

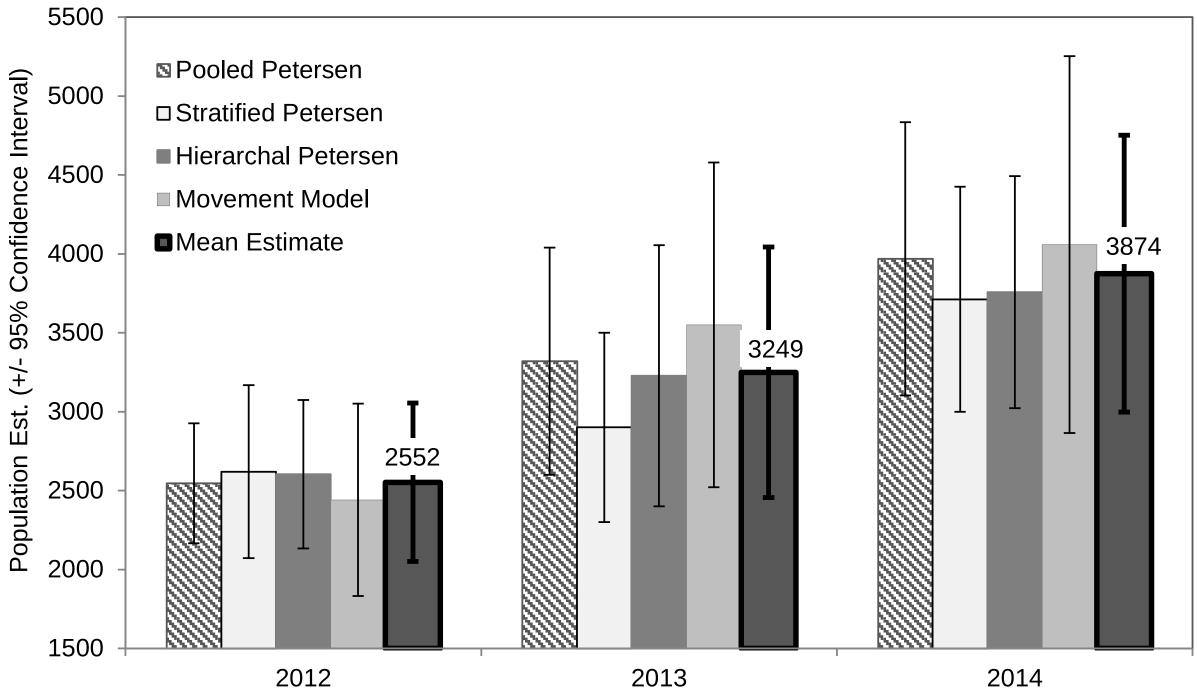


Figure 3.2.9. Annual population estimates (Pooled Petersen, Stratified Petersen, Hierarchal Petersen, Movement Model) and the mean value for the four estimates for the pooled set of radio tags and Floy tags combined, upper Fording River, 2012 – 2014.

As previously outlined, the upper Bull River population was selected as the most similar population of the reference populations (above barrier, pure strain, adjacent watershed, same assessment methods). Westslope Cutthroat Trout within the upper Bull River yielded an estimate (2010) of 108 fish/km > 200 mm and 55 fish/km > 300 mm (Cope and Prince 2012). However, there was a substantial difference in river size (volume). The mean annual discharge of the upper Fording River was approximately 25% that of the upper Bull River (Table 3.1.2).

Michel Creek was another tributary to the Elk River of similar size (mean annual discharge) to the upper Fording River that was used as a reference population. In 2008 the Michel Creek average density of Westslope Cutthroat Trout > 300 mm was estimated to be 46 fish/km (Hagen and Baxter 2009).

The upper Fording River density of large Westslope Cutthroat Trout (28.2 fish/km > 300 mm) was comparable to the overall average density of 28.9 fish/km > 300 mm for estimates that were collected for a number of high priority Westslope Cutthroat Trout streams in the upper Kootenay. These include the Elk River mainstem, Wigwam, St. Mary, White (Middle, East and North Forks) and Bull Rivers, and Michel Creek (Table 3.2.26). Based on a more encompassing dataset, it has been suggested that 45 fish greater than 300 mm per km (from systems that are dominated by catch and release) may approximate the unfished equilibrium abundance for large productive systems (Pollard 2010, *pers. comm.*).

Table 3.2.26. Summary of recent density estimates (snorkel) for Westslope Cutthroat Trout greater than 300 mm in Classified Waters from the upper Kootenay River watershed. Note that estimates (fish/km) are in order from highest to lowest density.

Population Group	Year	Fish/km (> 300 mm)	Reference
Upper Bull River	2010	55	Cope and Prince 2012
Michel Creek	2008	46	Hagen and Baxter 2009
Lower St. Mary River	2008	44	Hagen and Baxter 2009
Upper Bull River	2005	40	Baxter 2006a
Elk River	2008	39	Hagen and Baxter 2009
Middle Fork White River	2011	37.5	Heidt 2013, *pers. comm.*
Upper Fording River	**2014**	**28.2**	
Upper Fording River	**2012**	**27**	
Upper Fording River	**2013**	**23**	
Wigwam River	2008	12-24	Hagen and Baxter 2009
Upper St. Mary River	2011	19	Heidt 2013, *pers. comm.*
Upper St. Mary River	2008	14	Hagen and Baxter 2009
North Fork White River	2011	9.7	Heidt 2013, *pers. comm.*
East Fork White River	2012	3.7	Heidt 2013, *pers. comm.*

Density estimates for upper Kootenay River tributaries reflect higher abundance and densities in warmer, more productive sections of the rivers, and the presence of large fish in all cases (Pollard 2010, *pers. comm.*). There was some evidence that general trends in Westslope Cutthroat Trout abundance (catch-per-unit-effort improvement, increased presence of large fish) within the upper Kootenay River tributaries may be improving (Cope and Prince 2012, Pollard 2010, *pers. comm.*, Hagen and Baxter 2009), and that these trends were linked to the implementation of more conservative regulations in the spring of 2005 (*e.g.,* East Kootenay Angler management Plan 'EKAMP', Heidt 2007).

By species standards within their worldwide distribution, the upper Fording River represents a large, relatively intact system (57.5 km mainstem river plus approximately 59 km of tributary habitat) with relatively high densities and "trophy" sized fish for a species that thrives in low productivity, high elevation, above barrier watersheds (*e.g.,* low productivity term used as opposed to a lower elevation, no migration barrier, anadromous watershed that can produce thousands of salmonid juveniles per river kilometer; Cope 2013, Bradford *et al.* 1997).

The estimated population trend (stable or possibly increasing), combined with an apparently healthy population age structure with some very large, long-lived fish (*i.e.,* 16^+ years) are indicative of a viable and sustainable population. This data was also supported by annual recruitment observations and juvenile densities discussed in the following section.

3.2.3.2.Recruitment and Juvenile Density Estimates

3.2.3.2.1.Population Monitoring (Electrofishing Surveys)

Recruitment (fry) and juvenile (fish < 200 mm fork length) population monitoring of the upper Fording River Westslope Cutthroat Trout population was examined through annual estimates of density in 19 representative locations. Estimates were generated using removal – depletion electrofishing methods.

In total, 906 Westslope Cutthroat Trout representing 5 age classes (0^+, 1^+, 2^+, 3^+, 4^+) were captured in 43 meso-habitat units of approximately 100 m^2 each at 19 locations September 2013, 2014 and 2015 (Figure 2.4.1, Table 3.2.1). Ideally, density estimates for each age class within individual meso-habitat units (100 m^2) would be examined through the use of an Allen plot. Plotting raw or observed fish density (FPU) on the Y-axis with paired mean size (g) on the X-axis for all ages derives a scatter plot or Allen Plot named after K.R. Allen (1969). However, there were a possible 504 meso-habitat and age class density estimates based on 4 age classes (0^+, 1^+, 2^+, 3^+ and 4^+ combined) and 42 meso-habitat sites in 2013 and 2014 and 43 sites in 2015. Of these only 73, or 14% had sufficient catch to generate individual age class density or biomass estimates (Table 3.2.27); and the majority of these estimates had poor precision. The remaining data were; 1) zero catch, 2) all catch in one pass, or 3) no decline in catch (*e.g.,* 0, 1, 0 for 3 passes). In all these cases the estimate was set to the catch and the variance could not be calculated by Microfish. This data precludes the development of a standard Allen Plot or the use of correlate analyses to determine the effect of habitat attributes on individual age class densities.

Subsequently, the data were pooled in various ways to explore potential temporal and spatial trends in fry and juvenile densities within the upper Fording River. First, age data was pooled from five age classes (0^+, 1^+, 2^+, 3^+, 4^+) to two life stages (fry and juvenile). The data was then combined (pooled) by location, watershed segment (*i.e.,* lower, mid, upper, tributary) and meso-habitat (*i.e.,* pool, riffle, glide, side-channel).

Table 3.2.27. Population, density and biomass estimates for individual age classes by meso-habitat sample unit (n=73).

Year	Stream	Seg-ment	Site	Area (m^2)	Habitat	Age Class	Population (No. Fish) Est.	Min	Max	Density (No./100m^2) Est.	Min	Max	Biomass (g/100m^2) Est.	Min	Max	Capture Prob.	Mean Wt (g)
2013	Fording	10	1	99.0	S/C	0+	27	11	43	27.27	11.11	43.43	10.91	4.44	17.37	0.38	0.41
2013	Fording	2	2	108.0	Glide	0+	4	1	7	3.70	0.93	6.48	1.48	0.37	2.59	0.57	0.41
2013	Fording	2	3	101.0	S/C	0+	5	4	6	4.96	3.97	5.95	1.98	1.59	2.38	0.71	0.41
2014	Fording	10	1	112.2	S/C	0+	21	20	22	18.72	17.83	19.61	5.60	5.30	5.90	0.71	0.30
2014	Fording	10	3	123.8	Pool	0+	5	2	8	4.04	1.62	6.46	1.62	0.65	2.58	0.71	0.40
2014	Fording	4	1	83.7	S/C	0+	8	6	10	9.56	7.17	11.95	5.73	4.30	7.17	0.67	0.60
2014	Fish Pond	1	1	170.0	Glide	0+	14	2	26	8.24	1.18	15.29	1.87	0.27	3.45	0.35	0.23
2015	Fording	10	1	103.9	S/C	0+	3	0	8	2.89	0.00	7.70	2.17	0.00	5.78	0.42	0.75
2015	Fording	8	1	148.5	Riffle	0+	58	47	69	39.06	31.65	46.46	29.29	23.74	34.85	0.50	0.75
2015	Fording	8	4	182.5	Glide	0+	14	13	15	7.67	7.12	8.22	5.75	5.34	6.16	0.76	0.75
2015	Fording	8	5	89.9	Riffle	0+	7	6	8	7.79	6.67	8.90	5.84	5.01	6.67	0.76	0.75
2015	Fording	6	3	85.1	Riffle	0+	11	9	13	12.93	10.58	15.29	9.70	7.94	11.46	0.65	0.75
2015	Fording	3	2	89.6	Glide	0+	25	0	69	27.90	0.00	77.00	20.92	0.00	57.75	0.45	0.75
2015	Fording	2	1	105.0	Glide	0+	6	2	10	5.71	1.90	9.52	4.29	1.43	7.14	0.65	0.75
2015	Fording	2	2	89.1	S/C	0+	4	3	5	4.49	3.37	5.61	3.37	2.53	4.21	0.65	0.75
2015	Lake Mtn.	1	1	100.5	Riffle	0+	27	21	33	26.87	20.90	32.84	20.15	15.67	24.63	0.65	0.75
2015	Dry	1	1	53.4	Riffle	0+	18	0	140	33.71	0.00	262.17	25.28	0.00	196.63	0.17	0.75
2013	Fording	8	1	125.0	Pool	1+	7	5	9	5.60	4.00	7.19	49.18	35.13	63.27	0.64	6.96
2013	Fording	8	3	103.0	Glide	1+	6	3	9	5.85	2.92	8.77	51.40	25.70	77.11	0.60	6.96
2013	Fording	7	2	100.0	S/C	1+	5	3	7	5.00	3.00	7.00	43.95	26.37	61.53	0.63	6.96
2013	Chauncey	1	2	115.0	Pool	1+	8	7	9	6.96	6.09	7.83	61.15	53.50	68.79	0.73	6.96
2013	Fish Pond	1	2	122.0	Riffle	1+	11	9	13	9.05	7.41	10.70	79.58	65.11	94.05	0.65	6.96
2013	Dry	1	3	102.0	Glide	1+	4	1	7	3.94	0.99	6.90	34.64	8.66	60.62	0.57	6.96
2014	Fording	11	3	108.0	Glide	1+	9	8	10	8.33	7.41	9.26	49.17	43.70	54.63	0.80	5.90
2014	Fording	8	1	147.6	Riffle	1+	2	0	7	1.36	0.00	4.74	19.44	0.00	68.06	0.60	14.35
2014	Fording	8	2	147.0	Glide	1+	2	0	7	1.36	0.00	4.74	15.10	0.00	52.64	0.67	11.10
2014	Fish Pond	1	1	170.0	Glide	1+	31	0	125	18.24	0.00	73.53	113.00	0.00	456.84	0.35	6.21
2014	Fish Pond	1	1	144.0	Riffle	1+	75	4	146	52.08	2.78	101.40	323.59	17.26	629.93	0.24	6.21
2014	Henretta	1	2	210.0	Glide	1+	5	4	6	2.40	1.90	2.90	16.10	12.70	19.40	0.71	6.70
2015	Fording	11	2	114.8	Riffle	1+	14	2	26	12.20	1.74	22.66	91.38	13.05	169.71	0.55	7.49
2015	Fording	11	3	73.7	Run	1+	18	16	20	24.42	21.70	27.13	182.88	162.56	203.20	0.55	7.49
2015	Fording	10		103.9	S/C	1+	4	1	7	3.85	0.96	6.74	28.85	7.21	50.49	0.42	7.49
2015	Fording	8	1	148.5	Riffle	1+	7	5	9	4.71	3.37	6.06	35.31	25.22	45.39	0.35	7.49
2015	Fording	8	6	128.4	Pool	1+	4	2	6	3.12	1.56	4.67	23.34	11.67	35.01	0.76	7.49
2015	Ewin	2	1	171.4	Riffle	1+	4	2	6	2.33	1.17	3.50	17.48	8.74	26.23	0.67	7.49
2015	Ewin	2	2	111.0	Pool	1+	3	0	6	2.70	0.00	5.40	20.24	0.00	40.48	0.67	7.49
2015	Ewin	2	3	130.9	Glide	1+	2	0	15	1.53	0.00	11.46	11.44	0.00	85.83	0.67	7.49

Table 3.2.27. Concluded.

Year	Stream	Seg-ment	Site	Area (m^2)	Habitat	Age Class	Population (No. Fish) Est.	Min	Max	Density (No./100m^2) Est.	Min	Max	Biomass (g/100m^2) Est.	Min	Max	Capture Prob.	Mean Wt (g)
2015	Lake Mtn.	1	1	100.5	Riffle	1+	34	31	37	33.83	30.85	36.82	253.39	231.03	275.75	0.65	7.49
2015	Chauncey	1	1	148.8	Pool	1+	11	10	12	7.39	6.72	8.06	55.37	50.34	60.40	0.84	7.49
2015	Chauncey	1	2	86.6	Riffle	1+	4	3	5	4.62	3.46	5.77	34.58	25.93	43.22	0.84	7.49
2015	Dry	1	2	64.6	Glide	1+	5	3	7	7.74	4.64	10.83	57.94	34.76	81.11	0.17	7.49
2015	Henretta	1	3	103.6	Riffle	1+	30	28	32	28.97	27.04	30.90	217.00	202.53	231.46	0.59	7.49
2015	Fish Pond	1	4	172.8	Glide	1+	24	24	24	13.89	13.89	13.89	104.03	104.03	104.03	0.83	7.49
2015	Fish Pond	1	5	96.3	Riffle	1+	11	8	14	11.43	8.31	14.54	85.57	62.24	108.91	0.83	7.49
2013	Fording	8	1	125.0	Pool	2+	5	3	7	4.00	2.40	5.60	75.52	113.29	264.33	0.67	38.23
2013	Fording	7	2	100.0	S/C	2+	2	0	7	2.00	0.00	7.00	94.48	0.00	330.68	0.67	38.23
2013	Fish Pond	1	1	190.0	Glide	2+	6	5	7	3.16	2.63	3.68	149.18	124.32	174.04	0.75	38.23
2013	Chauncey	1	2	115.0	Pool	2+	4	1	7	3.48	0.87	6.09	164.31	41.08	287.55	0.57	38.23
2013	Chauncey	1	3	120.0	Riffle	2+	4	3	5	3.34	2.51	4.18	157.86	118.40	197.33	0.80	38.23
2014	Fording	11	3	108.0	Glide	2+	3	2	4	2.78	1.85	3.70	127.69	85.13	170.26	0.80	45.97
2014	Henretta	1	1	100.0	S/C	2+	6	4	8	6.00	4.00	8.00	276.60	184.40	368.80	0.67	46.10
2014	Fish Pond	1	1	170.0	Glide	2+	7	5	9	4.12	2.94	5.29	146.65	104.75	188.54	0.35	35.61
2014	Fish Pond	1	1	144.0	Riffle	2+	25	14	36	17.36	9.72	25.00	618.30	346.25	890.35	0.44	35.61
2014	Chauncey	1	1	144.0	Pool	2+	5	2	8	3.47	1.39	5.56	111.11	44.44	177.78	0.56	32.00
2014	Chauncey	1	2	85.8	Riffle	2+	4	3	5	4.66	3.50	5.83	149.18	111.89	186.48	0.88	32.00
2015	Fording	11	2	114.8	Riffle	2+	6	5	7	5.23	4.36	6.10	144.10	120.09	168.12	0.55	27.56
2015	Fording	10		98.8	Pool	2+	3	0	6	3.04	0.00	6.07	83.68	0.00	167.37	0.42	27.56
2015	Fording	8	6	128.4	Pool	2+	6	5	7	4.67	3.90	5.45	128.84	107.36	150.31	0.76	27.56
2015	Henretta	1	1	90.0	S/C	2+	16	0	37	17.78	0.00	41.11	489.96	0.00	1133.02	0.22	27.56
2015	Lake Mtn.	1	1	100.5	Riffle	2+	26	25	27	25.87	24.88	26.87	713.00	685.57	740.42	0.65	27.56
2015	Henretta	1	2	100.0	Glide	2+	4	2	6	4.00	2.00	6.00	110.24	55.12	165.36	0.78	27.56
2015	Henretta	1	3	103.6	Riffle	2+	31	24	38	29.94	23.18	36.70	825.07	638.76	1011.38	0.59	27.56
2015	Fish Pond	1	4	172.8	Glide	2+	20	19	21	11.57	11.00	12.15	318.98	303.03	334.93	0.83	27.56
2015	Fish Pond	1	5	96.3	Riffle	2+	13	13	13	13.50	13.50	13.50	372.12	372.12	372.12	0.83	27.56
2014	Fording	11	2	138.0	Riffle	3+	3	0	6	2.17	0.00	4.35	156.30	0.00	312.61	0.57	71.90
2014	Fording	11	3	108.0	Glide	3+	4	3	5	3.70	2.78	4.63	554.44	415.83	693.06	0.80	149.70
2014	Fording	10	2	139.0	Riffle	3+	5	4	6	3.60	2.88	4.32	290.20	232.10	348.20	0.71	80.60
2014	Fording	7	2	174.0	Riffle	3+	2	0	7	1.15	0.00	4.02	84.20	0.00	294.68	0.67	73.25
2014	Henretta	3	3	180.0	Riffle	3+	2	0	7	1.11	0.00	3.89	148.78	0.00	520.72	0.67	133.90
2014	Fish Pond	1	1	144.0	Riffle	3+	6	3	9	4.17	2.08	6.25	415.93	207.96	623.89	0.60	99.82
2015	Fording	10		98.8	Pool	3+	19	15	23	19.23	15.18	23.28	2726.73	2152.68	3300.78	0.42	141.79
2015	Fording	8	6	128.4	Pool	3+	7	6	8	5.45	4.67	6.23	773.30	662.83	883.77	0.76	141.79
2015	Henretta	1	3	103.6	Riffle	3+	2	0	15	1.93	0.00	14.49	273.86	0.00	2053.94	0.59	141.79

3.2.3.2.2. Population Estimates

Annual estimates of fry and juvenile densities demonstrated an increasing trend over the duration of the study (Figure 3.2.10). Increasing densities at representative locations sampled in all three years (n=10) suggest that fry and juvenile population abundance was increasing during the three years; however, caution must be exercised in data interpretation as there was bias in the estimates.

The June 2013 flood appears to have impacted fry and juveniles with resulting low recruitment and juvenile densities during the first year (September 2013). Subsequent increases in 2014 and 2015 were likely influenced by post flood recovery and study design changes in the final year (2015). In 2015, four low density locations (typically zero catch or nearly so in previous two years) were substituted for five locations with high densities of spawners and redds observed during the unique 2015 spawning season. Higher density sites may have a higher capacity for recovery (*i.e.,* zero for a reason). Nevertheless, the following sections illustrate the increasing trend was broad based and consistent with the increasing trend in sub-adult and adult population estimates.

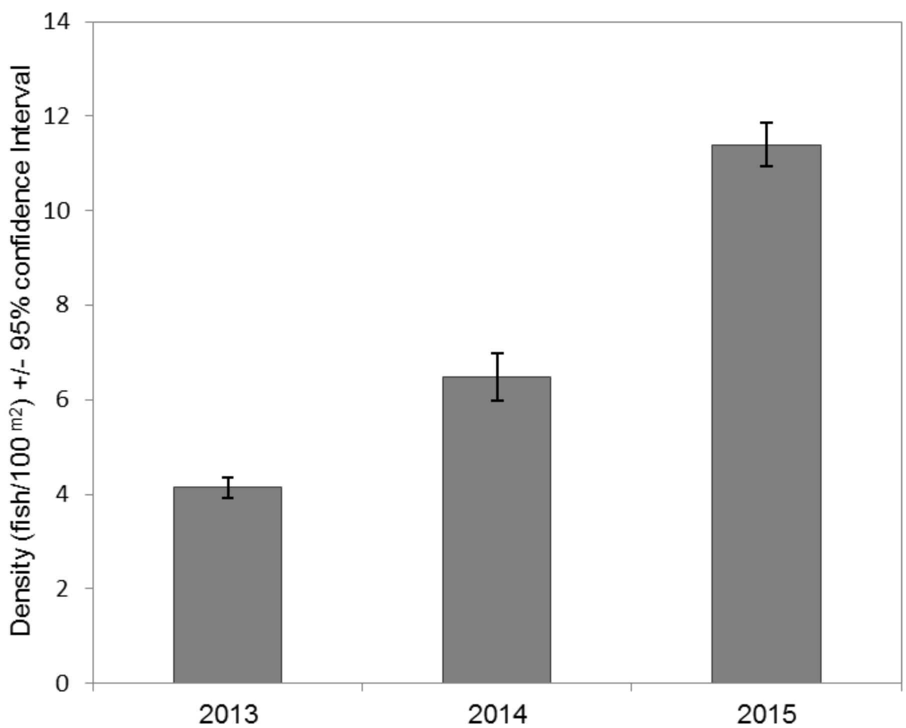


Figure 3.2.10. Average fry and juvenile (combined) density (fish/100 m^2) and the 95% confidence interval for sites sampled in all three years (n=10), upper Fording River, 2013 – 2015.

Location

The 3 meso-habitats within each location were pooled to provide a composite location and Figure 3.2.11 illustrates the density estimates (fry and juveniles combined) for the 19 locations within the upper Fording River watershed sampled in 2013, 2014 and 2015. Increased density across all sites during the three years of study suggest fry and juvenile increases were broad based and indicative of an increasing population trend.

The highest densities of fry occurred between the multi-plate culvert (Segment S8, 57.4 rkm) and the Turnbull arch culvert (Segment S9, 61.6 rkm) in 2015 (Table 3.2.28; Lake Mountain Creek 26.9 fry/100 m^2, Fording River Section 8b 27.3 fry/100 m^2). In 2015 the tributary site (lower Lake Mountain Creek) and the mainstem Section 8b site (below Clode Ponds Arch Culvert 59.7 rkm) were targeted based on the high densities of spawners observed in the mainstem and tributary habitat within this river reach extending from the side-channel flowing into lower Lake Mountain Creek (Segment S8, 58.4 rkm) to the Turnbull arch culvert (Segment S9, 61.6 rkm). This river Segment has been referred to as “Clode Flats” and also includes Fish Pond Creek, Clode Creek and the Clode settling ponds (Figure 3.2.12). This area was historically identified as spawning habitat (Lister and Kerr Wood Leidal 1980). Fry were also consistently present in Fish Pond Creek. Fish Pond Creek has been confirmed as a spawning tributary in previous studies (Oliver 1999, Amos and Wright 2000, Wright *et al.* 2001).

Fry densities were also high but variable within the headwaters above FRO (river Segment S10). In 2013 the river Segment S10 fry density was 10.8 fry/100 m^2, however; by 2015 this had decreased to 1.3 fry/100 m^2. The headwaters sustained extreme channel bed scour in the June 2013 flood and this may explain the decrease.

River Segment S2 (Greenhills log jam complexes adjacent to GHO) consistently produced fry (approximately 3.0 fry/100 m^2). The log jam pool areas within Segment S2 were also identified as spawning areas through radio telemetry monitoring. Subsequently, Greenhills Creek was also identified as part of this spawning area. Segment S2 and Greenhills Creek were historically identified as spawning habitat (BC Research 1981). Further sampling in similar habitat upstream in river Segments S3 and S6 in 2015 demonstrated pockets of similar spawning and fry rearing habitat with fry densities in the 3.2 to 7.6 fry/100 m^2 range (Table 3.2.28).

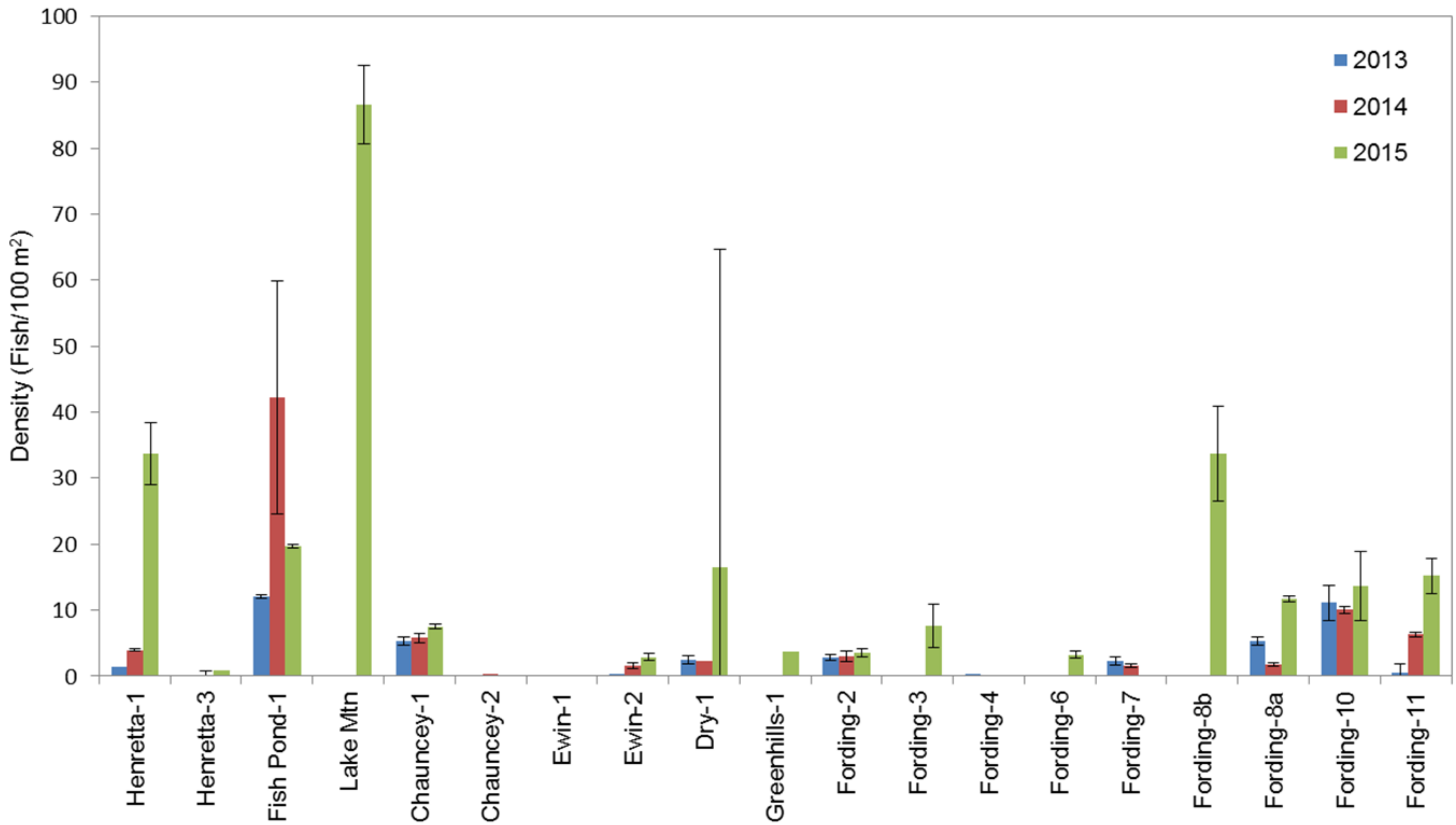


Figure 3.2.11. Density estimates (all age classes 0^+, 1^+, 2^+, 3^+, 4^+ combined) for the 19 locations within the upper Fording River watershed sampled in 2013, 2014 and 2015. Note that meso-habitats within each location were pooled to provide a composite location.

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Table 3.2.28. Fry and juvenile density and biomass estimates by composite location, upper Fording River, 2013 – 2015.

			Area	Density (Fish/100 m2)			Biomass (g/100 m2)		
Year	Stream	Segment	(m^2)	Fry	Juv	Comb.	Fry	Juv	Comb.
2013	Henretta	1	370.8	0.00	0.80	0.80	0.00	20.90	20.90
2014	Henretta	1	505.0	0.00	3.96	3.96	0.00	136.20	136.20
2015	Henretta	1	293.6	1.02	33.38	33.73	0.77	691.97	692.74
2013	Henretta	3	307.4	0.00	0.00	0.00	0.00	0.00	0.00
2014	Henretta	3	810.0	0.00	0.25	0.25	0.00	33.48	33.48
2015	Henretta	3	342.8	0.00	0.88	0.88	0.00	24.12	24.12
2013	Fish Pond	1	375.5	0.50	10.90	11.40	0.20	281.40	281.60
2014	Fish Pond	1	374.0	3.74	37.17	42.25	0.85	911.23	1035.79
2015	Fish Pond	1	359.4	0.83	18.92	19.76	0.63	326.01	326.64
2015	Lake Mtn.	1	100.5	26.87	59.70	86.57	20.15	966.39	986.54
2013	Chauncey	1	319.7	0.00	4.90	4.90	0.00	126.50	126.50
2014	Chauncey	1	277.3	0.00	5.77	5.77	0.00	282.77	282.77
2015	Chauncey	1	281.4	0.00	7.46	7.46	0.00	98.67	98.67
2013	Chauncey	2	300.4	0.00	0.00	0.00	0.00	0.00	0.00
2014	Chauncey	2	320.9	0.00	0.31	0.30	0.00	40.95	40.95
2013	Ewin	2	325.5	0.00	0.30	0.30	0.00	8.10	8.10
2014	Ewin	2	247.5	0.81	0.80	1.62	0.08	22.26	22.35
2015	Ewin	2	413.3	0.00	2.90	2.90	0.00	63.96	63.96
2013	Ewin	1	334.5	0.00	0.00	0.00	0.00	0.00	0.00
2014	Ewin	1	283.4	0.00	0.00	0.00	0.00	0.00	0.00
2013	Dry	1	294.9	0.00	2.50	2.50	0.00	65.30	65.30
2014	Dry	1	266.5	0.00	2.25	2.25	0.00	71.14	71.14
2015	Dry	1	163.6	6.11	3.06	16.50	4.58	22.89	27.47
2015	Greenhills	1	187.6	0.53	3.20	3.73	0.40	23.96	24.36
2013	Fording	11	373.5	0.00	0.50	0.50	0.00	13.30	13.30
2014	Fording	11	332.5	0.30	6.00	6.30	0.10	304.00	304.00
2015	Fording	11	263.5	0.38	14.42	15.18	0.28	207.55	207.83
2013	Fording	10	299.0	10.80	0.30	11.10	4.30	8.70	13.00
2014	Fording	10	374.9	6.90	3.20	10.10	2.30	445.20	239.30
2015	Fording	10	308.0	1.30	12.01	13.64	0.97	943.74	944.71
2013	Fording	8a	338.2	0.30	5.00	5.30	0.10	129.40	129.50
2014	Fording	8a	401.1	0.00	1.76	1.76	0.00	62.00	62.00
2015	Fording	8a	400.8	5.74	5.99	11.73	4.30	329.52	333.83
2013	Fording	2	446.1	2.90	0.00	2.90	1.20	0.00	1.20
2014	Fording	2	268.4	2.98	0.00	3.00	1.79	0.00	1.79
2015	Fording	2	305.7	3.27	0.33	3.60	2.45	2.45	4.90
2015	Fording	8b	278.5	27.30	5.75	33.75	20.47	426.15	446.62
2013	Fording	7	300.0	0.00	2.30	2.30	0.00	60.40	60.40
2014	Fording	7	392.0	0.00	1.53	1.53	0.00	50.82	50.82
2015	Fording	6	336.8	3.27	0.00	3.27	2.45	0.00	2.45
2013	Fording	4	366.0	0.00	0.30	0.30	0.00	7.00	7.00
2014	Fording	4	508.8	0.00	0.00	0.00	0.00	0.00	0.00
2015	Fording	3	275.1	7.63	0.00	7.63	5.72	0.00	5.72

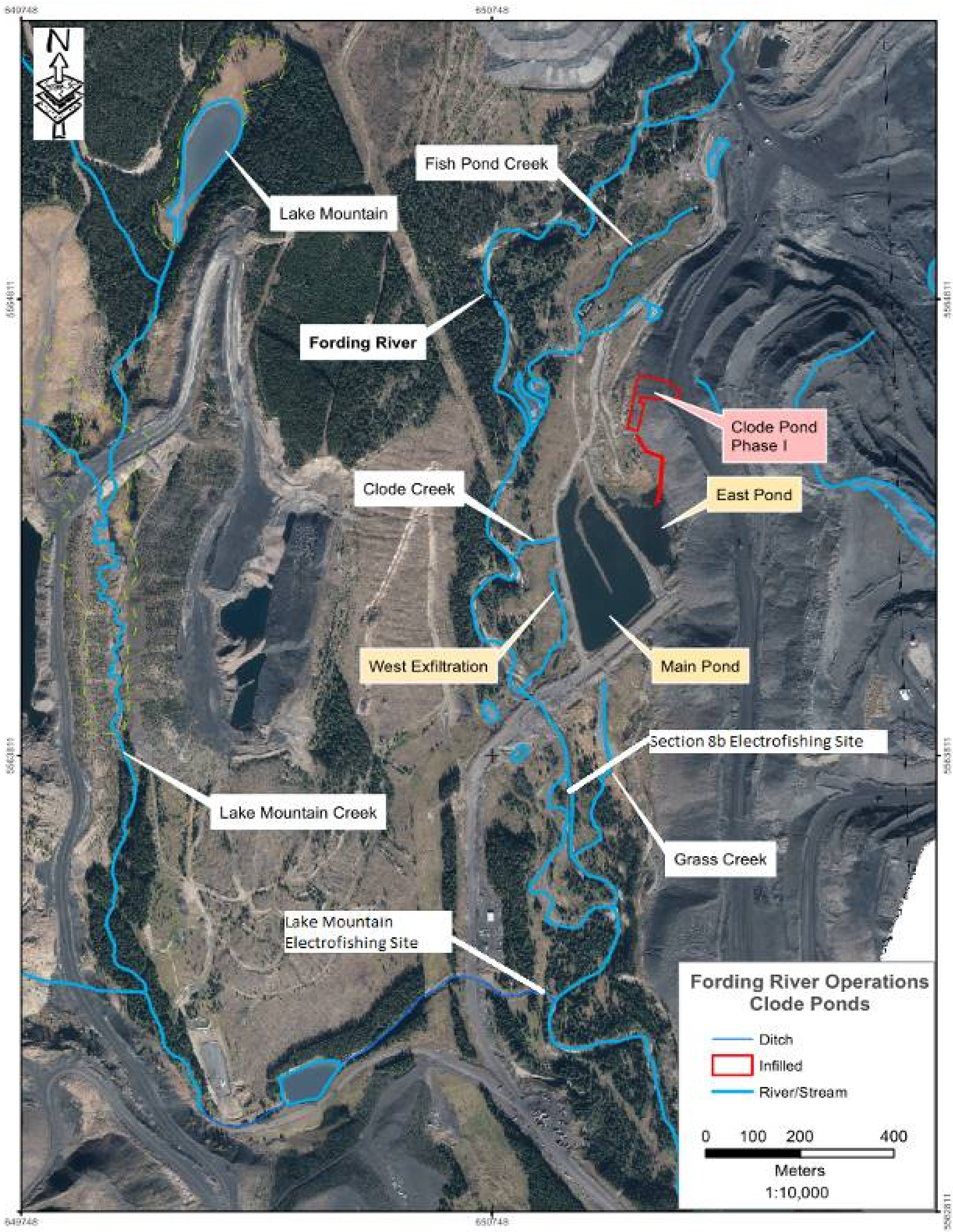


Figure 3.2.12. Aerial photograph illustrating the Clode Ponds area, Fording River Operations.

Juvenile densities were highly variable but did illustrate consistencies that were expected based on known habitat preferences for juvenile Westslope Cutthroat Trout. The juvenile density data for the years 2013, 2014 and 2015 illustrate that tributary habitat connected to the mainstem upper Fording River consistently had the highest juvenile densities. Variation was exemplified by lower Henretta Creek (below the culverts). In 2013 the juvenile density was 0.8 fish/100 m^2. By 2015 this had increased to 33.4 fish/100 m^2 (Figure 3.2.11, Table 3.2.28). Additional tributaries of note included Lake Mountain Creek, Henretta Creek, Fish Pond Creek, Chauncey Creek, and to a lesser extent Dry, Ewin and Greenhills Creeks (Table 3.2.28). In addition, the headwaters above FRO (Section S10 and S11) and the onsite Segment S8 (S8a and S8b) were also relatively productive in terms of juvenile density. Recall that the upper Fording River onsite and above FRO was tributary in size and character (Table 3.1.1; 0.85 m^3/s river Segment S8b, Sept 11, 2015). Based on these results, the FRO mainstem onsite segments, the headwaters above FRO and tributaries represent critical juvenile habitat for a large segment of the population (*i.e.,* “nursery areas” critical for recruitment).

Lost connectivity and resulting habitat fragmentation between tributaries and the mainstem upper Fording River due to culverts (impassable culverts or size based life stage limits to culvert passage) were reflected in the juvenile density data. In Chauncey Creek, fry or juveniles were captured in relatively high densities in the 900 m of stream channel below the Fording Road culvert. Less than one kilometer upstream (above the culvert), juveniles were present in extremely low densities (Table 3.2.28). Presumed non-migratory resident adults above the Fording Road culvert were confirmed in low densities during the sub-adult and adult capture program (*e.g.*, designation of residency based on 2 radio tagged fish 1 km upstream from the culvert that did not out-migrate when similar fish tagged within Henretta Creek and the mainstem headwaters did, *see* Section 3.3.1 Sub-adult and Adult (Radio telemetry Monitoring)). This data was consistent with professional opinion which identified the Chauncey Creek Fording Road culvert as an upstream barrier to fish passage (Figure 3.2.13). This barrier limits juvenile rearing capacity for the upper Fording River population of Westslope Cutthroat Trout to the lower 900 m of Chauncey Creek. Chauncey Creek represents the only tributary habitat available for the population residing in Segments S5 and S6. There has been high density spawning habitat identified in the Fording River within 2 km of the Chauncey Creek confluence. The exclusion of approximately 4 km of mainstem tributary habitat (Chauncey Creek) above the Fording Road culvert, with many preferred or high quality habitat attributes, could be interpreted as creating a “bottleneck” that may be limiting productivity of this population segment.

Figure 3.2.13. Chauncey Creek Fording Road culvert illustrating potential upstream passage barrier approximately 900 m upstream from the Chauncey Creek confluence with the upper Fording River.

Capture and radio tracking (ground and helicopter) within Chauncey Creek upstream from the culvert has identified a predominance of potential high density juvenile habitat (*e.g.,* moderate gradient riffles (1-3%), coarse substrate (cobble-boulder) and abundant LWD). Riffles (1-3%) combined with coarse substrate (cobble-boulder) and abundant overhead cover in the form of interstices or LWD are known preferences for salmonid juveniles in general and Westslope Cutthroat Trout in particular (McPhail 2007, Ptolemy *et al.* 2006, Jakober *et al.* 1998, Ford *et al.* 1995). Chauncey Creek also represents reference level water quality and restoration of connectivity should be a first priority for increased population resilience and a fail safe water quality refuge for a segment of the population. This would augment similar habitat within the headwaters (above FRO) and Ewin-Todhunter Creek.

Similarly, the Henretta Creek sites above and below the twin culverts and their grade control structures represented by three grouted weirs (located approximately 400 m above the confluence with the upper Fording River) were separated by approximately 2.0 km. In three years, the lower Henretta Creek site increased from very low densities (0.8 fish/100 m^2) to very high densities (33.73 fish/100m^2), yet the site above the culvert did not demonstrate any increase in juveniles during the same time period. It was clear from the radio telemetry data that larger fish (Fish > 230 mm fork length or 200 g) migrated upstream through the culverts (Sept-Oct) to over-winter in Henretta Pit Lake and migrated out in spring (April-May) to spawn in downstream or headwater mainstem river segments. This was interpreted to suggest that the Henretta Creek haul road culverts and associated weirs were a size or life stage barrier to upstream juvenile fish passage (*i.e.,* a partial barrier that prevents juveniles (smaller fish) from upstream migration but allows larger sub-adults and adults > 230 mm fork length to navigate through the weirs and culverts) (Figure 3.2.14). Again, there was high density spawning habitat identified in the mainstem Fording River downstream approximately 2 km of Henretta Creek. Exclusion of all but the lowermost Henretta Creek to rearing juveniles could also be interpreted as a potential "bottleneck" that may be limiting productivity of this population segment.

Figure 3.2.14. Henretta Creek Haul Road culvert and the three grouted weir structures illustrating the potential juvenile passage barrier (*i.e.,* life stage or partial barrier) approximately 400 m upstream from the Henretta Creek confluence with the upper Fording River.

Chauncey and Henretta culverts are only two of many connectivity concerns within the study area. The cumulative impact of lost connectivity among tributaries was identified as a concern due to its potential to limit life history diversity as well as a bottleneck (limitation) to juvenile recruitment. Recall that recruitment is typically the strongest determinant influencing populations and recruitment failure, due to habitat alterations can lead to reduced adult abundance (Maceina and Pereira 2007). Although each individual habitat loss (impassable culvert) may have a relatively small population effect, the cumulative effect of many small migration blockages in dynamic environments has important consequences by reducing life history diversity, population abundance and population resilience which is a threat to population viability and sustainability (Homel *et al.* 2015, Waples *et al.* 2008).

In order to quantify the scale of cumulative impacts in lost connectivity and habitat fragmentation within the upper Fording River study area, a GIS model was utilized to provide a preliminary estimate of lost or fragmented tributary fish habitat (*i.e.,* isolated by a barrier to fish passage). Fish bearing tributary habitat and fish passage barriers were defined using the "Fish Passage GIS Analysis Version 2", methodology outlined in Norris and Mount (2015). Briefly, this methodology utilizes a combination of known fish observation points (*i.e.,* Fisheries Information Summary System or FISS), modelled stream gradient (*i.e.,* based on Terrain Resource Information Management or TRIM topographic database at 1:20,000) and barriers to fish passage to provide an accounting of inferred fish distribution (kilometers of tributary habitat less than 25% gradient). Output data were preliminary and coarse in scale with the intent not to define a precise number but rather to illustrate the scale and context of this perceived threat and the opportunity to alleviate productivity constraints (limiting factor) for maximum effect in habitat "offsetting" (*i.e.,* in the past or in other literature variously termed habitat mitigation, rehabilitation, restoration, compensation and remediation).

For the purposes of this exercise, the upper Fording River above Henretta Creek was considered tributary habitat. These impacts may be understated since the following two partial barriers to upstream fish passage were not included; 1) the Henretta Haul Road culvert likely represents a life stage (*i.e.,* juvenile) passage barrier and tributary habitat above this culvert (38 km) is under-utilized except for utilization of Henretta Pit Lake by migratory sub-adult and adult fish (*see* Figure 3.2.11 for juvenile densities above and below the culvert), and 2) the multi-plate culvert on the mainstem Fording River 5.5 km downstream from Henretta Creek likely represents a partial life stage barrier (*i.e.,* juvenile) under certain flow conditions (*i.e.,* seasonal). While seasonal aggregations of juveniles noted in the current and past (Lister and Kerr Wood Leidal 1980) projects suggest a point of difficult passage, juveniles were documented successfully migrating upstream confirming the multi-plate culvert was not a complete barrier (*see* Figure 3.3.25).

Using these methods it was estimated that roughly 59% of all historically available tributary habitat has been lost (*i.e.,* infilled) or fragmented (*i.e.,* isolated upstream of a fish passage barrier such as a culvert, in line settling pond of rock drain) from the mainstem upper Fording River population of Westslope Cutthroat Trout. These methods estimated that historically there was approximately 183 km of fish bearing tributary habitat (*i.e.,* less than 25% gradient and no apparent barrier to the mainstem fish population) and that 107 km of this estimated tributary habitat has been lost to the mainstem upper Fording River population of Westslope Cutthroat Trout due to valley infill and fish passage barriers. This highlights the opportunity to address a limiting habitat by restoring access to those tributaries that still have habitat, but have been fragmented (*i.e.,* isolated) by culvert barriers or settling ponds and their associated exclusion barriers.

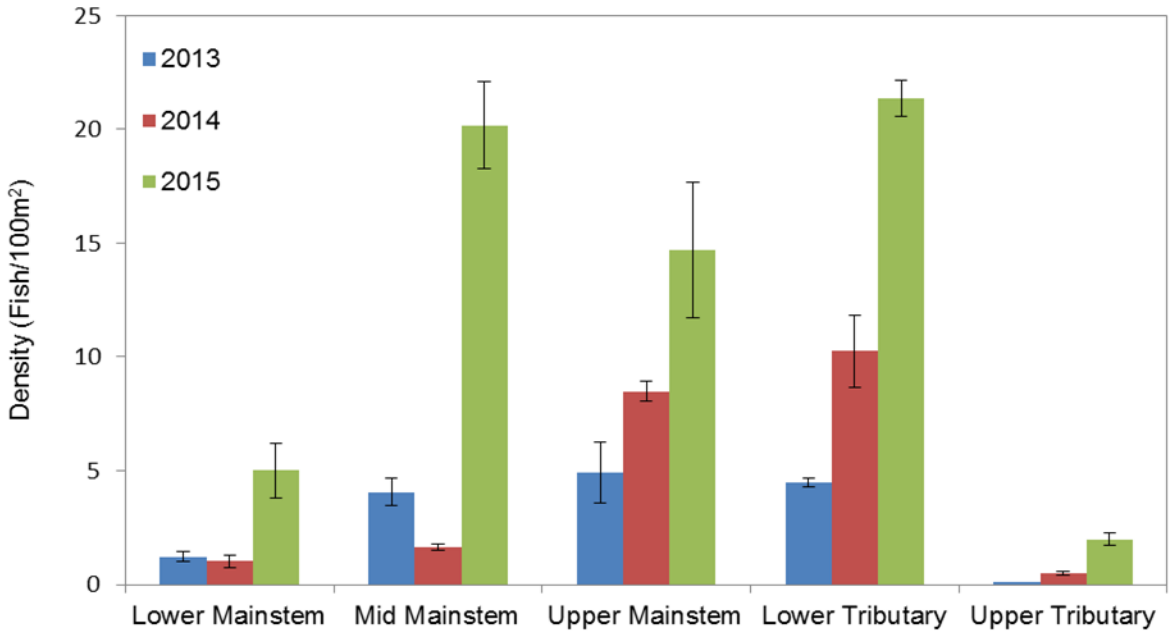
Within the literature it is well documented that juvenile Westslope Cutthroat Trout often prefer small tributary streams of 1 to 3% gradient with coarse substrate, large woody debris and undercut banks. Passage barriers isolate preferred juvenile rearing tributary habitat (and possibly some spawning) in locations identified as “nursery areas,” with high density juvenile habitat immediately downstream. The importance of connectivity to a large interconnected migratory or meta-population such as the upper Fording River is essential to maintaining diverse life histories and resistance to demographic extinction (Homel *et al.* 2015, Waples *et al.* 2008, Shepard *et al.* 2005).

Passage barriers also concentrate a large proportion of the juvenile population in very localized areas (*i.e.,* the few hundred meters of tributary that remains below the culvert). This represents an increased predation risk that may also contribute to the impacts of lost connectivity. Many predators and observations of active fishing immediately below barriers have been observed and include bears, otters, mink, weasels, osprey, red-tailed hawks, herons, mergansers, and eagles.

Pooled Segments

The precision of the location estimates were still typically poor so the locations were further pooled into five watershed areas or strata. The fry and juvenile Westslope Cutthroat Trout densities and biomass for the upper Fording River sample locations were illustrated in Figures 3.2.15 and 3.2.16. These figures illustrate the mid-mainstem (FRO onsite population segments S7 – S9), upper mainstem (population segments S10, S11 above FRO), and lower tributary reaches were the most important fry and juvenile rearing habitat.

A. Density



B. Biomass

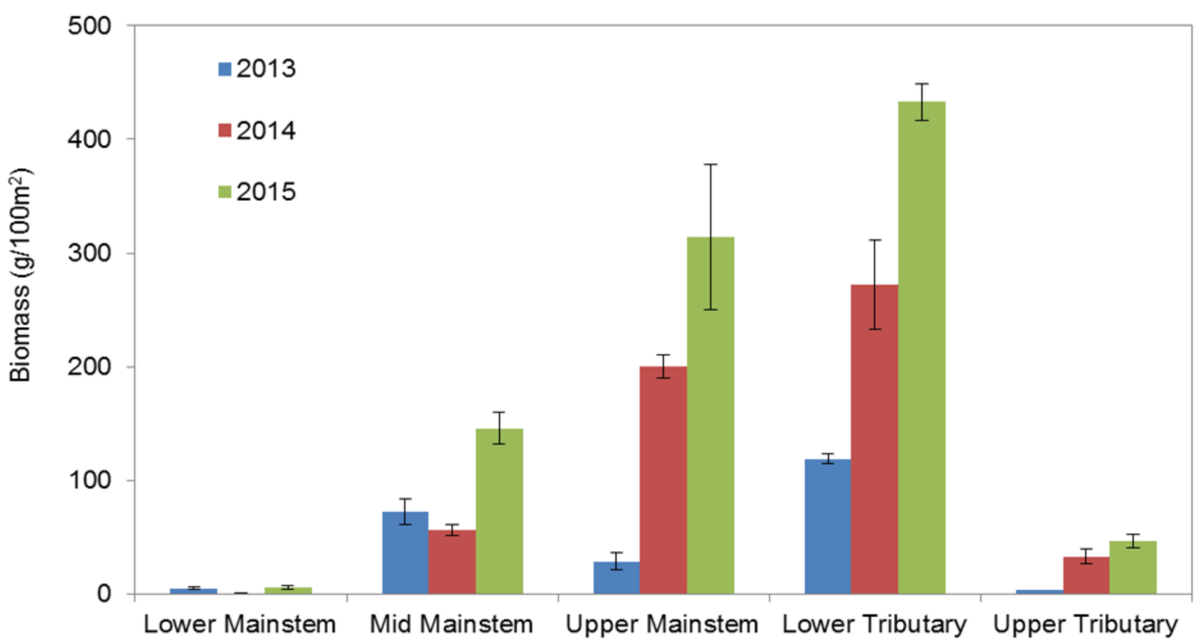
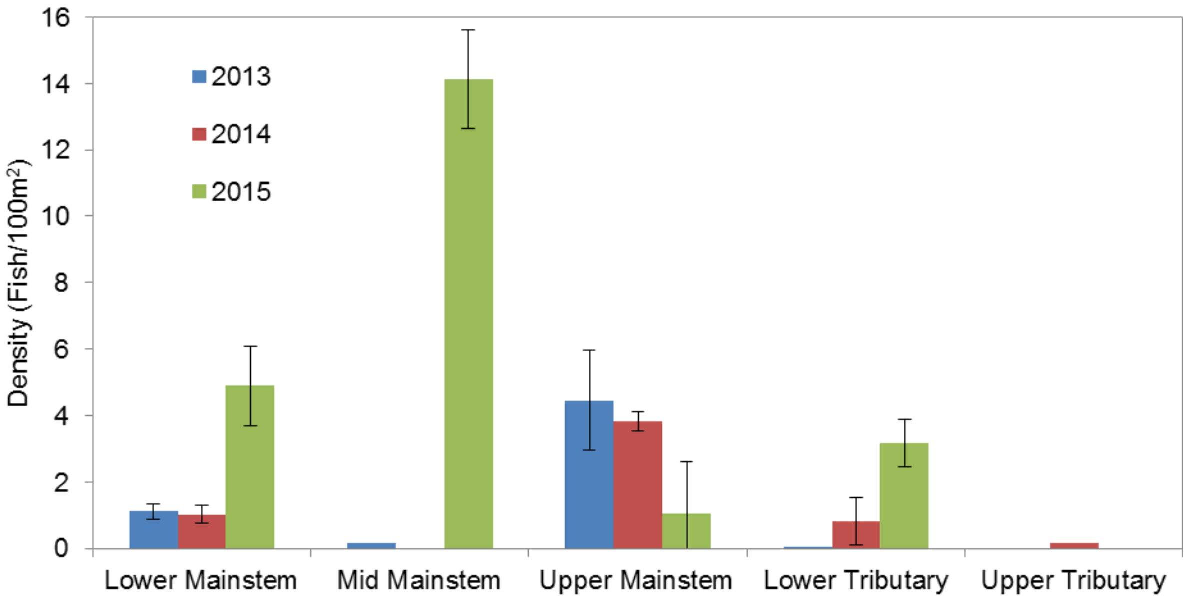


Figure 3.2.15. Density and biomass estimates for fry and juveniles combined by pooled river segments or watershed area, upper Fording River, 2013- 2015.

A. Fry



B. Juveniles

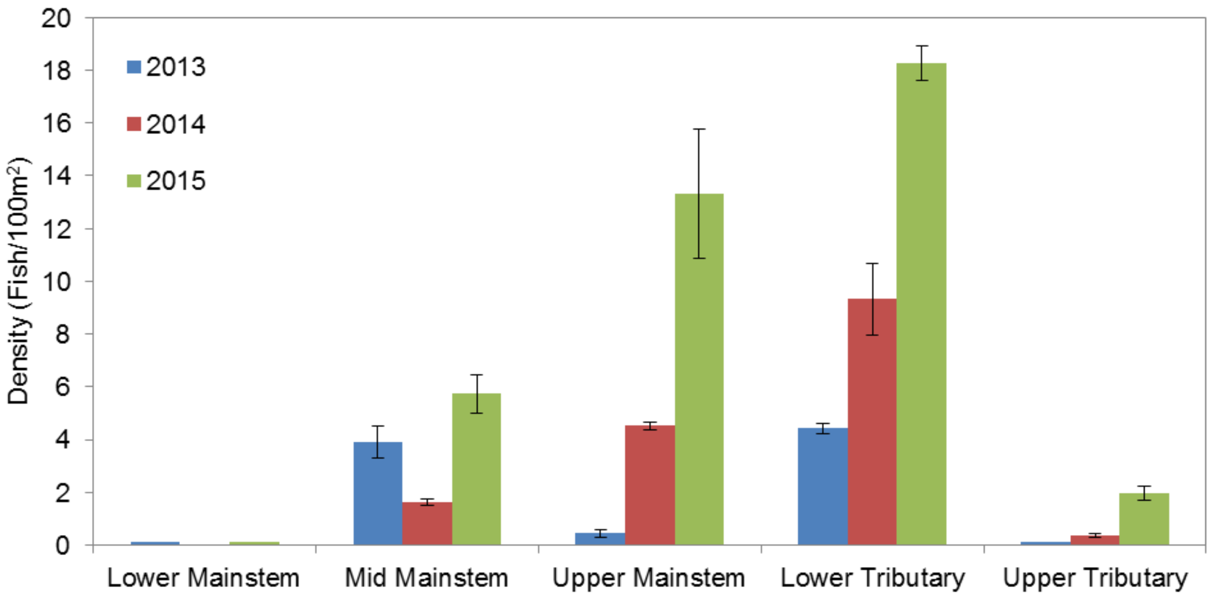


Figure 3.2.16. Fry and juvenile density estimates for pooled river segments or watershed area, upper Fording River, 2013- 2015.

Meso-Habitat

Finally, the catch data were pooled by meso-habitat type and Figure 3.2.17 illustrates that while fry were present in all habitats they clearly preferred shallow side-channel or braided channel habitat. Braided habitat was very similar to side-channel habitat; a small, shallow, secondary channel within the bankfull channel separated from the primary channel by a gravel or cobble bar. Juveniles were more ubiquitous in their distribution suggesting all meso-habitat types contained micro-habitats capable of sustaining Westslope Cutthroat Trout juveniles. Typically, smaller juveniles (*i.e.,* 1^+ < 100 mm) represented the higher side-channel densities while the larger juveniles (*i.e.,* 2^+ and 3^+ > 100 mm) were documented in higher gradient (1-3%), coarse substrate (boulder-cobble) riffles.

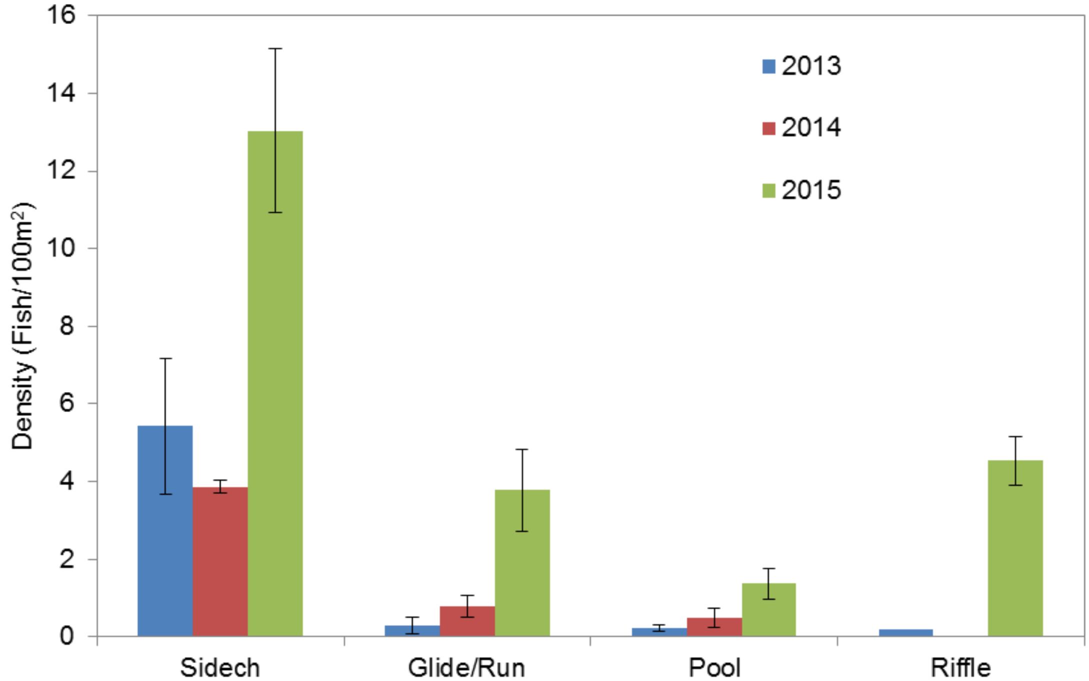
3.2.3.2.3. Literature Review for Existing Juvenile Density Data.

Fry and juvenile Westslope Cutthroat Trout recruitment within the upper Fording River were consistent with those for the remaining Elk River watershed; and by inference within the range expected for a healthy, self-sustaining population. In addition, current density and biomass estimates meet or exceed “baseline” data compiled for the upper Fording River; suggesting there has not been any large scale change in juvenile densities over the duration of baseline data used (1979 to present).

The conclusion that the upper Fording River fry and juvenile densities were within the range expected for a healthy, self-sustaining population was drawn from a comparison of the 2013, 2014 and 2015 density estimates for the upper Fording River with those completed in a companion program on the Elk River and tributaries in 2013 by Robinson (2014). Upper Fording River fry density estimates for pooled location data (*i.e.,* all three meso-habitat removals pooled into one location) ranged from 0.0 to 27.3 fry/100 m^2 (Table 3.2.28). The Elk watershed estimates using the same methods and pooled in the same manner (including Elk mainstem, lower Fording River below Josephine Falls, Line, Lizard, Michel, Morrissey, and Wheeler Creeks) were 0.0 to 88.1 fry/100 m^2 or less (Robinson 2014). Lizard Creek stood out among the Elk watershed sample sites at 88.1 fry/100 m^2. Lizard Creek was previously confirmed to be an important Elk River spawning tributary through radio telemetry (Prince and Morris 2003). Targeting fry sampling on previously identified spawning habitat within the upper Fording River in 2015 resulted in high fry densities of 26.9 and 27.3 fry/100 m^2.

Similarly, juvenile density estimates for pooled or composite locations within the upper Fording River watershed ranged from 0.0 to 59.7 juveniles/100 m^2 (Table 3.2.28). Estimates for the Elk watershed sample program ranged from 0.0 to 34.0 juveniles/100 m^2 (Robinson 2014).

A. Fry



B. Juveniles

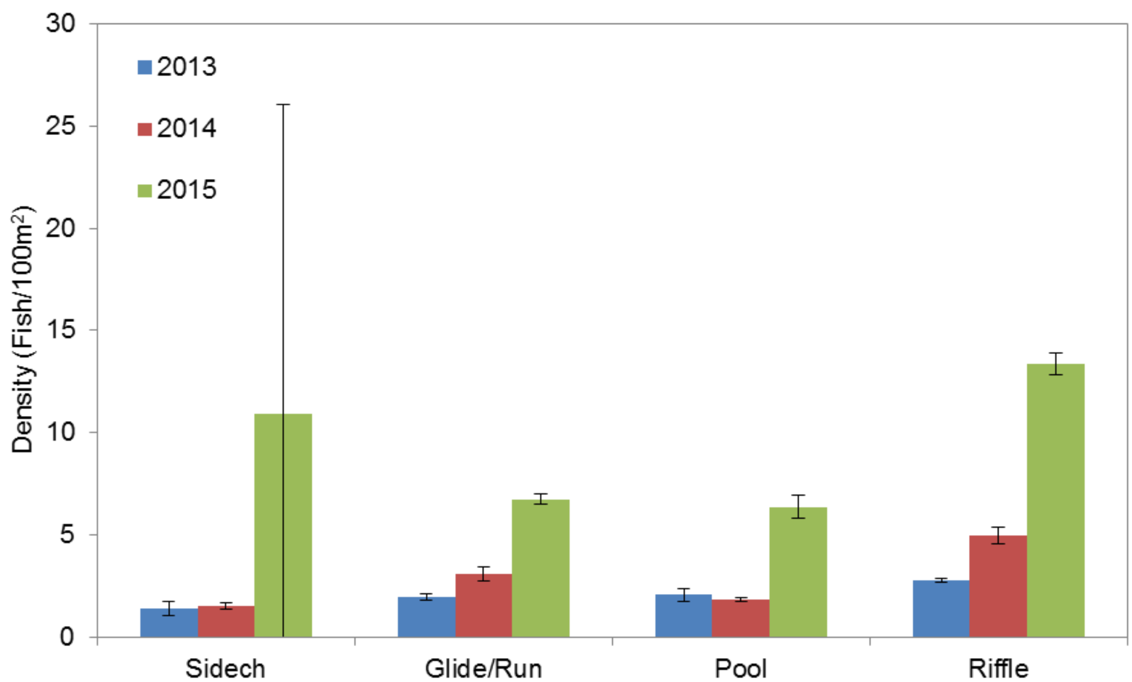


Figure 3.2.17. Density estimates by meso-habitat type. Side channel includes braided channel sections.

A literature review of previous reports completed within the upper Fording River was completed with the goal of compiling baseline data using existing juvenile density data. Previously, juvenile recruitment and population monitoring has been completed on and adjacent to FRO property (current Segments S7, S8, S9 and S10 or approximately 49.0 rkm to 63.4 rkm) but have extended from 63.4 rkm (above Henretta Creek) downstream to Ewin Creek (33.2 rkm) (Lister and Kerr Wood Leidal 1980, Oliver 1999, Amos and Wright 2000). These estimates utilized similar methods to this study (*i.e.,* electrofishing removal-depletion, each location includes at least one pool and riffle unit) and thus form a baseline for determination of possible trends in recruitment. While these data have been summarized for use as baseline data, this approach has not been successful in the past due to differences in focus, timing and variability of sampling area combined with the migratory nature of the population (Amos and Wright 2000). It does however, form another line of evidence that was explored to determine if the upper Fording River population was limited by recruitment (Table 3.2.29).

Given the variation and small sample sizes, Table 3.2.29 was inconclusive. As a generalization, the current density estimates, particularly those of the final year (2015) were consistent with the 1975 to 1999 mean values presented by Wood and Berdusco (1999).

Table 3.2.29. Summary of Westslope Cutthroat Trout densities (no. Fish/100 m^2) collected using removal electrofishing methods illustrating the expected variation for FRO and adjacent river sections from select studies, upper Fording River, 1979-2000.

Year-Month		Upstream	FRO	Downstream	Fish Pond Creek	Henretta Creek
1979-July[a]	Mean	3.1	22.2	15.6		
	Range	1.4 - 15.0	1.2 - 75.7	0.3 – 104.7		
	N	4	4	4		
1979-Sep-Oct[a]	Mean	20.0	19.2	15.6		
	Range	1.3 – 45.5	4.4 – 53.7	0.3 – 104.7		
	N	4	4	4		
1998-Aug[b]	Mean	6.0		28.0	11.4	
	Range	2.0 – 14.0		16.0 – 40.0	0.0 – 23.0	
	N	6		2	5	
1999-Aug[c]	Mean	8.6		13.0	19.5	
	Range	3.0 – 16.0		4.0 – 22.0	5.0 – 54.0	
	N	6		2	6	
1975-1999[d]	Mean	4.3	22.9	10.7	31.3	1.6
	Range					
	N					
2000[e]	Mean					6.7
	Range					2.7 - 11.5
	N					3
2012-2015[f] Sep-Oct	Mean	9.4	8.6	2.4	24.5	6.6
	Range	4.9 – 14.7	1.6 – 20.2	1.2 – 5.01	11.4 – 42.3	0.0 – 33.7
	N	6	6	7	3	6

[a] Lister and Kerr Wood Leidal 1980.
[b] Oliver 1999.
[c] Amos and Wright 2000.
[d] Berdusco and Wood 1992. Wood and Berdusco 1999.
[e] Wright *et al.*2001.
[f] Current study.

3.3. Movement Patterns and Distribution

Westslope Cutthroat Trout sustainability depends on the availability of habitat for key components of the life cycle; over-wintering, spawning, juvenile rearing and summer feeding (rearing). Cold clean water with varied instream structure and riparian cover, which provide both complexity and areas of refuge, clean gravel for spawning, shallow low-velocity areas for fry rearing, coarse substrate riffles and step pools for juvenile rearing, pools for adult holding, and deep pools and/or groundwater discharge areas for over-wintering; all connected by passable migration routes (because these habitat features are rarely found in the same locations), are all essential characteristics of their habitat (Cleator *et al.* 2009).

Monitoring frequency, emigration, survival and mortality mechanisms, home range, seasonal movement, and site fidelity were described; including periodicity and timing. The results of this study expand on the general pattern of Westslope Cutthroat Trout behaviour described in the literature by providing observations on life history strategies (*i.e.,* migration patterns, timing and distances), habitat utilization and critical habitats. Examination of home range by individual fish illustrates six generalized patterns and by inference life history strategies. These strategies are identified and discussed to illustrate the diversity of habitat use employed by fish within the upper Fording River. Seasonal meso-habitat locations utilized for over-wintering, spawning, and summer rearing were characterized and areas or locations of high utilization (*e.g.,* critical habitat) are identified and discussed.

3.3.1. Sub-adult and Adult (Radio Telemetry Monitoring)

Radio telemetry monitoring of three cohorts or replicates of $n=57_{2012}$, $n=58_{2013}$, and $n=51_{2014}$ Westslope Cutthroat Trout sub-adults and adults was completed from August 2012 through November 2015. A total of 166 radio tagged Westslope Cutthroat Trout were confirmed alive by a combination of movement (telemetry) and visual (snorkel) methods. These fish were at large for between 46 and 655 days. Recall that any fish that were either; a) recovered dead within 30 days or, b) never relocated after tag implantation, were removed from their respective cohort. Given the short duration at large these fish were not available for relocation or recapture and there was little or no movement reported. To eliminate this bias, these fish ($n=3_{2012}$, $n=3_{2013}$, $n=9_{2014}$) were not included in further movement pattern and distribution analyses.

This section focuses on the seasonal movement patterns, distribution and habitat use of the dataset containing 166 radio tagged Westslope Cutthroat Trout through approximately one full year of life (*e.g.,* annual life history analyses). This information was supplemented with; a) examination of variation in site fidelity (*e.g.,* repeated use of spawning, summer rearing and over-wintering habitat) during the first five months of an individual's second year at large (recall that guaranteed battery lifespan was 390 days but the actual lifespan was up to 655 days and radio tracking of individual fish capitalized on this extended battery life), and b) examination of repeating patterns among the three cohorts (2012, 2013 and 2014) seasonal movement, distribution and habitat use under the varying flow and temperature conditions documented.

Due to the size restrictions of radio telemetry methods (*i.e.,* 2% rule, Winter 1983), only the sub-adult and adult life stages were evaluated using these methods. The juvenile stages utilize electrofishing methods (*see* Section 3.3.2 Juveniles Movement Patterns (Electrofishing Mark-Recapture). Table 3.2.3 previously summarized the life history characteristics of the 180 Westslope Cutthroat Trout implanted with radio tags. Sub-adult and adult fish ranging from 223 mm to 485 mm fork length were radio tagged. The corresponding weight ranged from 170 g to 1,400 g. These included 61 males (34%), 95 females (53%) and 24 unidentified sex (13%). Fish life stage was classified based on gonad development during the internal exam and included 28 sub-adults (16%), and 152 mature adults (84%). All fish less than 233 mm fork length or 170 g were classified as sub-adults (immature gonads). All fish greater than 290 mm fork length or 300 g were classified as mature or maturing (mature, anticipated first spawning event next spring). As such, the size range 230 to 290 mm or 170 to 300 g represents maturity variation containing both mature and sub-adult Westslope Cutthroat Trout. Minimum size of maturity (males 200 mm, females 233 mm) was independently validated during egg and sperm collections (Robinson 2015, *pers. comm.*). Based on the length-at-age data, the age of first maturity was between 3 and 5 years (*see* Section 3.2.2. Age Class Structure, Growth and Condition).

Since Westslope Cutthroat Trout as small as 223 mm fork length were radio tagged, and the length interval of first sexual maturity ranges between 200 mm and 290 mm, it was unlikely these results were biased to characterize the habitat use and migratory life history of only the fastest-growing, larger individuals. This was an important distinction as considerable effort was completed to assess the alternative hypothesis that one or more headwater or tributary populations may exist with a smaller size-at-maturity and less migratory life history strategy. Juvenile scale ages confirmed upper Fording River Westslope Cutthroat less than 200 mm were juveniles 3 years old or less (*see* Section 3.2.2.1.1 Scale Ages). Smaller sized mature fish were not restricted to just the headwaters or tributaries, and radio-telemetry monitoring confirmed migration patterns between these and downstream watershed areas (*see* Section 3.3.1.5 Life History Strategies).

These results confirm headwater segments and tributaries do not contain adults with smaller size-at-maturity that are less migratory; but rather, headwaters and tributaries represent rearing and spawning habitat within the larger inter-connected mainstem population (*i.e.,* meta-population theory as opposed to distinct isolated local populations). Rieman and Dunham (2000) provide a review of meta-populations and salmonids based on their work with Bull Trout and Cutthroat Trout. Briefly, a meta-population view implies that regional populations of a species may persist in variable environments as collections of local populations interacting through dispersal. The spatial geometry (size, number, distribution) of suitable habitats matters to the dynamics and long-term persistence (sustainability) of these species' populations. Such issues are particularly relevant for land managers that must decide about the priority of habitat or watershed conservation and restoration efforts.

3.3.1.1. Monitoring Frequency and Interruptions

Six fixed receiver stations provided continuous monitoring of radio tagged fish from August 22, 2012 through October 6, 2015. Continuous monitoring was maintained uninterrupted (*e.g.,* 24 hr per day 7 days per week) at all six stations with the following exceptions:

1. The June 21, 2013 flood event destroyed the Fording River Headwater Station (F3) and the Henretta Creek Station (T3). There was no fixed receiver monitoring at these two locations from June 18 (last download) to October 10 (stations replaced and operational again). These two sites were manually scanned on the three week station maintenance schedule during this period in an effort to partially compensate for the loss of the fixed receivers during this time.

2. During the last 6 months of operation (May 2015 to October 2015) batteries were reaching the end of their scheduled life-span. During these months it was routine for one or two stations to have minor interruptions of a few days due to low battery power before the scheduled battery replacement every 3 weeks.

Mobile monitoring (*i.e.,* ground-based or helicopter) was completed monthly and approximately weekly during the anticipated spawning period (May 15 to July 20) for a total of 15 annual relocation tracking sessions. Ground-based tracking sessions traversed the mainstem and connected tributary stream channels over a four day period while helicopter surveys traversed all watershed habitats in a single day; including upper tributaries, upper headwaters and the lower Fording River below the falls (*i.e.,* to validate fixed receiver logs, assumed barriers and confirm no fish were present in unexpected areas).

The frequency of monitoring outlined above resulted in the following relocation statistics that were utilized for examination of mortality rates, home range, seasonal movement patterns, distribution and habitat use by sub-adult and adult Westslope Cutthroat Trout (Table 3.3.1).

Table 3.3.1. Summary statistics for radio tags at large and frequency of relocation through a combination of fixed and mobile receivers.

	Cohort 1 (2012)	Cohort 2 (2013)	Cohort 3 (2014)	Total (2012-14)
Confirmed Alive[1]	57	58	51	166
Mortalities (%)	15 (26%)	23 (40%)	17 (34%)	55 (33%)
Annual Mortality Rate (%/year)	21	32	27	26
Confirmed Alive > 300 days	42	35	34	111
Mean Days at Large	475	487	407	458
Minimum Days at Large	312	316	305	305
Maximum Days at Large	523	655	467	655
Mean No. Relocations at Large	47.5	64.2	36.6	49.0
Minimum No. Relocations at Large	7	7	7	7
Maximum No. Relocations at Large	253	216	144	253

[1] Note that fish recovered dead within 30 days (n=5) or never relocated after tag implantation (n=10), were removed from their respective cohort and not included in movement pattern and distribution analyses.

There were 180 radio tags implanted in Westslope Cutthroat Trout. Recall (*see* Section 3.2.1.1.1 Radio Tag Implantation) that there were 15 radio tags that were either recovered mortalities within 30 days or “missing” fish that were never relocated after release. Also recall that one recovered radio tag (predation mortality) was recovered within one week and was reused in a second fish and that is why the total at large was 166 rather than 165. These 166 fish were confirmed alive by a combination of movement (telemetry) and visual (snorkel) methods and were at large for between 46 and 655 days between August 2012 and November 2015. Of these fish, 111 or 67% were confirmed alive and at large for at least 305 days (average 458 days, range 305 – 655 days). Fish confirmed at large for at least 305 days (n=111) were relocated on average, 49 times (range 7 to 253) using a combination of fixed and mobile receivers (Table 3.3.1).

3.3.1.2.Emigration

There were no radio tagged fish documented emigrating out of the study area (*i.e.,* going downstream over Josephine Falls). This observation was validated through continuous monitoring for radio tags at the F1 (Josephine Falls) fixed receiver. Fixed receiver efficiency was validated through range testing during station set-up and helicopter tracking sessions on the lower Fording River to ensure no missing tags managed to pass the receiver undetected.

One Floy tagged fish was confirmed emigrating over the falls. This fish was recaptured by anglers in August 2013 several km below Josephine falls and released in good condition (angler report). This fish was originally Floy tagged in August 2012 in river Segment S3 (31.40 rkm) and was 224 mm at that time.

3.3.1.3.Survival

Mortalities and the mechanism of mortality were documented for the three cohorts of radio tagged sub-adult and adult Westslope Cutthroat Trout (Table 3.3.2). The overall mortality was 33% based on 111 (67%) radio tagged fish confirmed alive and at large for at least 305 days (average 458 days, range 305 – 655 days). Mortality estimates ranged from 26% to 40% for individual cohorts (Table 3.3.1). Given that survival was confirmed for fish at large for an average of 458 days and mortalities were summarized by cohort rather than on an annual basis, these mortality estimates were reduced by a factor of 1.25 (*i.e.,* 458/365 days) and expressed as an annual rate that ranged between 0.21/year and 0.32/year. The robustness of comparing these mortality “rates” to the population at large or to other populations was problematic given the tagging techniques and headwater channel conditions (*i.e.,* low turbidity, high visibility, relatively shallow water depths). Placing a fluorescent Floy tag on a fishes back in such a headwater stream environment with an abundance of predators must surely increase the susceptibility of these fish to predation and hence bias the mortality rate of these fish.

Table 3.3.2 summarizes the 55 confirmed or assumed mortalities from the 166 fish confirmed alive by a combination of movement (telemetry) and visual (snorkel) methods and were at large for between 46 and 655 days between August 2012 and November 2015. These fish were at large for an average of 248 days (range 46 - 443 days). All confirmed mortalities were recovered tags with apparent mechanism of mortality assumed from location evidence (*i.e.,* dewatered channel, ice jam, animal den, teeth marks, digestion of plastic antennae shroud, avian perch and guano). Assumed mortalities went “missing” (*i.e.,* relocated then never relocated again) for at least 180 days. These fish were included as mortalities since the fixed receiver stations and the frequency of ground-truthing monitoring, combined with the extended period of disappearance, provided a level of confidence that their demise was very likely. Recall that based on experience “missing” fish were typically mortalities that have had the tag or antennae mechanically damaged due to predation (*i.e.,* not transmitting), have been

Table 3.3.2. Confirmed mortalities and missing fish assumed to represent mortalities and their apparent mortality mechanism, timing and location.

Radio Code	Confirm Or Missing	fork length (mm)	Last Confirm Date	Confirm Days at large	Last Location (RKM)	Assumed Activity (Timing)	Assumed or confirmed Mortality mechanism
21	M	331	10-Apr-13	228	41.96	Migrating	Post-Spawn
22	C	425	9-Jul-13	317	52.50	Spawning	Post-Spawn
23	C	440	15-Jan-13	142	54.75	Over-winter	Ice-dewater
28	C	422	18-Jul-13	326	55.00	Spawning	Avian Pred.
31	C	440	18-Jul-13	325	55.50	Spawning	Avian Pred.
33	C	290	9-Jul-13	315	K0.68	Spawning	Otter Pred.
42	C	425	19-Aug-13	355	53.10	Summer	Avian Pred.
45	M	278	6-Jun-13	281	H0.72	Migrating	Post-Spawn
48	C	252	19-Mar-13	201	62.20	Over-winter	Ice-dewater
55	C	320	15-Jan-13	136	50.60	Over-winter	Ice-dewater
56	M	300	26-May-13	265	41.96	Migrating	Post-Spawn
63	M	242	23-Apr-13	242	41.96	Migrating	Post-Spawn
65	C	244	24-Apr-13	244	30.60	Migrating	Predation.
68	M	394	20-Feb-13	182	24.82	Over-winter	Ice-dewater
70	C	298	17-Jun-13	300	21.00	Spawning	Post-Spawn
72	C	240	23-Jun-14	212	69.30	Over-winter	Ice-dewater
74	C	240	3-Jul-14	327	65.00	Spawning	Post-Spawn
79	M	274	29-Apr-14	261	41.96	Migrating	Predation
93	C	370	10-Mar-14	202	48.00	Over-winter	Ice-dewater
94	C	278	8-Apr-14	232	41.73	Migrating	Predation
96	C	305	11-oct-13	51	35.23	Migrating	Predation
98	C	303	3-Jul-14	317	31.99	Spawning	Post-Spawn
101	C	273	3-Jul-14	314	66.18	Spawning	Post-Spawn
105	C	260	24-Jun-14	306	60.01	Spawning	Post-Spawn
106	C	438	19-Jun-14	301	42.84	Spawning	Post-Spawn
108	C	233	8-Oct-13	46	61.00	Migrating	Dewatered
109	C	278	16-May-14	266	60.27	Migrating	Post-Spawn
110	C	248	19-Jun-14	300	60.32	Spawning	Post-Spawn
114	C	284	23-Jul-14	351	57.4	Spawning	Post-Spawn
116	C	254	25-Jun-14	323	60.12	Spawning	Post-Spawn
117	C	280	25-Aug-14	383	60.27	Rearing	Predation
119	C	419	14-Oct-14	434	61.99	Migrating	Avian Pred.
125	C	239	3-Jul-14	329	57.4	Spawning	Post-Spawn
126	C	253	3-Jul-14	327	64.60	Spawning	Post-Spawn
128	C	286	12-Feb-14	186	51.10	Over-winter	Ice-dewater
129	C	223	3-Jul-14	314	66.60	Spawning	Post-Spawn
130	C	375	28-Oct-14	443	43.33	Migrating	Predation
131	C	307	10-Mar-14	213	58.20	Over-winter	Avian Pred.
134	C	336	17-Feb-15	191	C0.05	Over-winter	Pred. or Ice-dewater
146	C	257	17-Feb-15	194	58.12	Over-winter	Pred. or Ice-dewater

Continued next page.

Table 3.3.2 Concluded.

Radio Code	Confirm Or Missing	fork length (mm)	Last Confirm Date	Confirm Days at large	Last Location (RKM)	Assumed Activity (Timing)	Assumed or confirmed Mortality mechanism
147	M	283	20-Oct-14	75	H1.04	Rearing	Predation
151	C	290	21-Jan-15	167	61.81	Over-winter	Ice-dewater
153	C	271	18-Jun-15	318	H0.44	Spawning	Predation
154	C	260	28-Oct-14	84	59.65	Rearing	Avian Pred.
157	M	264	18-Oct-14	74	H0.72	Migrating	Predation
158	C	255	17-Aug-15	377	59.99	Rearing	Predation
170	C	301	15-Jan-15	148	32.89	Over-winter	Predation
173	M	355	22-Apr-15	246	41.96	Rearing	Predation
175	M	296	31-Mar-15	225	41.96	Over-winter	Predation
177	M	294	21-Jan-15	157	42.99	Over-winter	Predation
179	M	298	28-Oct-14	72	42.84	Over-winter	Predation
181	M	351	2-Apr-15	228	41.96	Over-winter	Predation
185	M	318	22-May-15	278	59.49	Spawning	Post-Spawn
187	M	264	26-May-15	282	41.96	Spawning	Post-Spawn
190	C	342	1-Apr-15	232	43.68	Over-winter	Avian Predator

transported into an area with poor signal strength (*i.e.,* in an earth den, buried in silt), or predators or angler harvest have transported the tag outside of the study area. Therefore, in the case of missing tags, the assumed mortality mechanism was an estimate based on the timing of their disappearance and/or the habitat they occupied at the time.

Mortality mechanisms summarized in Table 3.3.2 included:

1. Predation (n=24, 44%). The following predators were visually confirmed consuming or actively hunting Westslope Cutthroat Trout in the upper Fording River; bears, otters, mink, weasels, osprey, red-tailed hawks, herons, mergansers, and eagles,
2. Post-spawning (n=20, 36%). Post spawning refers to mortality immediately following spawning and may include mortality due to predation on redds or resulting from a weakened state,
3. Winter ice and/or channel dewatering (n=9, 16%), and
4. There were two (6%) that could not be estimated.

The distribution of mortality occurrence (Table 3.3.3) was influenced by a number of factors including; fish distribution during spawning, rearing, over-wintering, stream channel and habitat condition of migration corridors, channel dewatering and possible illegal harvest of fish. The majority of the mortalities (53%) occurred within river Segments S7, S8 and S9 (*i.e.,* rkm 51 through 65) which are located within the FRO property. Mortalities within these segments were due to several factors. First, channel dewatering occurred within these reaches during the late fall and winter. Channel dewatering within upper watersheds of Kootenay River tributaries is not uncommon having been documented in the Upper Elk and Wigwam Rivers; however, common impacts of surface mining such as vegetation removal, water withdrawals' and altered sediment supply could exacerbate these effects. Secondly, high density spawning sites (*see* Section 3.3.1.6.1 Spawning) result in seasonal migrations into the FRO river segments and as a result higher incidents of post spawning mortality should be expected. Aggregations of spawning fish also provide an attractant for predators placing fish at higher risk of mortality. Segments S7, S8 and S9 (FRO) also meander through open meadows (previously clear-cut) supporting a ground squirrel population with an abundance of raptors. Thirdly, both Level 1 FHAP and Rosgen habitat quality diagnostics identify river Segments S7 through S9 (FRO) as deficient in fish habitat attributes such as width to depth ratio, water depths, pool frequency, LWD frequency and fish cover components due to channel disturbance features (*see* Section 3.4 Habitat Mapping). Westslope Cutthroat Trout spawning and migrating in relatively large numbers within a shallow riffle dominated channel lacking overhead cover with an abundant raptor population could reasonably be assumed to be at increased predation risk. High width to depth ratio channels are also prone to increased frequency and extent of dewatering.

Table 3.3.3. Distribution of confirmed and assumed mortality events within the headwaters, FRO onsite, river Segment S6 and the lower study area below Chauncey Creek.

Watershed Area	Mortalities		Lineal River	Mortalities
	N	%	km	Per km
Headwaters[1]	5	9.1	6.0	0.83
FRO Onsite[2]	29	52.7	15.8	1.84
Segment S6	14	25.5	6.6	2.12
Lower River (Below S6)	7	12.7	21.0	0.33

[1] River Segments S10 and S11 upstream of 65 rkm above FRO.
[1] River Segments S7, S8 and S9 between 51 rkm and 65 rkm including tributaries (Clode Creek, Clode Settling Pond, Henretta Creek, Fish pond Creek, Kilmarnock Settling Pond).

The high mortalities identified in river Segment S6 (*i.e.,* also referred to as the groundwater reach or oxbow pools), an old growth stream channel with an abundance of high quality habitat attributes (*see* Section 3.4 Habitat Mapping), was unexpected (Table 3.3.3). Again, high densities of spawning and over-wintering Westslope Cutthroat Trout were identified in this river Segment (Figure 3.3.1), and otters were documented fishing in this Segment.

Figure 3.3.1. The river Segment S6 over-wintering school of Westslope Cutthroat Trout numbering in excess of 500 fish illustrating the high densities and vulnerability of this large proportion of the mature upper Fording River population.

The relatively abundant prey base may attract a higher number of predators. However, closer examination of the data in Table 3.3.2 reveals that 10 of the 14 mortalities (71%) went "missing" at the Chauncey Creek confluence with the Fording River or immediately upstream at the fire pit pullout at the first upstream meander. Eight of the 14 "missing" fish disappeared in April and May. This was consistent across all three years. This may be interpreted as evidence of illegal harvesting of fish. In April and May of 2015 the tracking crew investigated this theory and found discarded bait bags along the shoreline of the Fording River and fish entrails at the Chauncey Creek confluence confirming illegal harvest of fish at this time and location.

3.3.1.4.Home Range

Home range was defined as the total area required by an animal to fulfill its life requirements (food, shelter, and reproduction) and is a function of the presence of physical barriers, type and diversity of habitat, the degree of interspecific and intraspecific competition, maturity status, season, and abundance of food. Not all parts of a home range are used equally.

The average home range was 11.54 km +/- 1.51 km (95% Confidence Interval, n=111). Individual home ranges varied between 0.68 km and 31.59 km (Figure 3.3.2). The home range for upper Fording River sub-adult and adult Westslope Cutthroat Trout (*i.e.,* mature fish > 223 mm FL) was estimated for the 111 fish confirmed alive and at large for at least 305 days. These fish were relocated on average, 49 times (range 7 to 253).

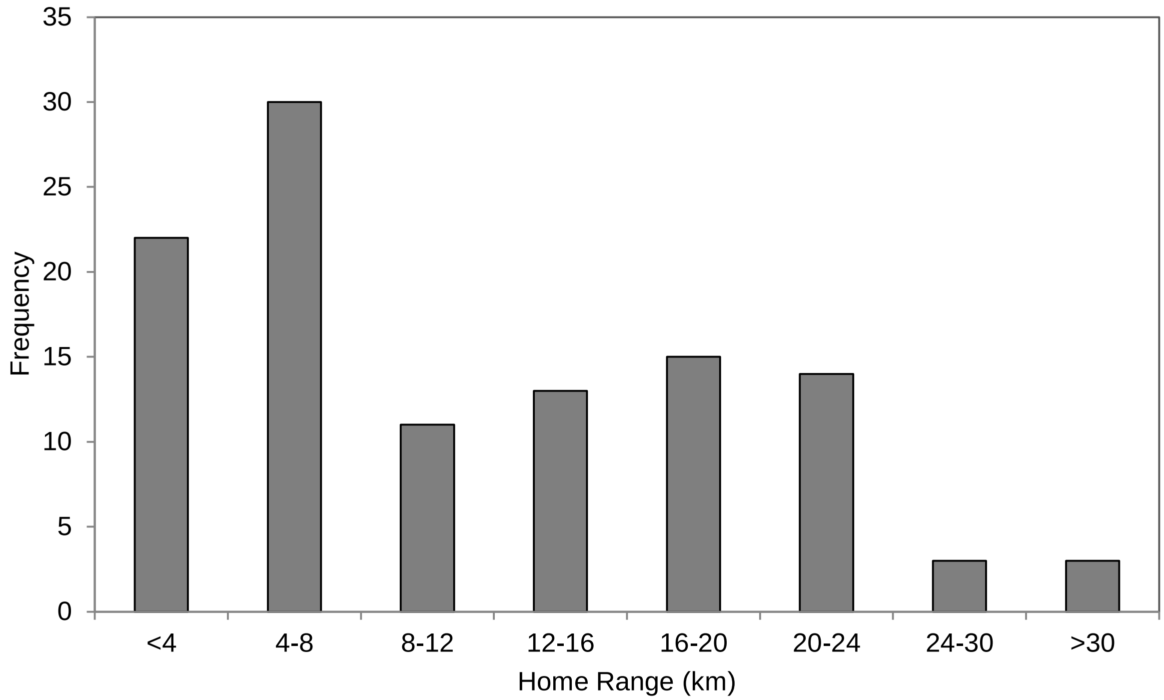


Figure 3.3.2. Frequency and extent of home ranges for radio tagged Westslope Cutthroat Trout (n=111) within the upper Fording River August 2012 through October 2015. Note that home range scale was arbitrarily assigned.

Table 3.3.4. illustrates home ranges were consistent across the three years of study with mean cohort home ranges varying between 10.20 km +/- 2.31 km and 13.26 km +/- 2.66 km. The home range and movement documented in the upper Fording River population of Westslope Cutthroat Trout was within the range expected for a fluvial, above barrier, upper Kootenay River population of sub-adult and adult Westslope Cutthroat Trout. The average home range of Westslope Cutthroat Trout has been reported for the upper Bull River (7.6 km, range 0.7 - 27.9 km; Cope and Prince 2012), Elk River above the Elko Dam (11.2 km, range 1.8 km - 35.9 km; Prince and Morris 2003), upper St. Mary River (8.9 km, range 1.5 – 24.9 km) and lower St. Mary River (19.6 km, range 2.1 – 55.5 km; Morris and Prince 2004). These populations

.

Table 3.3.4. Summary of home ranges for the three cohorts of radio tagged Westslope Cutthroat Trout (2012, 2013, 2014) within the upper Fording River.

	2012	2013	2014	2012-14
Mean Home Range	13.26	10.20	10.81	11.54
95% Confidence Interval	2.66	2.31	2.97	1.51
Minimum	0.68	1.19	0.86	0.68
Maximum	31.59	23.56	30.47	31.59
N	42	35	34	111

represent largely migratory fluvial life-histories (Elk and St. Mary Rivers also include some adfluvial migratory). It is also important to note that these studies did not utilize fixed receivers to the extent of the current study and most likely under-estimate home range compared to the more rigorous movement monitoring of the current study

There was no relationship between the size (fork length) of mature radio tagged Westslope Cutthroat Trout and home range (Figure 3.3.3, regression, r^2=0.001, p=0.71, n=111). A similar result was observed in the upper Bull River Westslope Cutthroat Trout telemetry study (Cope and Prince 2012).

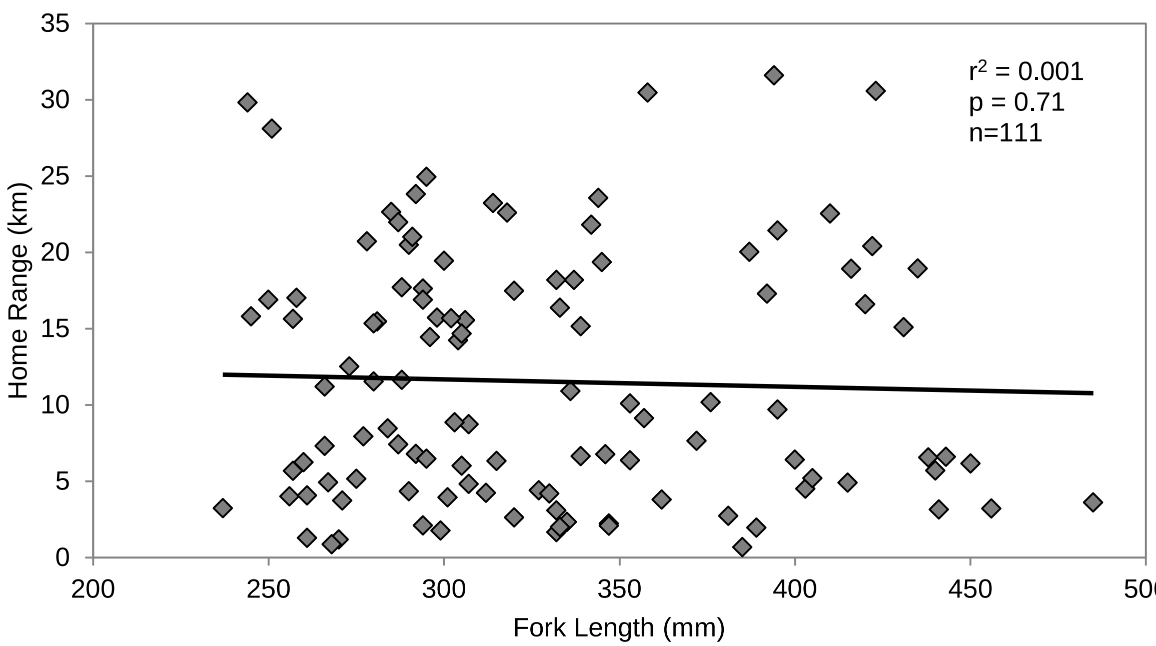


Figure 3.3.3. Home range in relation to size (fork length) for radio tagged Westslope Cutthroat Trout at large for a minimum of 305 days, upper Fording River 2012-15.

3.3.1.5.Life History Strategies

Resident and migratory life history strategies are discussed in detail in the following subsections to illustrate the diversity of strategies employed by Westslope Cutthroat Trout within a high elevation, fluvial habitat (*i.e.,* approximately 57.5 km mainstem and 59 km of accessible tributary habitat). This population (*i.e.,* between 2,552 and 3,874 fish > 200 mm) represents a unique opportunity for Westslope Cutthroat Trout research as movements and distribution are not confounded by inter-specific competition or predation (*i.e.,* no other fish species are present above Josephine Falls) and is a genetically pure, above barrier population.

Seasonal habitat locations of note are introduced in the discussion below in relation to Question 6 (What are the movement patterns and why?). Habitats discussed in this section were illustrated through mapping and photographs in the following sections on seasonal habitat use and habitat characterization to better understand the seasonal distribution (Question 7) and both critical and overall habitats (Question 5) for the upper Fording River population of sub-adult and adult Westslope Cutthroat Trout.

In this study, Westslope Cutthroat Trout were classified as migratory if their movements were greater than 8.0 km and resident if movements were less than 8.0 km. This definition was based on previous East Kootenay Westslope Cutthroat Trout radio telemetry studies that documented mean home ranges for the upper Bull River (7.6 km, range 0.7 - 27.9 km; Cope and Prince 2012), Elk River above the Elko Dam (11.2 km, range 1.8 km - 35.9 km; Prince and Morris 2003), upper St. Mary River (8.9 km, range 1.5 – 24.9 km) and lower St. Mary River (19.6 km, range 2.1 – 55.5 km; Morris and Prince 2004). These populations characterized largely migratory fluvial life-histories (Elk and St. Mary Rivers also include some adfluvial migratory). This classification was further supported by similar characterizations for Bull Trout; another native species resident to these watersheds. Bull trout are generally considered migratory if their movements were greater than 10 km (Homel 2007, Al-Chokhachy and Budy 2008, Prince 2010) and resident if movements are less than 10 km (Jakober 1995, Chandler *et al.*, 2001).

Table 3.3.5 summarizes the life history strategies in relation to their contribution to the total population of radio tags. These life history strategies represent repeating patterns of habitat use and are discussed below.

Table 3.3.5. Summary of life history patterns for radio tagged Westslope Cutthroat Trout in the upper Fording River 2012-2015.

	N	%
Migratory		
Upper and Mid-Watershed	26	23
Mid and Lower Watershed	31	28
Subtotal	*57*	*51*
Resident		
Upper Watershed	27	24
Mid Watershed	14	13
Lower Watershed	11	10
Chauncey Isolates	2	2
Subtotal	*54*	*49*
Total	*111*	*100.0*

Home range data confirm both resident and migratory life history forms of Westslope Cutthroat Trout within the upper Fording River population. This population structure is typical for Westslope Cutthroat Trout populations in relatively large, intact watersheds; both within the species geographic range and the East Kootenay Region (Cope and Prince 2012, Oliver 2009, Morris and Prince 2004, Prince and Morris 2003). Unique to these East Kootenay populations is that home range was not related to fish size (Figure 3.3.3, regression, r^2=0.001, p=0.71, n=111) and therefore, there was no significant size difference between the migratory (324.6 mm fork length +/- 14.2 mm 95% confidence interval, range 244 mm to 435 mm, n=57) or the resident life history strategy (333.7 mm +/- 17.2 mm 95% confidence interval, range 237 mm to 485 mm, n=54). This observation was consistent with the Bull River population (pure strain, above barrier) in an adjacent watershed (Cope and Prince 2012).

Migratory Life History Strategy

In total, 51% (n=57) of radio tagged Westslope Cutthroat Trout (at large for at least 305 days) were classified as migratory. The home range for these fish averaged 18.2 km +/- 1.5 km (95% confidence interval, range 8.8 to 31.6 km). These fish predominantly over-wintered in river Segment S6 (59%) and Henretta Pit Lake (16%). The remaining 25% over-wintered in a diversity of locations including; the log jams in river Segments S2, S3, S4, S5, the multi-plate culvert plunge pool in Segment S8, Clode Flats in upper Segment S8 and lower Segment S9

(Figure 3.2.12), Fording Headwaters in Segment S10 and immediately downstream of the Kilmarnock Creek confluence area in Segment S7. These fish demonstrated a propensity for site fidelity with 65% returning to the same locations in their second winter.

The dominant spawning area these fish migrated to were river Segment S6 (38%). Specific spawning sections were identified at 44.0 to 45.0 rkm and 47.0 to 48.9 rkm (including the oxbow side-channel). Spawning fish originated from areas as far upstream as Henretta Pit Lake (63.9 rkm) and as far downstream as the Segment S2 log jams (25.0 rkm).

The FRO Clode Flats (*i.e.,* upper river Segment S8 and lower Segment S9, Figure 3.2.12) (13%) and the Segment S2 log jams and Greenhills Creek confluence area (13%) in the GHO area were the other two dominant spawning areas. Fish migrated from as far upstream as the multi-plate culvert (Segment S8, FRO onsite) and the oxbow over-wintering pools (Segment S6) to spawn in the Segment S2 area and Greenhills Creek (*see* Section 3.3.1.6.1 Spawning). The remaining fish were confirmed spawning in a diversity of areas including areas associated with the log jam complexes in Segments S3, S4, S5, the headwaters (Segments S10 and S11), Fish Pond Creek, Clode Creek, Clode Exfiltrate, the Segment S8 side-channel that flows into lower Lake Mountain Creek and Segment S7 below the South Tailings Pond.

These fish reared in a variety of locations in predominantly pool habitats but were typically centred around the core areas of the approximately 11.0 km of stream channel between the Henretta Pit Lake over-wintering area, the Clode Flats and the South Tailings Pond Diversion (*i.e.,* FRO onsite Segments S7, S8, S9), within the approximately 6.6 km of river Segment S6, and within the very large log jam complexes in river Segments S2 through S5.

Figures 3.3.4 and 3.3.5 illustrate two representative life-histories in terms of periodicity and movement patterns. Figure 3.3.4 illustrates the Segment S6 migration upstream to spawn in the Clode Flats area (upper Segment S8 and lower Segment S9, Figure 3.2.12); returning to over-winter in Segment S6. Figure 3.3.5 illustrates the downstream migration of fish over-wintering onsite in Henretta Pit Lake or the multi-plate culvert to spawn in Segment S6 and log jam associated areas in Segments S2 through S5; typically returning to Henretta Pit Lake or the Segment S6 ox-bow areas to over-winter.

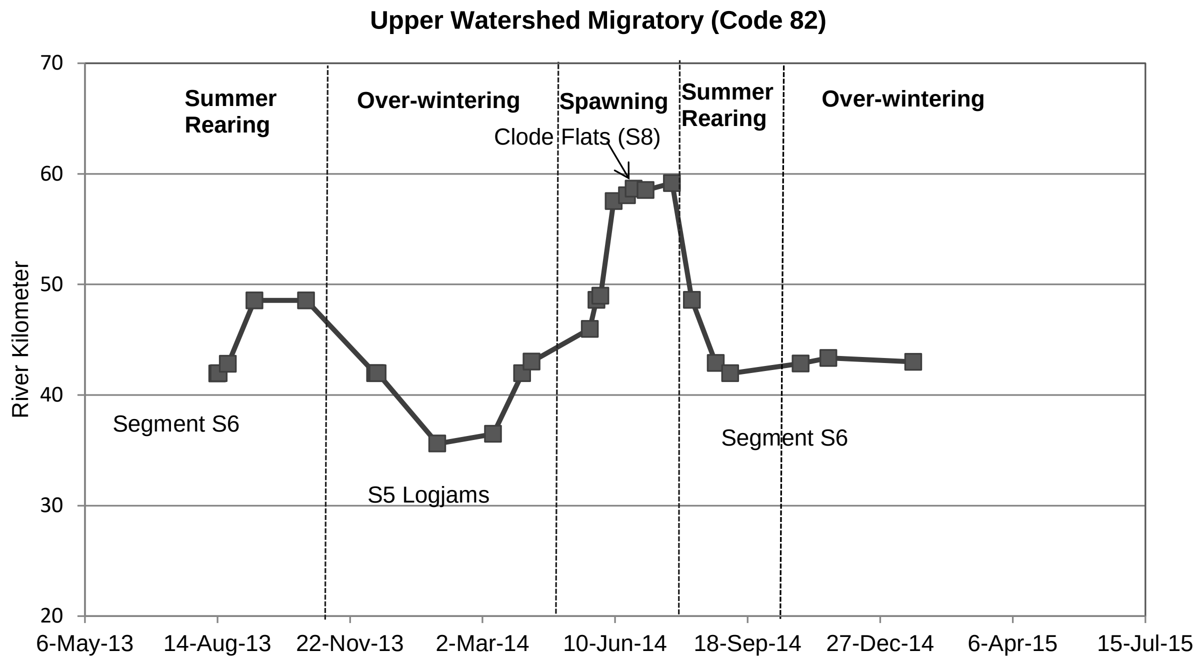


Figure 3.3.4. Radio telemetry data illustrating a representative migratory life history strategy (Code 82) centered around the core areas of the Segment S6 over-wintering area and the FRO Clode Flats spawning area.

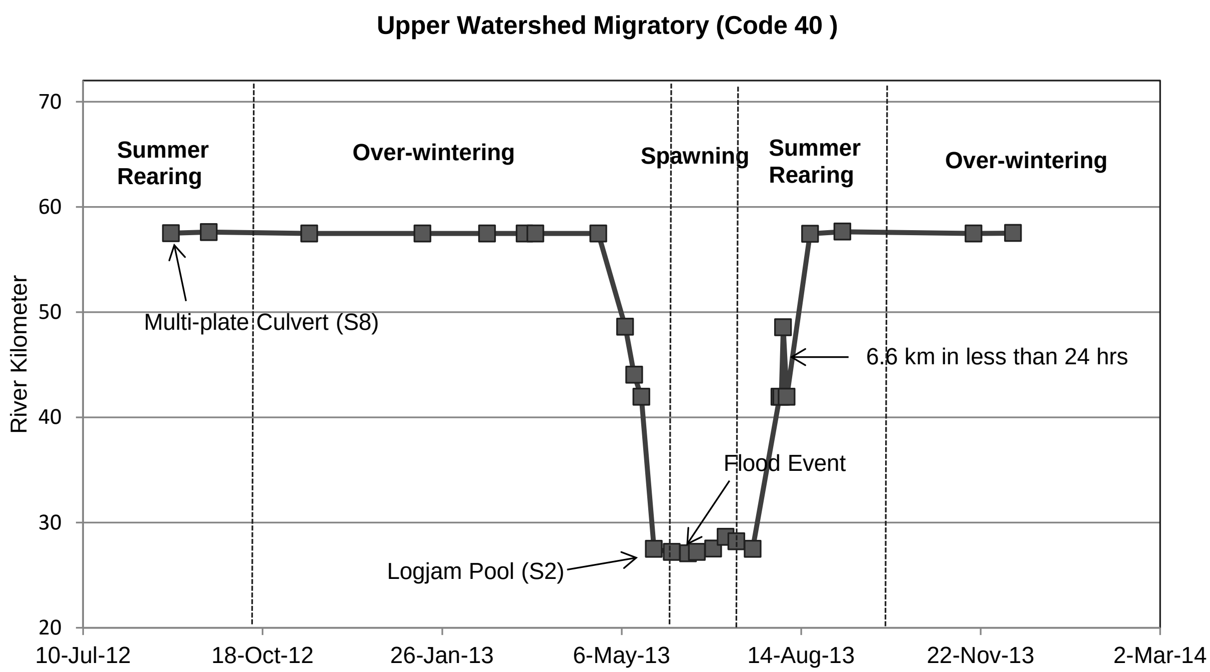


Figure 3.3.5. Radio telemetry data illustrating a representative migratory life history strategy (Code 40) centered around the core areas of the FRO Clode Flats over-wintering area and the GHO Segment S2 spawning area.

Resident Life History Strategy

There were 54 (49%) of radio tagged Westslope Cutthroat Trout that were classified as resident. The home range for these fish averaged 4.6 km +/- 0.6 km 95% confidence interval (range 0.7 km to 8.7 km). These fish predominantly resided within a given river Segment or reach completing all life history requirements (*i.e.,* over-wintering, spawning, rearing) in close proximity to each other. There were three dominant resident life history strategies based on upper, middle or lower watershed residence. The exceptions were two fish radio tagged above the Chauncey Creek highway culvert.

During the course of the Project the Chauncey Creek culvert on the BC Ministry of Highways Fording Road was confirmed to be an upstream fish passage barrier based on multiple lines of evidence and a balance of probability approach (Figure 3.2.13). The lines of evidence included; 1) these telemetered fish and their lack of downstream movement into one of the two dominant over-wintering habitats in the upper Fording River represented by the Segment S6 over-wintering site that was within 1.5 km of these fish but separated (*i.e.,* isolated) by the culvert, 2) the absence of migratory mainstem fish moving up through the culverts in any of the three years despite a large number of radio tagged fish immediately downstream of the culvert in Segment S6 (only 0.9 km downstream from the culvert), 3) the isolated fish above the culvert moved upstream to spawn rather than downstream to the mainstem Segment S6 spawning area (within 3.0 km), and 4) the high densities of juveniles below the culvert and the extremely low densities of juveniles above the culverts (Figure 3.2.11). Note that there was no spawning habitat identified below the culvert (no substrates of small enough size and no fry present) so the juveniles migrated into lower Chauncey Creek (*i.e.,* preferred tributary habitat) from other mainstem habitats but were limited to the habitat below the culvert and did not migrate up through the culvert despite similar preferred juvenile habitat attributes above and below the culvert. This evidence was further supported by the documentation of the preferential use of tributaries by Westslope Cutthroat Trout for spawning and juvenile rearing within similar tributaries in the upper Fording River (and their distribution similarly restricted by culvert or settling pond barriers). The importance and inherent inclination of Westslope Cutthroat Trout to utilize tributaries for spawning and rearing are well documented within the Fording River, other upper Kootenay River tributaries, and within the species literature.

Upper Watershed Residents

The dominant resident life history strategy was upper watershed residency (N=27 or 50% of resident fish). These fish resided within the core area centred around Henretta Pit Lake and

Clode Flats within FRO (upper Segment S8 and lower Segment S9, Figure 3.2.12). The home range for these fish averaged 4.5 km +/- 0.7 km 95% confidence interval.

Henretta Pit Lake represented the predominant over-wintering habitat (74%), followed by the multi-plate culvert plunge pool (14%) in Segment S8, headwaters (7%) Segments S10 and S11 and the Clode Flats (4%) in Segment S8 and S9. Over-wintering site fidelity to Henretta Pit Lake and the multi-plate culvert was 80% in the second winter. Table 3.3.3 illustrates that those fish that did not over-winter in either of these two habitats sustained high mortality rates (note that Henretta Pit Lake and the multi-plate plunge pool represent the only high quality over-wintering pools within FRO with maximum depths of 5 m or more and an absence of anchor ice and dewatering *see* Section 3.4 Habitat Mapping).

The predominant spawning area was the onsite reach identified as the Clode Flats in Segment S8 and S9 extending from the side-channel flowing into lower Lake Mountain Creek (Segment S8, 58.4 rkm) to the Turnbull arch culvert (Segment S9, 61.6 rkm) (Figure 3.2.12). In total, 52% of radio tagged fish classified as upper watershed residents were confirmed spawning in this area (includes Fish Pond Creek, Clode Creek, Clode Exfiltrate, Clode Settling Ponds, side-channel flowing into Lake Mountain Creek). Resident fish also spawned in the lower headwaters (15%). The remaining 33% were undetermined but may have spawned in gravel pockets in places such as the multi-plate culvert plunge pool and the South Tailings Pond Diversion reach. The Clode Flats and its associated tributaries (Fish Pond Creek, Clode Creek, Clode Exfiltrate, Clode Settling Ponds, and the S8 side-channel that flows into Lake Mountain Creek) were also identified as spawning areas in the migratory life history patterns.

These fish reared in a diversity of locations in predominantly pool habitats but were typically centred around the core areas of the approximately 11.0 km of stream channel between the Henretta Pit Lake over-wintering area, the Clode Flats and the South Tailings Pond Diversion (*i.e.,* FRO Onsite Segments S7, S8 and S9 plus Henretta Pit Lake). Figure 3.3.6 illustrates the predominant life history pattern for these fish in terms of periodicity and movement patterns. Henretta Pit Lake fish migrate downstream to spawn in the Clode Flats area; returning to over-winter in Henretta Pit Lake.

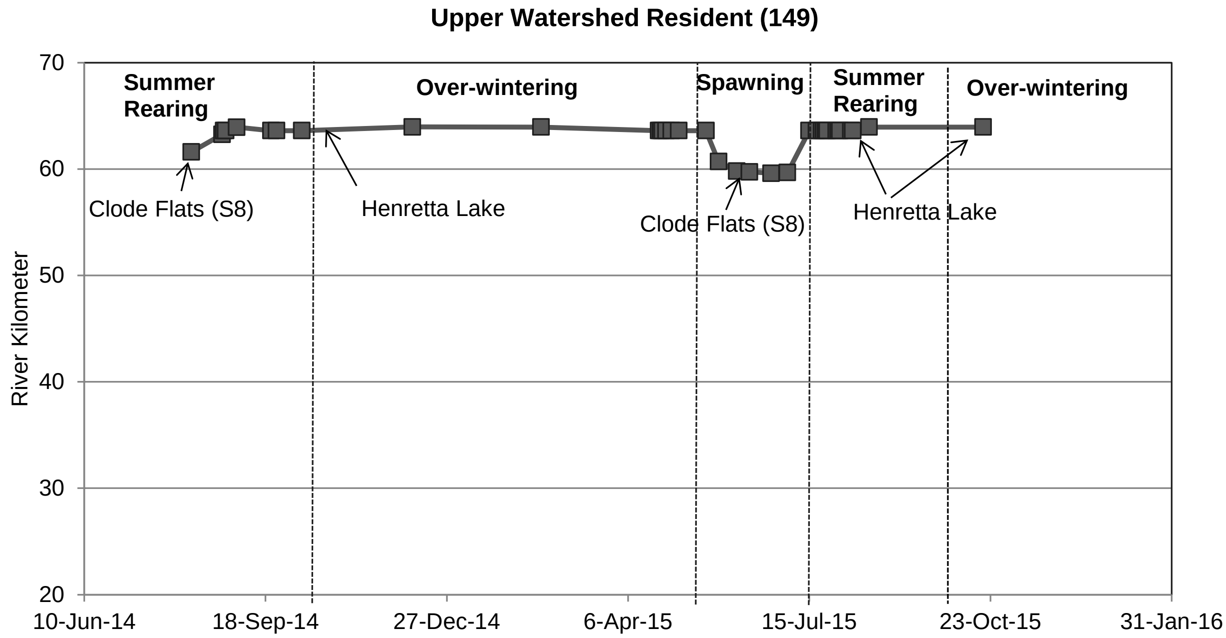


Figure 3.3.6. Radio telemetry data illustrating a representative resident life history strategy (Code 149) centered around the core areas of the FRO Henretta Pit Lake over-wintering site and the Clode Flats spawning area.

Mid-Watershed Residents

The second resident life history pattern was mid-watershed residency (N=14 or 26% of resident fish). These fish resided within the core area centred on river Segment S6 extending from the Chauncey Creek confluence (41.96 rkm) to the groundwater upwelling area (49.00 rkm). The home range for these fish averaged 5.5 km +/- 1.3 km 95% confidence interval.

The Segment S6 oxbow pools were the over-wintering habitat for these fish (100%). The core area extended from 42.10 to 43.66 rkm (71%) but fish were documented as far upstream as 48.00 rkm. Over-wintering site fidelity was 91% in the second winter. Recall that these fish (and a large component of the migratory fish) over-winter as a very large school of fish within the core area (Figure 3.3.1) and experience high mortality rates (Table 3.3.3) presumably due to their attraction to predators and illegal harvest; despite high quality over-wintering habitat attributes such as deep pools, high large woody debris content and groundwater (*see* Section 3.4 Habitat Mapping).

There were two predominant spawning areas within river Segment S6: the spawning sections identified in 44.0 to 45.0 rkm and 47.0 to 48.9 rkm (including the oxbow side-channel). The remaining 7% (n=1) spawned in the vicinity of the large log jam downstream in Segment S5 (37.8 rkm). These spawning sites were also identified in the migratory life history patterns.

These fish predominantly reared in pool habitats within Segment S6 (71%) but were distributed more broadly throughout the segment in riffle-pool segments than during over-wintering. The remaining 29% reared immediately downstream in Segment S5 pool and log jam habitats. Figure 3.3.7 illustrates the predominant life history pattern for these fish in terms of periodicity and movement patterns. Segment S6 fish move upstream short distances to spawn in gravel riffle margins and glides or pool tail-outs.

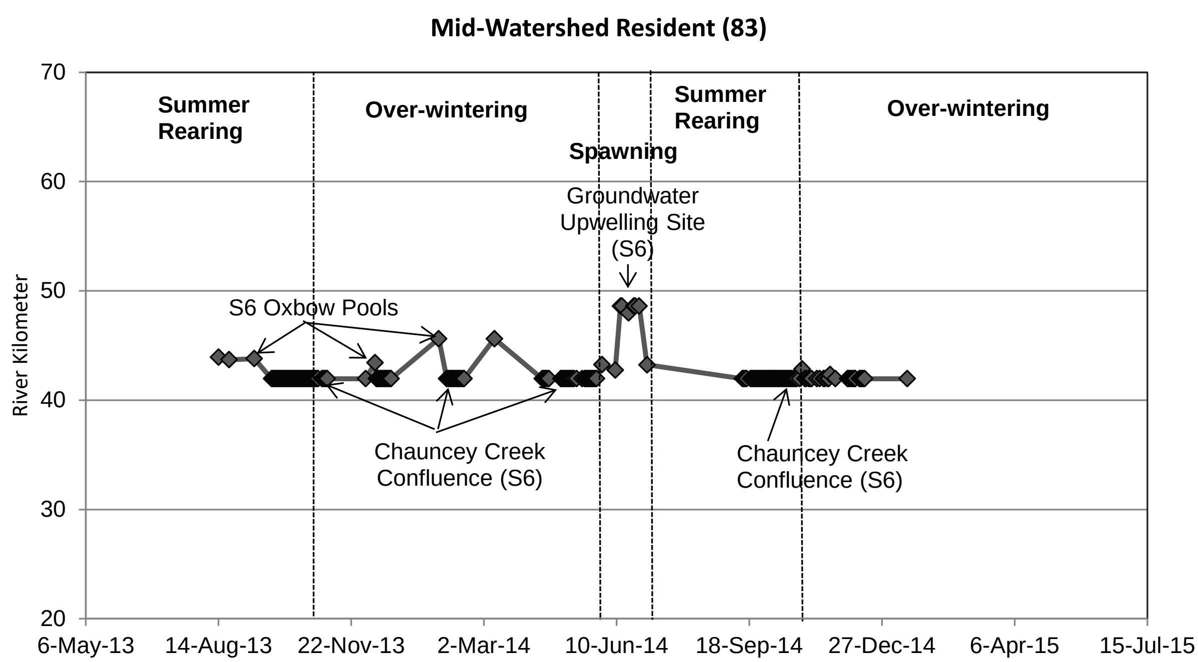


Figure 3.3.7. Radio telemetry data illustrating a representative resident life history strategy (Code 83) centered on the core area of the Segment S6 including the Oxbow pools, Chauncey Creek confluence and the groundwater upwelling area spawning site.

Lower Watershed Residents

The third and last resident life history pattern was lower watershed residency (N=11 or 21% of resident fish). These fish resided within the core areas centred around large log jam complexes as well as Greenhills and Dry Creeks extending from upper river Segment S1 (starting at 24.2 rkm), through river Segment S2 and lower river Segment S3 (ending at 30.5 rkm) within the GHO area. The home range for these fish averaged 3.7 km +/- 1.3 km 95% confidence interval. The 6.3 km of river channel extending from upper river Segment S1 to lower river Segment S3 represents the core area for this life history pattern. These fish over-wintered in log jam and bedrock pools within this area. Over-wintering site fidelity was only 36% in the second winter; although 100% of fish resided within 2.0 km of their previous winter's location. Field observations noted that ice conditions were far more dynamic and over-wintering fish moved among adjacent deep pool units under varying ice conditions.

There were three predominant spawning areas within this range; Greenhills Creek below the Fording Road highway culvert (upstream fish passage barrier) and the mainstem Fording River extending from the Greenhills Creek confluence downstream 1.0 km (82%) (upper limit of river Segment S1), and the 1.0 km upstream and downstream of the log jam complex and split river channel at 27.4 rkm (18%) (river Segment S2). These were also one of the three dominant spawning areas identified in the migratory life history patterns.

These fish predominantly reared in pool habitats associated with large log jam complexes, bedrock outcrops and stream confluences (Greenhills, Dry and unnamed S1 ephemeral creeks) within the 7.7 km of river channel extending from upper Segment S1 to lower Segment S3. In 2012, two radio tagged fish went "missing" from the highway-CPR bridge pools (Segment S2). Anglers were consistently observed in this area over the years and this was another area of suspected illegal harvest. Figure 3.3.8 illustrates the predominant life history pattern for these fish in terms of periodicity and movement patterns.

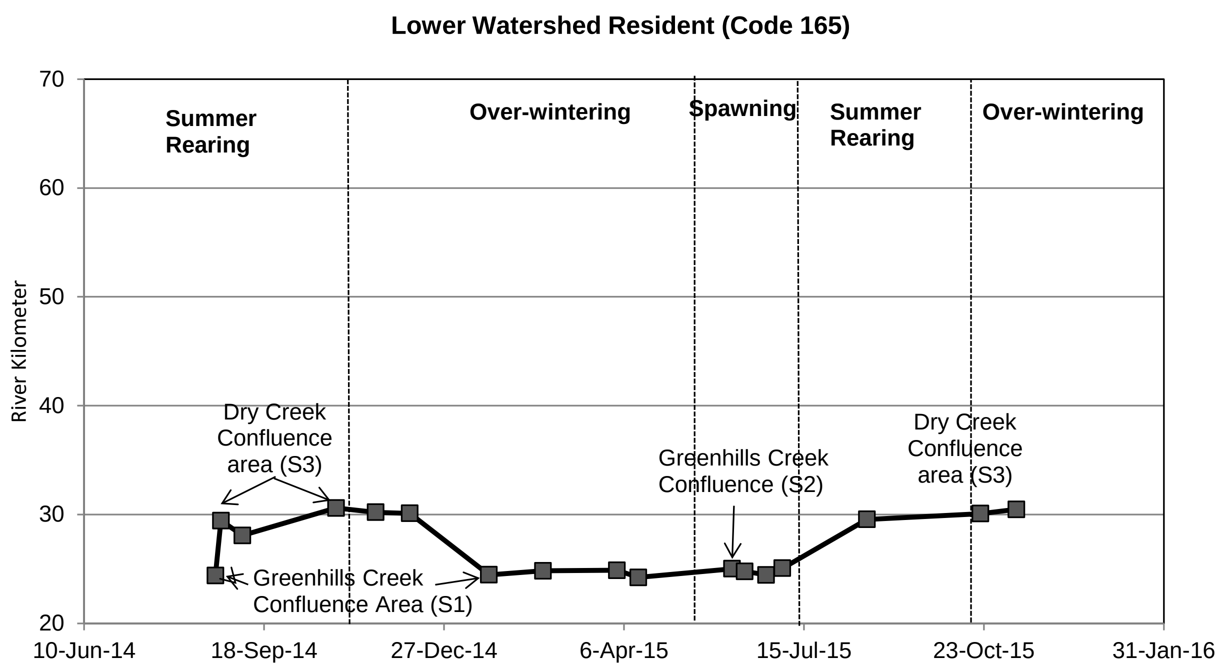


Figure 3.3.8. Radio telemetry data illustrating a representative resident life history strategy (Code 165) centered on the core area of the upper Segment S1 to lower Segment S3 (GHO) over-wintering and spawning areas.

In summary, the overlap in habitat use by both the migratory and resident life history strategies illustrates the high use critical habitat within the upper Fording River. Resident and life history forms both centre around the same core areas with the migratory form moving among at least two of these same areas:

1. *Upper Watershed.*

   The approximately 6.5 km of river Segments S8 and S9 between the Henretta Pit Lake over-wintering area (63.9 rkm) and the multi-plate culvert plunge pool (57.4 rkm), encompassing the Clode Flats spawning and rearing area should be considered as a core population maintenance area (*i.e.,* critical habitat) for both resident and migratory population components. Tributaries (Henretta, Fish Pond and Lake Mountain Creek) and mainstem side-channels in this area represent the highest recorded rearing juvenile densities and form part of this critical habitat.

2. *Mid-Watershed.*

   The approximately 7.0 km of stream channel representing river Segment S6 "ox-bow" over-wintering pools, the riffle-pool rearing areas and the spawning sites identified between the oxbow pools at 43.5 to 44.5 rkm and the groundwater upwelling area between 47.0 and 49.0 rkm (including the side-channel in this same area) should be considered as a core population maintenance area (*i.e.,* critical habitat) for both resident and migratory population components. Chauncey Creek represents the only tributary habitat and high juvenile densities support the inclusion of this habitat as part of the critical habitat.

3. *Lower -Watershed.*

   The approximately 6.3 km of stream channel extending from upper river Segment S1 (24.2 rkm) through lower Segment S3 (30.5 rkm) within the GHO area, encompassing the Segment S2 log jams, Greenhills and Dry Creeks should be considered as a core population maintenance area (*i.e.,* critical habitat) for both resident and migratory population components. Log jam, bedrock pools and stream confluences within this area represent critical over-wintering, spawning and rearing habitat. Greenhills Creek, the mainstem Fording River at Greenhills Creek, Dry Creek and the large log jam complexes in this area represent critical spawning and juvenile rearing habitat within this core area (*i.e.,* critical habitat).

The seasonal distribution and habitat use of the above over-wintering, spawning and summer rearing habitats are discussed further in the following section. Distribution maps and representative photographs are included for reference.

3.3.1.6.Seasonal Distribution and Habitat Use

The seasonal distribution of radio tagged fish (Question 7 – What is the seasonal distribution?) was used to identify aggregations or high utilization areas that by inference represent "preferred" or critical habitat. To address, "What are the movement patterns and why?" (Question 6), seasonal distribution was examined with respect to the important life functions of over-wintering, spawning and summer rearing. High utilization areas were ground-truthed to identify habitat use (*i.e.,* identification of redds, direct observations of animals constructing nests, ground-water over-wintering, actively feeding animals). Where visual confirmation was not possible, multiple lines of evidence (repeating spatial and temporal movement patterns, adult physical examinations, fry capture data) were used to infer use and identify critical habitats (Question 5 – What are the critical habitats in the study area?). Habitat features that are important for the survival and recovery of a species are referred to as critical habitat (SARA), namely: spawning, over-wintering and summer rearing habitats and migration corridors.

Representative seasonal movement patterns for the diversity of life history strategies identified were presented in Figures 3.3.4 through 3.3.8. During April and May there was a movement period that coincided with rising water temperatures (Figure 3.1.3) and shortly thereafter with increasing flows (Figure 3.1.2). Peak spawning in the Fording River Westslope Cutthroat Trout population occurred between late May (Greenhills Creek) and mid-July (Clode Flats) on the descending limb of the hydrograph and mean daily water temperatures in the 6 ^{0}C to 10 ^{0}C range. This period was consistent with other high elevation Westslope Cutthroat Trout populations in the East Kootenay Region (*i.e.,* Bull River, Cope and Prince 2012) and elsewhere in their geographic range (Muhlfeld *et al.* 2009). Summer rearing extended from mid-July through August and then during September there was a movement period that coincided with declining temperatures. By mid-October fish were typically in their over-wintering habitats where they remained until late March. Water temperature provides important cues for Westslope Cutthroat Trout to elicit behaviours which maximize survival in dynamic environments (*i.e.,* Rocky Mountain riverine) and limit genetic introgression by offsetting their reproductive timing from sympatric species (Muhlfeld *et al.* 2009).

3.3.1.6.1.Spawning

Spawning locations were identified through visual observations of redds, nest construction, and spatial and temporal adult movement patterns. Spawning use of these locations was supported by captures of emerging fry in these same locations (Table 3.2.28). While the June 20-22, 2013 flood event disrupted spawning and prevented visual redd observations due to high and turbid flows, redds and nest construction were visually observed in 2014 and 2015. The 2015 spawning season was exceptionally productive in this regard due to the low snowpack in 2014-15 and the low incidence of spring precipitation (Figure 3.1.2). We observed typical salmonid mating groups of one female (actively constructing a nest), one alpha male (quivering the female and defending her against other males) and one or two satellite males in areas with high densities of redds (Healey and Prince 1998). High density spawning areas (*i.e.,* critical habitat) were identified in tributaries, side-channels and mainstem habitats.

Direct observations of mating behaviour and redds in 2015 corroborated telemetry data (repeating movement and residence patterns during the spawning season) that was used to infer spawning within these areas in 2013 and 2014. The seasonal distribution of radio tagged fish during the peak spawning period (mid to late June) was consistent with the redd observations in 2014 and 2015 (Figure 3.3.9, Figure 3.3.10). Furthermore, the telemetered spawning locations were consistent across years indicating a high degree of site fidelity to spawning habitats (Figure 3.3.10). These behaviours support reproductive homing and site fidelity in Westslope Cutthroat Trout, a trait commonly observed among *Oncorhynchus* spp. that have evolved in dynamic Western North America environments (Waples *et al.* 2008).

To avoid pseudo-replication and better qualify the degree of use (*i.e.,* high vs low), only one spawning location was associated with each telemetered fish presented in Figure 3.3.10; however, it was important to note that in salmonid mating systems males often spawn with multiple females and are expected to have more than one spawning location (Healey and Prince 1998). Therefore, the data presented here underestimates the spawning habitat used by the telemetered study population. Review of individual movement data was consistent with such strategies. For example, Code 188 moved between the side-channel and the mainstem river spawning sites in upper river Segment S6 several times. Redds were identified at both locations. Also note that previously these side-channel complexes were referred to as “oxbows” and lentic habitat with beaver dam and log jam “barriers”. Clearly this was not the case and log jams and beaver dams are not typically barriers to Westslope Cutthroat Trout (Prince and

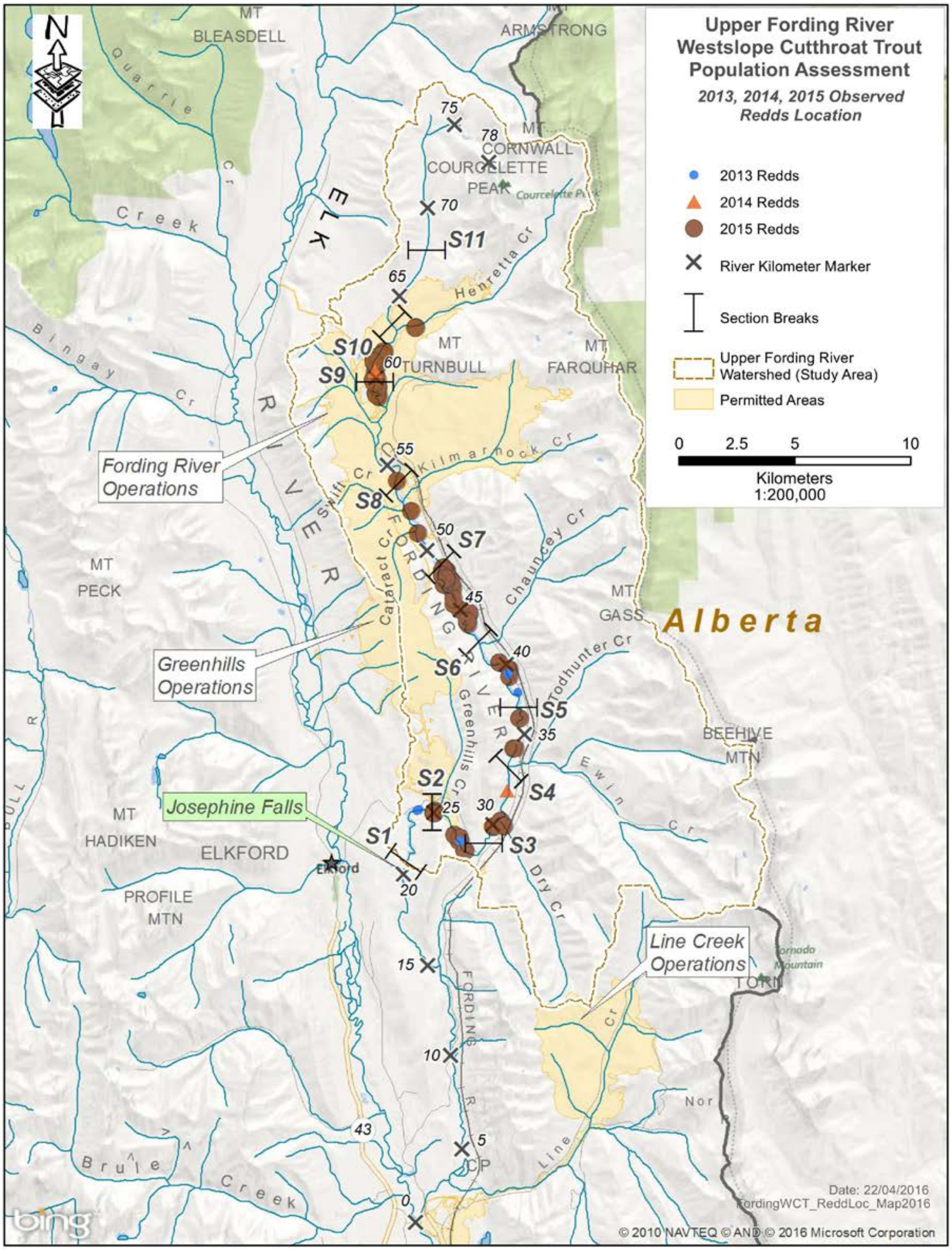


Figure 3.3.9. Observed Westslope Cutthroat Trout redd locations in the upper Fording River (2013-2015). Note low snowpack and reduced freshet flows in 2015 improved visibility at a time (June) when visual observations are normally limited.

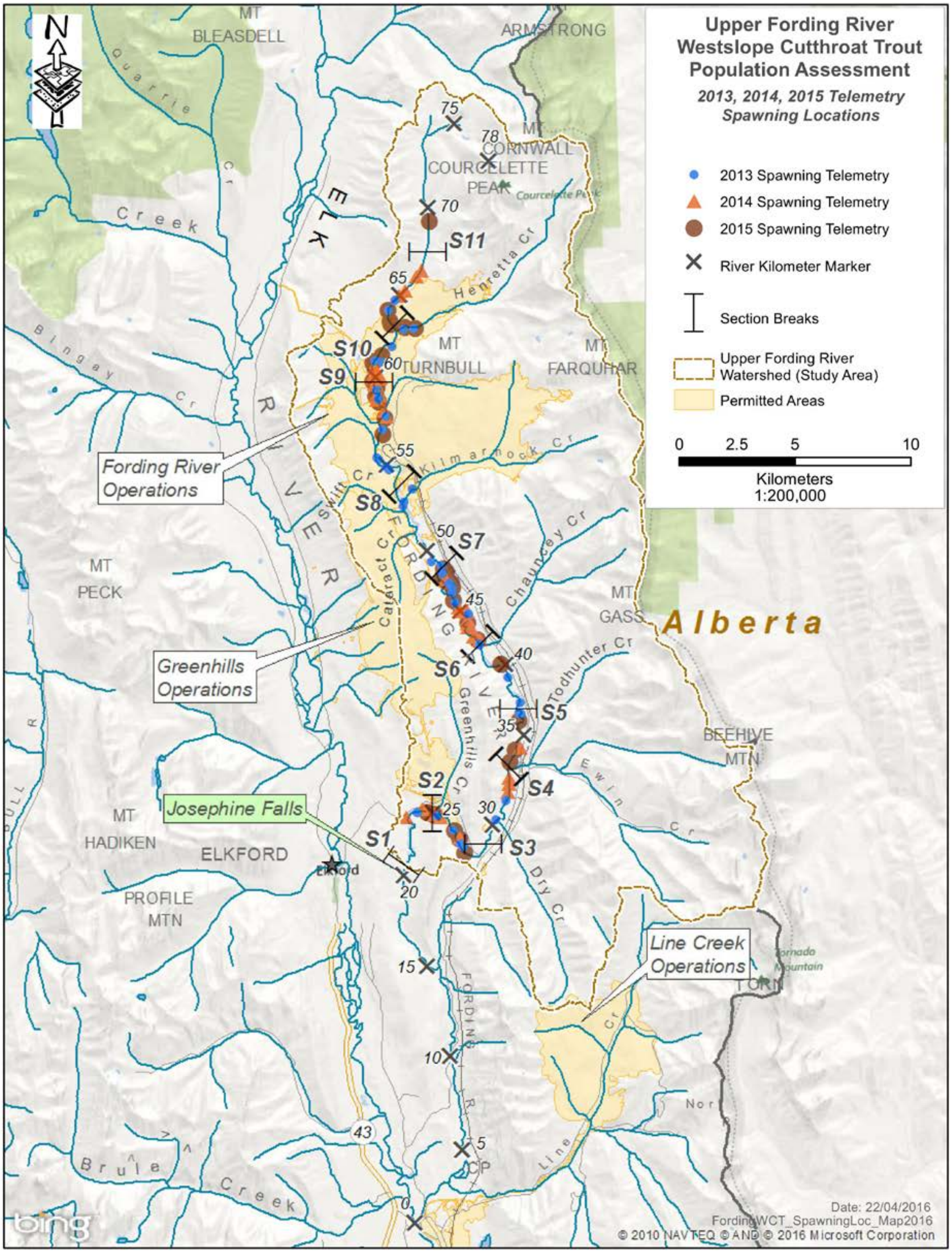


Figure 3.3.10. Westslope Cutthroat Trout spawning locations determined using radio telemetry in the upper Fording River (2013-2015).

Morris 2003), other sub-species of cutthroat trout (Lokteff *et al.* 2013), or Bull Trout (Prince 2010); all are species that have co-evolved with beavers in these environments.

To summarize, the results of the spawning distribution are presented in Figures 3.3.9 and 3.3.10 and illustrate diversity in spawning habitat type and location. There were mainstem, mainstem side-channel, mainstem braided channel, tributary and pond locations where spawning was documented. The diversity in the high density spawning locations (*i.e.,* critical habitat) was briefly described below.

1. *Clode Flats and associated remnant tributary habitat:* The core spawning area was the mainstem river, side-channels and associated remnant tributary habitat (Fish Pond Creek, Clode Creek, Clode Exfiltrate Creek and the side-channel flowing into lower Lake Mountain Creek) of the Clode Flats area between Lake Mountain Creek (Segment S8, 58.4 rkm) and the Turnbull arch culvert (Segment S9, 61.6 rkm). Clode Flats has apparent groundwater influx and suitable substrates for spawning and incubation habitat with resulting high fry and juvenile densities (Table 3.2.28); despite the mainstem stream channel being assessed as degraded during ground-truthing (*see* Section 3.4 Habitat Mapping). Fish Pond Creek, certain features within the Clode settling pond system and Clode Pond outflows have previously been identified as spawning habitat (Oliver 1999, Amos and Wright 2000, Wright *et al.* 2001). Clode Pond itself was unsuitable spawning habitat as it represents a permitted settling pond with high selenium concentrations (Windward Environmental *et al.* 2014). In spite of constructed fish barriers telemetered adults were documented migrating into Clode Pond (2014), and redds were observed (2015). Additional measures have since been implemented to prevent further access into the pond. Clode Creek and Clode exfiltration flows represent receiving environments for settling pond outflows with water quality concerns (Windward *et al. 2014*). The side-channel that flows into Lake Mountain Creek has subsequently been isolated and dewatered by riprap infrastructure protection works.
2. *The Segment S6 groundwater upwelling area and side-channels:* Downstream of the southern FRO property boundary groundwater upwelling has been confirmed within upper Segment S6 at 48.6 rkm (Monitoring Station F2, *see* Section 3.1.2 water Temperature). The core high density spawning area lies between 47.0 and 49.0 rkm within upper Segment S6 and includes the side-channel formerly known as the oxbow. Figure 3.3.11 illustrates this spawning habitat which was characterized by a river channel and meso-habitat features that support spawning and staging behaviours in

Westslope Cutthroat Trout (*i.e.,* riffle-pool gravel channel with high quality fish habitat features, *see* Section 3.4 Habitat Mapping). Fry were observed in channel margins within these areas during all three years and had moderate densities during electrofishing in 2015 (Table 3.2.28). Lister and Kerr Wood Leidal (1980) previously identified Westslope Cutthroat Trout spawning habitat in this area of the river.

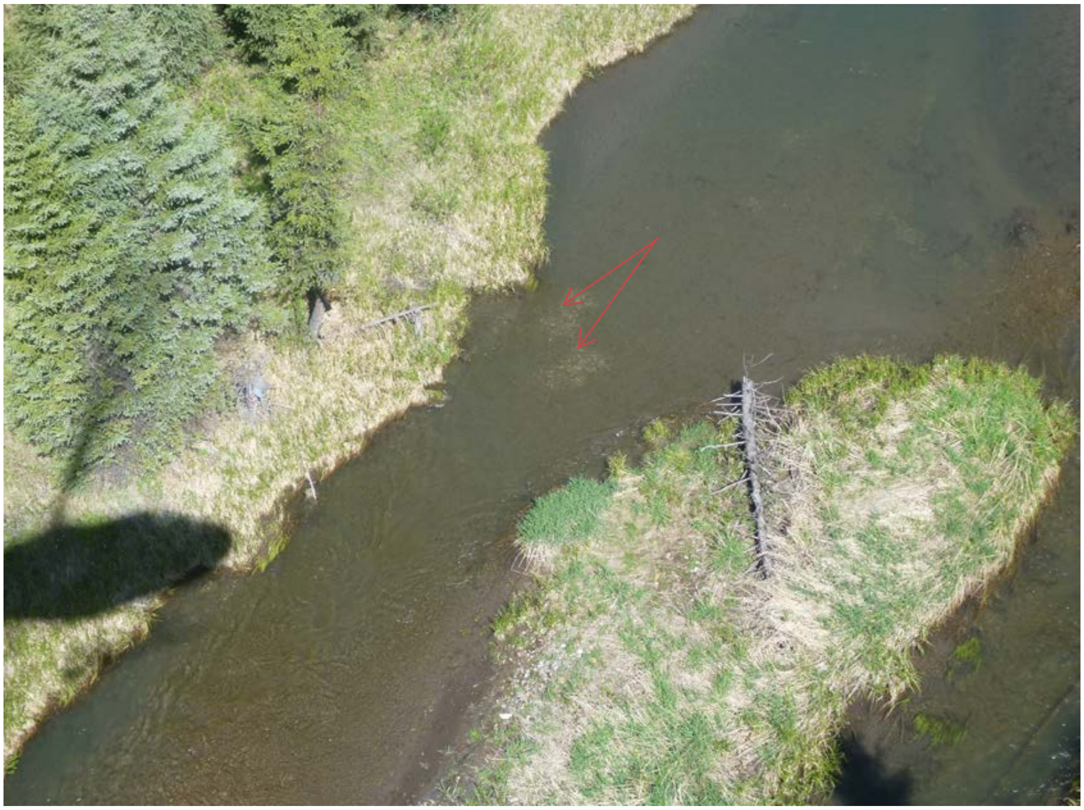


Figure 3.3.11. Westslope Cutthroat Trout redds identified by the arrows. Redds were observed June 06, 2015 in the oxbow side-channel immediately below the F2 monitoring Station. This habitat had a very large channel spanning log jam at the inlet and a beaver dam at the outlet. Telemetry data and direct visual observations confirmed fish moving between redds at this site and adjacent mainstem sites. The log jam provided holding cover for staging adults and staging adults were documented at this site in previous years during higher turbidity that prevented direct redd observations (2013, 2014).

3. *Segment S6 Fording River Oxbow:* Spawning aggregations (2013, 2014, 2015) and redds (2015) were identified within a gravel reach between 44.0 to 44.5 rkm immediately upstream of Chauncey Creek (Figure 3.3.12). This site was bounded by over-wintering oxbow habitat both upstream and downstream. Groundwater influence, though attenuated, was still identifiable (Figure 3.1.3a, Monitoring Station S6). This habitat was characterized by clean, ideally sized spawning substrate with low compaction and

abundant holding cover for staging adults within an old growth forest setting (undercut banks, overhanging vegetation and large woody debris).

Figure 3.3.12. Large Westslope Cutthroat Trout redd at 44.0 rkm (May 28, 2015) illustrating supporting habitat features of overhanging cover, undercut bank and gravels.

4. *Mid-River Log Jams*: There were five very large channel spanning log jams that resulted in channel diversity, holding cover and gravel substrates ideal for spawning. There were two in Segment S5 (39.5 rkm, 37.3 rkm), two in S4 (37.0 rkm, 34.5 rkm) and one in S3 below Ewin Creek (32.5 rkm). These areas were identified through telemetry data and redds were identified by helicopter in 2013 and on foot in 2015 (Figures 3.3.9 and 3.3.10). Visual observations of redds near log jams were hindered by the increased water depth and the large amounts of wood associated with these habitats. These logjams were similar in nature to the lower river logjams illustrated below.

5. *Dry Creek and Segment S3 (30.0 to 32.0 rkm).* Radio tagged fish were located in the mainstem river immediately adjacent to Dry Creek during the spawning period in all three years of monitoring (Figure 3.3.10). In 2015, redds were observed distributed up to the highway-CPR culvert barriers (Figure 3.3.9).

Larger redds were located near the confluence while smaller redds were noted further upstream. Fry were also captured at these sites during juvenile electrofishing (Table 3.2.28).

6. *Lower River Log jams:* Similar to mid-watershed log jams these were very large, typically channel spawning log jams within upper Segment S1 (24.2 rkm) and Segment S2 (25.8, and 27.4 rkm; Figure 3.3.13). Staging habitats included the log jam pool itself and adjacent pools within one km immediately upstream and downstream. Clearly identified spawning migrations and resident behaviour identified spawning habitats. Redds were observed at 24.1 rkm, 24.2 rkm and 27.2 rkm with the highest densities at 27.2 rkm (Figure 3.3.9). Fry were captured in adjacent habitats (Table 3.2.28).

Figure 3.3.13. Example of a channel spanning log jam illustrating the amount of large woody debris and extent of these features. Note the water flowing under the log jam reaches estimated maximum depths of 5 m. inevitably, there are gravel deposits and split channels or side-channels associated with these features also.

5. *Greenhills Creek:* The highest densities of redds observed within a tributary occurred in Greenhills Creek. Redds were distributed from the confluence upstream approximately 0.5 km to the highway culvert which was a barrier to further upstream migration. Telemetered adults were observed staging at the confluence of Greenhills Creek in all three years (2013, 2014, 2015) and may have also spawned within mainstem habitats immediately upstream and downstream (Figure 3.3.10). Greenhills Creek spawning sites represent receiving environments for settling pond outflows immediately upstream with water quality concerns (Windward *et al. 2014*). Unlike other high density redd sites documented in the watershed (*i.e.,* Lake Mountain Creek, Clode Flats, Segment S6) there were few fry captured in Greenhills Creek (Table 3.2.28). This result may be indicative of poor incubation survival.

High density spawning sites summarized above support both migratory and resident life history forms and were recommended for consideration as critical habitat. The distribution of redds (Figure 3.3.9) and telemetry locations (Figure 3.3.10) during spawning were combined to illustrate this combined distribution as occupancy rates of Westslope Cutthroat Trout available habitats in the Fording River and its tributaries during the spawning period in 2013, 2014 and 2015. Areas of high occupancy appear red to yellow with lower occupancy rates in green. Occupancy was defined as an observed redd or a telemetered position (one point per radio tagged fish) during the spawning period (Figure 3.3.14).

There were several unique spawning migrations noted in the following that were documented and assumed to represent the expression of life history diversity that was still present as inherent inclinations within at least some proportion of the population.

Fry were observed at the Henretta Pit Lake outlet in 2013 and two redds were observed in shoals in Henretta Pit Lake at the upper Henretta Creek inflow to Henretta Pit Lake in 2015. This was suggestive of a resident life history form present in very low numbers such as that identified in Chauncey Creek above the culvert barrier.

In 2013 two mature fish were radio tagged above the Chauncey Creek culvert. These fish were representative of a fragmented or isolated (resident) life history form *(see* Section 3.3.1.5 Life History Strategies). In the spring of 2014, these fish moved upstream during spawning season; presumably to spawn.

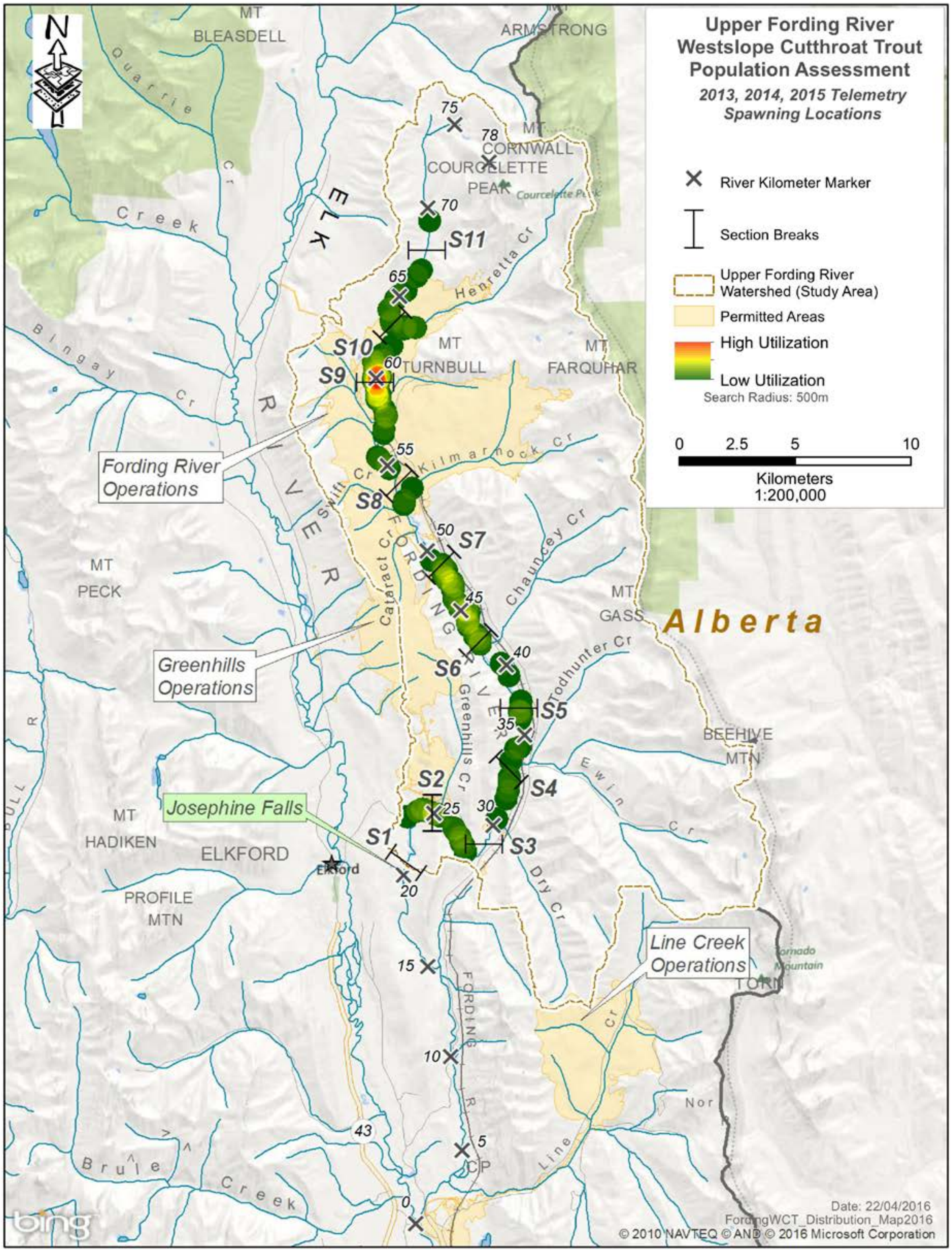


Figure 3.3.14. Westslope Cutthroat Trout occupancy rates of available habitats in the Fording River and its tributaries during the spawning period in 2013, 2014 and 2015.

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In the spring of 2013, several telemetered fish migrated to the confluence area of Kilmarnock Creek (Figure 3.3.10) and one (Code 33) by-passed the concrete fish barrier and entered the Kilmarnock Creek settling pond during high flood flows (spring freshet). Subsequently, as the settling pond began to dewater, a collection of three Floy tags and radio transmitter Code 33 were discovered 400 m upstream at the Kilmarnock Creek inflow to the settling pond. Upon examination, it appeared the tags were passed through the digestive track of an otter (several otters were noted in the study area and investigation found tracks in this area). Kilmarnock Creek has previously been identified as supporting mature trout during spawning season and was likely a spawning tributary (Lister and Kerr Wood Leidal, 1980). Subsequent repairs to the fish barrier of the pond outflow eliminated further excursions of radio tagged fish into Kilmarnock Pond in 2014 or 2015; although a redd was observed in the Fording River at the outflow in 2015 (Figure 3.3.9).

Westslope Cutthroat Trout belong to the family Salmonidae and as such, have a strong propensity for reproductive homing in their biology (Homel *et. al.* 2015, Waples *et al.* 2008). It is also well documented within the literature that they have a propensity to utilize tributaries for spawning (McPhail 2007, Prince and Morris 2003, Liknes and Graham 1988). Regardless of land use practices, salmonids will home to natal spawning tributaries that may no longer be suitable. These reproductive behaviours result from thousands of years of selective pressures, an evolutionary history that is not altered on a time scale of decades in regard to anthropomorphic landscape changes (Waples *et al.* 2008). Their homing behaviour leaves local populations at risk of extirpation when critical habitats are degraded or barriers erected that prevent access.

Currently, seven tributaries of note (or their remnant exfiltration flows) have been identified as spawning tributaries (redds and/or fry present). These include Henretta Creek, Fish Pond Creek, Clode Creek, Lake Mountain Creek, Kilmarnock Creek, Dry Creek and Greenhills Creek. An eighth tributary, Chauncey Creek contains a remnant, fragmented (*i.e.,* isolated and low density) population above the culvert as do, Greenhills Creek (Beswick 2007), Dry Creek (Interior Reforestation 2000), and Kilmarnock Creek (Arnett and Berdusco 2008). Seven of these eight tributaries identified as spawning tributaries have fish barriers (both specifically constructed fish barriers and inadequately designed culverts) within 30 m to 1.0 km of their confluence. Although each individual habitat loss (impassable culvert) may have a relatively small population effect, the cumulative effect of many small migration blockages in dynamic environments has important consequences by reducing life history diversity and creating small, fragmented remnant populations in tributaries with a resultant loss in population resilience, and abundance. Loss of connectivity and population fragmentation is a generally recognized threat of anthropogenic origin that has led to the decline in numbers of Westslope Cutthroat Trout in western Canada over the past 125 years (Isaak *et al.* 2012, Cleator *et al.* 2009, Mayhood 2009, Oliver 2009, Muhlfeld *et al.* 2009, Shepard *et al.* 2005, 1997).

In addition, the remaining remnant tributary habitat below barriers for five of these eight spawning tributaries represent receiving waters from settling ponds immediately upstream (Clode Creek, Lake Mountain Creek, Kilmarnock Creek, Dry Creek, and Greenhills Creek). Water quality concerns threaten this critical habitat (Windward *et al.* 2014). In addition to elevated water quality constituents of concern identified by Windward *et al. (*2014), the study team identified elevated rates of total dissolved solids (TSS) on a number of occasions and this results in precipitation of fine particulates and is a concern for incubation success and fry rearing within the substrate interstitial environment (Figure 3.3.15).

Figure 3.3.15. Redd site within the Greenhills Creek spawning habitat illustrating the effect of settling pond outflows (fine particulate and calcite precipitation). Note the photo was taken 130 days (October 5, 2015) after redd construction (May 28, 2015). Observed conditions were not considered conducive to successful embryo incubation or fry rearing and electrofishing results (Table 3.2.28) provide supporting evidence for this assessment.

3.3.1.6.2.Over-wintering

For the purposes of this discussion, over-wintering periodicity was defined as November 1 through February 28. This represents the heart of the over-wintering period and excludes the "shoulder" seasons of October and March to facilitate the evaluation of critical over-wintering habitat. To avoid pseudo-replication and better qualify the degree of use (*i.e.,* high vs low), only one over-wintering location was associated with each telemetered fish for each winter. Fish still at large in the second year of over-wintering were included to augment sample size and to provide for an evaluation of over-wintering site fidelity (*i.e.,* homing).

Recall that the availability, quality, quantity and distribution of over-wintering habitat is frequently limited for this species and, therefore, often disproportionately important habitat (*i.e.,* critical habitat) for survival and recovery of Westslope Cutthroat Trout populations in general (Cleator *et al.* 2009). Over-wintering habitat usually consists of deep pools, groundwater influx, or both, and an absence of anchor ice (Cope and Prince 2012, Brown *et al.* 2011, Morris and Prince 2004, Prince and Morris 2003, Brown and Stanislawski 1996, Brown and Mackay 1995, Boag and McCart 1993). These features are frequently limited in distribution in many stream networks (Cleator *et al.* 2009).

In total, 247 individual over-wintering locations were identified using telemetric methods; 163 in their first winter at large and an additional 84 (52%) in their second winter. Over-wintering movements by Westslope Cutthroat Trout were extremely limited, contrary to their predominantly migratory fluvial life history (mean home range 11.5 km +/- 1.5 km 95% C.I.). For example, in 2012, over-wintering movements averaged 1.1 km +/- 0.5 km 95% C.I. (range 0.0 – 10.5, n= 54) and in 2013 averaged 1.3 km +/- 0.6 km 95% C.I. (range 0.0 – 9.4, n= 49). Over-wintering site fidelity for radio tagged Westslope Cutthroat Trout in their second year was 62% (n=52).

Figure 3.3.16 illustrates the distribution of all 249 over-wintering locations confirmed through radio telemetry. Repeating patterns of over-wintering by telemetered fish from all three years (*i.e.,* cohorts) occurred in four areas; 1) Henretta Pit Lake (1.0 km upstream from the Henretta confluence in river Segment S9 at 62.9 rkm), 2) FRO river Segments S8 and S9 in the Clode Flats (58.4 rkm to 61.6 rkm) and the multi-plate culvert plunge pool (Segment S8, 57.5 rkm), 3) river Segment S6 oxbows (42 rkm to 48 rkm), and 4) the GHO area river segments from upper Segment S1 (24.2 rkm) through lower Segment S3 (30.5 rkm) log jams and bedrock pools. These habitats supported both migratory and resident life history forms (*see* Section 3.3.1.5 Life

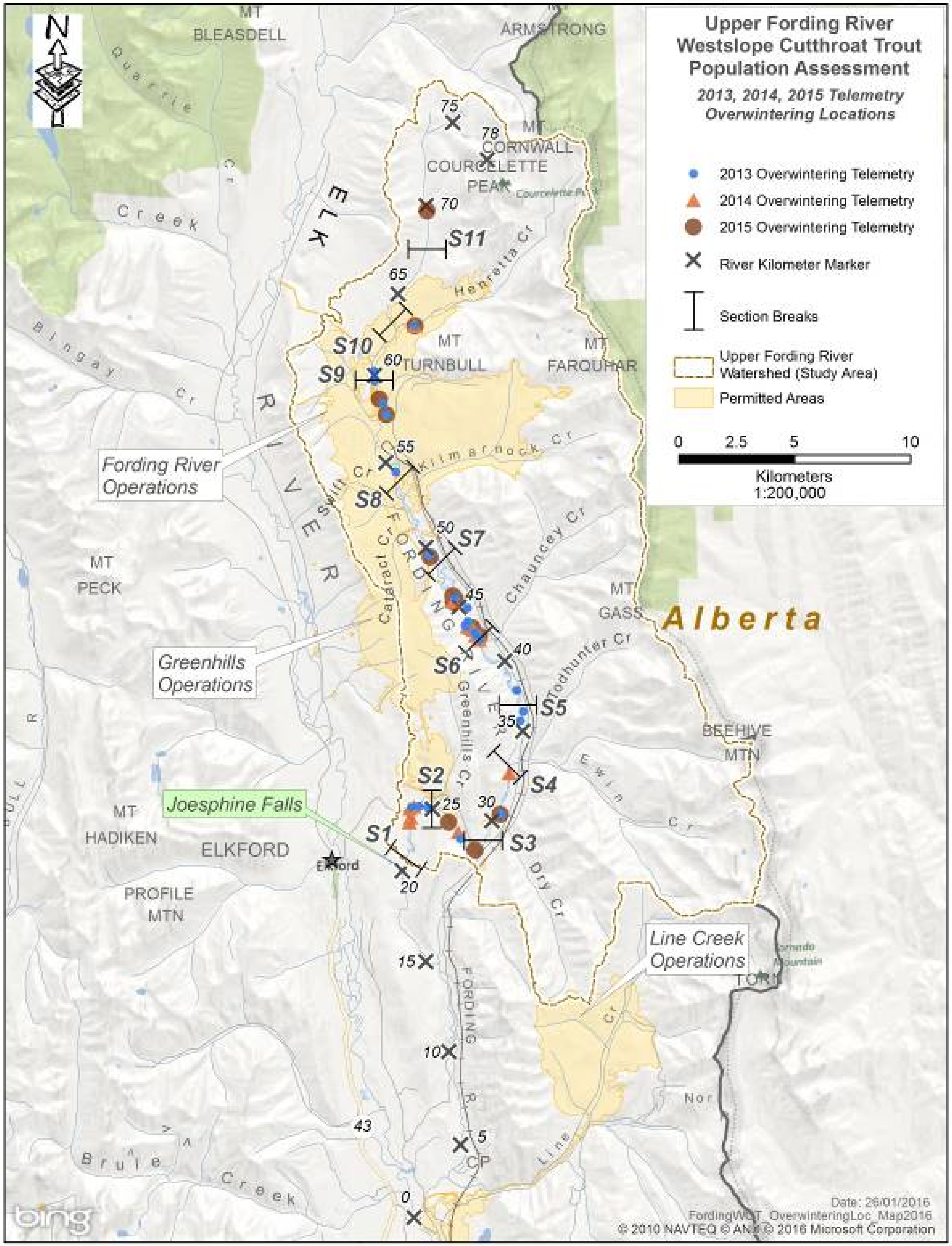

Figure 3.3.16. Westslope Cutthroat Trout over-wintering locations within the Fording River and tributaries during the over-wintering period in 2013, 2014 and 2015.

History Strategies). These four areas or meso-habitat units represent approximately 11.2 lineal kilometers of mainstem and tributary habitat representing approximately 20% of the total available habitat within the distribution documented (55.8 km). These habitats support 90% of the upper Fording River over-wintering population (Figure 3.3.17). The critical importance of Henretta Pit Lake in the survival of FRO fish populations was illustrated by converting the frequency data for each over-wintering area into a density metric (Figure 3.3.18).

Current over-wintering distribution differs from historically documented distribution and was reflective of the loss of historical over-wintering tributaries (Kilmarnock and Clode Creeks) and large log jam mainstem pool habitat within the FRO area. Fording Coal Limited (1985) demonstrated that fluvial migratory over-wintering populations existed in Kilmarnock Creek and the Clode Flats (including Clode Creek). For example, 45% of over-wintering fish enumerated in the FRO area in 1983 over-wintered in Kilmarnock Creek (37%) and Clode Creek (8%). These fish were confirmed to migrate out to spawn and summer rear elsewhere. These studies were supported by similar conclusions from previous studies (Norecol 1983, Lister and Kerr Wood Leidal 1980, BC Research 1979 cited in Fording Coal 1985). Groundwater influences were suspected in both tributaries.

In addition to lost tributary over-wintering habitat, mainstem Fording River stream channels within FRO have been identified as degraded and limiting in habitat features necessary for Westslope Cutthroat Trout over-wintering (Segments S7 through S9, *see* Section 3.3.4 Habitat Mapping). In addition, river diversions and log jam removal have further reduced the over-wintering potential of these river reaches within FRO (Wood 1978).

The cumulative impact of these over-wintering habitat losses threaten population resilience for fish residing within the FRO area. Fish are all “concentrated” into one habitat (Henretta Pit Lake) creating a habitat limitation and capacity “bottleneck”. Henretta Pit Lake represents constructed habitat to specifically address this limitation; and in that regard was successful. However, at the population scale, expression of multiple life history forms or use of multiple locations increases the probability that some component of the population will successfully reproduce in a given year. Over time, risk spreading and bet hedging result in selection for multiple life history forms and provide a greater range of opportunities for population resilience in a spatially and temporally variable environment. Any disturbance at the local scale that impacts Henretta Pit Lake will have serious and significant population impacts. This threat is exacerbated by the culverts immediately downstream of Henretta Pit Lake (Figure 3.2.14). The

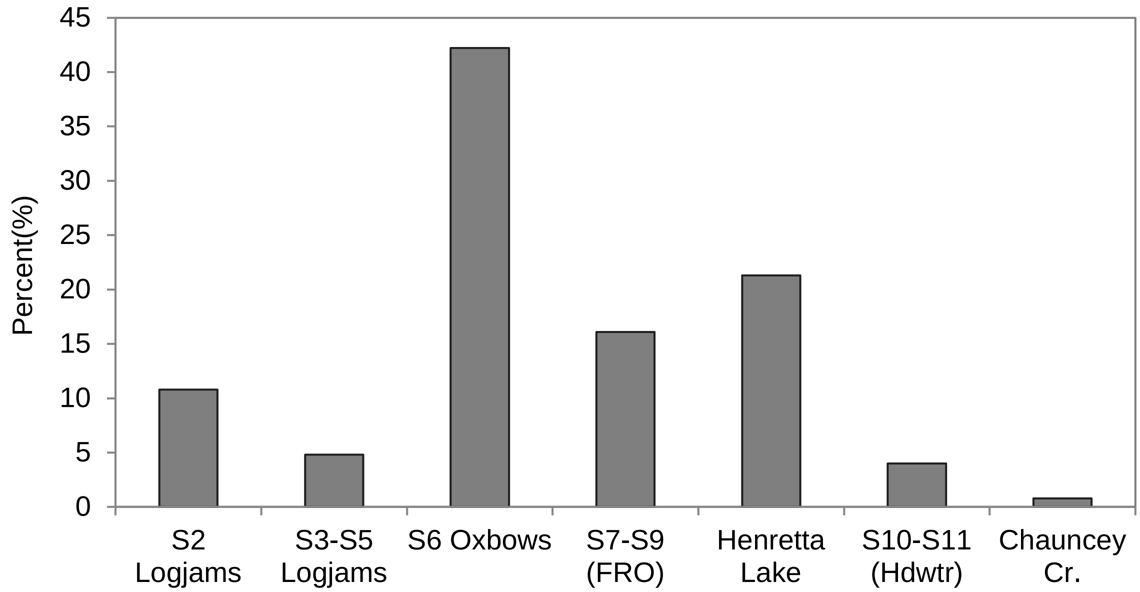

Figure 3.3.17. Frequency (%) of over-wintering radio tagged Westslope Cutthroat Trout (N=249) within watershed features for the upper Fording River 2012-15.

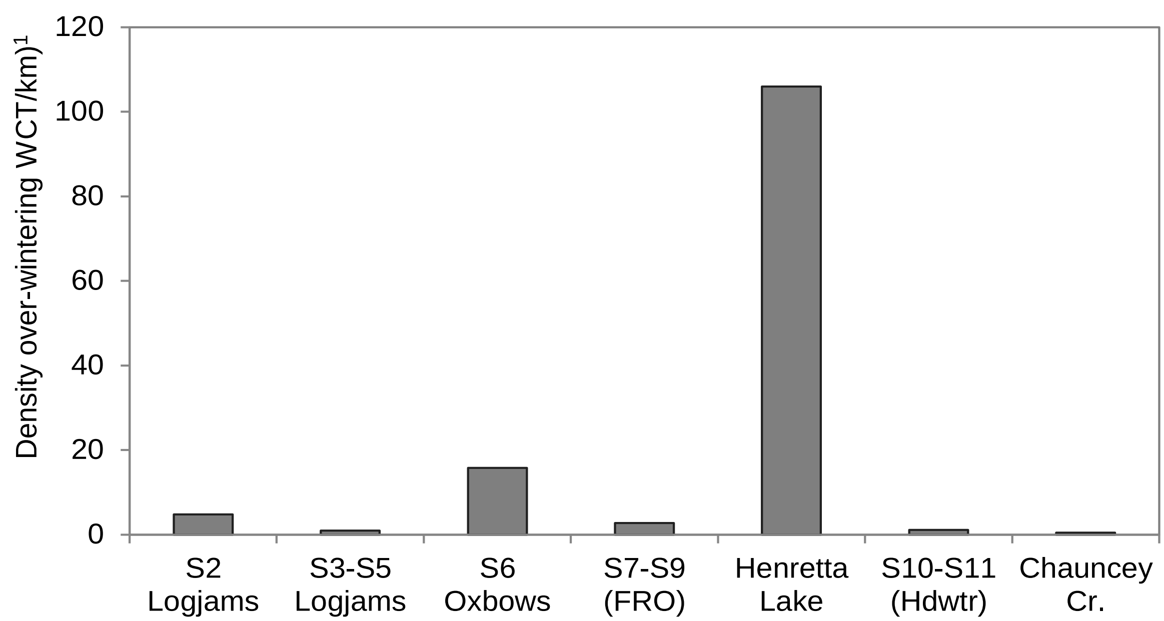

Figure 3.3.18. Relative density (WCT/km) of over-wintering radio tagged Westslope Cutthroat Trout (N=249) within watershed features for the upper Fording River 2012-2015.

construction of additional over-wintering habitat within river Segments S7 to S9, particularly in the Clode Flats area, combined with the culvert removal and restoration of tributary connectivity wherever feasible is recommended to alleviate the limiting habitat and risk to population resilience.

The four high use over-wintering areas identified above (Henretta Pit Lake, Clode Flats and the multi-plate culvert, river Segment S6 oxbows, river Segment S2 log jam complexes) support both migratory and resident life history forms and should be considered critical habitat. Figure 3.3.19 illustrates the concentration or overlap of the 249 data points for over-wintering telemetry locations as occupancy rates of available habitats in the Fording River. Areas of high occupancy appear red to yellow with lower occupancy rates in green or vacant. Occupancy was defined as a telemetered position (one point per radio tagged fish per year) during the over-wintering period. These four over-wintering areas were noted in the previous discussion on home range and life history strategies and are described in more detail in the following section:

1. *Henretta Pit Lake.* Henretta Pit Lake represents deep lentic habitat that was constructed to provide over-wintering habitat as part of the Henretta Creek Channel Reclamation Plan. This habitat supported the majority of over-wintering within the FRO mine site during all three years of study. Both resident and migratory life history forms are supported. Connectivity to Henretta Pit Lake was threatened by channel dewatering in Segment S9 and by the Henretta Haul Road culverts that were considered a life stage barrier (*i.e.,* barrier to smaller fish - juveniles) and a point of difficult passage at high flows for mature fish. The 2013 flood resulted in a culvert blockage, backwatering and fine sediment deposition that resulted in reduced surface area within Henretta Pit Lake (Figure 3.3.20).

2. *River Segments S8 and S9*. The historical Clode Flats in Segment S8 and S9 extending from the side-channel flowing into lower Lake Mountain Creek (Segment S8, 58.4 rkm) to the Turnbull arch culvert (Segment S9, 61.6 rkm) (Figure 3.2.12) includes the current Clode Settling Pond and Fish Pond Creek area. Although stream channels were identified as degraded (*see* Section 3.4 Habitat Mapping), groundwater influences (*i.e.,* Clode and Fish Pond Creeks, Clode exfiltration) were identified. Historical use of these areas including Clode Creek has been reported since original mine development (Lister and Kerr Wood Leidal 1980). The multi-plate culvert plunge pool (57.4 rkm) immediately downstream represents a very deep eddy pool lacking LWD or groundwater.

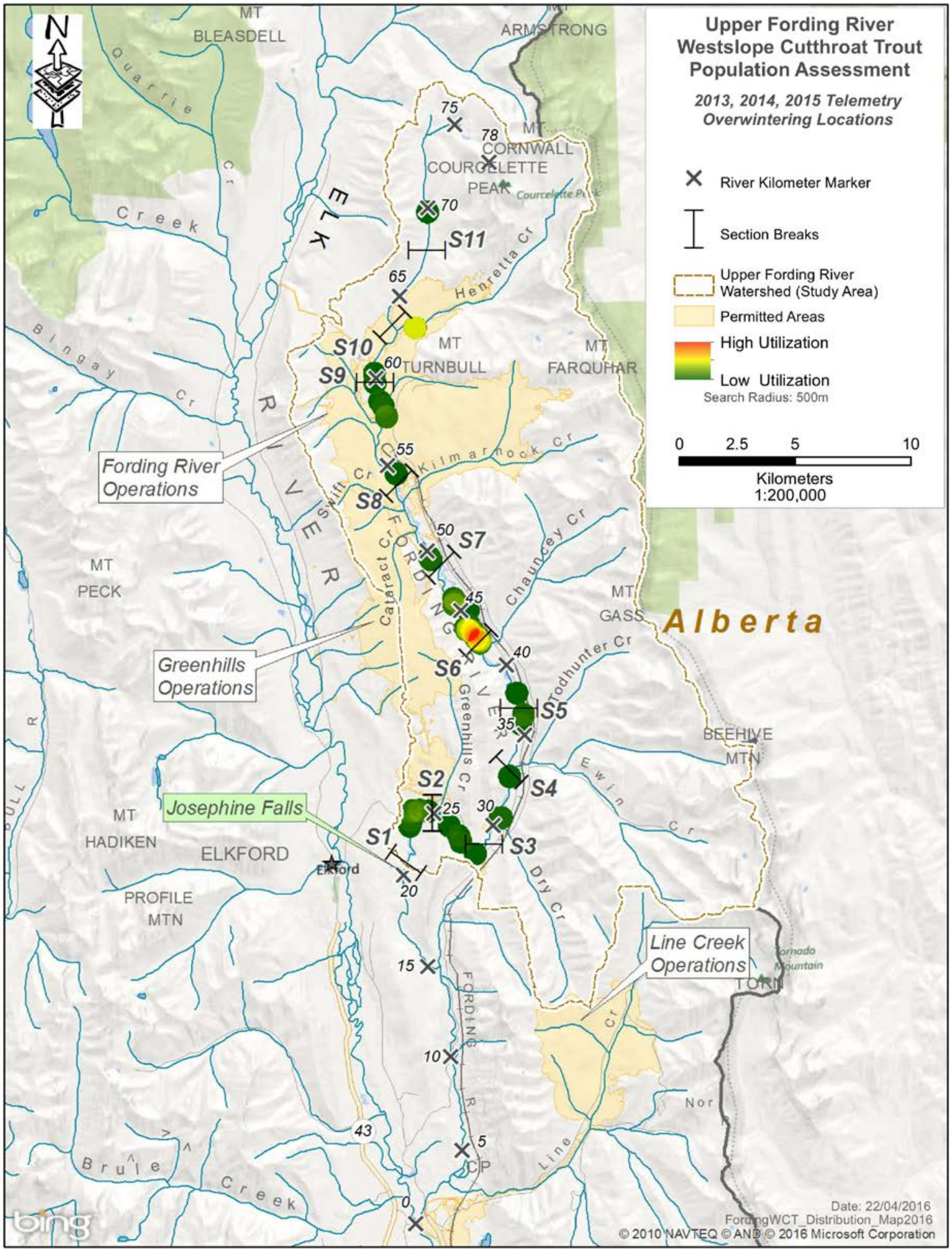

Figure 3.3.19. Westslope Cutthroat Trout occupancy rates of available habitats in the upper Fording River and its tributaries during over-wintering 2013-15. Areas of high occupancy appear red and yellow with lower occupancy rates in green.

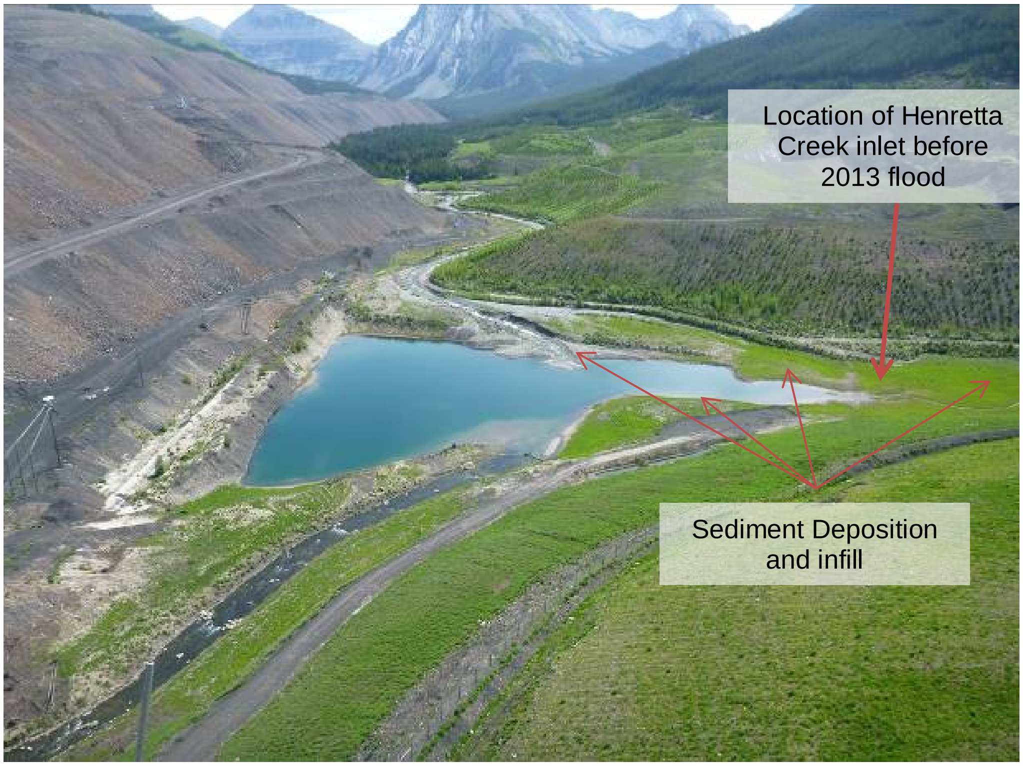

Figure 3.3.20. Henretta Pit Lake over-wintering and rearing habitat, August 25, 2015.

This location (multi-plate culvert plunge pool) represents the only deep pool (*i.e.,* 5.0 m max depth) within approximately 6 km of mainstem river. This culvert was also identified (current study and historically, Lister and Kerr Wood Leidal 1980) as a potential life stage barrier and point of difficult passage under certain high and low flow conditions (*i.e.,* seasonally a partial barrier).

3. *S6 Oxbow Segment*. Oxbow meander pools between 42.0 to 44.0 rkm and 45.0 to 48.0 rkm represent a high quality, very stable (*i.e.,* old growth riparian) river channel with very deep, slow moving pools with abundant large woody debris features and confirmed groundwater influence (Figure 3.3.21). Large aggregations of over-wintering fish were identified within these two sites every year of the current study. Fording Coal Limited (1986) identified historical use of this area.

Figure 3.3.21. Photograph (Nov. 2014) illustrating the lower S6 oxbow pool over-wintering area. This area also represents summer rearing habitat.

4. *Large Log Jam Pools.* Very large log jam pool complexes at 24.2, 25.8, and 27.4 rkm (note 24.2 represents the uppermost S1 pool) supported populations of over-wintering fish (Figure 3.3.22). These sites were more dynamic in terms of ice conditions and fish tended to move among pools within this and adjacent upstream areas (*i.e.,* lower S3 and upper S1). The 24.2 rkm location does not include a large LWD log jam like the other two locations but contains an ephemeral stream confluence (*i.e.,* possible groundwater influx).

   Large (channel spanning or nearly so) logjam pools have also been identified within Segment S5 (39.5 rkm, 37.3 rkm), S4 (37.0 rkm, 34.5 rkm) and one in S3 below Ewin Creek (32.5 rkm).

Figure 3.3.22. Photograph (Sept 2013) illustrating the S2 log jam over-wintering pool at 27.4 rkm. This area also represents spawning and summer rearing habitat.

3.3.1.6.3.Summer Rearing

For the purposes of this discussion, summer rearing periodicity was defined as July 15 through September 30. In contrast to the over-wintering and spawning distributions, summer rearing distribution was much more spatially distributed throughout the mainstem upper Fording River between upper Segment S1 (approximately 23.0 rkm) and Segment S10 to approximately 68.0 rkm (Figure 3.2.1). Lower Henretta Creek and Henretta Pit Lake were also identified as summer rearing habitat. Although present, the following areas contained lower densities of summer rearing Westslope Cutthroat Trout; the lower half of S11 (mainstem headwaters) and Henretta Creek above Henretta Pit Lake. Remnant fragmented (*i.e.,* isolated) populations were identified above barriers in Chauncey (current study data), Greenhills (Beswick 2007), Dry (Interior Reforestation 2000), and Kilmarnock Creeks (Arnett and Berdusco 2008). Despite barriers designed to prevent access fish were also within the Clode Settling Ponds. Mature fish were absent from Ewin Creek based on a CPUE = 0.0, but fry and juvenile captures identify low density presence (Table 3.2.28). This is likely related to the low water temperatures (Figure 3.1.3b).

Westslope Cutthroat Trout thrive in cold, clean streams (7-16 °C, Oliver and Fidler 2001, Behnke and Zarn 1976) with abundant pool habitat and cover, containing features such as undercut banks, pool-riffle habitat and riparian vegetation (Cleator *et al.* 2009). As expected, the distribution of summer rearing habitats was much more diverse and distribution broader (Figure 3.3.23) than that previously illustrated for spawning (Figure 3.3.14) or over-wintering (Figure 3.3.19) habitats.

Pools dominated summer rearing habitat for sub-adult and adult Westslope Cutthroat Trout captures in all years (Table 3.3.6). Radio telemetry data confirms these habitats were found in all reaches with subjective differences in perceived habitat quality and differences in frequency or area. In addition, movement and/or migration patterns of radio tagged Westslope Cutthroat Trout to and from different river segments coincide with these same meso-habitats (pools).

Pool habitat had a mean maximum depth estimate of 2.2 m +/- 0.2 m 95% C.I. (range 0.5 m – 10.0 m, n=497). Substrate was predominantly cobble-gravel (Table 3.3.7). The cover features of depth, LWD, cutbank, and boulder accounted for 90% of the capture locations dominant cover elements (Table 3.3.8). These pool habitat units and fish position within the habitat unit were closely associated with inflows at the head of the pool (top or upstream end) from riffle habitat units immediately upstream.

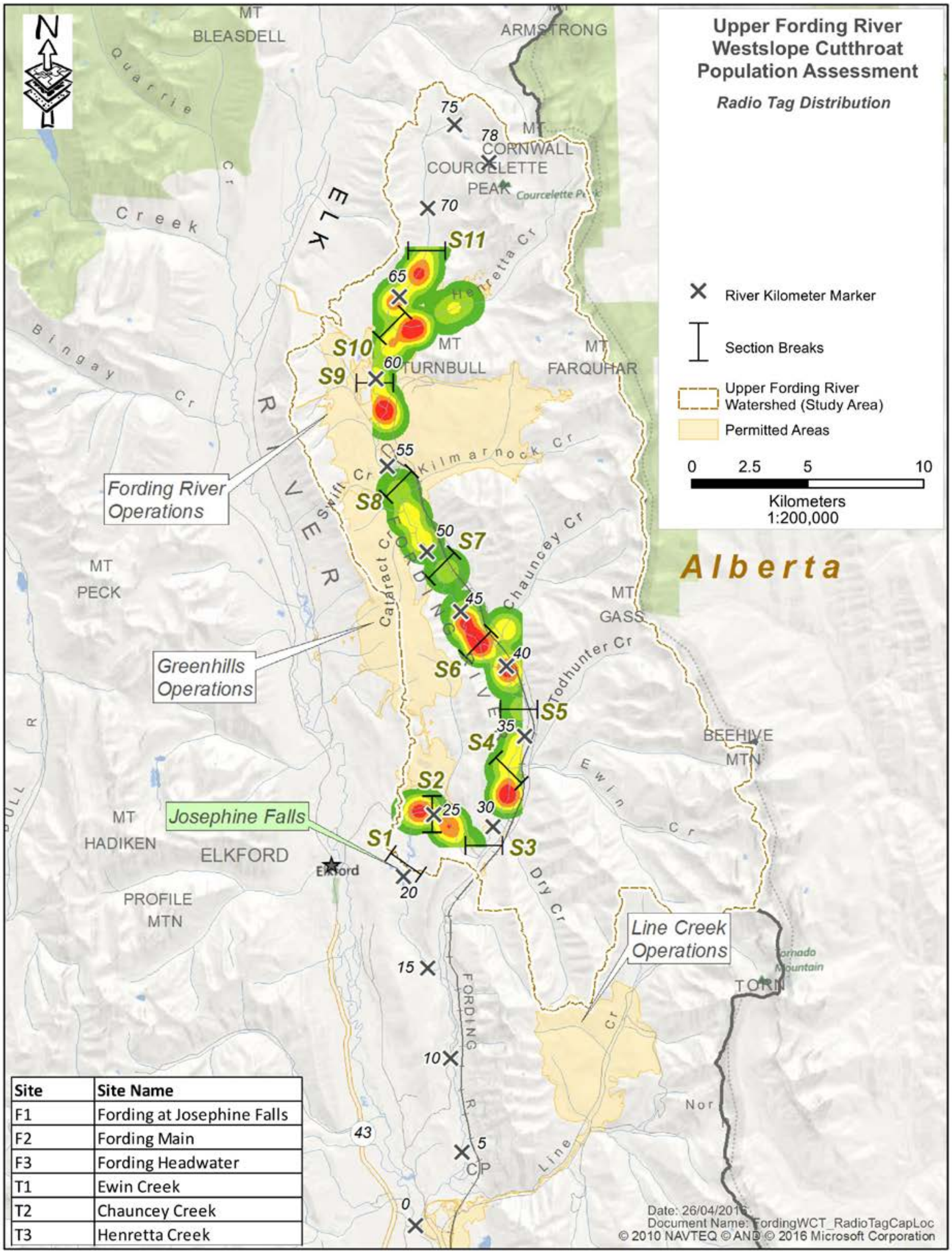

Figure 3.3.23. Westslope Cutthroat Trout summer rearing locations determined using radio telemetry (n=742), July 15 to Sept 30, 2012 and 2013.

Table 3.3.6. Meso-habitat classification for summer rearing habitat capture locations, upper Fording River, August – September 2012, 2013 and 2014.

Meso-habitat	2012	2013	2014
Lake	4 (6.7%)	10 (4.4%)	13 (4.8%)
Pool	55 (91.7%)	184 (80.7%)	223 (82.9%)
Run	1 (1.6%)	22 (9.7%)	7 (2.6%)
Riffle	0	7 (3.0%)	10 (3.7%)
Glide	0	5 (2.2%)	16 (5.9%)
Total	60	228	269

Table 3.3.7. Dominant substrate for summer rearing habitat capture locations, upper Fording River, August – September 2012, 2013 and 2014.

Substrate	2012	2013	2014
Bedrock	6 (10.0%)	14 (6.1%)	22 (8.2%)
Boulder	2 (3.4%)	13 (5.7%)	6 (2.2%)
Cobble	26 (43.3%)	99 (43.4%)	70 (26.0%)
Gravel	20 (30.3%)	53 (23.2%)	132 (49.1%)
Fines	6 (10.0%)	49 (21.5%)	39 (14.5%)
Total	60	228	269

Table 3.3.8. Dominant cover for summer rearing habitat capture locations upper Fording River, August – September 2012, 2013 and 2014.

Cover	2012	2013	2014
Boulder	7 (11.6%)	48 (21.0%)	20 (7.5%)
Cutbank	10 (16.7%)	5 (1.8%)	22 (8.2%)
Depth	21 (35%)	58 (25.4%)	13 (4.9%)
LWD	17 (28.3%)	96 (42.1%)	140 (52.2%)
Nil	1 (1.7%)		5 (1.9%)
Overhanging Veg.	1 (1.7%)		18 (6.7%)
Turbulence	3 (5.0%)	22 (9.7%)	50 (18.6%)
Total	60	228	268

3.3.2. Juvenile Movement Patterns (Electrofishing Mark-Recapture)

Juvenile distribution during the fall season was previously illustrated using the 43 meso-habitats sampled at 19 representative locations distributed throughout the watershed; including select tributaries (*see* Section 3.2.3.2 Recruitment and Juvenile Density Estimates). Distribution was summarized by life stage (fry and juvenile), location, watershed segment (*i.e.,* lower, mid, upper, lower and upper tributary) and meso-habitat (*i.e.,* pool, riffle, glide, side-channel). These summaries illustrated relative densities among the watershed and identified either complete passage barriers or likely life stage barriers that limited distribution. Although fish were present above barriers, habitat fragmentation and isolation could be one factor contributing to limited productive capacity since these fish were present in very low densities.

Since sampling was conducted annually (2013, 2014, 2015) during the same fall period (late September), seasonal distribution and movement pattern analyses were not possible. However, during sampling in years two (2014) and three (2015) there were 28 recaptures of PIT tagged juveniles from previous years. This data was used to investigate possible movements of juvenile fish among locations within the watershed.

Of the 28 recaptures, there were three (11%) that moved between the annual fall electrofishing locations within the watershed. One fish moved 2.9 km upstream from Fish Pond Creek (131 mm fork length) and was recaptured in Henretta Creek (135 mm) immediately below the Henretta Haul Road culverts and weirs. Recall previously (*see* Section 3.2.3.2 Recruitment and Juvenile Density Estimates), the Henretta Creek Haul Road culverts and grouted weirs (Figure 3.2.14) were assessed as a size or life stage passage barrier preventing upstream access of juveniles into all but the lowermost 400 m of Henretta Creek. Electrofishing sites within Henretta Creek were approximately 2.0 km apart and separated by the haul road culvert (and associated grouted weirs). In three years, the lower Henretta Creek site increased from very low densities (0.8 fish/100 m^2) to very high densities (33.7 fish/100m^2), yet the site above the culvert did not demonstrate any increase in juveniles during the same time period. It was clear from this juvenile recapture data that juveniles were migrating into preferred tributary rearing habitat in Henretta Creek. Similar habitat exists within Henretta Creek above the culvert.

A second fish moved 29.6 km downstream from Fish Pond Creek (92 mm fork length) to Ewin Creek and was recaptured 2.1 km up Ewin Creek (141 mm fork length). This fish navigated upstream through the Ewin Creek culvert crossing on the Fording Road. These culverts were the one set, based on professional opinion at the outset of the Project, which was not considered a barrier (Figure 3.3.24).

Figure 3.3.24. Ewin Creek Fording Road culvert illustrating fish passage characteristics.

The final movement was a 91 mm fish originally tagged at the upstream end of the South Tailings Pond Diversion. This fish moved 4.4 km upstream and was recaptured in Fish Pond Creek (119 mm). This fish moved up through the multi-plate culvert sometime between September 2013 and October 2015 confirming juvenile Westslope Cutthroat Trout can navigate this culvert at some flows (Figure 3.3.25). The multi-plate culvert was considered a point of difficult passage (*i.e.,* a seasonal juvenile fish passage barrier under certain flow conditions) based on the current and previous assessments noting seasonal aggregations of juveniles in the downstream plunge pool. The multi-plate culvert was first identified as a likely juvenile migration barrier in 1979 (Lister Kerr Wood Leidal 1980). Snorkel observations during the current program and past programs (Amos and Wright 2000) have identified large aggregations of smaller fish in the multi-plate plunge pool during some seasons, and an absence of fish at other times. This was interpreted as representing a migration barrier during certain seasonal conditions for smaller fish (*i.e.,* juveniles). While documentation of a migration through this culvert by a juvenile Westslope Cutthroat Trout was encouraging, it was still considered an under-sized culvert (back-watered during the 2013 flood) that was an inadequate design given the critical importance of this migration route.

Figure 3.3.25. Multi-plate culvert on the mainstem upper Fording River illustrating fish passage characteristics.

Given the low incidence of movements between locations, it might seem tempting to consider juvenile Westslope Cutthroat Trout sedentary or residents with movements of such low frequency to represent “straying” (Quinn 1984), rather than a defined and repeatable migratory life history strategy; when in fact juveniles were moving in and among tributaries and between mainstem and tributary habitat.

The following comparison between radio telemetry data and annual (August) Floy tag recapture data for these same radio tagged fish (mature Westslope Cutthroat Trout within the upper Fording River) was presented to demonstrate the effect of monitoring frequency on fish movement assumptions (Table 3.3.9). It was clear from the radio tag data that there were two life history forms (50% migratory, 50% resident) with a mean home range of 10.6 km. This was consistent with the data previously documented in reference streams using similar telemetric methods. Annual Floy tag recapture data would erroneously lead one to classify the same population of radio tagged fish as resident with a mean home range of 0.6 km. This illustrates the propensity for seasonal site fidelity (in this case summer rearing pool habitat) by what are in fact migratory Westslope Cutthroat Trout.

Table 3.3.9. Comparison of home ranges calculated from radio telemetry data with a high frequency of relocation effort and annual summer sampling Floy tag recaptures for these same radio tagged fish.

Radio Code	Home Range (km) Based on Radio Tag Data	Movement Distance (km) Based on Annual (August) Floy Tag Recapture
119	3.38	3.00
44	3.73	1.05
80	11.65	0.02
103	18.92	0.00
107	5.19	0.04
38	10.18	0.60
19	4.50	0.15
14	3.80	0.04
25	22.53	0.01
37	21.80	1.06
N=10	10.57	0.60

This continues to be a common issue within the literature for Westslope Cutthroat Trout and illustrates the power of telemetric methods provided appropriate levels of monitoring intensity and frequency are employed. Recaptures of fish from annual sampling programs, without intensive seasonal recapture components, cannot be relied upon to make life history inferences.

3.4. Habitat Mapping

In order to document available habitat and its distribution, the mainstem population segments and lower fish bearing reaches of tributaries were mapped at the meso-habitat level through air photo interpretation (2012 imagery). An understanding of the available habitat and its distribution provides necessary context and one of the lines of evidence used for interpretation of fish movements, life history strategies, and limiting factors within the upper Fording River watershed.

In September 2012, the length of the mainstem upper Fording River, the lower fish bearing sections of tributaries and the associated riparian area were captured on digital colour images with an image pixel size of 10 cm ground sampling distance. In Year 2 (2013), the aerial photographs were compiled into a composite ortho-photograph watershed display with 10 cm resolution. In 2014, at a scale of 1:500 to 1:1,000, meso-habitat mapping results were compiled and summarized by river Segment. Only mainstem river Segments S1 through S9 results are presented in this report since habitat mapping from imagery was not feasible for headwater segments and tributaries due to poor visibility on the imagery (*i.e.,* small stream size, canopy cover, channel confinement, shadows). In 2015, ground-truthing surveys were completed in river Segments S2 and S6 (two off-site reference locations) and river Segments S7, S8 and S9 (three locations within FRO) to validate air photo interpretation and to complete a morphological stream channel survey.

Table 3.4.1 summarizes the meso-habitat available within each mainstem upper Fording River segment. The null habitat values clearly illustrate these methods were feasible for the larger mainstem river habitat from Segments S1 through S9 but not feasible for the smaller headwater Segments (S10, S11).

These data form the basis for the Level 1 FHAP Form diagnostics summary (Table 3.4.2). Table 3.4.2 indicates there were differences in physical habitat quality between river Segments S1 through S6 which are downstream off-site population segments (*i.e.,* 26% to 81% pool habitat, LWD frequency 1.20 to 3.91) and river Segments S7, S8 and S9 which are the FRO on-site river segments (*i.e.,* 7% to 19% pool habitat, LWD frequency 0.00 to 0.76). The Level 1 FHAP diagnostics form was developed by the British Columbia Watershed Restoration Program as a tool to identify rehabilitation opportunities within watersheds by identifying potential physical habitat limitations to salmonid production in impacted or impaired river reaches (Johnston and Slaney 1996).

Table 3.4.1. Meso-habitat availability by mainstem upper Fording River segments; based on September 2012 imagery.

Segment	Meso-Habitat	N	Length (m)	Area (m^2)	% By Length	LWD Tally
1	Cascade	11	131	2,510	3.0	0
	Glide	25	1,455	28,496	33.1	34
	Pool	18	909	18,334	20.7	44
	Riffle	19	1,094	20,758	24.9	131
	Null	34	809		18.4	
2	Glide	27	806	13,174	18.2	46
	Pool	40	1,522	23,425	34.3	698
	Riffle	36	1,265	20,009	28.5	84
	Run	27	565	7,780	12.7	110
	Null	4	277		6.2	46
3	Glide	25	1,157	21,295	27.0	286
	Pool	25	1,450	25,325	33.9	377
	Riffle	22	1,084	20,368	25.3	78
	Run	17	529	8,470	12.3	99
	Null	1	64		1.4	
4	Glide	34	1,001	15,626	21.6	47
	Pool	33	1,295	19,148	27.9	240
	Riffle	37	1,332	21,409	28.7	153
	Run	16	309	3,960	6.7	18
	Null	9	697		15.7	
5	Glide	24	707	11,223	15.5	68
	Pool	28	1,295	21,351	28.5	162
	Riffle	29	1,572	24,762	34.6	107
	Run	23	525	6,717	11.5	34
	Null	8	449		9.9	
6	Glide	17	333	4,748	4.3	32
	Pool	30	5,488	103,226	71.3	881
	Riffle	26	1,180	16,943	15.3	168
	Run	12	264	3,024	3.4	65
	Null	22	434		5.6	
7	Glide	22	837	8,163	16.4	0
	Pool	12	288	2,450	5.6	0
	Riffle	28	2,478	26,378	48.4	0
	Null	61	1,513		29.6	
8	Glide	18	894	8,158	16.0	0
	Pool	11	231	2,804	4.1	0
	Riffle	24	4,462	44,471	79.9	0

Continued next page

Table 3.4.1. Concluded.

Segment	Meso-Habitat	N	Length (m)	Area (m^2)	% By Length	LWD Tally
9	Glide	30	514	4,555	13.6	7
	Pool	37	705	5,803	18.7	108
	Riffle	44	1,844	15,768	48.8	81
	Run	29	613	3,961	16.2	47
	Null	5	102		2.7	
10	Glide	4	48	309	1.1	0
	Pool	11	148	899	3.4	0
	Riffle	6	168	1,007	3.9	0
	Run	6	197	1,135	4.5	0
	Null		3,789		87.1	
11	Glide	5	43	307	0.5	0
	Pool	6	75	373	0.8	2
	Riffle	7	267	1,755	3.0	5
	Run	4	45	169	0.5	0
	Null		8,570		95.2	

Table 3.4.2. Level 1 Fish Habitat Assessment Procedure (FHAP) diagnostics summary.

Segment	**% Pools**		**Pool Frequency**		**LWD Pieces per**		**% Wood Cover in**		**Dominant**		**Off-Channel Habitat**		**Holding Pools**	
Number	Value	Rating	Value	Rating	Value	Rating	Value	Rating	Value	Rating	Value	Rating	Value	Rating
1	26.15	Poor	9.75	Poor	1.20	Fair	6 - 20%	Fair	R	Good	few	Poor	Abundant	Good
2	36.38	Poor	5.99	Poor	3.91	Good	greater than 20%	Good	G	Good	abundant	Good	Abundant	Good
3	33.56	Poor	8.97	Poor	3.75	Good	greater than 20%	Good	G	Good	abundant	Good	Abundant	Good
4	31.84	Poor	8.13	Poor	1.71	Fair	6 - 20%	Fair	G	Good	some	Fair	Abundant	Good
5	33.33	Poor	9.24	Poor	1.45	Fair	6 - 20%	Fair	G	Good	some	Fair	Abundant	Good
6	80.68	Good	14.95	Poor	2.56	Good	greater than 20%	Good	S	Poor	few	Poor	Abundant	Good
7	6.62	Poor	22.72	Poor	0.00	Poor	0	Poor	G	Good	few	Poor	Few	Poor
8	10.47	Poor	29.18	Poor	0.00	Poor	0	Poor	C	Good	few	Poor	Few	Poor
9	19.29	Poor	8.62	Poor	0.76	Poor	0	Poor	G	Good	few	Poor	Few	Poor
10	26.84	Poor	48.38	Poor	0.00	Poor	0	Poor	G	Good	few	Poor	Few	Poor
11	16.22	Poor	122.44	Poor	0.01	Poor	0	Poor	G	Good	few	Poor	Few	Poor

Note that regional criteria for habitat conditions do not exist and current WRP diagnostic criteria to evaluate habitat condition are exclusive of Westslope Cutthroat Trout data.

River Segments S7, S8 and S9 (*i.e.,* on-site mainstem habitat within the FRO area) has very limited pool habitat (pool area, pool frequency), virtually no large woody debris, and less off-channel habitat. These represent potential physical habitat limitations to salmonid and Westslope Cutthroat Trout production (Cleator *et al.* 2009, McPhail 2007, Johnston and Slaney 1996, Ford *et al.* 1995). Despite these limitations, high density use by both juvenile and adult fish (including spawning and over-wintering) of this on-site habitat has been documented historically (Fording Coal Limited 1985, Norecol 1983, Lister and Kerr Wood Leidal 1980). However, there have clearly been habitat losses since these early years of mine operation. For example, in 1977, 1.22 km of river channel was diverted for development of the South Tailings Pond. Large numbers of fish were relocated from this reach (currently lower river Segment S8). Of particular note were three or four large log jam pools in this Segment S8 diversion that were identified as rearing and holding areas and good “fishing holes” (Wood 1978). Approximately 10,000 Westslope Cutthroat Trout were salvaged and relocated from these pools. This confirms two points. Firstly, it is not surprising data from this time period document high densities of fish within these same reaches a couple years later (*i.e.,* current river Segments S7, S8 and S9 *in* Fording Coal Limited 1985, Norecol 1983, Lister and Kerr Wood Leidal 1980). Secondly, it confirms critical large log jam pool habitat once existed in greater frequency than currently (*i.e.,* higher pool frequency, higher large woody debris frequency). During this same time period, BC Research (1979) documented similar log jam pool habitat within the GHO area (Segment S2) and that these habitats accounted for the bulk of the fish captured in their attempt to conduct a population estimate. These log jams and their use by both resident and migratory fish for spawning, rearing and over-wintering in large numbers still exist within river Segment S2 and have been documented in the current study (*see* Figure 3.3.22 for two examples of large log jam habitats dated to be at least decades old).

Current juvenile density estimates illustrate these same on-site river Segments (S7, S8 and S9) and adjacent tributary habitat were higher density locations, relative to other areas (Figure 3.2.11). This suggests that FRO on-site reaches and tributaries were historically important high use areas of Westslope Cutthroat Trout habitat; and continue to be, despite apparent habitat impacts or impairment. Based on these results, ground-truthing surveys were completed at two off-site reference locations and three locations within FRO to complete a Rosgen (1996) morphological stream channel survey and validate air photo interpretation.

Ground-truthing survey data were input and archived using the Reference Reach Spreadsheet Version 2.4 L SI (Mecklenburg 1999) and summarized using the Rosgen Level II Stream Channel Classification Form and the Reference Reach Data Summary Form (Rosgen 1996). These results were summarized in Table 3.4.3 for river Segments S2 and S6 (the two off-site reference locations) and Segments S7, S8, and S9 (the three FRO on-site locations). These results confirmed the Level 1 FHAP diagnostic data that identified impacted or impaired river segments with physical habitat limitations to salmonid and in this case Westslope Cutthroat Trout production onsite within FRO river Segments S7, S8 and S9.

These impacts were identified as over-widened channels (Bankfull Width) with shallow depths (Bankfull Depth) that result in excessive width to depth ratios, shallow pool depths (Maximum Bankfull Pool Depth), reduced pool habitat (area and spacing), and a loss of channel sinuosity with resulting increased gradient, low entrenchment ratio and LWD structural elements (Table 3.4.3).

The collection of hydrometric and channel dimension data using standardized methods has been applied within other regions to develop regional curves for channel types (Lawlor 2004, Rosgen 1996). Regional curves serve as a data supported basis for estimating the drainage area versus bankfull discharge and related channel dimensions at bankfull stage. Typically, departure from the predicted regional dimensions results when natural stream channel stability has been compromised through alterations to the landscape that impact river flow and sediment inputs resulting in predictable impacts to channel pattern, profile and dimension (Rosgen 1996). As yet, there are no East Kootenay Regional curves developed for channel dimensions. Nevertheless, these principles were illustrated in Figure 3.4.1 using the upper Fording River data, similar data collected within the East Kootenay Region (Skookumchuck Creek, Cope and Morris 2005; White River, Cope 2006) and western Montana (Lawlor 2004). While this was a very coarse and preliminary use of these methods, Figure 3.4.1 illustrates that the upper Fording River Segments S2 and S6 fall within the range of channel widths expected. The Segments S7, S8, S9 depart from the expected and are identified as impacted or degraded. The FRO mine site river Segments S7, S8 and S9 were the widest channel widths for a given drainage area within the dataset provided. This provides supporting evidence for the classification of onsite FRO stream channels as impacted and degraded habitats represented by over-widened D3 and D4 stream channels.

Table 3.4.3. Summary of channel dimensions, Level 1 FHAP diagnostic criteria and stream channel classifications from ground-truthing surveys in the upper Fording River 2015. Note the arrows for Segment S8 and S9 classifications indicate trending from one classification to another (*i.e.,* width/depth ratio in the "D" category but sinuosity and/or entrenchment ratio within "C" range. Such assignments of "trending" are associated with field indicators of recent channel disturbance that suggest channel geometry is unstable and changing (*i.e.,* degrading).

A. Summary Rosgen Stream Classification

	River Segment				
	S2	S6	S7	S8	S9
Drainage Area (km^2)	396.0	197.8	133.2	102.0	87.4
Bankfull Width (m)	21.2	24.3	59.3	41.1	39.9
Bankfull Depth (m)	1.20	1.00	0.54	0.45	0.76
Width/Depth Ratio	17.6	24.2	110.2	90.8	51.1
Max. Pool Depth (m)	3.1	2.9	1.9	2.4	2.2
Width Flood Prone Area (m)	328	240	211	286	170
Entrenchment Ratio	15.5	9.9	3.6	7.0	4.4
Sinuosity	1.55	1.67	1.13	1.34	1.07
D50 (mm)	41	31	68	27	75
Slope (%)	0.36	0.39	0.85	0.86	1.51
Stream Type	C4	C4	D3	C4 → D4	C3 → D3

B. Summary of Level 1 FHAP Diagnostic Criteria From Rosgen Survey

	River Segment				
	S2	S6	S7	S8	S9
Pools (% by Area)	38.4	43.0	3.3	16.0	5.3
Mean Pool Spacing (m)	73.9	40.5	190.0	106.0	133.5
LWD (Pieces/W_b)[1]	13.3	7.1	0.2	1.2	0.3
% wood Cover in Pools	26.7	18.3	10.0	16.3	35.0
Off-Channel Habitat	Abund.	Abund.	Few	Abund.	Few
Holding Pools	Abund.	Abund.	Few	Fair	Few

[1] W_b = bankfull channel width (m)

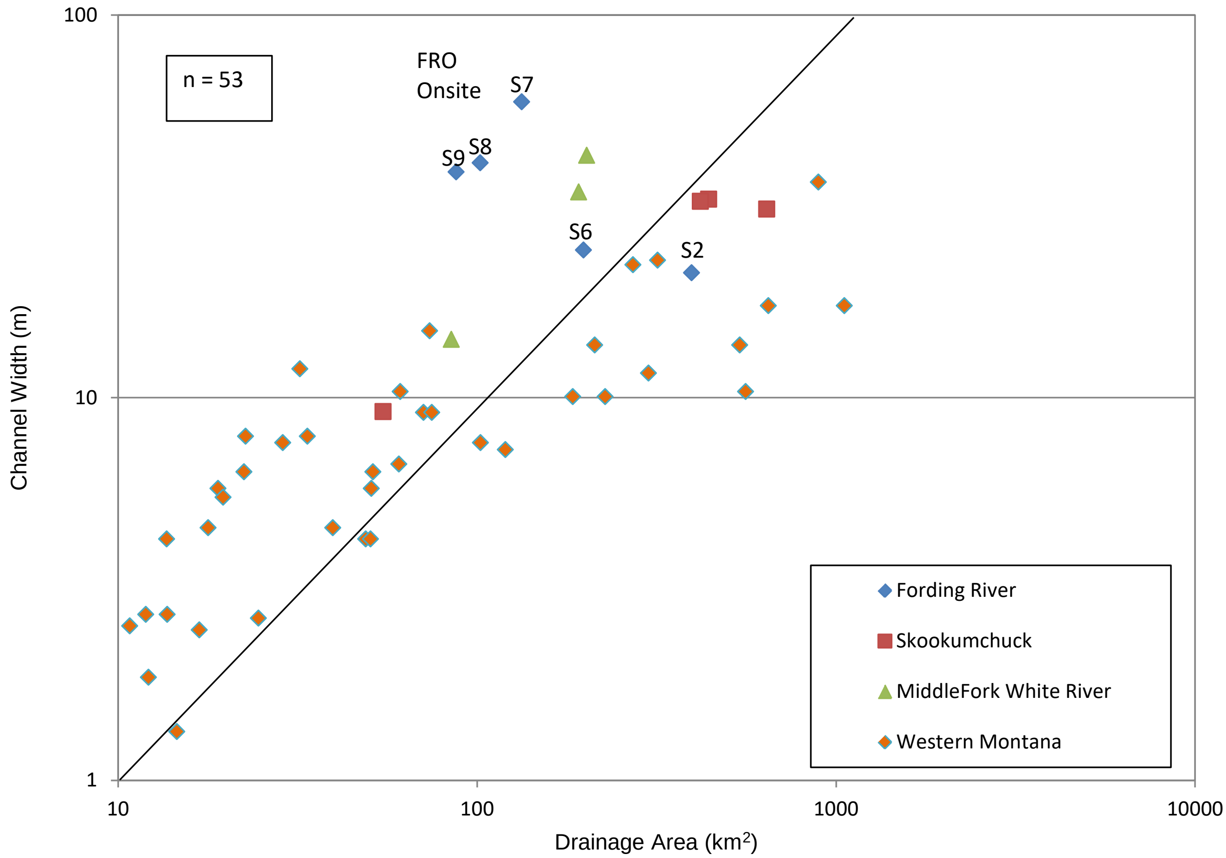

Figure 3.4.1. Stream channel widths versus drainage area for streams within the East Kootenay Region of British Columbia and Western Montana.

The “D” stream channel type occurs naturally as glacial outwash channels and alluvial fans and manifests itself as a degraded stream channel in situations where natural stream channel stability is compromised through alterations to the landscape that impact river flow and sediment inputs resulting in unstable stream banks and aggrading stream channels. The D stream channel was characterized by high bank erosion rates, excessive sediment deposition and annual shifts of bed location. This combination of conditions are responsible for channel braiding, high bank erodibility, high sediment supply, moderately steep gradients (due to longitudinal and transverse bars) and flashy run-off conditions (Rosgen 1996).

There are a number of conditions associated with surface mining and forest harvesting that are well documented impact pathways for these effects to manifest themselves in stream channels (Nelson *et al.* 1991, Chamberlin *et al.* 1991). These include the loss of vegetation, topsoil and riparian disturbance resulting in changes to the water infiltration rate. This in turn results in overland flow over disturbed landscapes which alters peak streamflow and increases sediment entering the stream (from both overland flow and eroding banks). The result is channel instability and altered channel geometry reflected in over-widened channel widths (Figure 3.4.2). Slope steepness for, 1) the surrounding disturbed landscape (*i.e.,* the slope of spoil areas adjacent to stream channels), and 2) stream channel, reinforces these effects (Figure 3.4.3).

The end result is a loss of riparian habitat and degraded fish habitat with decreased channel sinuosity, increased channel gradient, increased width:depth ratios, shallow water depths, increased substrates size (with less size diversity) and reduced pool:riffle ratios as structural elements become depleted. These impacts also contribute to increased water temperatures (*see* Section 3.1.2 Water Temperature) and increased extent and duration of channel dewatering (creating migration barriers and a loss of connectivity). These effects may be magnified by mine related water withdraws and use during seasonal low flow time periods (*i.e.,* fall migration period and over-wintering period).

Despite the identified habitat impairments, high fish utilization and a propensity to site fidelity across life stages for both resident and migratory fish have been documented within the onsite FRO river Segments S7, S8 and S9. Although high utilization of an area identified as “impaired” or “impacted” with physical habitat limitations may seem counter-intuitive, recall that this area was identified as spawning and over-wintering reaches during the early years of mine development (Fording Coal Limited 1985, Lister and Kerr Wood Leidal 1980, Wood 1978). Also recall that there appeared to be relatively higher mortality rates within this area due to these impacts. As previously discussed in terms of spawning behaviours and life history diversity, these apparent discrepancies must be viewed in the context of the evolutionary history of the population as well as the current altered landscape they utilize. The strong propensity for reproductive homing and site fidelity in salmonids, *Oncorhynchus* spp. and Westslope Cutthroat Trout (Homel *et. al.* 2015, Waples *et al.* 2008) demonstrates that these fish are in many ways “hard-wired”. Hard-wired is an out-dated lay mans’ term used by animal behaviourists that refers to an animals innate or inherent inclination (*i.e.,* propensity) towards a particular complex behavior. These behaviours result from thousands of years of selective pressures, an evolutionary history that is not altered on a time scale of decades in regard to anthropomorphic landscape changes (Waples *et al.* 2008). In other words, the current observed behaviours (*i.e.,* population distribution) are a result of those traits (*i.e.,* heritable genes) that made survival possible in the evolutionary past; not just currently.

In the case of the upper Fording River Westslope Cutthroat Trout, this would mean residing within a specific area that historically conferred a survival advantage such as providing high

Figure 3.4.2. Representative photograph illustrating unstable channel geometry (over-widened, braided, shallow) and degraded fish habitat conditions - FRO Segment S9.

Figure 3.4.3. Representative photograph illustrating slope steepness, riparian disturbance and unstable stream banks reinforcing effects of altered hydrology and overland flow on stream channel instability in Henretta Creek and mainstem Segment S9.

quality habitat attributes necessary for the completion of their life-cycle. For example, the Clode Flats habitat complex (Figure 3.2.12) between Lake Mountain Creek (Segment S8, 58.4 rkm) and the Turnbull arch culvert (Segment S9, 61.6 rkm) represented a low gradient mainstem channel and associated tributaries (Lake Mountain Creek, Clode Creek and 1.3 km upstream lies Henretta Creek) with appropriate stream gradient, sinuosity, and substrate to provide a diversity of spawning, juvenile rearing and over-wintering habitat supported by groundwater influences and tributaries. This explicitly assumes habitat conditions have changed (*i.e.,* degraded) over the last 45 years (*i.e.,* since mine development in the 1970's)

Level I FHAP diagnostics (Table 3.4.2), ground-truthing (Table 3.4.3), regional curves (Figure 3.4.1) and photographs (Figures 3.4.2 and 3.4.3) document stream channels that have been over-widened and straightened by altered streamflow ,and increased sediment supply (*i.e.,* simplified or homogenized), as well as by heavy equipment (*i.e.,* includes altered, diverted and bermed channels) The balance of probability from these lines of evidence confirm habitat conditions have changed (*i.e.,* degraded) within FRO onsite river Segments S7, S8 and S9 since mine development in the 1970's.

Another way to test this hypothesis (*i.e.,* riparian habitat, stream channels, and fish habitat conditions have degraded since mine development in 1971) was to locate photo-documentation and habitat data for an assessment of habitat conditions early in mine development and compare these conditions to current data and photographs within the same location or reach. An understanding of such changes is important since they result in limitations to fish habitat and productive capacity for Westslope Cutthroat Trout and could decrease population abundance and life history diversity thus decreasing population resilience, increasing the risk to viability and sustainability (*see* Section 3.6 Population Viability and 3.7 Population Sustainability). Documented high utilization and site fidelity across life stages of both resident and migratory fish within the onsite FRO river Segments S7, S8 and S9 identifies these river segments as critical habitat and indicates that if habitat impairments and limitations were both present and addressed, a corresponding strong positive population response to fish habitat improvements could be expected (a testable hypothesis). Although back casting into conditions based on photographs alone can never be certain, this evidence contributes to the conceptual impact pathway hypothesis and adds to the balance of probability approach for accepting or rejecting the impact hypothesis. This can then facilitate a path forward as to the best approach to addressing population limitations to productivity and habitat offsetting can proceed with maximum effect.

Teck has attempted to do this analysis using 1950's air photographs. While there were indications of changes, the scale (1:40,000) precluded any conclusions. In addition, natural landscape changes due to wildfires, flood, and forest succession were to be expected in the period from 1952 to 2012. Subsequently, historical reports and photographs were reviewed for locations that could be replicated in the current study to address the above conceptual impact hypothesis. Such a report was identified in Lister and Kerr Wood Leidal (1980). The following photographs were taken at the same location in Segment S9 (62.5 rkm) in 1979 and in 2015 (Figures 3.4.4 and 3.4.5). Note the same mountain in the background in both photographs (although mined as part of the Henretta Phase II Project and subsequently modified into a spoil dump by 2015). Henretta Creek flows downstream on the right of this mountain and the upper Fording River on the left and they converge approximately 400 m upstream from this point.

In addition, ground truthing survey data was also available and comparison of the photographs and stream channel data provide a strong case that stream channels have been degraded through over-widened stream channels, loss of fish habitat (*i.e.,* pools), and increased gradient (*i.e.,* loss of sinuosity) (Table 3.4.4).

Table 3.4.4. Comparison of select stream channel attributes between 1979 and 2015 within Sections S7, S8 and S9, upper Fording River, Fording River Operations area. 1979 data from Lister and Kerr Wood Leidal (1979).

	River Section							
	S9		S8		S7		S6	S2
Stream Characteristic	1979	2015	1979	2015	1979	2015	2015	2015
Gradient (%)	0.9	1.5	0.9	0.9	0.6	0.9	0.4	0.4
Bankfull Width (m)[1]	11.2	38.9	13.5	41.1	20.3	59.3	24.3	21.2
% Pool	50.0	5.3	60.0	16.0	47.0	3.3	43.0	38.4

[1] Referred to as mean total bed width in Lister Kerr Wood Leidal (1979).

These results were consistent in that the 1979 stream widths, percent pool habitat and gradients were within expectations from the current (2015) reference reach values (Segments S2 and S6) in Table 3.4.3 and were what the regional curve would predict based on drainage area (Figure 3.4.1). These are but one of several examples within Lister and Kerr Wood Leidal (1979) that could be generated for all three FRO on-site river Segments S7, S8 and S9. Similar data exists in Norecol (1983) and Fording Coal Limited (1985) appendices but the identification of exact locations within Segments S7 through S9 were less precise. These impacts could reasonably be expected to negatively impact Westslope Cutthroat Trout productivity and carrying capacity

Figure 3.4.4. Upper Fording River Segment S9 viewed upstream/north approximately 400 m below the Henretta Creek confluence in 1979 (Lister and Kerr Wood Liedal 1980).

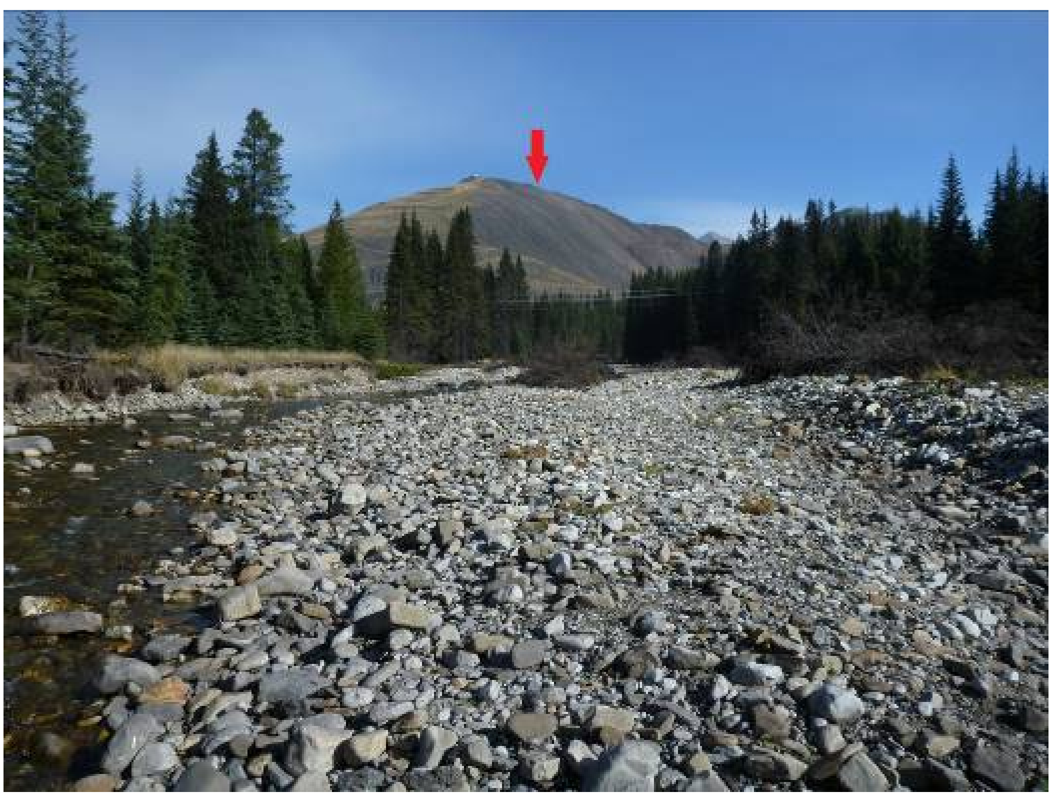

Figure 3.4.5. Upper Fording River Segment S9 viewed upstream/north from approximately the same site as 1979 (400 m below the Henretta Creek confluence) in 2015.

which in turn reduce population abundance and resilience, and hence are perceived threats to long-term sustainability (*see* Section 3.7 Population sustainability).

In addition, a stable channel endpoint for the degraded stream Segments S7, S8 and S9 were documented in Segments S2 and S6 (“C” channel; gravel-cobble riffle-pool channel with a predominance of large woody debris pool habitat and undercut banks representing high value rearing, over-wintering and spawning habitat). These reference river Segments S2 and S6 have similar channel features of gradient, channel width, and pool habitat frequency as those identified within FRO onsite river Segments S7, S8 and S9 by Lister and Kerr Wood Leidal (1980) in the very early days of mine development. The South Tailings Pond river diversion report also confirms these conditions, particularly very large log jam complexes once existed onsite (Segment S8) and contained large numbers of Westslope Cutthroat Trout of all life stages (Wood 1978). Therefore a natural template exists in Segment S2 for habitat design.

Multiple lines of evidence have been illustrated to demonstrate the balance of probability suggests Westslope Cutthroat Trout demonstrate an inherent inclination towards using the FRO onsite stream reaches and tributaries and that impacts accumulated over the last 45 years have altered these stream channels (and associated tributaries through lost connectivity and infilling) in ways that threaten their productivity, viability and long-term sustainability. Teck has committed significant resources to addressing water quality and habitat offsetting. Directing these resources in a manner that addresses limitations, connectivity and wherever possible restores stream channel, riparian and fish habitat conditions should produce a measureable positive impact thus improving the viability and sustainability of the upper Fording River Westslope Cutthroat Trout population as the regional and range wide significant resource it currently represents.

3.5. Genetics

It has been suggested that hybridization with other salmonid species, most notably Rainbow Trout (*Oncorhynchus mykiss*), is the most important factor responsible for the loss of native Cutthroat Trout (Carscadden and Rogers 2011, Allendorf and Leary 1988). As a result, non-hybridized populations of Westslope Cutthroat Trout were estimated to persist in only 20% of their historical range in Canada (COSEWIC 2006).

The upper Fording River Westslope Cutthroat Trout population has been identified as genetically pure (Carscadden and Rogers 2011, Rubidge and Taylor 2005, Rubidge *et al.* 2001). Josephine Falls represents a natural barrier to upstream fish movement and this barrier has protected this population from hybridization with non-native Rainbow Trout. Recently, critical habitat for Westslope Cutthroat Trout has been identified by some jurisdictions as all areas occupied by pure-strain populations (Muhlfeld *et al.* 2009; AWRT 2013). Thus, the Fording River population of Westslope Cutthroat Trout above Josephine Falls are an important population in the context of Westslope Cutthroat Trout conservation.

Previous population genetic analyses indicate there was no genetic differentiation between Westslope Cutthroat Trout captured approximately 22.5 km apart within the lowermost reaches of Dry and Swift Creeks (tributaries to the upper Fording River); indicating the upper Fording River population of Westslope Cutthroat Trout is one interconnected (migratory) population rather than a number of small isolated (resident) populations (Carscadden and Rogers 2011).

Telemetry data supports the genetic data through documentation of both resident and migratory life history forms from the upper, mid and lower watershed segments mixing during spawning season. Based on this data, one could assume inter-breeding among fish within the watershed rather than genetically isolated sub-populations. The mean home range for upper Fording River mature Westslope Cutthroat Trout (*i.e.,* mature fish > 200 mm FL) was 11.5 km +/- 1.5 km 95% Confidence Interval (n=111). Individual home ranges varied between 0.7 km and 31.6 km and individual fish were documented undergoing return spawning migrations in excess of 60 km between the upper reaches in the FRO area and the lower reaches in the GHO area. Individual fish movements of up to 10 km in a 24 hour period were documented. These results were consistent with other above barrier pure strain populations within the upper Kootenay River that demonstrated migratory fluvial behaviour and fish from differing watershed areas mixing during spawning (Cope and Prince 2012, Prince and Morris 2003).

3.6. Population Viability

One of the goals of the upper Fording River Westslope Cutthroat Trout study was to assess the status of the population's relative "health" or viability. Population Viability Analysis (PVA) and Recovery Potential Assessments are primarily modeling tools used for managing rare and endangered species in the absence of key variables such as abundance, recruitment, and mortality (*e.g.,* stock productivity; Cleator *et al.* 2009, Hilderbrand and Kershner 2000a, Ackakaya 1998).

Like many threatened species, determining reference values for Westslope Cutthroat Trout population thresholds is difficult. There is usually limited distribution or abundance information and in many cases there are many small, discrete populations with little or no abundance data available for a given population (AWRT 2013, Mayhood 2012, Johnston 2010, *pers. comm.*, Cleator *et. al.* 2009, DFO 2009, Johnston *et. al.* 2002). Stock productivity, stock-recruitment, harvest and mortality variables, which are essential to determining the rate of recovery for a population (Ricker 1975, Hilborn and Walters 1992), are poorly understood and imprecise for Westslope Cutthroat Trout (Johnston 2010, *pers. comm.*). Alternatively, tools have been developed to assess the risk of extinction for Westslope Cutthroat Trout in portions of their range (Shepard *et. al.* 1997, Lee and Reiman 1997). As a result, discussions around Westslope Cutthroat Trout conservation and population viability typically use population estimates and/or statistical models to estimate fish populations relative to critical management thresholds, and evaluate the risk of extinction based on key threats to life history requirements, demographic stochasticity, genetic variation, environmental variation and catastrophes.

Based on the results of a literature review for Westslope Cutthroat Trout population viability analyses, this section proposes a range of values for two metrics of viability; 1) abundance levels necessary to maintain a population, and 2) the amount of stream required to maintain a population. The viability of the upper Fording River population was then discussed within the context of the four general types of anthropogenic threats (*i.e.,* hybridization, over-exploitation, habitat damage and loss, water quality and quantity) that have led to the decline in numbers of Westslope Cutthroat Trout in western Canada over the past 125 years. Identified threats were then explored in more detail in the following section (*see* Section 3.7 Population Sustainability).

Typically, the literature provides estimates of population viability based on the ability of (and requirement for) a population to maintain itself over a number of generations. The Recovery Potential Assessment of Pure Native Westslope Cutthroat Trout, Alberta Population, suggests, "…a population must have about 470 adults to have a 50% probability of persistence for at least

40 generations (*i.e.,* 120-200 years), and more than 4,600 adults to have a 90% probability of long-term persistence" (Cleator *et al.* 2009, DFO 2009). Based on this definition, the range that encompasses what would be defined as a viable population was 470 to 4,600 adults; depending on the level of risk accepted in the management of the population. The current range of estimates for the upper Fording River population of mature Westslope Cutthroat Trout was between 2,552 and 3,874 fish greater than 200 mm fork length. Based on these estimates the upper Fording River population falls within the range defined as a viable population of Westslope Cutthroat Trout.

There remains statistical uncertainty in regards to the population trend since the annual point estimates for sub-adult and adult (*i.e.,* fish > 200 mm) abundance across the three years appear to be increasing but the 95% confidence intervals were wide enough (*i.e.,* overlap among years) that the evidence of an increase in population size among the three years was weak.

Another approach to estimating population viability has been to estimate the amount of stream required to maintain a population (Hilderbrand and Kershner 2000a). In streams with high abundance, and incorporating an annual population loss rate of 10% due to mortality and permanent emigration, it has been estimated that about 9 km of stream is required to maintain an isolated population. In streams with low abundance, the length of stream needed was estimated to be about 28 km. The upper Fording River population encompasses approximately 57.5 km of mainstem river habitat and 59 km of tributary habitat (note that this differs from the tributary assessment methods that identified the upper Fording River above Henretta Creek (16.6 km) as tributary habitat in size, character and population utilization). Based on these estimates the upper Fording River population falls within the range defined as a viable population of Westslope Cutthroat Trout.

The one caveat would be that mortality estimates of radio tagged Westslope Cutthroat Trout were much higher (range 21% to 32% per year) than the 10% used by the authors to estimate the amount of stream required to maintain a population. Although uncertainty in mortality rates remain since the tagging procedure may have contributed to elevated mortality rates through increased susceptibility to predation, potential radio tag failure and delayed mortality due to surgical procedures.

To summarize, the upper Fording River represents a healthy or viable population of Westslope Cutthroat Trout of between 2,552 and 3,874 mature fish greater than 200 mm fork length within approximately 57.5 km of mainstem river habitat and 59 km of tributary habitat. The long-term viability of this population was subsequently evaluated in the context of perceived or existing threats. These threats are introduced below and discussed in more detail in the following discussion of population sustainability.

It is generally recognized that the following four general types of threats of anthropogenic origin have led to the decline in numbers of Westslope Cutthroat Trout in western Canada over the past 125 years (Isaak *et al.* 2012, Cleator *et al.* 2009, Mayhood 2009, Oliver 2009, Muhlfeld *et al.* 2009, Shepard *et al.* 2005, 1997, Hilderbrand and Kershner 2000a, Mayhood 1999, Jakober *et al.* 1998, Thurow *et al.* 1997, Woodward *et al.* 1997):

1. Introduction of non-native salmonids resulting in competition, replacement and hybridization. In fact hybridization is most often considered the greatest current threat to native Westslope Cutthroat Trout populations;
2. Historically, over-exploitation beginning around the turn of the century with the arrival of the Canadian Pacific Railroad;
3. More recently, habitat damage and loss; and
4. Water quality and quantity.

SARA identifies the threats of the highest impact to this species are associated with water use, forest harvest, linear projects, mining, and aquaculture (hatcheries and stocking); however, threat impacts are variable across the species' range. These threats are not mutually exclusive and can interact to have cumulative and synergistic effects on the species (ARWT 2013).

Hybridization with non-native Rainbow Trout is often cited as the greatest threat to Westslope Cutthroat Trout persistence (Carscadden and Rogers 2011, Muhlfeld *et al.* 2009, Allendorf and Leary 1988). This threat does not currently apply to the upper Fording River population of Westslope Cutthroat Trout. The upstream migration barrier of Josephine Falls has protected the upper Fording River population which has been confirmed genetically pure (Carscadden and Rogers 2011, Rubidge and Taylor 2005, Rubidge *et al.* 2001).

Throughout their range, native species of Cutthroat Trout have experienced severe restrictions in their distribution and abundance due to over-harvest (Cleator *et al.* 2009, Mayhood 2009, Allan 2000). Again, this threat does not currently apply to the upper Fording River population of Westslope Cutthroat Trout since the upper Fording River has remained closed to angling since 2010 and harvest is forbidden. However, within the species range, local/East Kootenay populations are generally considered relatively healthy and can support some level of recreational angling. Management objectives for this population include the provision of sustainable and diverse recreational opportunities and based on prior use of the area, there are societal aspirations for recreational use (catch-and-release angling), commercial guiding use (catch-and-release) and harvest opportunities within the upper Fording River watershed. To incorporate these aspirations into the future while maintaining long-term sustainability of the population, the upper Fording River Westslope Cutthroat Trout population would likely need to be managed toward the higher end of the viability range suggested (*i.e.,* greater than 470 adults, and likely much closer to 4,600 adults, Cleator *et al.* 2009, DFO 2009).

Should the re-introduction of catch and release angling be considered it must be done in the context of potential threats to long-term viability that were identified in the current study and in the literature (Mayhood 2009, Oliver 2009). The main threats are non-compliance in harvest and vulnerabilities to catch and release post hooking mortality. Non-compliance is compounded by the vulnerability of the population as identified by large aggregations representing a large proportion of the population that are easily accessible by road in a remote area. Given the remoteness of the area a strong enforcement presence is problematic and costly. Non-compliance was routinely observed during the current study. Catch and release is believed to result in low mortality (*i.e.,* < 5%) but cumulative effects of multiple catch and release incidents for individual fish can be significant. Mayhood (2009) reported some fish in the Elk River being released 11 times in a summer season. Prince and Morris (2003) reported that late in the Elk River fishery season 40% of Westslope Cutthroat Trout were missing all or part or all of their maxillary. This Project identified the vulnerability of the largest sized fish to angling, with the majority of these fish being captured in all three years of study (using only two professional anglers). These vulnerabilities may be a greater concern given the short summer rearing season in the upper Fording River. Higher mortality may occur with warm water temperatures and poor handling by some anglers.

Further anthropogenic impacts related to habitat damage and loss (point 3 above) and water quality and quantity (point 4 above) were identified within the upper Fording River and were likely limiting Westslope Cutthroat Trout productivity and population resilience. These threats include; 1) water quality and quantity concerns (*see* Section 1.1 Background, 3.1.2 Water Temperature and 3.4 Habitat Mapping), 2) loss of tributary habitat through the construction of rock drains (*i.e.,* valley infilling) and inadequate culvert design and placement (*i.e.,* lost connectivity, *see* Section 3.2.3.2.2 Population Estimates), 3) degraded stream channels (*see* Section 3.4 Habitat Mapping), and 4) re-introduction of angling (noted above).

Notwithstanding the above threats, the population viability metrics for the upper Fording River population were generally positive. The abundance (between 2,552 and 3,874 fish greater than 200 mm fork length) and available habitat (57.5 km mainstem river plus 59 km of tributary habitat) of the upper Fording River Westslope Cutthroat Trout population were considered very good in terms of the geographic distribution of the species. The genetic integrity of the population has been preserved and will continue to be protected by Josephine Falls; a barrier to upstream migration. The upper Fording River has remained closed to angling since 2010 and harvest is forbidden.

3.7. Population Sustainability

The use of telemetric methods and representative juvenile locations was used for the identification of life history patterns and habitat use. These observations and patterns were then assumed to represent the population as a whole. Ground-truthing and the consistency of conclusions in regards to reference populations within the upper Kootenay watershed and known species preference within the literature support the conclusions contained within the report regarding life history strategies, critical habitats, perceived threats and population effects. The determination of critical habitats and threats to these habitats and the fish population relies on this balance of evidence approach.

In the short-term, sustainability is attainable given the viability analyses in the previous section *(i.e.,* abundance and habitat metrics, genetic integrity protected by a barrier to upstream migration, angling and harvest prohibited). However, there remain two key statistical uncertainties that require further population monitoring and four perceived threats to population resilience identified that require mitigation to ensure long-term population sustainability.

Statistical uncertainty remain due to; 1) the point estimates for sub-adult and adult (*i.e.,* fish > 200 mm) abundance for the three years appear to be increasing over time but the 95% confidence intervals were wide enough (*i.e.,* overlap among years) that the evidence of an increase in population size among the three years was weak, 2) the differences between the mortality rate estimates of radio tagged Westslope Cutthroat Trout (*i.e.,* 21% to 32% per year) and those used by the model authors to estimate the amount of stream required to maintain a population (*i.e.,* 10%, Hilderbrand and Kershner 2000a). Methods may have contributed to elevated mortality rates through increased susceptibility to predation. Further long-term population monitoring (*i.e.,* 10 years) is recommended to address these uncertainties (*see* Section 5 Population Monitoring Recommendations).

There were four perceived threats identified in the population viability analyses to long-term population resilience and hence sustainability of current population abundance. These threats are explored in further detail below. The four identified threats were:

1. Water quality (*i.e.,* both constituents of concern and elevated water temperatures) and water quantity,
2. Loss of tributary habitat through the construction of rock drains (*i.e.,* valley infilling) and inadequate culvert design and placement (*i.e.,* lost connectivity) limits population productivity and reduces the full expression of life history diversity thus reducing population resilience and abundance. These impacts are manifest in some form or other within 1.0 km on all tributaries present within the upper Fording River study area except Ewin-Todhunter Creek. Many streams of note (*i.e.,* Clode, Lake Mountain, Dry and Greenhills Creeks) represent receiving environments for settling ponds and threat one above also applies,
3. Stream channel degradation of Segments S7, S8 and S9 (*i.e.,* mainstem habitat within the FRO property boundary extending from river kilometer (rkm) 51 to rkm 65) limit population productivity and reduces the full expression of life history diversity thus reducing population resilience and abundance. Habitat assessments documented riparian vegetation loss, channel instability and degraded fish habitat conditions such as excessive width: depth ratios, shallow water depths, limited pool habitat (pool area, pool frequency), limited structural elements in the form of large woody debris (LWD), increased gradient and coarser substrates with decreased substrate diversity. These impacts also contribute to increased water temperatures and increased extent and duration of channel dewatering creating migration barriers and a loss of connectivity
4. The possible re-introduction of angling. Given the vulnerability of Westslope Cutthroat Trout in general and the upper Fording River population in particular to angling related mortality this possibility was a concern given the potential for cumulative impacts within the watershed. The main threats were non-compliance in harvest and vulnerabilities to catch and release post hooking mortality.

Note that a number of Teck initiatives (Elk Valley Water Quality Plan (EVWQP), Regional Fish Habitat Management Plan, Regional Offsetting Strategy, Tributary Evaluation Program, Tributary Management Plan) in collaboration with the Elk Valley Fish and Fish Habitat Committee and the Environmental Monitoring Committee are currently working towards addressing the perceived threats identified above. For example, provided the target timelines and concentrations outlined in the Elk Valley Water Quality Plan (EVWQP 2014) are met, these concerns will be alleviated. Provided the habitat offsetting strategies identified/recommended for the remaining three perceived threats are implemented in a timely and effective manner, these concerns will also be alleviated. In 2016, habitat rehabilitation (offsetting) measures were constructed to address the stream channel degradation in Segments S8 and S9 and connectivity concerns at the multi-plate culvert and Henretta culvert and associated weirs. Additional offsetting measures are planned to address the stream channel degradation in Segment S7, Henretta Creek/Lake and Fish Pond Creek from 2017 to 2019.

The greatest outstanding threats to long-term viability are the concerns identified for water quality and water quantity. As summarized in the background section of this report, water quality constituents of concern have reached average concentrations that while still inconclusive, could have the ability to cause population level impacts. If not addressed, the continued increasing trend in water quality constituents of concern could threaten the viability of the aquatic environment and Westslope Cutthroat Trout (Lemly 2014).

The current Project has identified high utilization core areas that are important (*i.e.,* critical habitat) for spawning and incubation (Figure 3.3.14), juvenile rearing (Figure 3.2.11), and over-wintering (Figure 3.3.19) that overlap with areas of high selenium concentrations and increasing trends (*see* Windward Environmental *et al.* 2014). The areas include Greenhills Creek, river Segment S6, as well as the log jam complexes within river Segments S4 and S5 (above Ewin Creek). High density spawning (redds) in Greenhills Creek combined with the high reported selenium concentrations and very low densities of fry (Table 3.2.28) were suggestive of recruitment failure. Given the observed redd densities, fry densities similar to those in other high density spawning sites (*i.e.,* river Segments S8, S6, the side-channel that flows into Lake Mountain Creek, and Dry Creeks) were expected. Dry Creek has recently been permitted as a receiving environment for the Line Creek LCO Phase II Project and increasing selenium levels may pose a threat to this habitat in the future. A high proportion of the population (42%) were concentrated within the “oxbow” pools of river Segment S6, which was identified to have high selenium (Windward Environmental *et al.* 2014). These fish spend a majority of their life within this high selenium environment and are known to contain elevated and high selenium bioaccumulation within tissue samples (McDonald 2013).

These concerns have been addressed through the Elk Valley Water Quality Plan (EVWQP 2014) and Teck Coal has committed to stabilizing and decreasing water quality constituents of concern. Provided the target timelines and concentrations outlined in the Elk Valley Water Quality Plan are met, these concerns will be alleviated.

Thermal loading, or increased water temperatures within FRO onsite river Segments S7, S8 and S9 were another water quality threat identified. Westslope Cutthroat Trout thrive in cold, clean streams preferring stream temperatures of 7-16 °C (*see* Section 3.1.2 Water Temperature) and

Segment S7 daily maximum temperatures exceed water quality guidelines for spawning, incubation and rearing (Figure 3.1.4). Stream water temperatures in Segment S7 in the lower FRO were routinely elevated 3.0 ^{o}C and increased by as much as 6.2 ^{o}C (Figure 3.1.3a). Segment S7 maximum daily temperatures were within 0.8 °C of the upper incipient lethal temperature for Westslope Cutthroat Trout (19.7 ^{o}C 95% C.I. 19.1 – 20.3 ^{o}C, Bear *et al.* 2005). The upper incipient lethal temperature is a commonly used measure to define the upper boundary to the zone of thermal tolerance above which mortality effects due to temperature can be expected. Elevated water temperatures and surface mining are most commonly associated with the removal of riparian vegetation (increased solar heating), channel geometry impacts (increased solar heating due to increased width:depth ratios and shallow water depths) settling ponds releasing warmer water, and the loss of cooler headwater tributary inflows (water withdrawals; Nelson *et al.* 1991).

Water quantity concerns have also been identified as a threat to FRO river Segments S7, S8, and S9. A number of studies dating back to when mine operations began in 1971 have identified dewatered and/or frozen sections of river channel. The current study has confirmed dewatered channels and associated fish mortalities within river Segments S7 and S9 (*see* Section 3.3.1.3 Survival). These conditions make the upper Fording River sensitive to common impacts of surface mining that have the potential to increase the frequency and/or extent of channel dewatering such as alterations in flow (*i.e.,* water withdrawals) and channel conditions (*i.e.,* vegetation removal, over-widened channels, altered sediment supply, “re-aligning” or diverting of channels) (*see* Section 3.4 Habitat mapping). While incidents of channel dewatering are not unique to the upper Fording River and it is recognized that at least some proportion of these incidents of dewatering are a naturally occurring phenomenon, the balance of probabilities suggests that water withdrawals and degraded stream channels are contributing to increased risk of dewatering extent and frequency.

The largest habitat losses over the last 45 years, and a current limiting factor for Westslope Cutthroat Trout in the upper Fording River, was the loss of tributary habitat through the construction of rock drains (*i.e.* valley infilling) and inadequate culvert design and placement (*i.e.,* lost connectivity). For species such as Westslope Cutthroat Trout and Bull Trout that have migratory life history strategies, preserving movement corridors and connectivity is critical for such species that utilize different habitats located in different parts of the watershed. For such species, human caused fragmentation of rivers and tributaries can reduce population resilience and viability (Schrank and Rahel 2004, Rieman and Dunham 2000, Brown and Mackay 1995).

It was estimated that roughly 59% to 79% (depending on whether or not one includes the multi-plate and Henretta Creek partial barriers) of all historically available tributary habitat has been lost (*i.e.,* infilled) or fragmented (*i.e.* isolated upstream of a fish passage barrier such as a culvert, in line settling pond of rock drain) from the mainstem upper Fording River population of Westslope Cutthroat Trout. Recruitment is typically the strongest determinant influencing populations (Maceina and Pereira 2007), so the estimated loss of roughly 59% of all historically available tributary habitat (*i.e.,* preferred juvenile rearing habitat*)* may have important consequences for population growth if this habitat is limiting.

Complete passage barriers (*i.e.,* lost connectivity) within the lowermost 1.0 km were identified and include; Chauncey Creek (BC Ministry of Transportation), Lake Mountain Creek (Teck), Greenhills Creek (BC Ministry of Transportation and Teck) and Dry Creek (BC Ministry of Transportation and Canadian Pacific Railway). Clode and Kilmarnock Creeks (Teck) have been lost to infill and development as settling ponds; except for the lowermost 50 m of Clode Creek as remnant settling pond outflow and seasonal freshet overflows from Kilmarnock Creek settling ponds. The Henretta Haul Road culvert (Teck) represents a life stage (juvenile) passage barrier and tributary habitat above this culvert (located 400 m upstream from the confluence) is under-utilized except for sub-adult and adult over-wintering and rearing in Henretta Pit Lake. The multi-plate culvert (Teck) on the mainstem Fording River 5.5 km downstream from Henretta Creek likely represents a seasonal point of difficult passage for juvenile life stages under certain flow conditions.

Spawning and high densities of juveniles have been identified below all these culvert barriers. Henretta and Chauncey Creeks retain much of their habitat characteristics (and Chauncey its water quality also), while other tributaries of the upper Fording River (Clode, Lake Mountain, Kilmarnock, Greenhills Creeks, and in the near future LCO Dry Creek) represent remnant tributary habitat with constructed barriers, in line settling ponds, and water quality concerns. Improvement to water quality conditions and innovative methods of eliminating settling ponds from stream networks may need to be considered prior to reconnecting some of these streams for fish use. Remnant, fragmented (*i.e.,* isolated) populations remain within upper Chauncey Creek (current study data), Greenhills Creek (Beswick 2007), Dry Creek (Interior Reforestation 2000), and Kilmarnock Creek (Arnett and Berdusco 2008). Kilmarnock Creek was historically identified as an important over-wintering tributary for migratory upper Fording River Westslope Cutthroat Trout (Lister and Kerr Wood Leidal 1980, Fording Coal Limited 1986) and is currently isolated by valley infill. Clode Creek was identified as over-wintering habitat early in mine development (Fording Coal Limited 1986, Lister and Kerr Wood Leidal 1980) and as a tributary to the Clode Flats core area likely represented important tributary spawning and rearing habitat. This highlights the opportunity to address a limiting habitat by restoring access to those tributaries that still have habitat, but have been isolated by culvert barriers or settling ponds and their associated exclusion barriers. Re-establishing cold water tributary inflows would also alleviate water temperature concerns within onsite river segments.

The above tributaries represent critical habitat identified within the species literature for Westslope Cutthroat Trout life history in general and the upper Fording population in particular, where; 1) fish attain large size at maturity (*i.e.,* > 300 mm length), and 2) have adapted both ontogenetic habitat shifts and seasonal migratory behaviours to persist within a dynamic environment (*i.e.,* high elevation Rocky Mountain streams). A prerequisite for such a migratory species and population is the maintenance of migration corridors between areas such as tributaries, side-channels and headwater habitats that serve as juvenile nurseries and mainstem river habitats that serve as adult rearing and over-wintering habitats. In addition, the maintenance of seasonal migration corridors for mature fish to access seasonal habitats (*i.e.,* spawning and over-wintering habitats) is necessary to complete their life-cycle and to persist as a viable population. Ontogenetic habitat shifts are widespread in mobile aquatic species in which, for example, post-larval fry emerge from the gravel to rear in interstitial shallow margin habitats and side-channels, larger juveniles reside in small pools and riffles with coarse substrate, cut-banks and LWD in natal streams (tributaries) for one to four years but may range further depending on life history form and in response to environmental variables such as water flow, temperature or food availability. Larger mature fish move into mainstem river habitats with deeper water and fish must migrate to reach spatially separated over-wintering and spawning areas (because these habitat features are rarely found in the same locations) (Cleator *et al.* 2009).

These habitat use patterns have been identified in the upper Fording River through telemetric data, juvenile densities and habitat surveys. As well, similar habitat use patterns have been identified within other upper Kootenay River populations such as the Elk, St. Mary, Bull, Wigwam and Flathead Rivers (Morris and Prince 2004, Prince and Morris 2003, Cope and Prince 2012, Baxter and Hagen 2003, Shepard *et al.* 1984). Although each individual habitat loss (impassable culvert) may have a relatively small population effect, the cumulative effect of many small migration blockages in dynamic environments has important consequences by reducing life history diversity, population resilience, and population abundance.

In addition to tributary connectivity and habitat losses, degraded stream channel impacts within the FRO onsite river Segments S7, S8 and S9 include the loss of riparian habitat, increased width: depth ratios, shallow water depths, and reduced pool: riffle ratios as structural elements become depleted. These impacts also contribute to increased water temperatures and increased extent and duration of channel dewatering creating additional migration barriers and lost connectivity. As such, river Segments S7, S8 and S9 were also limiting population productivity further reducing life history diversity, population resilience, and population abundance.

Three of the four threats identified above (*i.e.,* #1 – high water temperatures and thermal exclusion within Segment S7, # 2 - Loss of between 59% and 79% of tributary habitat, and #3 - Stream channel degradation within FRO onsite river Segments S7, S8 and S9) reduce habitat availability and diversity which in turn reduces life history diversity. The result is a population that has been concentrated into certain, very limited habitats (*i.e.,* over-wintering habitats, lower tributaries, limited number of tributaries). The homogenization of life history reduces population resilience (and hence population viability and sustainability) by limiting a populations ability to respond to environmental change or disturbance (*i.e.,* natural and anthropomorphic). A population of diverse life histories is necessary, particularly within dynamic and unpredictable environments (such as the Pacific Northwest Rocky Mountain streams) and constraints to life history diversity in such environments result is an elevated risk of a significant population impact. A significant population impact was defined as an event that results in a loss of 25% or more of the population (C. Schwarz 2012, *pers. comm.*).

This is a recurring feature for species which have evolved within the dynamic environments of Western North America (Waldman *et al.* 2016, Homel *et al.* 2015, Waples *et al.* 2008). The evolutionary history of *Oncorhynchus* spp. (*i.e.,* Pacific salmon, Steelhead, Rainbow and Cutthroat Trout) have many recurring patterns including reproductive homing or site fidelity and the existence of two or more conspecific life history types within a single geographic area. Waples *et al.* (2008) and Homel *et al.* (2015) provide excellent recent summaries of Cutthroat Trout life history diversity, watershed disturbance regimes, and their interaction in population resilience and persistence (*i.e.,* self-sustaining and ecologically effective populations). This summary is paraphrased below because it is important in understanding apparently contradictory habitat use patterns and interpretations within the literature for this species. Refer to Waldman *et al.* (2016), Homel *et al.* (2015), Waples *et al.* (2008) and the seminal review of Holling (1973) for a synthesis of this literature.

Life history diversity is linked to population resilience through spatial and temporal variation in exposure to disturbance (*i.e.,* risk spreading) and in production of offspring (*i.e.,* bet hedging). Where individuals expressing different life history forms occupy spatially discrete seasonal habitats or use multiple locations for the completion of essential life history functions (*i.e.,* spawning, over-wintering and feeding or rearing), disturbance at the local scale may cause extirpation of one portion of the population associated with the affected habitat. Subsequently, recolonization can occur by other individuals from the same population; provided migration corridors (*i.e.,* connectivity) are maintained or restored within reasonable timeframes (*i.e.,* landslides are typically circumvented in days, months or occasionally a year). Similarly, egg or fry survival may vary among spawning locations or habitats associated with different life history forms as a result of environmental conditions. At the population scale, expression of multiple life history forms or use of multiple locations increases the probability that some component of the population will successfully reproduce in a given year. Over time, risk spreading and bet hedging result in selection for multiple life history forms and provide a greater range of opportunities for population persistence in a spatially and temporally variable environment.

Unfortunately, the majority of streams and rivers in the range of Cutthroat Trout are no longer in the same condition that permitted the evolution of diverse life history forms. This has resulted in drastic declines of Westslope Cutthroat Trout, particularly in larger river systems, from its historical range during the last 125 years (Homel *et al.* 2015, Cleator *et al.* 2009, COSEWIC 2006, Shepard *et al.* 2005, Liknes and Graham 1988). In Alberta, for example, most of the remaining populations persist mainly as severely fragmented, remnant headwater populations that average 8 km in length and contain an average of 100 adults (DFO 2009). Fragmentation and simplification of the physical habitat are often small in magnitude (*i.e.,* culverts) but replicated many times across the landscape leading to pervasive effects that artificially select against migratory life history forms; often the larger, more fecund fish (Homel *et al.* 2015, Waples *et al.* 2008). Because few large rivers are intact enough to permit full expression of life history diversity, care must be taken when interpreting the literature and what conservation targets are appropriate (Homel *et al.* 2015).

To illustrate the above effect of habitat loss and homogenization of life history resulting in decreased population resilience and increased risk of a significant population impact, two specific examples are summarized below to illustrate the elevated risk. First, the loss of sub-adult and adult over-wintering habitat (*i.e.,* Kilmarnock and Clode Creeks, FRO degraded stream channels and loss of large log jam over-wintering pools) has resulted in Henretta Pit Lake and the river Segment S6 ground-water over-wintering habitats supporting 90% of the sub-adult and adult over-wintering population. Any negative impacts to these habitats would have a significant negative impact on the population. The flood event of June 2013 and its impact on Henretta Pit Lake through the blocking of the twin culverts that resulted in backwatering and subsequent sediment deposition within Henretta Pit Lake represent an illustration of the validity of this risk. Secondly, with only one exception (Ewin-Todhunter Creek), all tributaries within the upper Fording River watershed have juvenile passage barriers within 1 km of their confluence with the Fording River. This limits preferred juvenile rearing habitat (*i.e.,* tributaries) and concentrates juveniles in high densities within very restricted tributary segments below culverts with large under-seeded segments above culverts. These impacts also likely constrain spawning habitat. This effect is moderated somewhat by the upper Fording River FRO Segments S8 and S9 and the headwaters (Segments S10, S11) that are tributary in character.

Such constraints to life history diversity, particularly constraints to the expression of migratory life history forms, have consistently been identified within the literature as reducing population resilience, increasing the risk to population viability (*i.e.,* extirpation) and has been identified as a precursor to precipitous population declines within the *Salmonidae* family, *Oncorhynchus* spp. and Westslope Cutthroat Trout (Waldman *et al.* 2016, Homel *et al.* 2015, AWRT 2013, Cleator *et al.* 2009, Mayhood 2009, Oliver 2009, Waples *et al.* 2008, Rieman and Dunham 2000, Hollings 1973). Therefore, life history diversity and its manifestation as population resilience, is central to population viability and the long-term population sustainability.

These impacts are pervasive in part, because past regulatory environments have not always credited proponents' habitat offsetting or compensation plans commensurate with the impact of restoring connectivity and migratory pathways that are of critical importance to population resilience. For example, they were often; 1) area based thus promoting the creation of novel habitat such as side-channels, sloughs or pools that may not be limiting population abundance but generate surface area, or 2) numerically based thus promoting targeting of the most productive life history variant in a population or hatchery stocking of fish; both strategies that result in homogenization of life histories. Recognition of such unintended consequences has led to new research and implementation of fish population restoration, mitigation or offsetting concepts that are more conservation or resilience based and consider a wider range of options within a multi-disciplinary, collaborative, communities of interest engagement framework.

Perceived threats number one through four above were identified as opportunities for habitat offsetting (*i.e.,* riparian and stream rehabilitation or restoration projects) for collaborative communities of interest engagement. Ongoing initiatives by Teck have already targeted some of the identified threats and are being developed in collaboration with the Elk Valley Fish and Fish Habitat Committee and Environmental Monitoring Committee (*i.e.,* Regional Fish Habitat Management Plan, Regional Offsetting Strategy, Elk Valley Water Quality Plan, Tributary Evaluation Program and Tributary Management Plan, and the Regional Aquatic Effects

Monitoring Program). In 2016, habitat rehabilitation (offsetting) measures were constructed to address some of the identified threats and additional offsetting measures are planned to be constructed over the next five years.

In conclusion, based on the population metrics of abundance, available habitat, and genetics, the upper Fording River population of Westslope Cutthroat Trout was considered a viable population. Furthermore, the population trend appears to be stable or increasing and supports the conclusion that the population is sustainable; at least in the near term. Threats to population resilience and sustainability have been identified as opportunities for improvement and Teck is currently working in a collaborative process to identify implementation strategies to alleviate or rectify perceived threats.

4. Study Question Discussion

Recall that this is a biological assessment of limiting factors, based on hindsight, current conditions, and a “balance of probability” approach. In no way should it be construed as a condemnation of previous management actions over the previous 45 years that were implemented based on government permitted practices of the day and the best available knowledge at that time. The fact that the upper Kootenay waters and the classified waters in particular, represent a range-wide stronghold for Westslope Cutthroat Trout and as such attract fly fishing enthusiasts from around the world to participate in the Westslope Cutthroat Trout fishery (providing substantial economic value to the Region), attest to the many dedicated resource managers and their management actions and conservation decisions.

4.1. Introduction

Life history diversity is a critical component of Westslope Cutthroat Trout population dynamics and what constitutes a “natural”, “healthy”, or “robust” population (the Project goal). This is particularly important as it relates to understanding apparently contradictory habitat use patterns and interpretation of well documented recurring threats to Westslope Cutthroat Trout populations within the literature for the species. Care must be taken when interpreting the literature and what represents an appropriate reference population and appropriate conservation targets (Homel *et al.* 2015).

Life history diversity is linked to population resilience through spatial and temporal variation in exposure to disturbance (*i.e.,* risk spreading) and in production of offspring (*i.e.,* bet hedging) (Homel *et al.* 2015). Where individuals expressing different life history forms occupy spatially discrete seasonal habitats or use multiple locations for the completion of essential life history functions (*i.e.,* spawning, over-wintering and feeding or rearing), disturbance at the local scale may cause extirpation of one portion of the population associated with the affected habitat. Subsequently, recolonization can occur by other individuals from the same population; provided migration corridors (*i.e.,* connectivity) are maintained or restored within reasonable timeframes (*i.e.,* landslides are typically circumvented in days, months or occasionally a year). Similarly, egg or fry survival may vary among spawning locations or habitats associated with different life history forms as a result of environmental conditions. At the population scale, expression of multiple life history forms or use of multiple locations increases the probability that some component of the population will successfully reproduce in a given year. Over time, risk spreading and bet hedging result in selection for multiple life history forms and provide a greater range of opportunities for population persistence in a spatially and temporally variable environment (Homel *et al.* 2015). Habitat alterations and disturbance can alter the expression of life history diversity in predictable ways that impact population viability, resilience, and sustainability and thus requires an understanding of known species preferences within this seemingly contradictory literature.

The use of telemetric methods and representative juvenile locations was used for the identification of life history patterns and habitat use. These observations and patterns were then assumed to represent the population as a whole. Ground-truthing and the consistency of conclusions in regards to reference populations within the upper Kootenay watershed and known species preference within the literature support the conclusions contained within the report regarding life history strategies, critical habitats, and perceived threats. The determination of limiting factors or habitats, critical habitats and perceived threats to these habitats and the fish population relies on this balance of evidence approach.

The use of telemetric methods has confirmed both resident and migratory life history forms of Westslope Cutthroat Trout within the upper Fording River population. The upper Fording River telemetry study employed a high level of monitoring frequency. The use of multiple fixed receiver stations (*i.e.,* n=6 with continuous monitoring) and a high level of seasonal ground-truthing effort (*i.e.,* 15 sessions per year conducted monthly and weekly during spawning season) have illustrated that annual Floy tagging recapture data (for example), and even seasonal telemetric monitoring would result in the erroneous conclusion that many of the migratory fish were sedentary in nature and “residents” or of such low frequency to represent “straying” (Quinn 1984), rather than a defined and repeatable migratory life history strategy.

For example, migratory fish were documented as resident within Henretta Pit Lake that migrate to spawn in the Fording River mainstem and return within 19 days. Such a short migration period with strong site fidelity means the migratory component of such fish would not be documented without fixed receivers (continuous monitoring) and weekly ground-truthing. Site fidelity identifies this as a repeatable behavior pattern. Replication of this behavior among telemetered fish and cohorts identifies temporal variation in the time at large outside Henretta Pit Lake; presumably due to variables such as intraspecific competition, temperature, stream flow and food availability.

The identification of both resident and migratory life history forms of Westslope Cutthroat Trout within the upper Fording River population was consistent with similarly documented life history diversity for reference populations within the upper Kootenay watershed and within the species literature. This is a recurring feature for species which have evolved within the dynamic environments of Western North America (Homel *et al.* 2015, Waples *et al.* 2008). The evolutionary history of *Oncorhynchus* spp. (*i.e.,* Pacific salmon, Steelhead, Rainbow and Cutthroat Trout) have many recurring patterns including reproductive homing or site fidelity and the existence of two or more conspecific life history types within a single geographic area (Waples *et al.* 2008).

These life history patterns and diversity (*i.e.,* reproductive homing, site fidelity and the existence of two or more conspecific life history types within a single geographic area) have been well documented within similarly investigated (*i.e.,* telemetric studies) upper Kootenay River tributaries (*i.e.,* Bull River, Cope and Prince 2012; Elk River, Prince and Morris 2003; St. Mary River, Morris and Prince 2004; Wigwam River, Baxter and Hagen 2003, Flathead River, Shepard *et al.* 1984). In contrast to many other jurisdictions, these upper Kootenay River tributaries (including the upper Fording River) remain relatively intact within a wilderness setting that contain sufficient geographical area to support substantial numbers of Westslope Cutthroat Trout (*i.e.,* 1,000's), that attain large sizes (*i.e.,* 30 to 50 cm), and retain migratory life histories. Similar results have also been documented within adjacent jurisdictions with similarly intact watersheds (*e.g.,* Salmon River, Idaho, Schoby and Keeley 2011; Blackfoot River, Montana, Schmetterling 2001, Snake River Fine-Spotted Cutthroat Trout, Wyoming, Homel *et al.* 2015).

Unfortunately, the majority of streams and rivers in the range of Cutthroat Trout are no longer in the same condition that permitted the evolution of diverse life history forms. This has resulted in drastic declines of Westslope Cutthroat Trout, particularly in larger river systems, from its historical range during the last 125 years (Homel *et al.* 2015, Cleator *et al.* 2009, COSEWIC 2006, Shepard *et al.* 2005, Liknes and Graham 1988). In Alberta, for example, most of the remaining populations persist mainly as severely fragmented, remnant headwater populations that average 8 km in length and contain an average of 100 adults (DFO 2009). Fragmentation and simplification of the physical habitat are often small in magnitude (*i.e.,* culverts) but replicated many times across the landscape leading to pervasive effects that artificially select against migratory life history forms; often the larger, more fecund fish. Because few large rivers are intact enough to permit full expression of life history diversity, care must be taken when interpreting the literature and what conservation targets are appropriate (Homel *et al.* 2015, Waples *et al.* 2008).

The remaining discussion has been framed in the context of the above population dynamics for the species and the current state of knowledge, relating to the seven specific study questions that defined the objectives of the Project (see Table 1.2.1). The overall goal or purpose of the Project was to determine whether the upper Fording River watershed Westslope Cutthroat Trout population was viable (healthy), resilient (robust) and sustainable (self-sustaining and ecologically effective population). The Project aimed to characterize the upper Fording River Westslope Cutthroat Trout population in terms of abundance estimates, condition factors (*e.g.,* age structure, standard weight equations), genetic differentiation, and life history strategies. Study results were expected to identify home range, movement patterns, limiting and critical habitats through the use of radio telemetry, mark-recapture techniques and habitat mapping.

4.2. Question 1. What is a viable Westslope Cutthroat Trout population?

4.2.1. Approach

Study question # 1 was addressed through a literature search of population viability analyses (PVA) available for Westslope Cutthroat Trout. The intention was to review Westslope Cutthroat Trout population viability estimates completed elsewhere in order to place current upper Fording River Westslope Cutthroat Trout population estimates in context with regard to evaluating the viability of the population.

PVA is a method of risk assessment frequently used in conservation biology that uses population estimates or models to evaluate the risk of extirpation relative to critical management thresholds, threats to life history requirements, demographic stochasticity, genetic variation, environmental variation and catastrophes (DFO 2009, Ackakaya 1998).

In the case of the upper Fording River, "viability" must be considered within the context of the management thresholds (*i.e.,* objectives), which, for the purposes of this study and for consistency with the assessment end-point being used for Teck development proposals in the area (*e.g.,* Baldy Ridge Extension Project Environmental Assessment, LCO Phase II and FRO Swift), was defined as a self-sustaining and ecologically effective population (this includes the capability to withstand environmental change and accommodating stochastic population processes such as unpredictable events (*e.g.,* several dry summers, floods, or an exceptionally cold winter). Management objectives for this population also include the provision of diverse recreational opportunities based on prior use of the area (recreational and commercial guiding catch-and-release use, First Nations harvest opportunities).

Therefore, given these management objectives, the underlying PVA model assumptions in regards to acceptable risk (*i.e.,* probability range and time frames), population size, and productive habitats or mortality rates were critical to defining appropriate management thresholds and thus viability.

The long-term viability of the upper Fording River population was subsequently evaluated in the context of existing viability estimates for Westslope Cutthroat Trout in the context of the management objectives and perceived or existing threats to life history requirements, demographic stochasticity (*i.e.,* population resilience), genetic integrity, environmental variation and catastrophes (DFO 2009, Ackakaya 1998). These threats were introduced in the evaluation of viability and discussed in more detail in the following discussion of population sustainability (*see* Section 4.4 Population Sustainability).

4.2.2. Results and Discussion

Based on the results of a literature review for Westslope Cutthroat Trout population viability analyses, two metrics were proposed;

- Abundance levels necessary to maintain a population, and
- The amount of stream required to maintain a population.

Intuitively, the importance of these two metrics to population viability can be understood as, "larger populations in more productive habitats will be more resilient to anthropomorphic influences than those in smaller, less productive habitats" (MacPherson *et al.* 2014).

In terms of abundance levels necessary to maintain a population, the Recovery Potential Assessment of Pure Native Westslope Cutthroat Trout, Alberta Population, suggests, "…a population must have about 470 adults to have a 50% probability of persistence for at least 40 generations (*i.e.,* 120-200 years), and more than 4,600 adults to have a 90% probability of long-term persistence" (Cleator *et al.* 2009, DFO 2009). Based on this definition, the range that encompasses what would be defined as a "viable" population size was 470 to 4,600 adults; depending on the level of risk accepted in the management of the population. To incorporate management objectives while maintaining long-term sustainability of the population, the upper Fording River Westslope Cutthroat Trout population would likely need to be managed toward the higher end of the viability range suggested (*i.e.,* greater than 470 adults, and likely much closer to 4,600 adults).

The current range of estimates for the upper Fording River population of mature Westslope Cutthroat Trout was between 2,552 and 3,874 fish greater than 200 mm fork length. There remains statistical uncertainty in the population trend over the three annual point estimates.

Another approach to estimating population viability has been to estimate the amount of stream required to maintain a population. In streams with high abundance, and incorporating an annual population loss rate of 10% due to mortality and permanent emigration, it has been estimated that about 9 km of stream is required to maintain an isolated population. In streams with low abundance, the length of stream needed was estimated to be about 28 km (Hilderbrand and Kershner 2000a). Again, to incorporate management objectives (*i.e.,* abundance greater than 470 adults, and likely much closer to 4,600 adults), the upper Fording River Westslope Cutthroat Trout population would likely need to be managed toward the higher end of the viability range suggested.

The current estimate for the upper Fording River population encompasses approximately 57.5 km of mainstem river habitat and 59 km of tributary habitat. However, the mortality estimates of radio tagged Westslope Cutthroat Trout were much higher (range 21% to 32% per year) than the 10% used by the authors to estimate the amount of stream required to maintain a population.

The long-term viability of this population was subsequently evaluated in the context of perceived or existing threats. These threats were discussed in more detail in the following discussion of population sustainability (*see* Section 4.4 Population Sustainability).

It is generally recognized that the following four general types of threats of anthropogenic origin have led to the decline in numbers of Westslope Cutthroat Trout in western Canada over the past 125 years (Isaak *et al.* 2012, Cleator *et al.* 2009, Mayhood 2009, Oliver 2009, Muhlfeld *et al.* 2009, Shepard *et al.* 2005, 1997, Hilderbrand and Kershner 2000a, Mayhood 1999, Jakober *et al.* 1998, Thurow *et al.* 1997, Woodward *et al.* 1997):

1. Introduction of non-native salmonids resulting in competition, replacement and hybridization. In fact hybridization is most often considered the greatest current threat to native Westslope Cutthroat Trout populations,
2. Historically, over-exploitation beginning around the turn of the century with the arrival of the Canadian Pacific Railroad,
3. More recently, habitat damage and loss, and
4. Water quality and quantity.

SARA identifies the threats of the highest impact to this species are associated with water use, forest harvest, linear projects, mining, and aquaculture (hatcheries and stocking); however, threat impacts are variable across the species' range. These threats are not mutually exclusive and can interact to have cumulative and synergistic effects on the species (ARWT 2013).

Hybridization with non-native Rainbow Trout is often cited as the greatest threat to Westslope Cutthroat Trout persistence (Carscadden and Rogers 2011, Muhlfeld *et al.* 2009, Allendorf and

Leary 1988). This threat does not currently apply to the upper Fording River population of Westslope Cutthroat Trout. The upstream migration barrier of Josephine Falls has protected the upper Fording River population which has been confirmed genetically pure (Carscadden and Rogers 2011, Rubidge and Taylor 2005, Rubidge *et al.* 2001).

Throughout their range, native species of Cutthroat Trout have experienced severe restrictions in their distribution and abundance due to over-harvest (Cleator *et al.* 2009, Mayhood 2009, Allan 2000). Again, this threat does not currently apply to the upper Fording River population of Westslope Cutthroat Trout since the upper Fording River has remained closed to angling since 2010 and harvest is forbidden. However, within the species range, local/East Kootenay populations are generally considered relatively healthy and can support some level of recreational angling. Management objectives for this population include the provision of sustainable and diverse recreational opportunities and based on prior use of the area, there are societal aspirations for recreational use (catch-and-release angling), commercial guiding use (catch-and-release) and harvest opportunities within the upper Fording River watershed. To incorporate these aspirations into the future while maintaining long-term sustainability of the population, the upper Fording River Westslope Cutthroat Trout population would likely need to be managed toward the higher end of the viability range suggested (*i.e.,* greater than 470 adults, and likely much closer to 4,600 adults, Cleator *et al.* 2009, DFO 2009). Should the re-introduction of catch and release angling be considered it must be done in the context of potential threats to long-term viability that were identified in the current study and in the literature (Mayhood 2009, Oliver 2009). The main threats are non-compliance in harvest and vulnerabilities to catch and release post hooking mortality.

Non-compliance is compounded by the vulnerability of the population as identified by aggregations representing a large proportion of the population that are easily accessible by road in a remote area. Given the remoteness of the area a strong enforcement presence is problematic and costly. Non-compliance was routinely observed during the current study.

Catch and release is believed to result in low mortality (*i.e.,* < 5%) but cumulative effects of multiple catch and release incidents for individual fish can be significant. Mayhood (2009) reported some fish in the Elk River being released 11 times in a summer season. Prince and Morris (2003) reported that late in the Elk River fishery season 40% of Westslope Cutthroat Trout were missing all or part of their maxillary. These vulnerabilities may be a greater concern given the short summer rearing season in the upper Fording River. This study identified the vulnerability of the largest sized fish to angling with the majority of these fish being captured in all three years of study with just two professional anglers. Higher mortality may occur with warm water temperatures and poor handling by some anglers.

Further anthropogenic impacts related to habitat damage and loss (point 3 above) and water quality and quantity (point 4 above) were identified within the upper Fording River and were likely limiting Westslope Cutthroat Trout productive capacity and population resilience (*see* Section 4.4 Population Sustainability). These threats include; 1) water quality and quantity concerns, 2) loss of tributary habitat through valley infilling and lost connectivity, and 3) degraded stream channels.

Notwithstanding the above threats, the population viability metrics for the upper Fording River population were generally positive. Management objectives, model assumptions and perceived or existing threats suggest the population should be managed at the higher end of existing viability estimates. Current estimates of viability metrics (*i.e.,* population abundance and amount of stream habitat available) for the upper Fording River population were at the higher end of existing viability estimates. The abundance (between 2,552 and 3,874 fish greater than 200 mm fork length) and available habitat (57.5 km mainstem river plus 59 km of tributary habitat) of the upper Fording River Westslope Cutthroat Trout population were considered very good in terms of the geographic distribution of the species. The genetic integrity of the population has been preserved and will continue to be protected by Josephine Falls; a barrier to upstream migration. The upper Fording River has remained closed to angling since 2010 and harvest is forbidden. Population characteristics such as condition factor, growth rates, von Bertalanffy growth model estimates and population age structure, were also indicative of a “healthy” or viable population.

4.3. Question 2. Are the fish healthy (with respect to condition factor)?

4.3.1. Approach

Study question # 2 was examined following three lines of evidence. First, all captured fish were visually examined externally for any signs of injury or deformity. Second, a sub-set of 60 sub-adults and adults were annually examined internally (n=180 total) to confirm gonad development, reproductive status and physical signs of injury, disease, and deformity during the radio tag implantation procedure. Third, all fish were measured for length and weight and relative length-weight and Fulton’s condition factor (Murphy and Willis 1996) were used for comparison with previous values for the upper Fording River and values for other East Kootenay populations sampled using similar methods (*e.g.,* Elk, St. Mary, upper Bull, Wigwam Rivers). Indices of condition or well-being have often been interpreted and compared in weight –

length relationships. In theory, stressed fish should be evident with lower condition indices relative to expected values for unstressed fish. Fulton condition factor was compared for both mature and juvenile fish since comparisons are typically limited to fish of similar lengths (Murphy and Willis 1996).

The fish condition work of the Project was designed to opportunistically assess fish health, but was not designed to understand causal relationships. Therefore, the fish condition work of the Project was primarily in support of substantive on-going work on ecosystem health, namely the EVWQP and the RAEMP.

4.3.2. Results and Discussion

Based on visual examination of captured fish and length-weight condition factors, the upper Fording River Westslope Cutthroat Trout appear to be healthy and robust. Only the Elk River had a higher condition factor among the upper Kootenay River populations reviewed. Based on a comparison of juvenile condition factor with similar historical data, there has been no change in condition factor over the last 30 years.

This assessment was corroborated by: a) the low incidence of deformities noted in the visual assessment of 1,662 fish (n=25 or 1.5%), b) the large average and maximum fish size (*e.g.,* fork length), and c) fish condition observations noted during the surgical procedure regarding the robust nature of upper Fording River Westslope Cutthroat Trout and their adipose tissue and white muscle tissue (*i.e.,* thick body wall). Shortened opercula (gill cover defects) were the only observed deformity. Shortened opercula are often described in many fish species and the condition is not uncommon in farmed salmonids, although numbers affected are usually low (Branson and Turnbull 2008).

In addition, population characteristics such as growth rates, von Bertalanffy growth model estimates and population age structure, were indicative of a “healthy” population.

4.4. Question 3. Is the Westslope Cutthroat Trout population sustainable?

4.4.1. Approach

Sustainability can be defined through change in the population over time (*i.e.,* decreasing, stable, increasing) and the intrinsic population growth potential (*i.e.,* productive potential of the habitat and the reproductive potential of the species). In its simplest form, a sustainable fish population can be defined as one that does not decline over time due to natural and anthropomorphic limitations to productivity.

Study question # 3 was examined through annual sub-adult and adult population monitoring and annual recruitment (fry) and juvenile population monitoring. Since it was anticipated that the Project timeframe (3.3 years or 40 months) would limit the ability of trend monitoring alone to define population sustainability, the current assessment also relied on criteria utilized by management agencies that employ Fish Sustainability Indices (Macpherson *et al.* 2014). These criteria include;

- Population viability (*i.e.,* population abundance and density, genetic integrity and ecological integrity or changes to predators, prey and competitors),
- Productive potential of the population's habitat (*i.e.,* geomorphic extent, natural and anthropomorphic habitat limitations to productivity),
- Trends in fry, juvenile and adult abundance (*i.e.,* increasing, decreasing, stable),
- Population threats and threat mitigation (*i.e.,* habitat loss, overharvest, water quality, exotic species, habitat protection needs and availability), and
- The reliability of the data collected and used for the assessment.

4.4.2. Results and Discussion

Sustainability is attainable given the viability analyses in question # 1 *(i.e.,* abundance and habitat metrics, genetic integrity protected by a barrier to upstream migration, angling and harvest prohibited, population age structure). However, there remain two key statistical uncertainties that require further population monitoring and four perceived threats to population resilience identified that require mitigation to ensure long-term population sustainability.

Statistical uncertainty remain due to; 1) the point estimates for sub-adult and adult (*i.e.,* fish > 200 mm) abundance for the three years appear to be increasing over time but the 95% confidence intervals were wide enough (*i.e.,* overlap among years) that the evidence of an increase in population size among the three years was weak, 2) the differences between the mortality rate estimates of radio tagged Westslope Cutthroat Trout (*i.e.,* 21% to 32% per year) and those used by the model authors to estimate the amount of stream required to maintain a population (*i.e.,* 10%, Hilderbrand and Kershner 2000a). Methods (Floy tagging) and conditions (shallow, low turbidity, high visibility, headwater environment with an abundance of predators) may have contributed to elevated mortality rates through increased susceptibility to predation. Potential radio tag failure and delayed mortality due to surgical procedures could also have contributed to mortality rates. Further long-term population monitoring (*i.e.,* 10 years) is recommended to address these uncertainties (*see* Section 5 Recommendations).

There were four perceived threats identified; 1) water quality and quantity concerns, 2) loss of tributary habitat due to connectivity and infilling, 3) degraded stream channels, and 4) re-introduction of angling. Long-term sustainability of the Westslope Cutthroat Trout population in the upper Fording River should be possible, if not probable, provided the implementation of suitable management strategies (*e.g.,* water quality treatment, water quantity protection, habitat protection and effective habitat offsetting and stream rehabilitation programs, angling prohibition).

The above perceived threats to life history diversity, particularly constraints to the expression of migratory life history forms in a dynamic environment such as the upper Fording River have consistently been identified within the literature as reducing population resilience (a populations capacity to deal with environmental change or disturbance (*e.g.,* natural and anthropomorphic)). A reduction in population resilience increases the risk to population viability (*i.e.,* extirpation) and has consistently been identified as a precursor to precipitous population declines (*i.e.,* sustainability) within the Salmonidae family, *Oncorhynchus spp.* and Westslope Cutthroat Trout (*see* Section 3.7 Population Sustainability).

Perceived threats number one through four above were identified as opportunities for multi-disciplinary habitat offsetting (*i.e.,* stream and riparian rehabilitation) for collaborative communities of interest engagement. Opportunities focused on identifying specific river segments and limiting habitats for habitat offsetting by Teck. These opportunities would target limiting habitats within the upper Fording River and known threats to Westslope Cutthroat Trout population persistence with expectations for increased productive capacity, population resilience and population abundance (*see* Section 5 Recommendations). Ongoing initiatives by Teck have already targeted some of the identified threats and are being developed in collaboration with the Elk Valley Fish and Fish Habitat Committee and Environmental Monitoring Committee (*i.e.,* Regional Fish Habitat Management Plan, Regional Offsetting Strategy, Elk Valley Water Quality Plan, Tributary Evaluation Program and Tributary Management Plan, and the Regional Aquatic Effects Monitoring Program). In 2016, habitat rehabilitation (offsetting) measures were constructed to address some of the identified threats and additional offsetting measures are planned to be constructed over the next five years.

4.5. Question 4. Is it one interconnected population or multiple populations (with respect to genetics)?

4.5.1. Approach

Study question # 4 was evaluated using existing genetic analyses completed for the upper Fording River Westslope Cutthroat Trout population. Conclusions derived from genetic analyses were supported through life history results collected using radio telemetry methods.

4.5.2. Results and Discussion

Previous population genetic analyses indicate there was no genetic differentiation between Westslope Cutthroat Trout captured approximately 22.5 km apart within the lowermost reaches of Dry and Swift Creeks (tributaries to the upper Fording River). This indicates the upper Fording River population of Westslope Cutthroat Trout was one interconnected (migratory) population rather than a number of small isolated (resident) populations (Carscadden and Rogers 2011).

Telemetry data supports the genetic data through documentation of both resident and migratory life history strategies mixing between fish from the upper, mid and lower watershed segments during spawning season. Based on this data one could assume inter-breeding among fish within the watershed rather than genetically isolated sub-populations. These results were consistent with other above barrier pure strain populations within the upper Kootenay River that demonstrated migratory fluvial behaviour (Cope and Prince 2012, Prince and Morris 2003).

4.6. Question 5. What are the habitats (critical and overall habitat) in the study area?

4.6.1. Approach

Study question # 5 was examined through four study design methods. Habitat data capture methods include; 1) meso-habitat utilization (location) data by life stage (fry, juvenile, sub-adult and adult) collected through population monitoring (angling, electrofishing, snorkel methods, Floy and PIT tag recaptures) and radio telemetry (sub-adults and adults only), 2) habitat mapping using high resolution (10 cm) ortho-photographs, 3) habitat characterization or ground-truthing during radio telemetry (location) and population monitoring data collection, and 4) inference from migratory or movement patterns and environmental cues; specifically water temperature and flow data.

Effective population conservation requires an understanding of habitat availability, identification of critical habitats and their spatial and temporal distribution within a watershed (*i.e.,* migration corridors and timing). Habitat provides the context necessary to complete a population assessment, especially as it relates to the productive potential of the habitat and population abundance (*i.e.,* limitations or “bottlenecks” to abundance), life history strategies (*i.e.,* seasonal distribution and movement patterns by life stage) and their effect on population resilience and sustainability (*i.e.,* habitat characteristics that increase the ability of a population to withstand and recover from disturbance). The identification of critical habitats and life history strategies will also support decision making regarding development, effective conservation and habitat offsetting in the upper Fording River watershed (*i.e.,* the study area).

For clarity, it is important to recall the following definitions (*see* Section 1.2 Study Questions and Definitions); “critical habitat, limiting factors or habitats, core population maintenance area (*i.e.,* core areas), fish habitat impact (or degraded stream channel), and population or perceived threat.”

4.6.2. Results and Discussion

Telemetric methods (sub-adults and adults) and density information for fry and juveniles have identified both critical and limiting habitats within the upper Fording River watershed. Critical habitats were consistent with species requirements identified in the literature. Limiting habitats were a function of both the species requirements, which are themselves often naturally limiting (*i.e.,* over-wintering habitat, Cleator *et al.* 2009, Brown 1999), historical impacts of resource development on the critical habitat itself (Windward *et al.* 2014, Fording Coal Limited 1991, 1986, Lister and Kerr Wood Leidal 1980, Wood 1978) and habitat fragmentation (*i.e.,* barriers to migratory corridors between spatially separated critical habitats necessary for the long-term viability and sustainability of the population) (Arnett and Berdusco 2008, Beswick 2007, Interior Reforestation 2000, Fording Coal Limited 1991, 1986, Norecol 1983, Lister and Kerr Wood Leidal 1980).

Although each individual habitat loss (river diversion, removed log jam, impassable culvert, constructed barrier, degraded river segment) may have a relatively small population effect, the cumulative effect of these small reductions in critical habitat and migration blockages over 45 years of mine operations, forest harvesting (specifically headwaters) and linear developments (specifically the Fording River Highway and the Canadian Pacific Railroad) has reduced life history diversity and population resilience resulting in an increased risk to the sustainability of the population within a variable and dynamic environment (Waldman *et al.* 2016, Homel *et al.* 2015, AWRT 2013, Isaak *et al.* 2012, Cleator *et al.* 2009, Mayhood 2009, Oliver 2009, Muhlfeld *et al.* 2009, Waples *et al.* 2008, Shepard *et al.* 2005, 1997, Schrank and Rahel 2004, Rieman and Dunham 2000, Brown and Mackay 1995, Hollings 1973).

Meso habitat utilization was also consistent with the literature (Cope and Prince 2012, McPhail 2007, Morris and Prince 2004, Prince and Morris 2003, Baxter and Hagen 2003, Ford *et al.* 1995). Adults spawned on the descending limb of the hydrograph in gravels cleaned by hydraulic processes during freshet. They spawned in a diversity of habitats represented by mainstem, mainstem braided channel, mainstem side-channel, tributary and lentic shoal locations. Once fry emerged they resided in shallow (*i.e.,* 0.05 to 0.2 m), low velocity stream margin, side-channel or tributary habitats. Juvenile densities were highest in tributary and headwater locations (also tributary in character), in higher gradient (1-3%), coarse substrate (boulder-cobble), moderate depth (*i.e.,* 0.2 to 1.0 m) riffles and small pools. Sub-adults and adults over-wintered within restricted over-wintering habitats that were lentic in nature (*i.e.,* Henretta Pit Lake, Segment S6 oxbows) and/or ground-water influenced (*i.e.,* Clode Flats, Segment S6). They also utilized very deep pools, typically associated with very large channel spanning log jam complexes. Preferred over-wintering habitats contained depth (*i.e.,* at least 3.0 m and preferentially > 3.0 m) and remained free of anchor ice in these high elevations.

Overlap in habitat use by both the migratory and resident life history strategies identified high use critical habitat within the upper Fording River. Resident and life history forms both centred around three core areas (*i.e.,* areas of critical habitat) within the upper, middle and lower watershed. The migratory form moving among at least two of these same areas. Spatial trends in fry and juvenile densities support these same core areas as critical habitat for recruitment. The highest densities of fry and juveniles were in mainstem side-channel and lower tributary habitat below culvert barriers. The three core areas identified as critical habitat are summarized briefly below. Recall that all habitat, including mainstem and associated tributaries, side-channels and riparian habitat within a core area was considered critical habitat necessary for population maintenance:

1. *Upper Watershed.*

   This core area of critical habitat was represented by approximately 6.5 km of stream channel within river Segments S8 and S9. This area extends between the Henretta Pit Lake over-wintering area (63.9 rkm) and the multi-plate culvert plunge pool (57.4 rkm). The mainstem channel and associated side-channels of Segments S8 and S9 encompass the historical "Clode Flats" (Figure 3.2.12) previously identified as important spawning, rearing (all life stages), and over-wintering habitat (Amos and Wright 2000, Fording Coal Limited 1986, Norecol 1983, Lister and Kerr Wood Leidal 1980). A case could also be made from the same studies to include Segment S7 (an additional 5.0 km) and Kilmarnock Creek within this core area as they historically contained high densities of Westslope Cutthroat Trout, spawning and over-wintering. However, current conditions (impacts) were such that these habitats were not included in the current core area.

Habitat mapping results confirmed impacted or impaired physical habitat limitations to salmonid and in this case Westslope Cutthroat Trout production onsite within FRO river Segments S7, S8 and S9 within the FRO area (*e.g.,* “on-site” habitat); compared to both off-site population segments and historical data (*i.e.,* over the 45 years of mine operations). Level I FHAP diagnostic data demonstrated segments S7, S8 and S9 had limited pool habitat (pool area, pool frequency), limited structural elements in the form of large woody debris (LWD), and less off-channel habitat. These represent potential physical habitat limitations to salmonid and Westslope Cutthroat Trout production (Cleator *et al.* 2009, McPhail 2007, Johnston and Slaney 1996, Rosgen 1996, Ford *et al.* 1995). Ground-truthing data confirmed the level I data and documented riparian vegetation loss, channel instability and degraded fish habitat conditions such as excessive width: depth ratios, shallow water depths, reduced pool: riffle ratios, increased gradient and coarser substrates with decreased substrate diversity. These impacts also contribute to increased water temperatures and increased extent and duration of channel dewatering threatening thermal exclusion or increased mortality rates as well as creating migration barriers and a loss of connectivity. These impacts could reasonably be expected to negatively impact Westslope Cutthroat Trout productivity and carrying capacity. Despite these limitations, high density use by both juvenile and adult fish (including spawning and over-wintering) has been documented in these same segments in both the current study and historically (Fording Coal Limited 1985, Norecol 1983, Lister and Kerr Wood Leidal 1980, Wood 1978).

There are a number of conditions associated with surface mining and forest harvesting that are well documented impact pathways for these effects to manifest themselves in stream channels (Nelson *et al.* 1991, Chamberlin *et al.* 1991). These include the loss of vegetation, topsoil and riparian disturbance resulting in changes to the water infiltration rate. This in turn results in overland flow over disturbed landscapes which alters peak streamflow and increases sediment entering the stream (from both overland flow and eroding banks). The result is channel instability and altered channel geometry reflected in over-widened channel widths. Slope steepness (both channel slope and adjacent landscapes) reinforces these effects.

This area also includes remnant tributary outflows (Clode Creek, Lake Mountain Creek) identified as critical spawning and juvenile rearing habitat. These outflows were less than 0.5 km and drain settling ponds isolated by constructed barriers. The current geographical extent was expanded from the historical Clode Flats upstream to include Henretta Pit Lake (critical over-wintering habitat constructed in 1998 as part of the Henretta channel reclamation project). This includes the migratory corridor between these habitats. It also includes Fish Pond Creek (currently providing critical tributary spawning and juvenile rearing habitat constructed in 1990 as mitigation for the Henretta Dragline Project). This area should be considered as a core population maintenance area (*i.e.,* critical habitat) for both resident and migratory population components. The tributaries (Henretta, Clode, Fish Pond and Lake Mountain Creek) and mainstem side-channels represent the highest recorded rearing fry and juvenile densities and form part of this core habitat. This habitat also provided linkages to both upstream (headwater) and downstream critical habitats utilized by migratory fish.

2. *Mid -Watershed.*

The approximately 7.0 km of stream channel representing river Segment S6 should be considered as a core population maintenance area (*i.e.,* critical habitat) for both resident and migratory population components. This river segment extends from the upstream limit of the groundwater upwelling area immediately below FRO (approximately 49.0 rkm) downstream to the confluence with Chauncey Creek (42.0 rkm). This includes the “ox-bow” over-wintering and rearing pools (42.0 rkm to 43.5 rkm and 45.0 to 47.0 rkm) and the adjacent spawning sites identified between the oxbow pools at 43.5 to 44.5 rkm and the groundwater upwelling area between 47.0 and 49.0 rkm (including the side-channel in this same area). The upper section of this river Segment (S6) represented the downstream limit of historical impact assessment studies that identified spawning and over-wintering within this groundwater influenced river channel (Fording Coal Limited 1985, Norecol 1993, Lister and Kerr Wood Leidal 1980). Segment S6 habitats also represent high selenium environments with an increasing trend (Windward Environmental *et al.* 2014) and Westslope Cutthroat Trout captured within these habitats are known to contain elevated and high selenium bioaccumulation within tissue samples (McDonald 2013, Fisher 2013, *pers. comm.*)

Chauncey Creek represents the only tributary habitat for Westslope Cutthroat Trout in this area. The high juvenile densities below the culvert barrier, the predominance of preferred Westslope Cutthroat Trout habitat attributes (particularly juvenile habitat attributes) and documentation of over-wintering and spawning (low density isolates) above the culvert support the inclusion of Chauncey Creek as part of the core habitat. A highway culvert 0.9 km upstream is a migration barrier and a fragmented remnant population exists upstream. Chauncey Creek also represents reference level water quality constituents of concern (*i.e.,* baseline concentrations) and thus would confer population resilience by offering a “fail-safe” refuge habitat in the case of unanticipated impacts.

3. *Lower- Watershed.*

   The approximately 6.3 km of stream channel extending from upper Segment S1 (24.2 rkm) through lower Segment S3 (30.5 rkm) and encompassing the Segment S2 log jams (*i.e.,* GHO area), Greenhills and Dry Creeks should be considered as a core population maintenance area (*i.e.,* critical habitat) for both resident and migratory population components. The log jam, bedrock pools and stream confluences within this area represent important over-wintering, spawning and rearing habitat. This includes Greenhills Creek, the mainstem Fording River at Greenhills Creek, Dry Creek, and the large log jam complexes in this area. Greenhills Creek has a highway culvert and a constructed barrier (*i.e.,* settling pond) located approximately 0.5 and 0.6 km upstream, respectively. Dry Creek has a highway culvert and Canadian Pacific Railway culvert barrier approximately 1.0 km upstream. Remnant fragmented populations exist above these barriers. Greenhills Creek drains a settling pond and Dry Creek is currently being developed as such.

Limitations to the above critical habitats (or core areas) were identified within perceived threats to population viability and/or sustainability (*see* Section 3.6 Population Viability and 3.7 Population Sustainability). The limitations to tributary and over-wintering habitats were a priority concern and are discussed below in relation to their impacts to the above mentioned core areas (*i.e.,* critical habitat).

The loss of historically accessible tributary habitat due to lost connectivity from culverts (Teck, Ministry of Highways, Canadian Pacific Railway), and development for use as settling ponds and valley infilling (Teck) are reviewed here due to the scale of impact identified to these critical habitats and their close association with the above mentioned core areas. The cumulative impact of lost connectivity among tributaries was identified as a concern due to its potential to limit life history diversity in spawning and over-wintering, as well as a potential bottleneck (limiting factor) to juvenile recruitment and spawning habitat. Although each individual habitat loss (impassable culvert) may have a relatively small population effect, the cumulative effect of many small migration blockages in dynamic environments has important consequences (*i.e.,* reduced population resilience and increased risk to population viability and sustainability).

To summarize, all remaining tributary habitat within the eight streams of import (Henretta, Fish Pond, Clode, Lake Mountain, Chauncey, Ewin-Todhunter, Dry and Greenhills Creeks) are recommended for the designation of critical habitat. The following is noted prior to the subsequent discussion on the rationale for this designation;

- Chauncey Creek represents limiting (a culvert barrier within 1.0 km of the confluence isolates the remaining habitat) and critical juvenile rearing habitat and reference level water quality in a river Segment with no tributary or preferred juvenile riffle habitat and water quality concerns,
- The Henretta Haul Road culverts and the multi-plate culvert were considered under-sized and inappropriately designed given the risk they pose to this critically important migration route and habitat for juvenile rearing, spawning and over-wintering,
- Greenhills and Dry Creeks represent limiting and critical tributary spawning habitat with highway, rail and settling pond barriers within 1.0 km and settling pond water quality and water quantity concerns, and
- Tributaries contain the highest densities of rearing juveniles. Recruitment (rearing juveniles) is typically the strongest determinant influencing populations, yet between an estimated 59% and 79% (depending on whether or not one includes the multi-plate and Henretta Creek partial barriers) of all historically available tributary habitat has been lost (*i.e.,* infilled or fragmented).

Habitat use patterns of both adults (telemetric observations) and juveniles (representative density locations) identify the largest historical habitat loss and a perceived threat to Westslope Cutthroat Trout in the upper Fording River is the loss of tributary habitat. It was estimated that roughly 59% of all historically available tributary habitat has been lost (*i.e.,* infilled) or fragmented (*i.e.,* isolated upstream of a fish passage barrier such as a culvert, in line settling pond of rock drain) from the mainstem upper Fording River population of Westslope Cutthroat Trout. These impacts are manifest in some form or other within 1 km of their confluence on all tributaries present within the upper Fording River study area except Ewin-Todhunter Creek and Fish Pond Creek (approximately 750 m of constructed groundwater fed tributary habitat). The

FRO mainstem onsite segments, the headwaters above FRO (both tributary in size and nature) and tributaries represent critical juvenile habitat for a large segment of the population (*i.e.,* "nursery areas" critical for recruitment).

Complete passage barriers (*i.e.,* lost connectivity) within the lowermost 1.0 km were identified and include; Chauncey Creek, Lake Mountain Creek, Greenhills Creek and Dry Creek. Clode and Kilmarnock Creeks have been lost to infill and development as settling ponds; except for the lowermost 50 m of Clode Creek as effluent outflow and seasonal freshet overflows from Kilmarnock Creek settling ponds.

These tributary impacts are understated since the partial barriers to upstream fish passage were not included. The Henretta Haul Road culvert and grouted weirs represent a life stage (juvenile) passage barrier and tributary habitat above this culvert (located approximately 400 m upstream of the confluence with the Fording River) is under-utilized except for sub-adult and adult over-wintering and rearing in Henretta Pit Lake. The multi-plate culvert on the mainstem Fording River 5.5 km downstream from Henretta Creek likely represents a seasonal point of difficult passage for juvenile life stages under certain flow conditions. Both the multi-plate culvert and the Henretta Haul Road culverts were considered under-sized and inappropriate stream crossings given the critical importance of this migration route to spawning, juvenile rearing and over-wintering.

Spawning and high densities of juveniles have been identified below all these culvert barriers. Henretta and Chauncey Creeks retain much of their habitat characteristics while other tributaries of the upper Fording River (Clode, Lake Mountain, Kilmarnock, and Greenhills Creeks, and in the near future LCO Dry Creek) represent remnant tributary habitat with constructed barriers, in line settling ponds, and water quality concerns. Improvement to water quality conditions and innovative methods of eliminating settling ponds from stream networks may need to be considered prior to reconnecting some of these streams for fish use. Remnant, fragmented (*i.e.,* isolated) populations remain within upper Chauncey (current study data), Greenhills Creek (Beswick 2007), Dry Creek (Interior Reforestation 2000), and Kilmarnock Creek (Arnett and Berdusco 2008). Kilmarnock Creek was historically identified as an important tributary for migratory upper Fording River Westslope Cutthroat Trout (Lister and Kerr Wood Leidal 1980, Fording Coal Limited 1986) and is currently isolated by valley infill. Clode Creek was identified as historical over-wintering habitat (Fording Coal Limited 1986, Lister and Kerr Wood Leidal 1980) and as a tributary to the Clode Flats core area likely represented important tributary spawning and rearing habitat. Henretta Creek utilization above Henretta Pit Lake was also likely being limited by the Henretta Haul Road culverts and grouted weirs that were a barrier to juvenile upstream migration.

Westslope Cutthroat Trout belong to the family Salmonidae and as such, have a strong propensity for reproductive homing in their biology (Homel *et. al.* 2015, Waples *et al.* 2008). It is also well documented within the literature that they have a propensity to utilize tributaries for spawning and juvenile rearing (Cope and Prince 2012, McPhail 2007, Morris and Prince 2004, Prince and Morris 2003, Liknes and Graham 1988). Within natal tributaries, riffles of moderate gradient (1-3%), combined with coarse substrate (cobble-boulder) and abundant overhead cover in the form of interstices or LWD are known preferences for salmonid juveniles in general and Westslope Cutthroat Trout in particular (McPhail 2007, Ptolemy *et al.* 2006, Jakober *et al.* 2000, Ford *et al.* 1995). This was also true within the upper Fording River where juvenile densities were highest within lower tributary habitat and the upper Fording River headwaters (tributary in nature, Figure 3.2.11, 3.2.16). Juvenile movements of up to 29.6 km were documented between tributaries and from mainstem habitat into tributary habitat (n=3, 91 to 141 mm fork length). Lower Chauncey Creek juvenile densities (completely lacking in spawning habitat or activity, fry and mature fish) also confirm juvenile movements from mainstem spawning areas into tributary rearing habitat. Recruitment is typically the strongest determinant influencing populations (Maceina and Pereira 2007), so the loss of tributary habitat (*i.e.,* infilled or fragmented) may have important consequences for population growth if this habitat is limiting.

Over-wintering habitat was identified as critical habitat and the loss of historically available over-wintering habitat has created a habitat limitation and capacity “bottleneck”; similar to the tributary losses identified in the preceding paragraphs. The cumulative impact of lost over-wintering habitat, particularly Kilmarnock Creek and Clode Creek over-wintering habitat (Fording Coal Limited 1986, Lister and Kerr Wood Leidal 1980), the loss of large log jam pools (Wood 1978) and degraded stream channels (over-widened, shallow channels without deep pool habitat within FRO onsite Segments S7, S8 and S9) are threatening population resilience and limiting habitat capacity and population abundance. Fish are being concentrated into a very restricted distribution with two locations (Henretta Pit Lake and the river Segment S6 oxbow pools) supporting 90% of all over-wintering fish in the upper Fording River. Any negative impacts to these habitats would have a significant negative impact on the population. The flood event of June 2013 and its impact on Henretta Pit Lake through the blocking of the twin culverts that resulted in backwatering and subsequent sediment deposition within Henretta Pit Lake represent an illustration of the validity of this risk. Henretta Pit Lake represents the only quality over-wintering habitat within the onsite river Segments S7, S8 and S9 (14.4 km). As noted above, there are concerns regarding the selenium levels and increasing trend within the critical habitat of Segment S6 where a significant proportion (59%) of the population spend the majority of their life.

Limitations to the above critical habitats (or core areas) were identified as priorities for habitat offsetting (Teck Coal Limited), as well as multi-disciplinary and multi-agency stream rehabilitation and riparian restoration projects for collaborative communities of interest engagement (*see* below). These opportunities for remediation and enhancement would target limiting habitats within the upper Fording River and known threats to Westslope Cutthroat Trout population persistence with expectations for increased productive capacity, population abundance and resilience (and hence viability and sustainability).

4.7. Question 6. What are the movement patterns and why? and Question 7. What is the distribution of Westslope Cutthroat Trout seasonally, considering, life history stage and upstream distribution limits?

Questions #6 and #7 were combined for this summary since both movement patterns and distribution are essentially driven by the same processes that are tightly linked. Movement patterns and the resulting distribution are driven by life history requirements and these requirements vary by life stage (*e.g.,* fry, juvenile, adult fish) and season (*e.g.,* reproduction, over-winter survival, feeding) (McPhail 2007, Morris and Prince 2004, Prince and Morris 2003, Ford *et al.* 1995, Likeness and Graham 1988).

4.7.1. Approach

Radio telemetry methods are a commonly used tool in the life history field of study and were selected by the Steering Committee as the most appropriate technique to address study question #6. Sixty sub-adult and adult Westslope Cutthroat Trout were implanted with radio tags annually for three years (n=180) and their movements were monitored using a combination of fixed receivers (continuous monitoring) and mobile receivers (monthly, or weekly during spawning). As fish behaviour may be affected by annual variations in river discharge and water temperature, these variables were also monitored.

To address seasonal distribution, “What is the distribution seasonally, by life stage and upstream limits?” (Question 7), telemetric locations of sub-adults and adults (n=166) as well as representative juvenile locations (n=19) were assumed representative of the population as a whole. Multiple lines of evidence (*i.e.,* repeating spatial and temporal patterns, habitat mapping, known species habitat requirements and preferences, reference populations and assessments of migration barriers) were used to infer habitat use during the spawning, over-wintering and summer rearing periods. These seasonal distributions were subsequently examined at various spatial scales, by life stage (*i.e.,* fry, juvenile and sub-adult or adult) (*see* Section 3.2 Population Monitoring and Section 3.3 Movement Patterns and Distribution).

To address "What are the movement patterns and why?" (Question 6), seasonal distributions were examined with respect to important life functions of over-wintering, spawning and summer feeding (*see* Section 3.2 Population Monitoring and Section 3.3 Movement Patterns and Distribution). This was done within the context of the mapped available habitat (*i.e.,* habitat quantity, see Section 3.4 Habitat Mapping) by life stage (*i.e.,* fry, juvenile and sub-adult or adult) and in the context of species biology (*i.e.,* habitat requirements) and known preferences (*i.e.,* habitat quality). Finally, since habitat alterations (*i.e.,* habitat impacts) and disruptions (*i.e.,* migration barriers) were hypothesized to be influencing the distribution of fish, distribution data were reviewed in the context of habitat availability and perceived impacts (*see* Section 3.4 Habitat Mapping).

4.7.2. Results and Discussion

The use of telemetric methods has confirmed both resident and migratory life history forms of Westslope Cutthroat Trout within the upper Fording River population. Reproductive homing or site fidelity has been identified within both life history forms. The existence of two or more conspecific life history types within a single geographic area, and site fidelity or reproductive homing are recurring features for salmonid species which have evolved within the dynamic environments of Western North America (Homel *et al.* 2015, Waples *et al.* 2008, Healey and Prince 1998). This includes Westslope Cutthroat Trout (McPhail 2007, Prince and Morris 2003, Liknes and Graham 1988).

Westslope Cutthroat Trout distribution within the upper Fording River mainstem has been documented from its downstream limit at Josephine Falls (rkm 20.5) to the upstream limit of fish distribution in the headwaters somewhere between 73.0 and 78.0 rkm. This represents approximately 57.5 km of mainstem river habitat. The multi-plate culvert (57.5 rkm) was identified as a possible seasonal migration barrier to juveniles during some flow conditions. Juveniles were confirmed migrating through this culvert so it was confirmed not to be a complete barrier and is instead considered a point of difficult passage.

Seven tributaries were identified as spawning habitat through reproductive homing of telemetered adults, the presence of redds and/or fry. These include; Henretta Creek, Fish Pond Creek, Clode Creek, Lake Mountain Creek (the side-channel flowing into Lake Mountain Creek), Kilmarnock Creek, Dry Creek and Greenhills Creek. All of the above tributary spawning habitat was restricted to the lowermost 1.0 km or less. Henretta Creek spawning was observed in shoals in Henretta Pit Lake (constructed lentic fish habitat 1.0 km upstream from the Fording River). Fish Pond Creek represents approximately 750 m of constructed tributary habitat from groundwater flows within the Clode Flats complex. Clode Creek (50 m), Lake Mountain Creek (200 m), Kilmarnock Creek (0 m) and Greenhills Creek (500 m) represent remnant discharge and/or effluent flows from settling ponds. Dry Creek (1.0 km) access was limited by the Fording Road-Canadian Pacific Railway culverts and settling ponds were being developed upstream during the completion of this project.

Lower reaches below constructed barriers (*i.e.,* culverts, settling ponds) within Henretta, Clode, Lake Mountain, Chauncey, Dry and Greenhills Creeks were also identified as important juvenile rearing habitat. Note that the highway culvert on Chauncey Creek (0.9 km) was a complete barrier to upstream passage and the Henretta Creek Haul Road culvert was a partial or life stage barrier that permitted upstream passage of sub-adults and adults greater than approximately 230 mm fork length but not smaller juveniles. It is well documented within the literature that Westslope Cutthroat Trout have a propensity to utilize tributaries for spawning and juvenile rearing (Cope and Prince 2012, McPhail 2007, Ptolemy *et al.* 2006, Morris and Prince 2004, Prince and Morris 2003, Jakober *et al.* 2000, Ford *et al.* 1995, Liknes and Graham 1988). As noted above, the presence of culvert barriers or exclusion barriers at settling ponds that prevented upstream passage and tributary utilization were documented within the lowermost 1.0 km of all available spawning streams (except Fish Pond Creek which consisted of 750 m of constructed steam channel). In addition to these spawning streams, juvenile distribution included Chauncey Creek below the Fording Road highway culvert (900 m) and Ewin-Todhunter (the only stream with no anthropomorphic barrier to juvenile passage. Juvenile movements of up to 29.6 km were documented between tributaries and from mainstem habitat into tributary habitat. The presence of remnant fragmented populations above constructed barriers was confirmed in Chauncey Creek (current study), Greenhills Creek (Beswick 2007), Dry Creek (Interior Reforestation 2000), and Kilmarnock Creek (Arnett and Berdusco 2008). Henretta Creek utilization above Henretta Pit Lake was also likely being limited by the Henretta Haul Road culverts and grouted weirs that were a barrier to juvenile upstream migration.

As expected, habitat use by sub-adult and adult Westslope Cutthroat Trout varied with season, time of day and life history form. Within the upper Fording River, shifts in distribution and habitat use were documented seasonally for spawning, summer rearing and over-wintering. The average home range for a radio tagged upper Fording River Westslope Cutthroat Trout sub-adult or adult (> 200 mm fork length) was 11.5 km +/- 1.5 km 95% Confidence Interval (n=111). Individual home ranges varied between 0.7 km and 31.6 km. Individual fish were documented undergoing return spawning migrations in excess of 60 km between the upper reaches in the FRO area and the lower reaches in the GHO area. Fish were documented undergoing migrations of similar distances to preferred over-wintering habitat. Individual fish movements of up to 10 km in a 24 hour period were documented. Frequent diel feeding migrations of up to several kilometers were documented at the confluence of Chauncey Creek.

Overlap in habitat use by both the migratory and resident life history strategies, combined with high fry and juvenile densities within these same habitats and adjacent tributaries underscores high use critical habitat within the upper Fording River. Resident and life history forms both centre on three core areas (*i.e.,* critical habitat) and their associated tributaries within the upper, middle and lower watershed. The migratory form moving among at least two of these same areas. These core areas within the distribution were discussed further in Question 5 (Section 4.6), “What are the critical habitats?”

4.8. Summary Discussion of Key Study Questions

To summarize the results of the Project, the upper Fording River population metrics of adult abundance (2,552 to 3,874), habitat availability (57.5 km of mainstem river plus 59 km of tributary) and genetic integrity (pure strain) represent a viable Westslope Cutthroat Trout Population. However, there remain two key statistical uncertainties that require further population monitoring and four perceived threats to population resilience identified that require mitigation or offsetting to ensure population sustainability.

Statistical uncertainty remain due to; 1) point estimates for sub-adult and adult (*i.e.,* fish > 200 mm) abundance for the three years appear to be increasing over time but the 95% confidence intervals were wide enough (*i.e.,* overlap among years) that the evidence of an increase in population size among the three years was weak, and 2) the differences between the mortality rate estimates of radio tagged Westslope Cutthroat Trout (*i.e.,* 21% to 32% per year) and those used by the model authors to estimate the amount of stream required to maintain a population (*i.e.,*10%, Hilderbrand and Kershner 2000a). Methods (Floy tags) and conditions (shallow, low turbidity, high visibility, headwater stream conditions with an abundance of predators) may have contributed to elevated mortality rates through increased susceptibility to predation. Further long-term population monitoring (*i.e.,* 10 years) is recommended to address these uncertainties.

The following perceived threats to population sustainability were identified; 1) water quality and quantity concerns, 2) loss of connectivity and resulting habitat fragmentation due to valley infill and constructed fish passage barriers, 3) degraded stream channels, and 4) re-introduction of angling. Long-term sustainability of a healthy, self-sustaining population of Westslope Cutthroat Trout in the upper Fording River should be possible, if not probable, provided the implementation of suitable management strategies (*e.g.,* water quality treatment, water quantity protection, habitat protection, effective habitat offsetting, stream and riparian rehabilitation programs, and continued angling prohibition).

Three of the four threats identified above (*i.e.,* #1 – high water temperatures and thermal exclusion within Segment S7, # 2 - Loss of between 59% and 79% of tributary habitat, and #3 - Stream channel degradation within FRO onsite river Segments S7, S8 and S9) reduce habitat availability and diversity which in turn reduces life history diversity. The result is a population that has been concentrated into certain, very limited habitats (*i.e.,* over-wintering habitats, lower tributaries, limited number of tributaries). The homogenization of life history reduces population resilience (and hence population viability and sustainability) by limiting a populations ability to respond to environmental change or disturbance (*i.e.,* natural and anthropomorphic). A population of diverse life histories is necessary, particularly within dynamic and unpredictable environments (such as the Pacific Northwest Rocky Mountain streams) and constraints to life history diversity in such environments result is an elevated risk of a significant population impact.

Perceived threats were identified as opportunities for habitat offsetting projects focused on specific river segments and limiting factors *(i.e.,* stream and riparian rehabilitation, restoration of connectivity). Ongoing initiatives by Teck have already targeted some of the identified threats and are being developed in collaboration with the Elk Valley Fish and Fish Habitat Committee and Environmental Monitoring Committee (*i.e.,* Regional Fish Habitat Management Plan, Regional Offsetting Strategy, Elk Valley Water Quality Plan, Tributary Evaluation Program and Tributary Management Plan, and the Regional Aquatic Effects Monitoring Program). In 2016, habitat rehabilitation (offsetting) measures were constructed to address some of the identified threats and additional offsetting measures are planned to be constructed over the next five years.

5. Recommendations

5.1. Population Monitoring Recommendations

A long-term population assessment strategy is recommended to track trends of Westslope Cutthroat Trout abundance in the upper Fording River to address the statistical uncertainty remaining and given the identified threats, to ensure the long-term objectives of Westslope Cutthroat Trout population viability and sustainability are being met. A water temperature monitoring program that includes the Fording River mainstem and all inflow contributions including; tributaries, settling pond outflows, and soon, treatment plant outflows within the FRO area is also proposed. A brief conceptual outline for these mainstem and tributary monitoring recommendations is presented below. The monitoring methods would replicate existing methods and effort thus detailed methods and cost certainty could be derived from the existing Project.

5.1.1. Sub-Adult and Adult Relative Abundance Monitoring Program

The proposed monitoring plan is to continue snorkel counts and extend the current sub-adult and adult population trend monitoring data (2012, 2013, 2014) to a 10 year data set (2012, 2013, 2014, 2017, 2019, 2021). Provided that similar effort is employed such that the majority of usable habitat is enumerated (*i.e., see* Section 2.4.1.2.1 Snorkel Methods and Table 3.2.20; > 80% habitat enumerated) these methods should provide a fairly robust catch-per-unit-effort (CPUE) index of sub-adult and adult abundance for trend monitoring.

Population monitoring data can be used to detect trends (*i.e.,* decreasing, stable, increasing) and monitor population sustainability (*i.e.,* does not decrease over time). However, as anticipated, the Project timeframe (3.3 years or 40 months) was insufficient to define a trend within desired precision levels; despite extensive effort and invasive methodology. Statistical uncertainty remains as represented by the point estimates for sub-adult and adult fish (*i.e.,* fish > 200 mm) for the three years (2012, 2013, 2014) that appear to be increasing over time but the confidence intervals were wide enough (*i.e.,* overlap among years) that the evidence of an increase in population size among the three years was weak. However, as the data set grows, the ability to detect a trend will improve and as such, additional monitoring is recommended to address statistical uncertainty.

In addition, assessing a population's sustainability represents a present day snapshot in time of the current status of a population and should be reassessed if the severity of population threats change, as new threats appear, or as management actions change. Given that Teck development proposals in the area (*e.g.,* LCO Phase II and FRO Swift) have identified perceived threats and potential impacts and offsetting measures are currently being designed and constructed, continued trend monitoring is recommended to ensure continued population sustainability (*i.e.,* stable or increasing population trend) and to address offsetting effectiveness monitoring. This rationale would also apply should the prohibition on angling change.

Therefore, rather than replicate the mark-recapture methods of the current program, a less invasive long-term relative abundance estimator (*i.e.,* snorkel count) with periodic mark-recapture calibration (*i.e.,* every 10 years or trigger based) is proposed. A full review every 10 years is recommended to ensure monitoring is achieving the desired objectives. At that time, based on the current state of knowledge, the project could be renewed as is, modified, or re-designed, for the subsequent 10 years of monitoring. This methodology was proposed for two reasons;

1. There are concerns for elevated mortality rates through increased susceptibility to predation using the current mark-recapture methods. There was evidence that placing brightly coloured Floy tags on the back of fish within a headwater stream channel (*i.e.,* low turbidity and high visibility, shallow water depths), with an abundant predator population, was placing fish at increased predation risk. For this reason, continuation of these mark-recapture methods is not recommended as an ongoing long-term approach. Instead, it was recommended that every 10 years (or based on a trigger event) a single year mark-recapture population estimate using snorkel observer methods should be completed to confirm the key assumption that snorkel count catchability remains reasonably constant (*i.e.,* +/- 25%) and representative of trends in actual abundance.

2. Long-term population trend monitoring is recommended to ensure continued population sustainability (*i.e.,* stable or increasing population trend) during ongoing coal production activities and to address offsetting effectiveness monitoring. To facilitate trend monitoring on a 10 year timescale (with review and up to 10 additional years of monitoring), a cost effective approach is recommended rather than a shorter duration more intensive approach. To achieve desired precision levels (+/- 25%) continued sub-adult and adult population monitoring is recommended to extend the current three year data set (2012, 2013, 2014) to a 10 year data set (2012 – 2021). For cost effectiveness reasons, a common practice in long-term population monitoring is to complete trend monitoring in alternating years. This approach is recommended (*i.e.,* monitoring in Years 6 (2017), 8 (2019) and 10 (2021)). However, for reasons outlined below (*i.e.,* flow and visibility triggers), it may be prudent to plan annual monitoring such that the cancellation of any one year would not result in unanticipated data gaps.

As a general rule, a relative abundance estimator (*i.e.,* snorkel count or CPUE) can be used to track trends in actual population abundance provided underlying assumptions are not seriously violated and sources of variation are minimized to the extent possible (Hubert and Fabrizio 2007). CPUE indexing methods are extremely sensitive to methodology deviations that affect catchability. Therefore, it will be imperative to standardize sampling design (*i.e.,* timing, visibility conditions, spatial extent and consistency in qualified trained observers) as much as possible between the current Project and the future sample years. Consequently, it is recommended the following practices be standardized to ensure snorkel count catchability remains reasonably constant (*i.e.,* +/- 25%) and representative of trends in actual abundance;

- Spatial extent remains consistent with the current Project snorkel program (*i.e.,* Table 3.2.20 > 48 km or 80% of available mainstem upper Fording River and Henretta Creek Habitat). A crew of four to six experienced snorkel observers would enumerate river Segments S1 through S10, Henretta Pit Lake and Henretta Creek below Henretta Pit Lake over a seven day period. The counts would then be summed by river Segment and their number and distribution compared from year to year. This ensures consistency and ensures changes in the spatial distribution of the population does not bias results,
- Timing *(i.e.,* Aug 25 – September 15) must be consistent and flow and visibility based (*i.e.,* ensure no precipitation in preceding days and no instream works activities). For this reason it may be prudent to plan snorkel surveys every year, as opposed to alternating years. Then in the event of precipitation or flow events that are not consistent cancellation will not result in unanticipated data gaps of two years but the occasional year, and
- To ensure consistency, the same trained and qualified observers (snorkelers) should be used in all years. Some staff turnover is to be expected but ideally there would be at least 50% carryover from snorkel observers from the current project and from each previous year moving forward (*i.e.,* one individual in each snorkel pair of observers).

Provided these measures can be standardized, catchability variation should be within the values calibrated in the years 2012 (55%), 2013 (27%), and 2014 (34%). This represents an expected variation of 28%, very close to the desired precision level of 25% identified in the Data Quality Objectives workshops.

While a relative population index can reduce the ability to identify a trend with sufficient power its advantage is that fish are not handled or externally tagged. This was considered a necessary trade-off given the current results that suggest elevated mortality rates through increased susceptibility to predation using the current mark-recapture methods. Placing brightly coloured Floy tags on the back of fish within a headwater stream channel (*i.e.,* low turbidity and high visibility, shallow water depths), with an abundant predator population, could reasonably be assumed to be placing fish at increased predation risk.

Another advantage of a relative population index as compared to a mark-recapture program is the reduced cost. This allows for on-going long term monitoring that could then be used to initiate specific more intensive assessments should a pre-defined “trigger” identify a potential concern through a feedback loop.

A timeline of 10 years (2012-2021) is recommended for the first phase of long-term monitoring of the sub-adult and adult population. This timeframe would ensure the collection of at least three more data points to support trend monitoring and provide a basis for a review of the efficacy of the proposed relative indexing trend monitoring methodology. In addition, a feedback loop mechanism is recommended.

A full review every 10 years is recommended to ensure monitoring is achieving the desired objectives (*i.e.,* a stable or increasing population trend and a desired precision level of +/- 25%). At that time, based on the current state of knowledge, the project could be renewed as is, modified, or re-designed, for the subsequent 10 years of monitoring. If there were no concerns remaining in regards to population viability and sustainability the long-term monitoring program could be terminated. Within the 10 year program, triggers could be built-in that would require specific, more intensive assessments to evaluate a potential concern through a feedback loop. Every 10 years a single year mark-recapture population estimate using snorkel observer methods should be completed to confirm the key assumption that snorkel count catchability remains reasonably constant (*i.e.,* +/- 25%) and representative of trends in actual abundance.

5.1.2. Fry and Juvenile Relative Abundance Monitoring Program

Continuation of the fry and juvenile abundance monitoring program is recommended as a second independent approach for long-term trend monitoring. A second independent trend monitoring approach facilitates confidence in the interpretation of population trends. This is an important consideration given the selection of relative indices (*i.e.,* CPUE data - snorkel counts) as the population estimator and their weakness in regards to being a misleading indicator of abundance when not applied properly or meeting underlying assumptions (Hubert and Fabrizio 2007).

Replication of current Project methods for estimating fry and juvenile densities within representative locations and meso-habitats is proposed. Methods utilize three-pass removal depletion electrofishing methods to generate density estimates for fry and juvenile life stages at 15 representative juvenile sample locations (*see* Section 2.4.2 Recruitment and Juvenile Population Monitoring). Replication of the 2015 locations is recommended as these were the most representative of the available habitat and habitat utilization patterns (Table 2.4.1). Locations were selected to represent the five primary strata delineated for the study area; the lower, onsite and headwater mainstem river segments and both lower and upper tributary sites. All sample locations consist of three meso-habitat units of approximately 100 m^2 each for a total of approximately 300 m^2. For consistency, sampling must be completed in September when fry have emerged and water temperatures are still greater than 5.0 ^{o}C. Fry and juvenile density trends are then compared on a number of spatial scales including; location, watershed strata, and meso-habitat type.

In the interest of cost efficiency, it is proposed that data capture be limited to the Field Data Information System (FDIS) Fish Collection Form. This would focus effort on the generation of density estimates for population trend monitoring rather than physical site attributes for potential correlation and Allen Plot analyses which have been shown to have limited applicability given the low densities and high variation expected for Westslope Cutthroat Trout fry and juveniles.

A common practice in long-term monitoring projects is to complete surveys every other year or alternatively on a two years on and two years off schedule. The fry and juvenile sampling should be conducted in the same years as the sub-adult and adult monitoring. Similarly, a timeline of 10 years is recommended with the same review and triggers built in (*see* Section 5.1.1 Sub-Adult and Adult Relative Abundance Monitoring Program above).

5.1.3. FRO Water Temperature Monitoring Program

A water temperature monitoring program is proposed for the stream network within the FRO area and adjacent river segments. This includes headwater inflows at the northern (upstream) property boundary, mainstem Segments S7, S8, S9 and all tributary and settling pond flows into the mainstem Fording River within these river Segments S7, S8, and S9. Monitoring should also include the critical groundwater upwelling area immediately downstream of FRO at the F2 monitoring location (upper Segment S6). This is necessary to further document and understand the extent and frequency of the temperature impacts observed in 2014 and 2015 within the FRO area. The monitoring plan should be designed similar to the current program (*see* Section 2.3.2 Water Temperature) and include representative locations, location replication and thermistor replication within locations.

Downloads should be conducted seasonally to minimize data loss. Data collection should include daily mean, minimum and maximum values (*see* Section 2.3.2 Water Temperature).

5.2. Recommendations for Long-Term Population Viability and Sustainability

In order to support the long-term viability and sustainability of the upper Fording River population of Westslope Cutthroat Trout, critical habitat, limiting factors and perceived threats to population resilience, productivity and abundance were identified. Critical habitats and limiting factors were identified through telemetric methods and fry and juvenile densities combined with mapping of available habitat and habitat ground-truthing within the watershed. Perceived threats are supported by well documented mechanisms that have consistently been identified as a precursor to precipitous population declines within the Salmonidae family, *Oncorhynchus* spp. and Westslope Cutthroat Trout within their historical range during the last 125 years.

Threats to the expression of life history diversity, abundance and population resiliency were then evaluated within the context of known species biology and habitat preferences documented both within the literature and empirically within the upper Fording River. Finally, these results were considered with respect to reference populations, within a balance of probability approach and the evolutionary history of *Oncorhynchus* spp. This history (*i.e.,* Pacific salmon, Steelhead, Rainbow and Cutthroat Trout) has many recurring patterns including homing or site fidelity and the existence of two or more conspecific life history types within a single geographic area (Waldman *et al.* 2016, Homel *et al.* 2015, Waples *et al.* 2008, Reiman and Dunham 2000, Healey and Prince 1995).

The identification of population level threats represents the first step in ensuring population sustainability. These threats have been identified as opportunities for habitat offsetting, as well as multi-disciplinary and multi-agency stream rehabilitation and riparian restoration projects for collaborative communities of interest engagement. These opportunities would focus on limiting habitats within the upper Fording River and known threats to Westslope Cutthroat Trout population sustainability with expectations for increased productive capacity, population resilience and abundance (and hence viability and sustainability). Ongoing initiatives by Teck have already targeted some of the identified threats and are being developed in collaboration with the Elk Valley Fish and Fish Habitat Committee and Environmental Monitoring Committee (*i.e.,* Regional Fish Habitat Management Plan, Regional Offsetting Strategy, Elk Valley Water Quality Plan, Tributary Evaluation Program and Tributary Management Plan, and the Regional Aquatic Effects Monitoring Program). In 2016, habitat rehabilitation (offsetting) measures were constructed to address some of the identified threats and additional offsetting measures are planned to be constructed over the next five years.

The following identifies threats and recommendations for mitigation and rehabilitation:

1. ***Water Quality Constituents of Concern.*** This concern is being addressed through implementation of the Elk Valley Water Quality Plan (EVWQP 2014) as regulated by permit #107517 issued under the Environmental Management Act. Provided target timelines and concentrations outlined in the EVWQP are met in a manner that protects critical habitats these concerns will be alleviated. When designing treatment plants, the EVWQP should consider designs for water withdrawals and diversions that have the ability to alleviate the selenium concentrations of core habitat areas, loss of tributary habitat, frequency and extent of channel dewatering and temperature impacts.
2. ***Migration Barriers and Population Fragmentation.*** A first priority for habitat offsets and rehabilitation projects should be the restoration of connectivity using appropriately sized full span structures wherever feasible. This will target limiting habitat, and result in incremental increases to life history diversity, population resilience and abundance. Henretta and Chauncey Creeks and the mainstem above the multi-plate culvert retain much of their habitat characteristics while other tributaries of the upper Fording River (Clode, Lake Mountain, Kilmarnock, Greenhills Creeks, and in the near future LCO Dry Creek) represent remnant tributary habitat with constructed barriers, in line settling ponds, and water quality concerns. Improvement to water quality conditions and innovative methods of eliminating settling ponds from stream networks may need to be considered prior to reconnecting some of these streams for fish use. The ongoing Teck initiatives of the Tributary Evaluation Program and Tributary Management Plan are currently evaluating these impacts and prioritizing options. Full implementation of priority tributary recommendations will require the commitment of groups other than Teck, such as British Columbia Ministry of Transport (*i.e.,* Chauncey, Dry and Greenhills highway culvert barriers) and Canadian Pacific Railway Ltd (Dry Creek culvert barrier).
3. ***Over-wintering Habitat Limitations (FRO).*** The construction of additional over-wintering habitat (*i.e.,* very large, nearly channel spanning log jam structures with depths exceeding 3 m and ideally 5 m) within river Segments S7 to S9, particularly in the Clode Flats area, is recommended to provide spatial diversity necessary to protect the Westslope Cutthroat Trout population. These onsite remedial works would be best suited

as a priority recommendation for the Teck Regional Offsetting Strategy. These works should be done in conjunction with recommendation 4 below.

4. ***Rehabilitation of Degraded Habitats (FRO).*** One of the best opportunities for the Teck Regional Offsetting Strategy is a long-term program to restore the riparian ecosystems and their respective stream channels within river Segments S7, S8 and S9 (*i.e.,* ongoing; delivered in 10 year plans with specific annual targets and 10 year review periods). This includes an integrated approach of revegetation programs (both riparian habitats and spoil slopes), re-contouring to eliminate overland flow, bank stabilization using natural material revetments and the incorporation of *very* large channel maintaining log jam complexes and over-wintering habitat (*see* recommendation 3 above). For maximum effect, these works should be completed in conjunction with the connectivity priorities above (*see* recommendation 2 above).

   Such works would also have the benefit of promoting channel stability and could be integrated with infrastructure protection works to provide bio-engineered solutions to current usage of rip-rap armouring, streambank berms and channel diversions.

5. ***Water Temperature Monitoring.*** A water temperature monitoring program for the Fording River and tributary inflows within the FRO area is proposed. The cumulative impacts of habitat alterations and mining operations result in elevated water temperatures in river Segment S7 that exceed water quality guidelines for spawning, incubation and rearing. However, the existing water temperature data was collected opportunistically. A water temperature monitoring program is recommended to identify thermal load sources, and determine the full extent and potential impact of elevated water temperatures within FRO. Previous recommendations one through four all contain elements that have the potential to alleviate water temperature concerns (*i.e.,* water treatment plants, moving settling ponds off-line and restoring cold water tributary inflows, riparian (shading) restoration, the restoration of width:depth ratios, re-placement of rip-rap with wood that has lower thermal conductance) and the water temperature monitoring program should explicitly include long-term effectiveness monitoring to test the efficacy of any remedial measures implemented.

6. ***Prohibition of Angling.*** The vulnerability of Cutthroat Trout in general and the upper Fording River population in particular to angling related mortality is a concern given the potential for cumulative impacts within the watershed. The main threats were non-compliance in harvest and vulnerabilities to catch and release post hooking mortality.

Continued prohibition by the British Columbia MFLNRO Fisheries Branch is recommended until such time as population monitoring and threat mitigation has reduced the concerns for cumulative effects on long-term population sustainability. When re-introduction of catch and release angling is considered it should be done in conjunction with limits to angler effort, increased vigilance in enforcement, and rigorous population monitoring (*see* recommendation 7 below). However, the re-introduction of angling will confound the population trend monitoring results and interpretation of the population response to habitat offsetting implementation.

7. ***Long-Term Population Trend Monitoring.*** Long-term population trend monitoring is recommended to track trends of Westslope Cutthroat Trout abundance in the upper Fording River to ensure the long-term objectives of Westslope Cutthroat Trout population viability and sustainability are being met. An ongoing population monitoring program is also necessary to test the efficacy and cost efficiency of the many remedial measures implemented through the ongoing initiatives implemented or those additional measures being considered by Teck and the Elk Valley Fish and Fish Habitat Committee.

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