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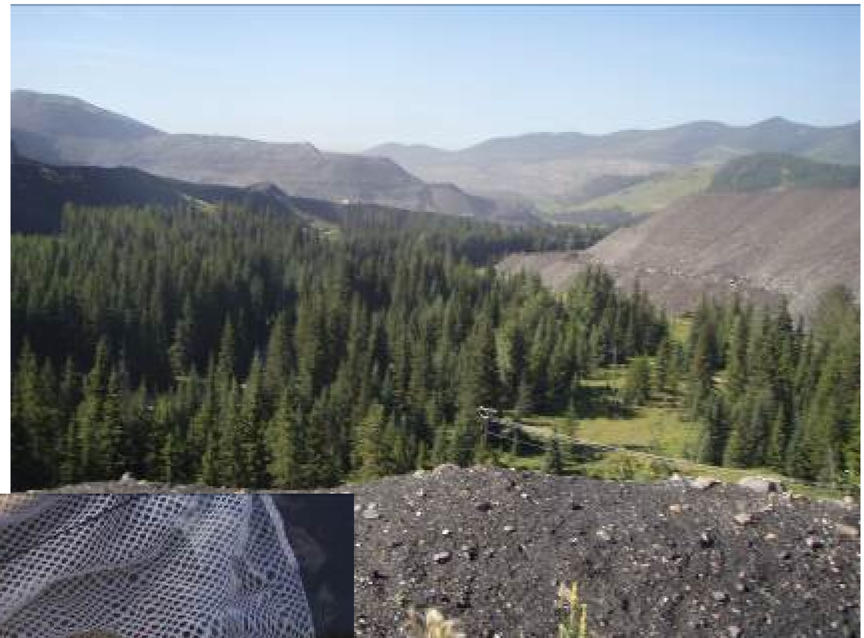

Upper Fording River Westslope Cutthroat Trout Population Assessment – Telemetry Project

Annual Report: 2012-13 (Interim Report 1)

Study Period: April 2012 to January 2013.

Project Lead:
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June 2013

Cover Photo:

Upper Fording River Operations and Upper Fording River viewed downstream (south) from the confluence of Henretta Creek and the Upper Fording River August 16, 2012.

Lower Mature female Westslope cutthroat trout (485 mm fork length, 1,340 g) being released after implantation of 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 watershed, August 30,2012.

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Executive Summary

Teck Coal Limited ("Teck") has commissioned a multi-year study to understand the current status of Westslope cutthroat trout in the upper Fording River watershed upstream of Josephine Falls. The title of the study is the *Upper Fording River Westslope Cutthroat Trout Population Assessment – Telemetry Project* (the "Project"). Westslope Fisheries Ltd. was retained by Teck to undertake the Project, under the guidance and direction of a Steering Committee. The Project is intended to provide supporting data for decision making around project planning within the upper Fording River watershed. This report is the first interim annual report (of three) with the final report anticipated in 2016.

The overall goal or purpose of this population assessment study is to determine whether the upper Fording River watershed Westslope cutthroat trout population is healthy, robust and sustainable. Concerns have been raised regarding resource development and recreational use in the area and it is 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 and current habitat availability and use.

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

1. *What is a viable Westslope cutthroat trout population?*
2. *Are the fish healthy?*
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?*

The rationale relating to the above study questions is described in the main body of the report.

Teck operates two surface coal mines within the upper Fording River watershed in southeastern British Columbia; the Fording River Operations (FRO) and the Greenhills Operations (GHO) with a total combined production capacity of approximately 14 million metric tonnes of clean coal (Mtcc) annually. Coal production began in 1971 and 1981, respectively. In addition, a third Teck surface mine, Line Creek (LCO), includes limited activities in the upper Dry Creek watershed, a tributary within the upper Fording River watershed. In addition to mining, forest harvesting, recreational activities, road, railway, and natural gas pipeline developments also occur in the upper Fording River watershed.

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 of British Columbia represent 42 highly productive trout streams. The classified waters licensing system was created to preserve the unique fishing opportunities provided by these waters, which contribute significantly to the province's 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 population status.

Westslope cutthroat trout are the only species known to occur in the upper Fording River, and its tributaries, which is defined by the portion of the watershed that is upstream of Josephine Falls. 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.

The current research aims to characterize the fluvial population of Westslope cutthroat trout in the upper Fording River watershed in terms of abundance, condition factors, age structure, genetic differentiation, and life-history strategies. Study results are expected to identify critical habitats (*e.g.* over-wintering, rearing, and spawning), movement patterns and home range through the use of radio telemetry and mark-recapture techniques.

It is generally recognized that 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:

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. Climate change could represent a significant challenge in the future for this cold-water dependent species.

Three of these four types of threats (items 1, 2 and 4 above) do not currently exist for the upper Fording River Westslope cutthroat trout population. Westslope cutthroat trout are the only species present within the upper Fording River and the population is a genetically pure population protected by a barrier (Josephine Falls), the upper Fording River watershed is currently closed to angling, and water temperatures are well within species optima.

Surface coal mining and forest harvesting are the primary resource development concerns within the upper Fording River. These activities have resulted in a number of historic impacts that include;

1. Elevated concentrations of a number of metal and non-metal water quality variables notably selenium;
2. Fine sediment production (noting that Teck has comprehensive sediment control and re-vegetation plans in place to ensure compliance with water quality guidelines);
3. Habitat fragmentation and loss of groundwater influenced over-wintering habitat. 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;
4. Fording River Road culvert crossings on Chauncey, Ewin and Dry Creeks create barriers (at least during some flows) that cut off access to these watersheds that represent a significant portion of available tributary habitat within the upper Fording River;
5. Loss of riparian habitat and spawning habitat;
6. Angling and over-exploitation may have contributed to population decreases as this population is easily accessible via Fording River Road and has been closed to angling due to uncertainties in population status; and
7. The historical use of bank armouring without current habitat mitigation techniques, thereby removing undercut banks, sweepers and log jams that provide Westslope cutthroat trout habitat.

Depending on the assumptions used in the model, and the level of confidence selected, literature on Population Viability Analyses (PVA) and Recovery Potential Assessments for Westslope cutthroat trout have shown that a viable population can range between 470 and 4,600 adults. Another approach to estimating population viability has been to estimate the amount of stream required to maintain a population. Depending on the population characteristics (*i.e.* abundance, mortality, emigration), it has been estimated that between 9 and 28 km of stream is required to maintain an isolated population. 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., LCO Phase II and FRO Swift), the objectives for the upper Fording River population include maintaining a healthy, self-sustaining population capable of withstanding environmental change and accommodating stochastic population processes in perpetuity. In addition, there are societal aspirations for recreational use (catch-and-release angling) and harvest activities based on past use within the upper Fording River watershed. To incorporate these aspirations while maintaining long-term persistence of the population, the upper Fording River Westslope cutthroat trout population would likely need to be managed toward the higher end of these ranges.

A total of 211 Floy tags were applied to Westslope cutthroat trout (size range 180 – 485 mm fork length, 80 – 1,550 g) in August-September 2012 as “marks” for the September snorkel survey (“recapture”) to facilitate population estimation using mark-recapture methods. The distribution target of four marks per kilometer was achieved for Sections S1 through S10 along the main stem of the upper Fording River (extending over 47.2 km starting at Josephine Falls) and lower Henretta Creek; but not the headwaters Section S11 or remaining tributaries of the upper Fording River. The resulting 2012 (Year 1) population estimate of 2,600 Westslope cutthroat trout greater than 200 mm over the snorkel distance of 47.6 km yields a density estimate of 55 fish/km > 200 mm and 27 fish/km > 300 mm. This preliminary population estimate is limited to fish within the main stem upper Fording River Sections S1 through S10 and lower Henretta Creek and Henretta Lake. It is recognized that additional sampling within the headwater sections and tributaries is required to confirm whether or not headwater sections and tributaries contain sub-adult and adult fish with smaller size-at-maturity. In Year 2 (2013) additional effort has been allocated to sample the headwater Section S11 of the upper Fording River and tributaries in an effort to tag and enumerate these habitats to provide a more complete population estimate for the upper Fording River.

Therefore, relating back to the question of maintaining a viable, self-sustaining population, given the current population estimate (2,600 mature fish), and the available habitat (57.5 km main stem river), it appears that it is possible, if not probable, for the upper Fording River population, with suitable management strategies (*e.g.* habitat protection, angling restrictions), to achieve population objectives of a healthy, self-sustaining population. A key objective over the remaining two years of planned population estimates is to demonstrate the validity of the 2012 estimate through replication and to begin to understand the overall population trend (increasing, stable, decreasing). This will include fry and juvenile abundance and distribution assessments that will begin in fall 2013.

Fish health was evaluated using condition factors. This included external visual examination (n=229), internal visual (surgical) examination (n=60) and comparison of size and weight-length condition factor (n=229) between the upper Fording River population of Westslope cutthroat trout and other upper Kootenay River populations sampled using similar study designs and methods (*i.e.* Elk, Bull, Wigwam, St. Mary Rivers). The upper Fording River population of sub-adult and adult Westslope cutthroat trout compared favourably among these populations and this was reflected in a robust Fulton's condition factor. Only the Elk River had a higher condition factor among the populations examined. This assessment was corroborated by: a) the low incidence of deformities that were more indicative of injuries (1.7%); b) the large average and maximum fish size; and c) fish condition observations noting the absence of deformities or disease and the robust nature of the upper Fording River Westslope cutthroat trout (very thick body wall and white muscle tissue) during internal visual assessments conducted as part of the surgical radio tag implantation procedure.

A review of previous genetic studies determined there was no genetic differentiation among samples taken from lower reaches of tributaries approximately 22.5 kilometers apart within the upper Fording River. This indicates there is enough "mixing" among fish with connectivity to the main stem upper Fording River to be managed as one interconnected population. Initial telemetry data for the summer and over-wintering periods supports the genetics illustrating individual fish movements of up to 28.3 km and substantial amount of mixing within the population.

At this time the evaluation of movement patterns and seasonal distribution of Westslope cutthroat trout within the upper Fording River is in the preliminary stages of investigation (*e.g.* 6 months of a planned 36 months). Radio tags (Lotek MST-930, 390 day life-span) were applied to 60 sub-adult and adult fish ranging from 234 to 485 mm fork length within the main stem upper Fording River Sections S1 through S10 and lower Henretta Creek (including Henretta Lake). There were 21 males (35%), 33 females (55%) and 6 unidentified sex (10%). Fish life stage was classified based on gonad development during the internal exam and included; 11 sub-adults (18.3%), 7 maturing or first spawners next spring (11.7%), and 42 mature (70%).

Home range will be reported on an annual basis following 12 months of monitoring; therefore home range will be reported on for the first time in Interim Report 2 (Q2, 2014). The project team is currently monitoring 56 radio tagged fish located between rkm 22.0 (lowermost Section (S1) above Josephine Falls) and rkm 72.0 (headwaters Section S11). Seasonal movement patterns between summer rearing habitat (August–September) and over-wintering habitat (November–January 15) are presented (mean=4.76 km, range 0.00–28.30, n=56) to illustrate preliminary results are meeting expectations for a migratory fluvial life-history strategy. Dynamic ice conditions, the presence or absence of surface water, potential ground-water influence and water depths appear to be influencing over-winter habitat selection by sub-adult and adult fish. An alternative explanation that headwater sections and tributaries may contain adults with smaller size-at-maturity and are less migratory has not yet been ruled out. In Year 2, additional effort has been allocated to sample the headwater section of the upper Fording River and tributaries.

It is anticipated that after three years (*i.e.* three replicate radio tag groups for a total of n=180) if repeating patterns of movement and seasonal distribution can be identified then critical habitats necessary for the completion of life-history functions (*e.g.* spawning, over-wintering, rearing) can be identified with confidence. Mortality rates between habitats with multiple fish and repeating patterns of annual use (*i.e.* habitats categorized as “critical”, “limiting” or “important”) will be compared to those habitats with lower use categorized as “alternative” or “low utilization” habitats. If differences in mortality risk can be demonstrated this will support the designation of critical habitat.

Aerial imagery was captured in September 2012 for the length of the main stem upper Fording River, the lower fish bearing reaches of tributaries and the associated riparian areas. A total area of 134.3 km^2 was captured on digital colour images with an image pixel size of 10 cm ground sampling distance. Using this imagery, the meso-habitat will be classified and mapped using a standard suite of overview level habitat measurements. The goal is to create a map containing all available fish habitat within the upper Fording River and the lower reaches of tributaries. Mapping of the main stem river and tributaries will be completed in

2013 and 2014. Subsequently, this data could be used to contrast habitat availability with seasonal fish distribution (habitat utilization). This would facilitate comparison of available habitat among river segments and enable analysis using resource selection methods.

The current state of knowledge, relating to the specific study questions identified by the project Steering Committee is presented in Table I. This table is a tool used to illustrate annual progress towards answering the study questions in a concise summary. It is important to note that these are early, preliminary results and further work is required and planned for Years 2 through 4 of the study. As a result, these preliminary summaries are expected to be refined and/or changed in subsequent interim reports as the study progresses toward the final report in 2016. The details regarding the status of each question are provided in the main body of the report.

Table I. Upper Fording River Westslope Cutthroat Trout (WCT) Population Assessment – Telemetry Project preliminary status of study questions after Year 1 (2012). Years 2 to 4 will continue to refine and address these initial results.

Study Question	Study method(s)	Year 1 (2012) Preliminary Status
1. What is a viable WCT population?	• Literature Review	**Between 470 and 4,600 adults** depending on model assumptions and level of confidence. Depending on population characteristics it has been estimated that between 9 and 28 km of stream is required to maintain an isolated population. The higher end of these ranges better represents the objective for a healthy, self-sustaining population capable of withstanding environmental change and accommodating stochastic processes in perpetuity.
2. Are the fish healthy?	• Visual exam during Sub-adult and Adult Population Monitoring • Condition Factor (*K*)	Based on visual external (229) and internal (60) examination, relative fish size, and Fulton's condition factor (*K*), **mature fish** do not exhibit any indication of "stressor" based on relative weight-length and **appear to be in good condition and robust compared to similar upper Kootenay River populations.**
3. Is the WCT population sustainable?	• Sub-adult and Adult Population Monitoring • Recruitment and Juvenile population Monitoring	2012 (Year 1) **population estimate of sub-adult and adult Westslope cutthroat trout > 200 mm FL was 2,600 fish** over a snorkel distance of 47.6 km yielding a density estimate of 55 fish/km > 200 mm and 27 fish/km > 300 mm. **Preliminary estimate suggests it is possible, if not probable, with suitable management strategies (*e.g.* habitat protection, angling restrictions), to achieve objectives of a healthy, self-sustaining population.** A key objective in the remaining two years of planned population estimates will be to demonstrate the validity of the 2012 estimate through replication and to begin to understand the overall population trend (increasing, stable, decreasing). **Recruitment and juvenile population monitoring will begin in Year 2 (2013).** It will include fry and juvenile density estimates, mark-recapture to confirm ages, growth rates and length-at-age variation within both main stem and tributary habitats.
4. One interconnected or multiple populations?	• Literature Review • Radio Telemetry	**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. Initial telemetry data supports the genetics with movements of up to 28.3 km and substantial amount of mixing within the population.
5. What are the habitats (critical and overall) in the study area?	• Radio Telemetry • Habitat Mapping • Habitat Characterization	At this time the evaluation of critical habitats in the study area is **in the preliminary stages of investigation.** High resolution (10 cm) aerial imagery capture completed for main stem river, lower tributary reaches and associated riparian areas in September 2012. Meso-habitat mapping of all available fish habitat will be completed in Years 2 and 3. It is anticipated that after three years (*i.e*. three replicate radio tag groups n=180), repeating patterns of movement and seasonal distribution can be identified and contrasted with available habitat such that critical habitats necessary for the completion of life-history functions can be identified.

Table I. Concluded.

6. What are the movement patterns and why?	• Radio Telemetry	At this time the evaluation of movement patterns **is in the preliminary stages of investigation (*e.g.* 6 months of a planned 36 months).** Radio tags (Lotek MST-930, 390 day life-span) were applied to 60 sub-adult and adult fish ranging from 234 to 485 mm Fork Length within the main stem river Sections S1 through S10 and lower Henretta Creek. This represents the first of three replicate radio tagging years. Home range and annual movement patterns will be reported on an annual basis following 12 months of monitoring, therefore home range will be reported on for the first time in Interim Report 2 (Q2, 2014). Seasonal movement patterns between summer rearing and over-wintering habitat are presented (mean=4.76 km, range 0.00–28.30, n=56) to illustrate **preliminary results are meeting expectations for a migratory fluvial life-history strategy**. Dynamic ice conditions, the presence or absence of surface water, potential ground-water influence and water depths appear to be influencing over-winter habitat selection by sub-adult and adult fish. An alternative explanation that headwater sections and tributaries may contain adults with smaller size-at-maturity that are less migratory has not yet been ruled out. In Year 2 additional effort has been allocated to sample the headwater Section S11 of the upper Fording River and tributaries.
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	At this time the evaluation of Westslope cutthroat trout distribution is **in the preliminary stages (e.g. 6 months of a planned 36 months) of investigation.** The project is **currently monitoring 56 radio tagged fish located between rkm 22.0 (lowermost Section S1 above Josephine Falls) and rkm 72.0 (headwaters Section S11).** In Year 2 additional effort has been allocated to sample the headwater Section S11 of the upper Fording River and tributaries. Recruitment and juvenile population monitoring will begin in Year 2 (2013 within main stem and tributary habitat.

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 is a partnership between Westslope Fisheries Ltd. and the Canadian Columbia River Inter-Tribal Fisheries Commission; 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 – Telemetry Project* is implemented under the guidance and direction of the Project Steering Committee. The Steering Committee consists of representatives from Teck, the Ktunaxa Nation Council, BC Ministry of Forests, Lands, and Natural Resource Operations, Fisheries and Oceans Canada, and Dr. Carl Schwarz (Simon Fraser University). The work of the Steering Committee leading up to the implementation of the project, as well as their ongoing guidance and contribution, are gratefully acknowledged.

Special thanks are extended to Teck as the funding source for the project and to Glenda Fratton (Teck Project Manager) for support, advice, and assistance.

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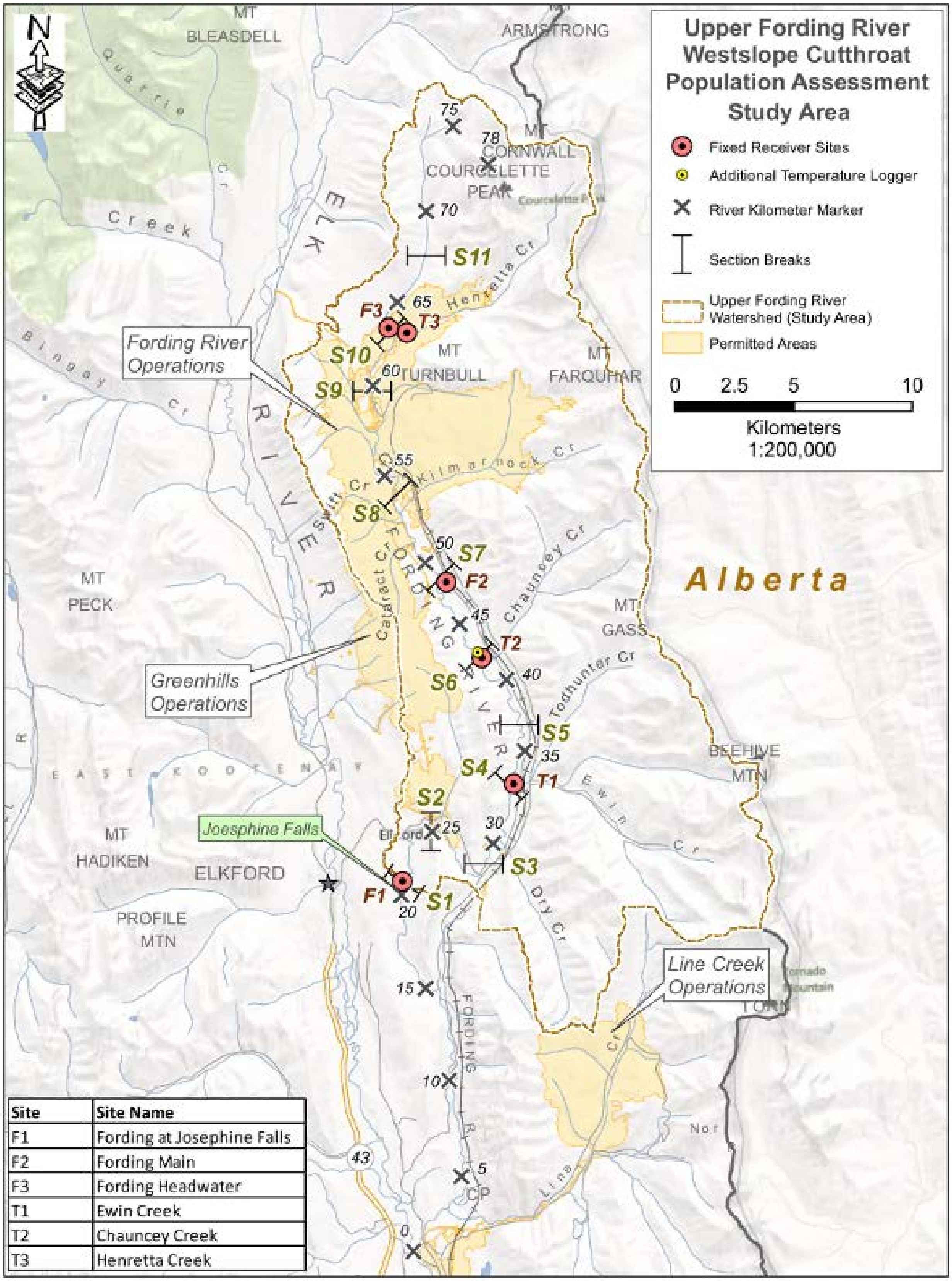
1. Introduction

Teck Coal Limited ("Teck") has commissioned the *Upper Fording River Westslope Cutthroat Trout (WCT) Population Assessment – Telemetry Project* to further understand the current status of Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) in the upper Fording River watershed upstream of Josephine Falls. This project operates under the guidance and direction of the Project Steering Committee comprised of representatives from Teck, the Ktunaxa Nation Council, BC Ministry of Forests, Lands and Natural Resource Operations, Fisheries and Oceans Canada, and Dr. Carl Schwarz (Simon Fraser University).

Concerns have been raised by stakeholders about the lack of information regarding the status of the Westslope cutthroat trout population in the upper Fording River watershed. This concern has largely been raised through dialogue regarding recent fisheries work related to resource development conducted in the area. In 2010, the Province of British Columbia closed the upper Fording River to angling due to uncertainty around the population status.

Teck operates two surface coal mines within the upper Fording River watershed (Figure 1.1.). These are the Fording River Operations (FRO) and the Greenhills Operations (GHO) with a total combined production capacity of approximately 14 million metric tonnes of clean coal (Mtcc) annually. The primary product is high quality metallurgical coal used to make coke for the international steel industry. Production at Fording River Operations began in 1971 and the operation (5,199 ha) lies along the Fording River valley with mining on both the east and west sides of the river. The mine at Greenhills 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 (Figure 1.1). A third Teck surface mine, Line Creek (LCO), includes limited activities in the upper Dry Creek watershed, a tributary within the upper Fording River watershed. In addition to mining, forest harvesting, recreational activities, road, railway, and natural gas pipeline developments also occur in the upper Fording River watershed.

The *Upper Fording River Westslope Cutthroat Trout Population Assessment – Telemetry Project* is a multi-year study which will provide supporting data for decision making around development in the upper Fording River. Concurrently, Teck's Aquatic Effects Monitoring



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

Figure 1.1. Upper Fording River study area.

Program ("AEMP"; Minnow *et al.* 2011) and Habitat Suitability Indexing Program ("HSI", G. Sword, Teck, FRO, Elkford, B.C. *pers. comm*.) will also be collecting data that will add to the understanding of fish health and habitat quality. In addition, a Pre-development Study, sponsored by Teck, is also under way to document historical conditions within the Elk Valley prior to development, using available information. The fish and fish habitat component of this study may provide historical context to the upper Fording River Westslope cutthroat trout population assessment study.

This report represents the first interim annual data report of three with the final project report due following completion of the research project in late 2015. Year 1 (2012) activities focused on the design and implementation of the sub-adult and adult population assessment and telemetry objectives. Year 2 includes the replication of Year 1 sub-adult and adult objectives as well as the design and implementation of recruitment and juvenile population assessment objectives and habitat mapping.

1.1. Study Area

The spatial boundary of the project is defined as the upper Fording River watershed (including tributaries) above Josephine Falls (Figure 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. (Figure 1.1). Josephine Falls represents a natural fish barrier in a steep walled canyon and is 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. The elevation of the study area ranges from 1,400 m at Josephine Falls to 2,740 m at the headwaters (rkm 78.00). For context, the Fording River Operations processing plant and dryer are located at 1,650 m elevation. As Josephine Falls represents a natural barrier, the Westslope cutthroat trout population of concern is considered a resident, fluvial, headwater population restricted to the approximately 57.5 km portion of the upper Fording River (and tributaries) between Josephine Falls and the upstream limit of fish distribution.

1.2. Background

The current research aims 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. After three years, study results are expected to identify home range, movement patterns and critical habitats through the use of radio telemetry and mark-recapture techniques. Critical habitat, as defined within the Canadian Species at Risk Act (SARA) and the United States Endangered Species Act (ESA), 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.

Westslope cutthroat trout are a key fisheries resource in the Fording River watershed. It is the only species known to occur in the Fording River, and its tributaries, 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 as an isolated upstream refuge where genetically pure Westslope cutthroat trout are present. Carscadden and Rogers (2011) confirmed the upper Fording River population are consistent with the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2006) designation of a genetically pure Westslope cutthroat trout population. 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).

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 British Columbia Ministry of Forest Lands and Natural Resource Operations (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 range (Cleator *et al.* 2009, Allan 2000). As early as 1905 it was being reported 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 extremely 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).

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, 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 significantly 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 (Bull River) 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); in 2009 the population was recommended for legal listing under the federal *Species at Risk Act* (Pollard 2010, *pers. comm.*). 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 resident to the upper Fording River are an above barrier resident or fluvial population that should not be predisposed to downstream displacement. Several studies on above barrier, non-migratory (resident or fluvial) populations of salmonids have been undertaken, and have focused on the study of life-history traits and population dynamics of these populations. Baxter (2004) has summarized these studies and provides commonalities observed within above barrier populations that are of note for the upper Fording River. For example, above barrier populations of Westslope cutthroat trout demonstrate limited downstream displacement and a later spawning period in the spring to avoid displacement during spring freshet (s*ee* Northcote 1992, Northcote and Hartman 1988, Elliott 1987 for reviews). Telemetry data (Bull River; Cope and Prince 2012, 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 (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 *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, U.S.A., mean home range = 67.4 km, Schoby and Keeley 2011; Blackfoot River, Montana, U.S.A., 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;

- The upper Bull River watershed lies immediately adjacent to the Elk River watershed;
- Both the upper Fording River and upper Bull River populations are genetically pure populations of Westslope cutthroat trout;
- Both populations are resident above naturally occurring barriers (*i.e.* falls);
- Habitat availability within the upper Bull River includes 30 km of main stem 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 main stem river plus several tributaries; and
- Both populations will have been assessed using similar methods, quality assurance and quality control measures and the same research staff.

However, there is 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.

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 will be examined for potential as "baseline" or "trend" data include; Lister and Kerr Wood Leidal (1980), Norecol (1983), Fording Coal Ltd. (1985), Oliver (1999), Amos and Wright (2000), and Wright *et al.* (2001). There is also data to be tracked down that has been referred to in reviews by Berdusco and Wood (1992) and Wood and Berdusco (1999). This 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 historical 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 Ltd. 1985). Regardless, the current study does not assume all segments of the population are migratory and intends to include examination of trends between the current study and historical studies to form one of several lines of evidence that will be explored to determine if the upper Fording River population growth is being limited.

1.3. Study Questions

The overall goal or purpose of this population assessment study is to determine whether the upper Fording River watershed Westslope cutthroat trout population is healthy, robust and sustainable. Concerns have been raised regarding resource development and recreational use in the area and it is 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 and current habitat availability.

The following study questions were identified by the project Steering Committee to address documented concerns raised by stakeholders, government agencies and First Nations. These questions were presented at a public information session held in October 2012.

1. *What is a viable Westslope cutthroat trout population?*
2. *Are the fish healthy?*
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?*

The rationale relating to the above study questions is described in the following section.

1.4. Study Design and Rationale

To answer the above questions multiple lines of evidence have been proposed. The study questions and study design were defined through a series of three workshops held in 2012 by the Steering Committee. 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 or additions as new information becomes available to address unanticipated uncertainties (Hilborn and Walters 1992). The following briefly summarizes the study design and rationale for the seven study questions. The detailed methodology to implement the study design is described in Section 2, and the results relating to the study questions are found in Section 3.

1.4.1. Population Viability

1. *What is a viable Westslope cutthroat trout population?*

One of the goals of the upper Fording River Westslope Cutthroat Trout study is to assess the status of the population and determine its relative "health". There are many measures of population "health"; including minimum viable population (Ackakaya 1998). In the case of the upper Fording River, "viability" must be considered within the context of 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.,* LCO Phase II and FRO Swift), the objective is defined as a healthy, self-sustaining population that is capable of withstanding environmental change and accommodating stochastic population processes such as unpredictable events (*e.g.* several dry summers, or an exceptionally cold winter). A self-sustaining population is one that is expected to be present in perpetuity. This question is being addressed through a literature review of viability analyses available for Westslope cutthroat trout and will be considered within the context of the self-sustaining and ecologically effective population definition above.

Population estimates derived for the upper Fording River Westslope cutthroat trout population in 2012, 2013 and 2014, along with the population trend (decreasing, stable, increasing) can then be placed in context of reported population abundances that can be expected to persist within a defined probability range for a given time frame.

1.4.2. Fish Condition

2. *Are the fish healthy?*

Question two is being examined following three lines of evidence. First, all captured fish (approximately 230 sub-adults and adults annually and as yet to be determined number of fry and juveniles) will be visually examined externally for any signs of injury or deformity. Secondly, a sub-set of 60 sub-adults and adults annually will be examined internally to confirm gonad development, reproductive status and physical signs of injury, disease, and deformity during the radio tag implantation procedure. Thirdly, all fish will be measured for length and weight and relative length-weight and Fulton's condition factor (Murphy and Willis 1996) is used for comparison with values for other East Kootenay populations sampled using similar methods (*e.g.* Elk, St. Mary, upper Bull, Wigwam Rivers). In theory, stressed fish should be evident with lower condition indices relative to expected values for unstressed fish.

Other studies, such as the AEMP, will be examining additional aspects of fish health in the area (*e.g.* fish tissue sampling and analysis, interpretation of water quality data, evaluation of benthic invertebrate communities, selenium concentration measurements in invertebrates).

1.4.3. Population Sustainability

3. *Is the Westslope cutthroat trout population sustainable?*

Sustainability can be defined through change in the population over time (decreasing, stable, increasing) and the intrinsic population growth potential. Question three is being examined through two methods; 1) annual sub-adult and adult population monitoring, and 2) annual recruitment (fry) and juvenile population monitoring. The study design has been developed such that data collected through annual population estimates will allow the project team to detect trends (*i.e*. stable, increasing, decreasing); it has also been designed such that the detection of annual population differences or trends will improve over time.

Data quality objectives for sub-adult and adult population estimates are to detect 10% change per year, after three years. In 2013 (Year 2), juvenile population estimates will be initiated. Data quality objectives for the first year of juvenile population estimates have not been defined beyond a proof of concept or feasibility approach given the low densities expected and the high variation typical of juvenile estimation methods.

Initially, only fairly substantial annual differences of population estimates (*e.g.* approximately 25% or more) will be detectable. Therefore, another line of evidence to place the upper Fording River population in context will be a comparative examination of densities (fish per kilometer or fish per 100 m^2) in relation to Westslope cutthroat trout densities derived using similar methods for previous studies in the upper Fording River and other regional populations that are generally considered to represent range-wide strongholds for the species (*i.e.* Wigwam, Bull, St. Mary, Elk, Flathead, Skookumchuck, White Rivers and Michel Creek).

This study component was designed in such a way that it could continue as a long-term population monitoring program following study completion (in 2015).

1.4.4. Population Genetics

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

There are intrinsic differences between populations of fluvial resident (non-migratory) and fluvial migratory forms of Westslope cutthroat trout and these differences have important population management implications (*e.g.* several small reproductively isolated populations versus one larger connected population). The population connectivity question is being evaluated using existing genetic analyses that have been previously completed for the upper Fording River Westslope cutthroat trout population. It is also expected that conclusions derived from genetic analyses can be supported through life-history results collected using radio telemetry methods.

1.4.5. Habitat

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

In order to manage, protect and enhance fish habitat within the upper Fording River watershed an understanding of available habitat and habitat use is necessary. Question five is being addressed through a number of study design methods to achieve a “weight of evidence approach”. Habitat data capture methods include; 1) radio telemetry (behavioural data), 2) habitat mapping using high resolution (10 cm) ortho-photographs, 3) habitat characterization and 4) inference from existing water sampling data.

Habitat characterization within the existing study will be conducted primarily at the meso-habitat scale. Teck's HSI Program (in development stage) is also expected to provide additional context at the more detailed micro-habitat scale. Meso-habitat represents a discrete area of stream exhibiting relatively similar characteristics typified by a common slope, channel shape and structure (Bovee *et al.* 1998). Pools and riffles are examples of meso-habitats. Meso-habitats can be sub-divided into micro-habitat components which range in area from less than one to several square meters. Micro-habitat is defined as a localized area of stream having relatively homogeneous conditions of depth, velocity, substrate and cover (Bovee *et al.* 1998).

To assist in characterizing habitat conditions, temperature will be measured using data loggers, and existing flow data (Water Survey of Canada and Teck monitoring) and water quality data (available through ongoing monitoring by the Teck mine sites and the AEMP) will be obtained. The AEMP is being undertaken to provide a comprehensive, regional assessment of mine-related effects on water quality and aquatic biota. The program will include monitoring in the upper Fording River. The AEMP will be designed to quantify and detect changes to water quality constituent concentrations, aquatic biota and potentially other media, as well as to evaluate the measured results with reference to water quality guidelines, benchmarks and/or action levels.

1.4.6. Fish Movement

6. *What are the movement patterns and why?*

Life-history data (*e.g.* movement patterns and habitat use) provide the basic foundation for all management, mitigation and habitat compensation programs (McPhail 1997). 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 evaluate fish movement patterns. Sixty sub-adult and adult Westslope cutthroat trout will be implanted with radio tags annually for three years (n=180) and their movements will be monitored using a combination of fixed receivers (continuous monitoring) and mobile receivers (monthly or weekly during spawning).

The technical rationale for the sample size of 60 radio tags per year is detailed in the methods section (2.5.1 Radio Telemetry) and was based on the trade-off between increased sample size and decreasing detection probabilities due to frequency saturation 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 coded tags maximum per frequency) and was supported by experience and what has worked well elsewhere (Cope and Prince 2012, Prince 2010, Morris and Prince 2004, Prince and Morris 2003). The use of a single frequency was considered vitally important to ensure tag detection by fixed receivers and helicopter.

As fish movement may be affected by annual variations in river discharge and water temperature, these variables are being monitored as part of this study. Water temperature is being monitored continuously using thermistors and river discharge has been monitored since 1970 by the Water Survey of Canada (Station 08NK018 – Fording River at Mouth).

1.4.7. Fish Distribution

7. *What is the distribution of Westslope cutthroat trout seasonally, considering life-history stage and upstream distribution limits?*

The seasonal distribution (*i.e.* spawning, summer rearing, over-wintering) of the upper Fording River Westslope cutthroat trout population will be documented using radio telemetry and population monitoring over a three year period. Questions six and seven are closely linked as life-history data (*e.g.* movement patterns, seasonal distribution and habitat use) provide the basic foundation for all management, mitigation and habitat compensation programs (McPhail 1997). Upstream distribution limits are important in determining total available habitat and will enable informed land-use decisions. The combination of movement patterns and seasonal distribution will be used to classify the types of life-history forms present (*e.g.* fluvial resident or fluvial migratory) thus enabling informed management decisions regarding management, mitigation and compensation.

Table 1.1 summarizes the seven study questions and the five study methods to be used to answer each study question. The five study methods shown in Table 1.1 are described in detail in Section 2. Note that water quality data are being captured through ongoing monitoring by Teck mine sites and related data reports from the AEMP. The HSI program will characterize micro-habitat rather than duplicate such methods within this program.

Table 1.1. Overview summary of study questions and study methods derived from the DQO workshops held in 2012. Table courtesy S. Swanson, Swanson Environmental Ltd., Fernie, B.C.

	Key Study Question	Radio Telemetry	Population Monitoring (Sub adult and Adult)	Recruitment and Juvenile Population Monitoring	Habitat Mapping	Habitat Character-ization	Water Quality
1	What is a viable WCT population?	Defining through literature review					
2	Are the fish healthy?		X				X
3	Is the WCT population sustainable?		X	X			
4	One interconnected population or multiple populations?	Question answered by existing studies showing one population based upon genetics					
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					
7	What is the distribution of WCT seasonally, by life-history stage?	X	X	X			

2. Methods

This section describes the five study methods and their timelines that are being 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, genetics, and water quality.

The layout of the sampling locations is summarized below and referred to further through subsequent subsections.

Figure 1.1, referred to previously, illustrates the location of the six fixed receiver station locations within the study area. The fixed receiver station locations were selected to isolate river sections or segments of differing character within the upper Fording River watershed. These sites 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, Amos and Wright 2000). Three stations, F1, F2, and F3, were located on the upper Fording River main stem to isolate the following respective river sections or segments; the lower river with a high sinuosity, low velocity, potential over-wintering area and apparently lower (summer) fish densities; the Fording River Operations area dominated by resource extraction activities, river sections known to dewater in some winters, lower gradient (0.4 – 1.0% gradient), and higher fish densities; and the headwaters (> 3% gradient). 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). Three tributary fixed receiver stations, T1, T2, and T3, were also installed; they were installed at locations designed to detect transmitters and isolate: Ewin; Chauncey; and Henretta Creeks (respectively). Table 2.2 provides a summary of the stations including location by river kilometer.

The upper Fording River main stem was further sub-divided into 11 population assessment sections of similar character to facilitate sub-adult and adult population assessment at a finer scale using snorkel methods (Figure 1.1; Table 2.3). These 11 river sections will be mapped at the meso-habitat scale to document the available habitat and facilitate examination of habitat differences and distribution among river sections (see Section 2.7 for details).

2.1. Study Period

The upper Fording River Westslope cutthroat trout Population Assessment project is a four year project (2012 – 2015) that will extend over three replicate fish tagging periods (2012, 2013, 2014). The resulting life-history (telemetry) and population monitoring field work will be completed August 2012 to October 2015. Table 2.1 provides a visual summary of the timelines for the five study methods or components through the project time period.

Table 2.1. Timelines for the five primary study methods or components designed to answer the 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		
Meso-Habitat Characterization		Ongoing seasonally and by life stage		
Water Quality		Existing data sources		

The focus of the first year of the study was initiation of the telemetry and population monitoring components. As such, the sub-adult and adult life-history stages of this population were the focus of the first year of study due to the constraints of fish size on radio tag implantation. Based on the 2% rule (weight of the radio tag not to exceed 2% of the fish weight, Winter 1983), fish selected for radio tagging needed to be a minimum 200 g, or based on other regional populations, approximately 230 mm fork length (FL). The telemetry and population monitoring will be replicated in Years 2 and 3.

Telemetry monitoring includes fixed and mobile tracking for movement, distribution and life-history assessment and will be completed over 13 months (guaranteed transmitter life 390 days). It will also include annual population estimates using mark-recapture snorkel methods, seasonal assessments of resident habitats during significant life stage timing (over-wintering, spawning, summer rearing), and, in subsequent years, annual assessments of juvenile recruitment. Flow (Water Survey Canada Station No. 08NK018) and temperature will be continuously monitored.

2.2. Environmental Data

Radio tagged sub-adult and adult Westslope cutthroat trout will be tracked over 36 months to examine a range of conditions as seasonal fish movement and habitat use may be affected by annual variations in climate, river discharge and water temperature.

2.2.1. River Discharge

The primary hydrometric data that will be utilized for this study is 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 the historical data will also be summarized to provide comparisons of study conditions within the range of historical conditions. Teck also operates hydrometric stations within their operating area and these records can also be used to examine more site specific conditions as necessary.

2.2.2. Water Temperature

Water temperatures are being recorded at each fixed receiver location (n=6) with two Tidbit V2™ loggers (replicates) to document main stem and tributary variation (Table 2.2; Figure 1.1.). Temperatures are recorded every 15 minutes and summarized to provide hourly and daily means.

Table 2.2. Upper Fording River fixed receiver monitoring sites. River kilometers are upstream from the confluence with the Elk River. The study area extends from river kilometer (rkm) 20.51 at Josephine Falls to approximately rkm 78.00 (headwaters > 20%). Fording River Operations extend from approximately rkm 51 to rkm 65.

Receiver Code	River Km	Location	Existing FRO Sample Site (rkm)
F1	20.6	Josephine Falls	
F2	48.6	Downstream FRO	FR2 (54.3)
F3	63.6	Headwaters	UFR1 (63.6)
T1	0.25E	Ewin Creek	
T2	0.10C	Chauncey Creek	
T3	0.72H	Henretta Creek	HC1 (0.72H)

All temperature loggers are 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 is attached to an anchor tree using 3/8" wire cable and cable clamps. The cable is attached to the concrete block by wrapping through the block twice and securing using cable clamps. The tidbits are 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 5.0 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 is 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 are checked to ensure the data has been logged; the status light is flashing “o.k.” to indicate the logger is functioning properly and a water temperature is taken using a hand-held thermometer and cross-referenced to the data logger at that time stamp for quality assurance.

Additional thermistors may be deployed in subsequent years to evaluate potential groundwater influences; particularly in locations where aggregations of over-wintering Westslope cutthroat trout are identified.

2.2.3. Water Quality

As part of this study, existing literature will be reviewed to briefly summarize what is currently known regarding water quality within the upper Fording River. Water quality data and reporting for the upper Fording River is available through various sources, including ongoing water quality monitoring programs conducted by Teck as part of permit conditions, the disbanded Elk Valley Selenium Task Force, and the AEMP. Water quality can form an important component of habitat and fish habitat use and this study will utilize the existing data and additional data as it becomes available to make some inferences on water quality in these habitats.

In the context of this study, water quality is considered important as there is concern that selenium concentrations may be approaching or could approach levels that have the ability to manifest themselves as population level effects due to larval mortality (Fisher 2013, *pers. comm., Ministry of Environment Submission to the Environmental Assessment Office (EAO), Teck Coal Limited Line Creek Phase II Project Application*). The coal-bearing rock formations contain selenium, which is released during weathering of mine waste rock (Orr *et al.* 2006). 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 compensation works.

2.3. Population Viability

One of the questions which have been frequently raised with a goal to effectively managing fish and wildlife populations and fish habitat in the face of increasing anthropogenic pressures is "what is a viable population?" Specific to the upper Fording River, "*what is a viable Westslope cutthroat trout population?"*

To provide context for this discussion and recommendations/targets as part of this study, a literature review of pertinent population viability analysis, and Westslope cutthroat trout research was undertaken.

2.4. 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. It is also expected that conclusions derived from genetic analyses can be supported through life-history results collected using radio telemetry and mark-recapture methods.

2.5. Radio Telemetry and Population Monitoring (Sub-adult and Adults)

Sub-adult and adult Westslope cutthroat trout were captured in August and September 2012 when water temperatures were less than 14.5 ^{o}C. 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 safe handling techniques designed to minimize potential hook and capture trauma.

Annual capture targets are for mark densities of approximately four fish per km over the 57.5 km main stem Fording River for a total of 232 radio and Floy tagged fish. The targets for each tag type are as follows:

- 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

- 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.

Captured fish are allowed to recover their oxygen deficit (created during capture) in an instream fish sleeve for 30 minutes prior to being anaesthetized and processed. Fish are anaesthetized in a 40 L bath of river water containing 2.0 ml clove oil yielding bath concentrations of 50 mg/l. 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 are 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 is required to ensure immobility. Once anaesthetized to a stage four level, fish are 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 are in contact with oxygenated water. All Floy tagged fish are externally assessed for maturity status. Fish selected for radio tag implantation are also assessed internally for sex and maturity. All radio tagged fish are photographed and any deformities encountered are photo-documented.

2.5.1. Radio-Telemetry

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 desired; therefore, for each river section (n=11, Figure 1.1) the number of tags deployed was determined by the length of the section and within a given section, the radio tags were randomly applied. A tag density of one tagged fish per river kilometer was selected based on previous experience and what has worked well elsewhere (Cope and Prince 2012, Prince 2010, Morris and Prince 2004, Prince and Morris 2003). Given the estimate of approximately 57.5 km of main stem river habitat the target density results in an annual sample size of 60 radio tags.

There is 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 coded tags maximum 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 resulting in a guaranteed tag lifespan of 390 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 minimum airspeed necessary to ensure safe hover criteria is approximately 17 knots.

2.5.1.1. Fish Tagging

Sixty Westslope cutthroat trout > 200 g were implanted with radio tags (frequency 150.210 MHz). Radio tags are 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 (10 sec. burst rate). All radio tagged fish were also Floy tagged with a unique colour (green) for visual identification and to differentiate them from Floy tagged fish without radio transmitters (white). Radio tags were individually coded (codes 11-70) so the individual fish could be identified in all receiver logs and the mobile relocation records. Floy tags are uniquely numbered so that any angling recaptures can be individually identified.

The radio and Floy tagging will be replicated in Year 2 (2013) and 3 (2014). Different colors unique to each year will be used to enable snorkelers to identify the year of tagging as well. Some care is needed in planning which colors are to be used in each year as not all colors can be readily identified during snorkel surveys (*e.g.* red and orange may be confused). New tags will not be added to previously tagged fish to facilitate enumeration of each cohort of tagged fish through the three years of snorkeling to estimate survival (corrected by tag loss). One third (n=78) of the Floy tagged fish will be double tagged so that tag loss can be evaluated through recapture events. In addition, the literature will be reviewed for tag loss estimates, to provide a comparison for study results.

Transmitter implantation methods are as follows. A small incision (2.0 cm) is made approximately 1.0 cm from the mid-ventral line and anterior to the pelvic fins. Gonadal development and any sign of deformity are examined internally with an otoscope to confirm reproductive status and visual signs of fish health. An equine intravenous catheter (1.7 X 133 mm) is 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 is inserted through the catheter and the transmitter into the body cavity. The catheter is 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 is then closed using independent and permanent monofilament sutures (4/0 Ethicon). Once they regain equilibrium and swimming ability, fish are transferred to an instream sleeve and allowed 30 minutes to fully recover (*i.e.* attainment of fear response) before release.

2.5.1.2. Monitoring and Tracking

This section describes how radio tagged fish are monitored and tracked through the use of fixed receiver stations and mobile (helicopter and ground-based) tracking methods.

2.5.1.2.1. 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 sections or between main stem and tributary habitats. Fixed stations are 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 is 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 may be necessary (Prince 2010). Direction of movement is validated through the use of two antennae (upstream and downstream) at each fixed receiver (Figure 2.1).

Figure 1.1 illustrates the location of the six fixed station locations within the study area. Three of the six fixed stations (F1, F2, and F3) were installed at locations that delineate the Upper Fording River main stem into 3 main river sections of differing character. 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) that suggest these areas delineate differing habitat and/or population characteristics. These areas include; 1) the headwaters (> 3% gradient); 2) the Fording River Operations area dominated by resource extraction activities, river sections known to dewater in winter, lower gradient (0.4 – 1.0% gradient), and higher fish densities; and 3) the lower river with a high sinuosity, low velocity, potential over-wintering area and apparently lower (summer) fish densities. 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 confluences of three tributaries to the Fording River: Ewin, Chauncey and Henretta Creeks. The locations of these stations are designed to detect transmitters and isolate the creeks. Table 2.2 summarizes the fixed receiver sites.

The intent of the fixed stations is to ensure continuous and effective monitoring for detection of movements between river sections or between main stem and tributary habitats. The intent is that even if a radio tagged fish goes “missing” its location can still be confirmed at a gross level based on which fixed receiver stations bound the last recorded position of the fish or alternatively, if the fish is 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 if there is ice cover and deep pools. Therefore, fixed stations are essential in assisting the tracking crew in isolating a river section to search for “missing” fish. Tributary fixed stations will also provide tributary residence time and allow for determination if the tracking frequency is sufficient to document tributary use accurately (*i.e.*

Figure 2.1. Photographs illustrating the streamside fixed receiver set-up on a shallow riffle at F2 (rkm 48.6); a) antenae and lockbox; b) Lotek SRX DL1 receiver and powersource; c) riffle “gateway” habitat selected to maximize detection probability.

are 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 2.1). Whenever possible, detection events and destinations are 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 (102 amp-hrs@20 hrs) are maintained on a three week rotation and station maintenance schedule.

Quality assurance in tag detection at fixed receiver locations is ensured through range testing to define transmitter detection patterns and ensure fish passage past receiver locations are 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.

Quality assurance in receiver operation is ensured through testing during each station maintenance and download session every three weeks. Before replacing the batteries and again once the batteries are replaced a “live” test tag is used to ensure the receiver is 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 are archived and backed up (off-site) in their original raw data format. A master excel spreadsheet is maintained with receiver detections and updated fish locations following each download session.

2.5.1.2.2. Mobile Tracking

Mobile tracking is used to document fish movement behaviour, habitat use, and seasonal distribution of sub-adult and adult fish throughout the upper Fording River study area. 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 are 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 are used. Fish are relocated during mobile tracking surveys that are performed once per month except during the spawning season. During the spawning season (approximately May 15 – July 25) mobile tracking surveys are completed weekly. Tracking surveys are completed for the length of the main stem upper Fording River, including tributaries. Surveys are equally divided between aerial (helicopter) and ground based. Ground based surveys are conducted on foot supported by light truck, all-terrain vehicle (ATV) and snowmobile.

Both aerial and ground methods are used each season as these methods complement each other. Aerial methods ensure complete coverage of the study area including tributaries, while ground methods are essential for quality assurance measures to ensure fish are alive and healthy as well as allow for ground-truthing to "pin-point" fish location and examine detailed micro- and meso-habitat characteristics (Figure 2.2). Ground methods within the active mining area and the plant area also enables the tracking crew to get into the river bottom and eliminate much of the interference "noise" that is generated by industrial activity within this area.

At any given time, there will be 60 Westslope cutthroat trout implanted with transmitters (codes 11 to 190) using radio frequency 150.210 MHz. To facilitate tracking and data capture, nomenclature used in databases and reporting follows 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 main stem centerline distance upstream from the Elk River confluence using GIS and 1:20,000 TRIM Maps. When tracking, UTM co-ordinates are recorded and using GIS the co-ordinates are converted to river kilometer. Figure 1.1 illustrates the river kilometers for the Fording River.

Fish locations are plotted after each tracking session and cross-referenced with station downloads after every tracking session and station download to ensure fish are 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) are the key to ensuring movements are not missed.

Figure 2.2. Photograph illustrating mobile tracking and visual (snorkel) ground-truthing methods used to document radio tagged fish location and condition.

2.5.2. Sub-Adult and Adult Population Monitoring

2.5.2.1. Estimating the abundance of Westslope cutthroat trout (> 200 mm) from a combined capture-recapture and snorkel survey

A combined capture-recapture and snorkel survey was conducted between August 22 and Sept 22, 2012. Briefly, capture (angling) and marking targets were 232 fish greater than 200 mm fork length; of these, 60 fish were to have radio tags implanted and a green Floy tag attached and an additional 172 fish were to have a white Floy tag attached. All fish were released within the meso-habitat unit in which they were captured. Approximately three weeks later, the same sections of the river were surveyed using snorkel survey methods and the surveyors recorded the number of fish with green tags, white tags, and no tags. Fish less than the 200 mm fork length cut-off are recorded for completeness even though population estimates are not completed for these size classes using these methods. At the same time, members of the team used mobile receivers on the shore to determine how many radio-tagged fish were currently present in the section of the river being surveyed. Not all sections of the river were surveyed at the same time.

In this report, an estimate of the total population of Westslope cutthroat trout greater than 200 mm in length (the cut off for tagging by the white tags) is provided. Several different estimates are obtained depending on the estimation method and which set of tags is used in the procedure.

2.5.2.1.1. Snorkel Methods

Given suitable watershed conditions, snorkel counts have been proven to be a reliable and efficient means of obtaining indices of relative abundance for salmonid populations in British Columbia streams (Korman *et 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 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.

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 marked fish densities of approximately four fish greater than 200 mm fork length per kilometer and an observer efficiency of approximately 50% or better are necessary to ensure these 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 main stem upper Fording River; for a total of 232 Floy tagged sub-adult and adult Westslope cutthroat trout. Therefore, in addition to the 60 radio tagged + green Floy tagged fish; an additional 172 fish required white Floy tags to meet mark re-capture requirements. The methods used to conduct the annual snorkel surveys are described below. These methods were applied in September 2012 for the first annual (Year 1) snorkel survey, and will be applied again in Year 2 (2013) and 3 (2014).

Snorkel surveys are conducted using a team of four. 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 is less than 15 m the snorkel team will form 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 is re-surveyed if there is uncertainty or obvious discrepancies. Observed fish are identified to species and the target species are 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 is taken from each observer and then averaged.

Eleven river population index strata or “sections” were established for the study and Table 2.3 summarizes these sections and their extent. Figure 1.1 visually represents the location of the sections in the study area.

Table 2.3. Upper Fording River index sections (*i.e.* strata) used for population monitoring and distribution assessments. River kilometers are upstream from the confluence with the Elk River. The study area extends from river kilometer (rkm) 20.51 at Josephine Falls to approximately rkm 78.00 (headwaters > 20%). Fording River Operations extend from approximately rkm 51 to rkm 65.

River Section	River Km	Length (km)	Section
1	20.51–25.00	4.49	Josephine Falls to GHO
2	25.00-29.00	4.00	GHO to above Fording Br.
3	29.00-33.16	4.16	Above Fording Br. To Ewin Cr.
4	33.16-37.59	4.40	Ewin Cr. To S-bends
5	37.56-41.96	4.40	S-bends to Chauncey Cr.
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
9	59.75-63.40	3.65	Turnbull to above Henretta
10	63.40-67.75	4.35	Above Henretta
11	67.75-78.00	10.25	Headwaters
	57.49	57.49	N = 11

To further ensure the assumption that all tags are available for recapture (*i.e.* minimize potential mortality and emigration losses), the annual snorkel surveys are planned to be completed within one month following the capture and tagging component. The snorkel surveys are scheduled over a seven day period, with the intent to cover the majority (*e.g.* 90% by length) of the 57.5 km length of main stem upper Fording River that can be safely accessed from the headwaters (river km 78.0) downstream to Josephine Falls (river km 20.5).

There are 11 main stem river population index sections of approximately 5 km each (Figure 1.1; Table 2.3). The intent was to apply Floy and radio tags within all 11 sections for subsequent snorkel enumeration of the entire main stem upper Fording River. The following exceptions were anticipated:

1) The headwaters above the limits of fish distribution. When snorkeling the headwater section, the limit to upstream fish distribution was defined in 2012 as a combination of a stream gradient of 20% or greater and no fish observations over at least 500 m.

2) Immediately upstream of Josephine Falls the river is confined, swift and contains rapids and small falls that may be deemed safety risks. A reconnaissance was completed in 2012 to determine the safe downstream limit to snorkeling. This limit was flagged approximately 500 m upstream of Josephine Falls and viewed by all staff prior to proceeding with the snorkel survey. In addition, a safety spotter is placed at this location each year to ensure the snorkel crew exits at this location.

In the event any additional length of river is not snorkeled it will be localized in nature (<1km), represent no more than 20% of a given section, mapped and justification provided.

In the case where an area is not snorkeled, the density calculated for the adjacent river section of similar habitat characteristics will be used and extrapolated to include the length of the section that was not snorkeled.

2.5.2.1.2. Population Estimates

Population estimates were calculated using the following four models for radio tags only (green Floy), Floy tags only (white Floy), 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 are computed by pooling the marked-sample, the recovery sample, and the number of recaptures over all sections of the river. The key assumption of the pooled-Petersen method is that either;

(a) The probability of marking is equal in all sections
(b) The probability of recovery is equal in all sections
(c) Complete mixing of marked and unmarked fish across all sections.

We use the term “recovered” even if fish are only sighted (*e.g.* snorkel surveys) and not physically handled.

It is 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 is 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 is 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 is 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 is 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:

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

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

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

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 main stem 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	$n_{1,Stratum\ 1}$	$n_{1,Stratum\ 2}$	…	$n_{1,Stratum\ k}$
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.

3. Hierarchical Model

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:

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

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 $E[p] = \frac{\alpha}{\alpha + \beta}$ and variance across the strata of $V[p] = \frac{\alpha\beta}{(\alpha + \beta + 1)(\alpha + \beta)}$. This Bayesian analysis was fit using OpenBugs (Lunn *et al.* 2009). The data are used to provide estimates of the individual p_i, U_i and the parameters of the beta distribution.

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.

4. Movement Model Combining Radio (green Floy) and Floy (white) Tags.

The previous two 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 white-tagged fish, 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 of the white tags among the sections. The model for movement will also accommodate "leakage", *i.e.* some fish move to other sections during the time they are not surveyed and so are "missed" during the snorkel surveys.

Because of the sparsity of the data, adjacent sections were again pooled reducing the number of sections from 12 (*i.e.* 11 main stem Fording River plus lower Henretta Creek and Henretta Lake) to 6 strata. A summary of the radio-tag movements among this reduced set of strata is illustrated below (Table 2.4). The table below shows that most fish stayed in their (combined) sections but there was movement, mostly to adjacent strata and tending to move upstream (towards higher section numbers).

Table 2.4. Summary of radio-tag movements among strata, upper Fording River, 2012.

	Recovered in combined sections						
Released in combined sections	1-2	3-4	5-6	7-8	9-10	HP	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

The data is too sparse for a model with a completely unspecified set of movement probabilities, so the probability of movement was approximated using 5 parameters: the probability of staying in the reduced section, moving 1 section to the left or right, and moving 2 sections to the left or right. Leakage is accounted for by moving to a final "dummy" section with 0 chance of recapture. Leakage occurs when the movement of the fish doesn't coincide with the snorkeling. For example, if you snorkel on 2 days, then some fish that were in sections not snorkeled on day 1 may move to the sections previously snorkeled on day 1 and so "disappear". You can imagine this happening due, for example, to "herding" as the snorkelers move through the sections.

A hierarchical model was used for the recovery rates with a common average detection rate for both green and white tags, but the recovery rates are allowed to vary among the (reduced) sections around this common average. For example, if the average detection was 50%, a section could have a detection rate of 45%; another section 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 are large enough, can they be substantially different. So a raw detection rate of 100% for a section would be pulled towards the mean detection rate if the number of tags available and recovered is small.

Intuitively, what happens is that the movement data from the radio tags is used to impute the movement of the white tags. The number of white tags then available in each reduced section (along with the radio tags) is used in a Petersen-estimator with the observed number of recoveries and unmarked fish. Estimates of recovery rates borrow information from other sections 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 MLE.

Once population estimates have been calculated, the upper Fording River Westslope cutthroat trout population status will be 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 (main stem), Wigwam River, Michel Creek, St. Mary River, and White River. Based on these data from predominantly catch and release fisheries it has been suggested 45 fish > 300 mm per km may approximate the unfished equilibrium (Pollard 2010, *pers. comm.*). Using similar methods and study team, the mean 2010 upper Bull River density of Westslope cutthroat trout was estimated to be 55 fish/km > 300 mm (Cope and Prince 2012).

The upper Fording River will be sampled annually for at least three years to generate estimates of abundance.

2.6. Recruitment and Juvenile Population Monitoring

Recruitment and juvenile population monitoring will begin in Year 2 (September – October 2013). The final study design for the 2013 recruitment and juvenile population monitoring is in the final stages of planning and will be completed, in consultation with the Steering Committee, in July 2013. Final site selection for the recruitment and juvenile population monitoring will be reviewed following the results of the 2013 spawning season monitoring (May 13 – July 25).

The goals for 2013 have been defined by the Project Steering Committee and include:

1. Literature review for existing mark-recapture 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.

The spatial scale will include the upper Fording River main stem and its tributaries upstream of Josephine Falls. It is anticipated that section specific analyses (n=11 main stem sections plus n=2 sections (lower and upper) per tributary) are unlikely but pooling of adjacent sections and examination of broader strata should be possible (*e.g.* n=4, headwaters or upstream, within FRO, downstream, tributaries). Data quality objectives for the first year of juvenile population estimates have not been defined beyond a proof of concept or feasibility approach given the high variation typical of juvenile estimation methods and the low densities expected.

Based on the above criteria and a preliminary review of available data, a sampling design similar to the outline illustrated in Table 2.5 is anticipated.

Table 2.5. Interim distribution of recruitment and juvenile population estimation effort within the study area. Note that additional sites on Fish Pond and Dry creeks have been recommended but not yet incorporated into the interim design pending results of monitoring through the 2013 spawning season.

No. Locations	Location	Section	Rkm	Designation
2	Upstream Henretta Creek	S10, S11	62.9 – 78.0	Headwaters or ‘upper’
3	FRO On-site	S7, S8, S9	49.0 – 62.9	Onsite
2	Downstream FRO site	S1 – S6	20.5 – 49.0	‘Lower’
2	Henretta Creek	S9	62.9	Tributary
2	Chauncey Creek	S5	42.0	Tributary
2	Ewin Creek	S3	33.2	Tributary

Sampling will predominantly utilize backpack electrofishing methods to sample approximately 13 locations at a rate of one location per day. Nested within each location will be three sites encompassing pool, riffle, glide, run and side-channel habitats; each site would be approximately 100 m^2 for a location total of approximately 300 m^2. To minimize sample variance an experienced crew will be employed and the same crew will be utilized for all sampling. Electrofishing will be completed September 16 to October 4, 2013. Sampling after September 1 is preferred to ensure fry emergence was completed (Amos and Wright 2000, Oliver 1999, Lister and Kerr Wood Leidal 1980).

This sampling will facilitate the collection of life-history data (*e.g.* length, weight, scale-age), tagging of individuals for mark-recapture, and the estimation of abundance (fry and juveniles/100 m^2) for recruitment trend monitoring among current study years (2013-15) and with the data available from 1978-79 (Lister and Kerr Wood Leidal 1980), and 1998-99 (Amos and Wright 2000, Oliver 1999). Final site selection will incorporate spawning areas and non-spawning areas identified during life-history monitoring (2013 May 15 – July 25).

As mentioned above, at each location, three sites of approximately 100 m^2 each will be individually sampled for fish densities. A Smith-Root LR-24 DC Backpack electrofisher will be used for three successive depletions within each closed sample unit. Catch results will then be used to estimate the number of fry (0+ age class) and juveniles (1+ and 2+ age classes) within the enclosure area. Estimates and their 95% confidence interval will then be reported as a standard numerical density (number fish/100 m^2) for each site. Capture, effort (area and electrofishing time for each pass) and life-history data (length, weight, scale sample) will be recorded using the BCMOE Microsoft Excel tool, "Fisheries Data Information Summary System (FDIS)". The data from each meso-habitat, by age class will also be analyzed through the use of an Allen plot (Ptolemy *et al.* 2006).

Estimates of juvenile fish density (number of fish/100 m^2) will be determined using closed, maximum-likelihood removal estimates (Riley and Fausch 1992, Van Deventer and Platts 1990). Ruiz and Laplance (2010) and Dorazio et al (2005) provide alternate methods that basically assume that catchability should be comparable (but not identical) in different locations of the same habitat so "share" information across sampling sites but still allow for site-specific factors that prevent a simple pooling of the data. This often provides estimates that are more precise (smaller standard errors).

While the fry and juvenile sampling will be generating density estimates, the primary long term objective is to tag fish to get recruitment estimates (*e.g.* survival to 1^+, 2^+, 3^+, to spawners). This requires recaptures and growth rates so all captured juveniles will be tagged with a Passive Inductive Transponder (PIT) tag. A scale sample will be collected for aging and length-at-age determination. All subsequent recaptures during sub-adult and adult tagging (angling) and juvenile tagging (electrofishing) will have their unique identification number recorded and measured for length and weight.

2.7. Habitat Mapping

The first step in understanding resource selection (*i.e.* habitat) is to document the resource availability and its distribution. Therefore, in order to understand the aquatic habitats (overall and critical) within the study area all available habitat will be mapped at the meso-habitat level (*i.e.* riffle, pool, glide, off-channel) by population section (n=11) and tributary. The goal is to create a map and database containing all available fish habitat within the upper Fording River and the lower sections of tributaries and to have this completed by the end of Year 3 (2014).

In September 2012, the length of the main stem upper Fording River, the lower fish bearing sections of tributaries and the associated riparian area were flown at an elevation of approximately 1,150 m above ground. A total area of 134.29 km^2 was captured on digital colour images with an image pixel size of 10 cm ground sampling distance (PHB Technologies, Broisbriand, Quebec).

In Year 2 (2013), the aerial photographs will be compiled into a composite ortho-photograph watershed display with 10 cm resolution. Using this imagery, the meso-habitat will be classified and mapped using a standard suite of overview level habitat measurements derived from two primary sources: 1) Applied River Morphology (Rosgen 1996); and 2) Fish Habitat Assessment Procedures (Johnston and Slaney 1996).

Measurements will be restricted to those that can be collected from aerial photographs. Ground-truthing by field crews will be used to validate estimates. It is anticipated measurements will include but not be limited to the following; stream type, habitat type, meso-habitat dimensions (bankfull channel width, wetted width, length), reach gradient, water depth (coarse scale; shallow or deep with deep being greater than maximum water visibility during image capture), dominant substrate, water velocity (slow, flowing, turbulence), available cover, large woody debris abundance, riparian vegetation and disturbance indicators.

The development of the final habitat data capture form will be done in consultation with the Steering Committee as well as the HSI and AEMP projects to ensure coordination of habitat data collection among projects. A trial reach will be completed and reviewed with the Steering Committee before proceeding with the mapping of the remaining watershed.

2.8. Habitat characterization

All radio tagged fish and their capture locations (sub-adult and adult summer rearing habitat) have been photographed and geo-referenced by UTM and rkm. This provides 60 records of summer rearing habitat locations, select habitat features (meso-habitat, dominant substrate and cover) and associated photographs. Further data can be captured for these habitat units during the habitat mapping task.

During ground-truthing tracking sessions conducted seasonally (n=7) and also opportunistically during mobile tracking, radio tagged fish positions are relocated to meso-habitat unit or, when possible, to the exact micro-habitat position within the meso-habitat unit and geo-referenced by UTM and rkm. Meso-habitat features (*i.e.* over-wintering, spawning, staging, summer-rearing) are photographed and characterized in terms of meso-habitat type, dominant and sub-dominant substrate, dominant and sub-dominant cover and water temperature. Starting in January 2013 estimated maximum water depth will also be collected.

Based on the telemetry data, seasonal Westslope cutthroat trout distribution will be illustrated using GIS mapping functions. Movement data will be analysed for home range, and life-history movement patterns that can then be compared to other upper Kootenay River watershed 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). As previously mentioned, the upper Bull River Westslope cutthroat trout population has been selected as the most similar population of the above reference populations for the following reasons;

- The upper Bull River watershed lies immediately adjacent to the Elk River watershed;
- Both the upper Fording River and upper Bull River populations are genetically pure populations of Westslope cutthroat trout;
- Both populations are resident above naturally occurring barriers (*e.g.* falls);
- Habitat availability within the upper Bull River includes 30 km of main stem river plus several tributaries and habitat availability within the upper Fording River includes 57.5 km main stem river plus several tributaries; and

- Both populations will have been assessed using similar methods, quality assurance and quality control measures and the same research staff.

Michel Creek represents another reference population of note as it represents a population from another Elk River tributary of similar size.

It is anticipated that after three years (*i.e.* three replicate radio tag groups for a total of n=180 radio tagged Westslope cutthroat trout) if repeating patterns of movement and seasonal distribution can be identified then critical habitats necessary for the completion of life-history functions (*e.g.* spawning, over-wintering, rearing) can be identified with confidence. Mortality rates between habitats with multiple fish and repeating patterns of annual use (*i.e.* habitats categorized as “critical”, “limiting” or “important”) will be compared to those habitats with lower use categorized as “alternative” or “low utilization” habitats. If differences in mortality risk can be demonstrated this will support the designation of critical habitat.

Fish distribution and movement data will also be contrasted with the total available habitat documented using the low level aerial imaging. This study design would facilitate comparison of available habitat among river segments and enable statistical analysis using resource selection methods (Manly *et al.* 2002).

3. Results

3.1. Environmental Data

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). The mean annual discharge of the Fording River has averaged 7.95 m^3/s over the last 41 years and has varied from 4.04 m^3/s in 2001 to 13.4 m^3/s in 1972 (WSC Stn. No. 08NK018). The 2012 mean annual discharge was 11.24 m^3/s (2012 data is preliminary and subject to change). The historical mean monthly discharge (1970-2011) for August (summer rearing) and February (over-wintering) are 6.49 m^3/s and 1.92 m^3/s, respectively. The 2012 mean monthly discharge was illustrated compared to the historical discharge for the Fording River (Figure 3.1). Westslope cutthroat trout behaviors documented within this report encompass those exhibited under slightly above average flow conditions for both summer rearing and early winter.

Typically, mean daily discharge is used to evaluate flow regime in relation to movement behaviour and Figure 3.2 illustrates the 2012 mean daily discharge for the Fording River (WSC Stn. No. 08NK018, preliminary data subject to revision).

Spot discharge estimates collected within FRO (upstream of Kilmarnock Creek, Teck Station FR2, 2010-2012, 54.3 rkm) ranged between 1.05 m^3/s and 16.75 m^3/s (Teck, FRO, File data, Jan 2013). These included August (summer rearing) flows 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 visual 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 ranges 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 December 2012 and January 2013 the main stem upper Fording River in FRO was observed to be dewatered and frozen with no surface flow over a short section immediately below the Turnbull Arch Culvert crossing (60.0 rkm). This river section was confirmed to have surface flow during previous site visits from May through November. The December and January observations of the dewatered section were made during helicopter tracking surveys and the extent of

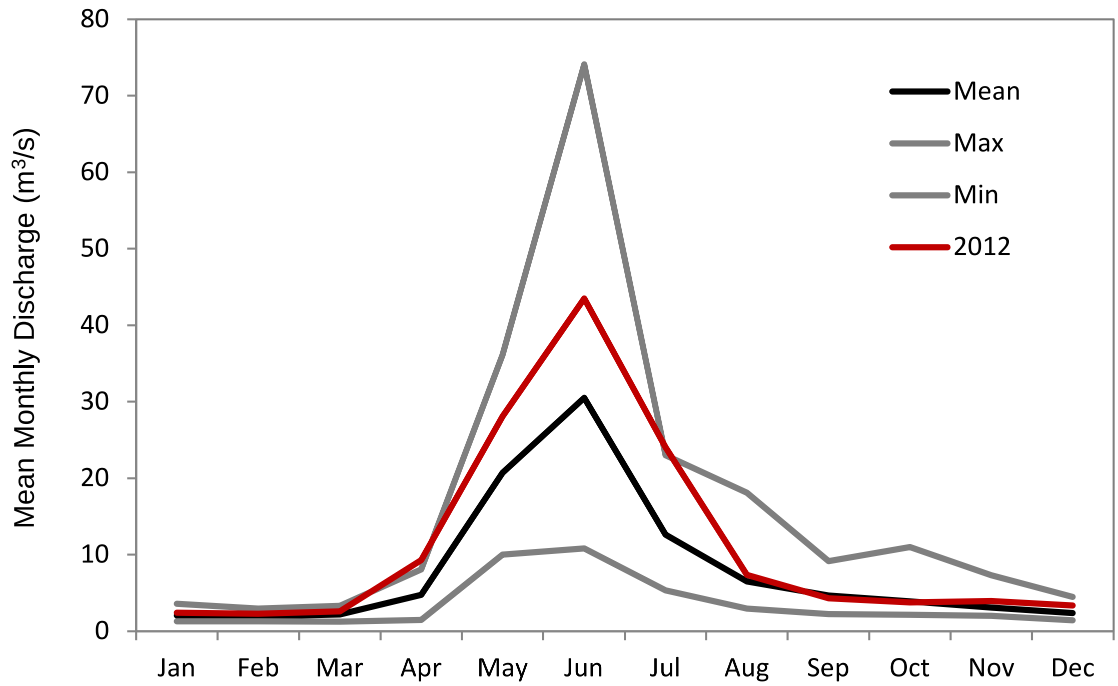


Figure 3.1. Mean monthly discharge for the Fording River at the mouth (WSC Stn. 08NK018) for the period 1970–2012. Note that 2012 data is preliminary and subject to revision.

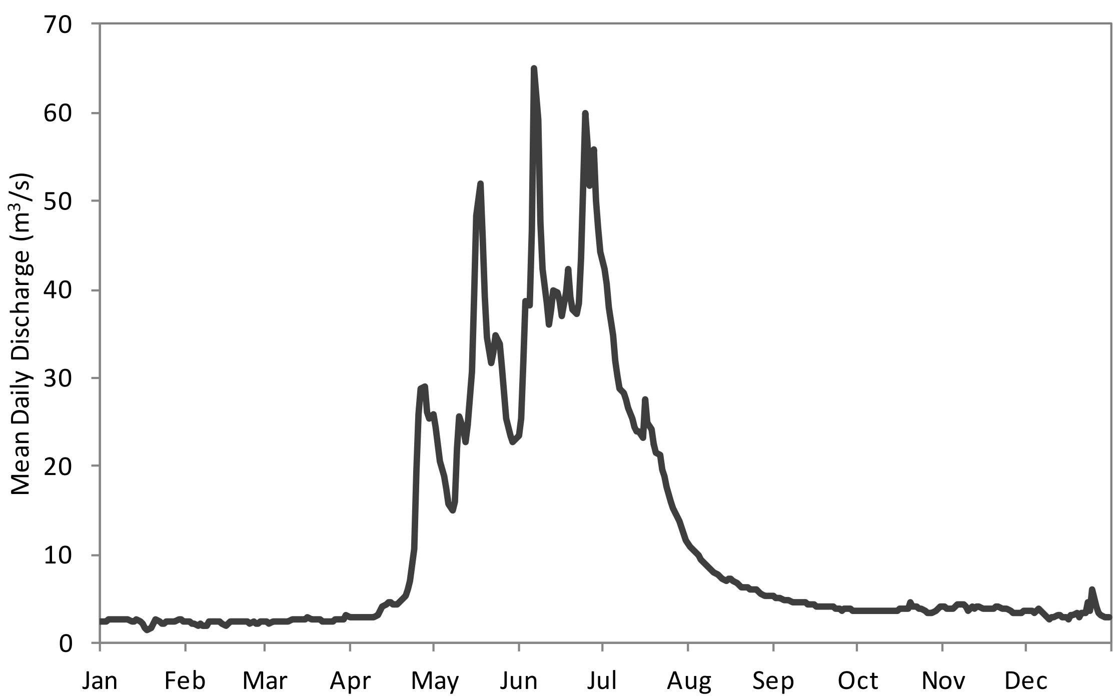


Figure 3.2. Fording River mean daily discharge for the 2012 study period (WSC Stn. 08NK018). Note that data is preliminary and subject to revision by WSC.

dewatering was not evident from the air due to partial snow and ice cover. By February the entire section of river in this area was snow covered and determination of surface flow would require ground reconnaissance. This observation was noted as relevant as it confirms 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, Teck, FRO, Elkford, B.C., *pers. comm.*) and fish kills due to winter (dewatered) conditions 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 (Prince and Cope 2001) and the Elk River (Prince and Morris 2003).

Density estimates for mature Westslope cutthroat trout (fish > 200 mm FL or fish > 300 mm FL) have been collected using similar snorkel methods (as described in Section 2.5.2) for a few priority Westslope cutthroat trout streams in the upper Kootenay drainage (Elk main stem, 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 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.

3.1.1. Water Temperature

This sub-species of cutthroat trout thrives in cold, clean streams preferring stream temperatures of 9-13°C (Ford *et al.* 1995, Behnke and Zarn 1976). British Columbia Water Quality Guidelines for optimal cutthroat trout rearing temperatures are 7-16 °C (Oliver and Fidler 2001). Recent work identified the upper incipient lethal temperature as just 19.6°C (Bear *et al.* 2007).

Note that due to the seasonal download schedule (as described in Section 2.2.2) water temperature data beyond the October download prior to freeze-up was not available at the time of this report and the annual temperature profile (August 2012 – August 2013) will be presented in the Year 2 report. Mean daily water temperatures recorded at three locations within the upper Fording River between August 22 and October 24, 2012 averaged 6.67 ^{o}C (F1-rkm 20.51), 7.11 ^{o}C (F2-rkm 48.60) and 5.29 ^{o}C (F3-rkm 63.6) and ranged between 0.72 ^{o}C and 9.75 ^{o}C (Figure 3.3). Daily maximums (15 min. intervals) ranged between 11.5 ^{o}C and 13.0 ^{o}C.

Table 3.1. 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).

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 and upper thermistors. Warmer water temperatures during winter and cooler during summer are typical signatures of groundwater influx (Cope 2003, Prince and Morris 2003b). Groundwater influences from the wet and very expansive riparian area within Section S6 were suspected. An additional temperature logger was placed at the downstream limit of this potential over-wintering area at 42.48 rkm on October 25, 2012.

Although the temperature divergence for F2 identified above may not appear significant it triggered further field investigation through the over-wintering period and it is expected that when the over-wintering water temperature data from the Tidbit loggers becomes available (May 2013) it will confirm groundwater influence within S6. At the time of reporting the following was considered preliminary evidence of groundwater influences on over-wintering habitat:

1) River Section S6 extending from F2 (48.60 rkm) downstream to the Chauncey Creek confluence (41.96 rkm) was the site of over-wintering fish (n=16) and these fish were principally in one large aggregation at rkm 43.66 from November 2012 and were still at this location January 15 (the cut-off date for data collection for this report),

2) This river Section (S6) remained ice free as opposed to adjoining river segments (S1-S5 downstream and S7-S11 upstream) that were ice covered and had anchor ice as well as frazil ice and ice jams, and

3) Spot measurements indicated water temperatures of 2.0 ^{o}C as opposed to 0.0 ^{o}C once one progressed upstream and downstream 10 km (Table 3.2).

Tributary (Ewin, Chauncey, Henretta Creeks) mean daily water temperatures were colder than the mid-Fording (F2) section and were more consistent with the Fording main stem headwaters (F3) (Figure 3.3). There did not appear to be any indication of groundwater influence for these tributary locations.

Mean daily water temperatures for the upper Fording River late summer to early winter season were considered ideal for Westslope cutthroat trout rearing and were consistent with other upper Kootenay River watersheds (*e.g.* upper Elk, upper Wigwam) that support significant fluvial populations of Westslope cutthroat trout (Table 3.3).

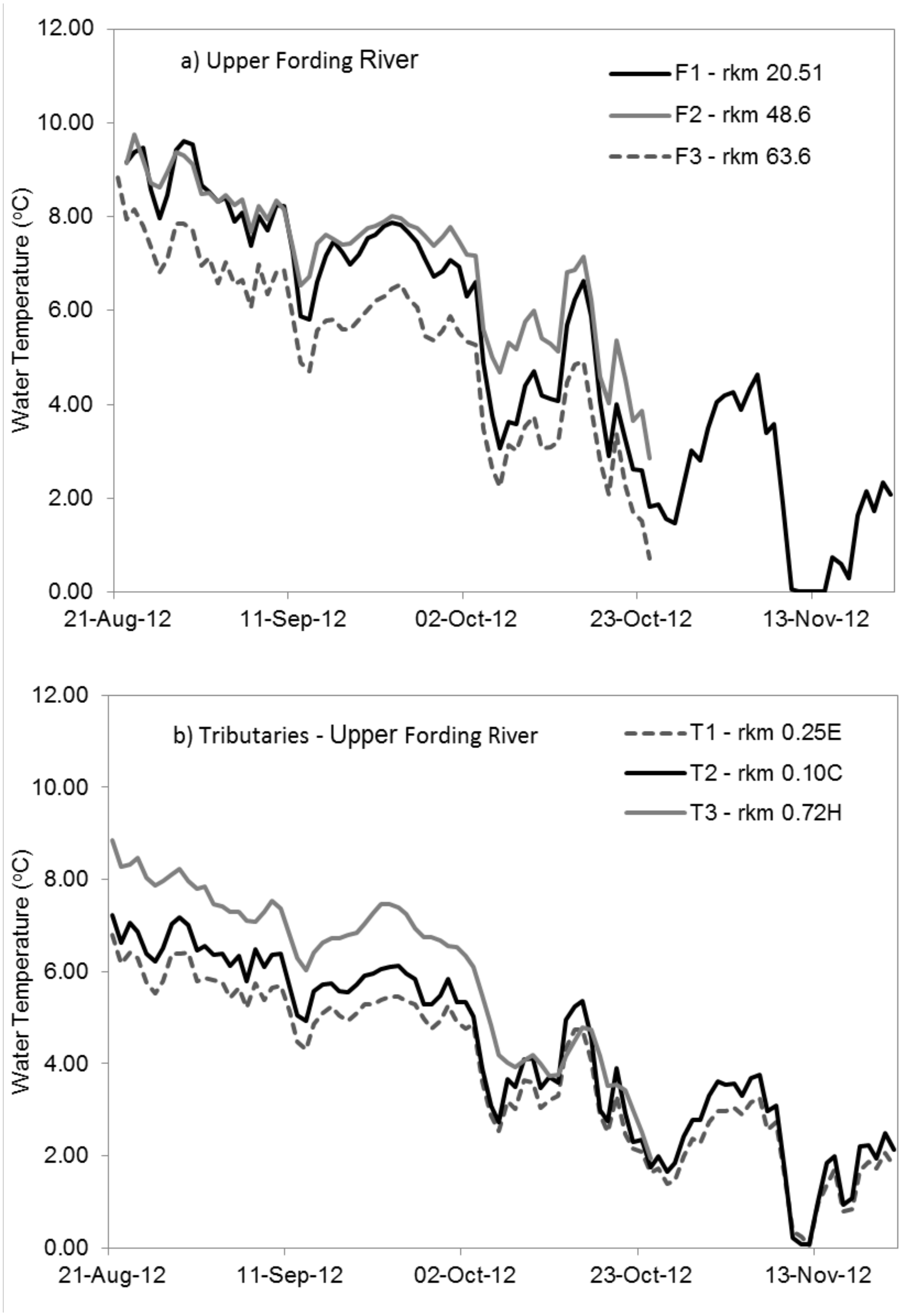


Figure 3.3. Upper Fording River mean daily water temperature at the six fixed receiver stations August 22, 2012 to November 22, 2012.

Table 3.2. Spot water temperature measurements within the upper Fording River, January 30-31, 2013.

Rkm	Location	Water Temperature (oC)	Date	Time	Water Temperature Logger
1.00H	Henretta Lake outlet	0.3	Jan 30, 13	12:15	Y
0.25E	Ewin Creek	0.5	Jan 31, 13	10:50	Y
0.1C	Chauncey Creek	Frozen:dry	Jan 30, 13	17:00	Y
63.6	Fording River	0.0	Jan 30, 13	12:45	Y
48.6	Fording River	2.5	Jan 31, 13	11:40	Y
46.7	Fording River	2.0	Jan 30, 13	16:00	N
42.2	Fording River	1.0	Jan 30, 13	17:00	Y
33.1	Fording River	0.0	Jan 31, 13	10:40	N
20.51	Fording River				Y

Table 3.3. 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	Mean daily Water temp (^{o}C)	Min	Max	Dates
Upper Fording	7.58	4.68	9.75	Aug 22 - Oct 12, 2012
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

Similarities in discharge and temperature among comparison populations are important in evaluating movement and life-history patterns. For example, in the upper Kootenay River drainage 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 (as recorded at the Cranbrook Airport, Canadian Climate Data Archive, Environment Canada) can range from lows in excess of -20 ^{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.

Recommended water quality guidelines for optimal spawning temperatures for Westslope cutthroat trout are 9 – 12 ^{o}C (Oliver and Fidler 2001). More generally, this species spawns when temperatures reach approximately 7 – 10 ^{o}C (Scott and Crossman 1973) and both the Elk and St. Mary River populations began spawning when mean daily water temperatures reached 7.0 ^{o}C (Prince and Morris 2003, Morris and Prince 2004). In the upper Bull River, spawning related movements were documented between May 25 and July 4 when mean daily water temperatures ranged between 3.98 ^{o}C and 7.81 ^{o}C (mean 5.69 ^{o}C).

In addition, life-history traits and population dynamics of above barrier, resident populations of salmonids demonstrate limited downstream displacement and a later spawning period in the spring (s*ee* Baxter 2004, Northcote 1992, Northcote and Hartman 1988, Elliott 1987 for reviews). 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).

3.1.2. Water Quality

The following section provides a brief summary of what is currently known regarding water quality within the upper Fording River. The relevance of water quality to this study is explained in Section 2.2.3.

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). In addition to this work the AEMP was established and replaced the original selenium monitoring program in late 2010 (Minnow *et al.* 2011).

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 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) (Minnow Environmental Inc and PLA 2012, Minnow *et al.* 2011, Chapman *et al.* 2008, Minnow *et al.* 2007). 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). The 2012 average Fording River selenium concentration for British Columbia Ministry of Environment 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*). Teck is leading a number of initiatives designed to increase its understanding of selenium and to identify technological solutions and management approaches to arrest the increasing trend in surface water concentrations (Strategic Advisory Panel on Selenium Management 2010).

The majority of Fording River Operations selenium loading originates from Kilmarnock Creek and Henretta Creek. Swift Creek and Cataract Creek represent the largest selenium load into the upper Fording River from Greenhills Operations. These sources result in high selenium loads within the river sections containing the notable over-wintering aggregations that represented 67.9% of the radio tagged fish (see Section 3.4.4.3). These include Henretta Lake, the multi-plate culvert (rkm 57.48) and most notably the Section S6 with assumed groundwater influence (rkm 42.5 to rkm 48.5). Section S6 also includes the "Fording Oxbow" referred to in selenium studies. The S6 Section represents the receiving environment for the Kilmarnock, Swift and Cataract Creek selenium sources. Westslope cutthroat trout captured during spawning season within the Fording Oxbow area and Henretta Lake have been documented with elevated selenium tissue samples (Fisher 2013, *pers. comm*., Minnow *et al.* 2011).

The most sensitive species to selenium toxicity are oviparous (egg-laying) animals and selenium tends to bio-magnify, accumulating to higher concentrations in tissues of organisms higher in the food web (Orr *et al.* 2006). Elphick *et al.* (2009) evaluated the effect of selenium on early life-stage development of Westslope cutthroat trout captured from the upper Fording River confirming larval mortality was the primary adverse effect and site specific effects threshold for Westslope cutthroat trout on the basis of tissue selenium concentrations were derived (EC 10 24.8 µg/g Se, EC 20 27.4 µg/g Se, EC 50 33.3 µg/g Se).

On the other hand, despite these increasing trends in selenium concentrations in surface water, there has been no discernible increase in fish tissue concentrations 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).

Poorly understood fish migratory patterns are confounding interpretation of fish tissue concentrations (Fisher 2013, *pers. comm.,* Orr *et al.* 2012). There is anecdotal evidence within the tissue selenium sampling and otolith data that supports a fluvial migratory life-history for mature Westslope cutthroat trout in the upper Fording River. Mature fish with high selenium tissue concentrations such as those documented within the Section S6 or \`Fording Oxbow\` have been documented within reference tributaries (*i.e.* Dry Creek, Fisher 2013, *pers. comm.).* The otoliths of most fish captured in the Orr *et al*. (2012) study had low selenium levels during the first 1-2 years of life. One hypothesis that would explain these otolith selenium patterns, and be consistent with fluvial migratory life-history strategies, would be juvenile residence within tributaries or headwater habitats not influenced by elevated selenium surface water inputs. Presumably, under this hypothesis exposure to elevated selenium occurs following migration into main stem habitats at later ages. Mechanisms of selenium uptake and dispersion or depuration are not fully understood (Orr *et al.* 2012).

3.2. Population Viability

One of the goals of the upper Fording River Westslope cutthroat trout study is to assess the status of the population and determine its relative “health”. There are many measures of population “health”, some of which include:

1. Minimum viable population (genetics);
2. Defining a “Sustainable” population – based on a perceived minimum population size.

This section proposes a range of values for defining or evaluating population viability of Westslope cutthroat trout in the upper Fording River. The overall recommended management approach for Westslope cutthroat trout in British Columbia based on Pollard (2010, *pers. comm*.), should ensure:

1. Wild population conservation;
2. Habitat protection;
3. Provision of sustainable and diverse recreational opportunities; and
4. Be consistent with the Fisheries Program Plan objectives, while meeting Species At Risk Act requirements.

The discussions around population viability are based on key animal population characteristics including stock productivity, stock-recruitment, harvest and mortality variables (Ricker 1975, Hilborn and Walters 1992). Conservation biologists typically use population estimates and/or statistical models to estimate animal (in this case fish) populations relative to critical management thresholds, and evaluate the risk of extinction based on four key variables:

1. Basic life-history;
2. Demographic stochasticity;
3. Genetic variation; and
4. Environmental variation and catastrophes.

There are a variety of ways currently used to determine what might be considered a viable population. Animal populations (and their ability to maintain/sustain themselves, grow or expand their range, maintain genetic and ecological viability) can vary considerably. Techniques for determining what level of information is appropriate and defensible for setting population thresholds are continually being assessed. More recently, statistical 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).

One approach includes the use of Population Viability Analysis (PVA), a relatively new assessment tool, developed in the late 1970's and initially used for grizzly bears in Yellowstone Park, and has been developed as a tool to examine spatial (GIS – landscape) data with PVA (Ackakaya 1998). It is primarily used as a tool for managing rare and endangered species and there are three key aspects, which include:

1. Planning research and data collection;
2. Assessing vulnerability; and
3. Ranking management options.

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 (Mayhood 2012, Johnston 2010, *pers. comm.,* Cleator *et. al.* 2009, DFO 2009, Johnston e*t. al.* 2002) with little or no abundance available for a given population. Stock productivity, which is key to determining the rate of recovery for a population, is poorly understood and imprecise for Westslope cutthroat trout (Johnston 2010, *pers. comm.*).

While models can provide a useful tool to assist in predicting population trends and targets, they have limitations and cannot replace field observations which help us to understand and characterize individual fish species and populations (hence this study). Some of this information will be collected with subsequent phases of this project for the upper Fording River Westslope cutthroat trout population. This will improve the understanding of the upper Fording River population and the development of associated management and monitoring programs into the future.

In an effort to establish values for "viable" populations, establishing effective limit reference points is particularly important because the small size of many populations increases their vulnerability to extirpation. Because of the data limitations, effective reference points that do not require stock productivity information are desirable. The province of British Columbia's approach is to use a simple analytical method to determine limit reference points and conservation concern thresholds (Johnston 2010, *pers. comm*.).

The type of animal population (and its ability to respond/recover) is often used to determine management thresholds. In the absence of productivity and population data, low/unproductive stocks (such as many Westslope cutthroat trout and other salmonids) which have a high risk of extinction, a more conservative approach is usually preferred (*i.e.* $0.4 \cdot N_{equili}$); for higher productivity stocks where stock-recruitment relationships are well established, a lower threshold (*i.e.* $0.1 \cdot N_{equili}$ to $0.2 \cdot N_{equil}$) is often considered (Pollard 2010, *pers. comm.*).

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). The higher end of this range would likely better represent the upper Fording River population objective for a healthy, self-sustaining population capable of withstanding environmental change and accommodating stochastic population processes in perpetuity.

For the reasons given in the previous paragraphs, a range that encompasses what would be defined as a "viable" population size will be provided rather than generating a specific number for the upper Fording River population. One of the values of this current study is that it achieves a much higher level of understanding of population characteristics including the key variables identified, to make informed management decisions; therefore, the range based on the literature review is 470 to 4,600 adults.

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 57.5 km of main stem river habitat (plus several tributaries).

Hybridization with non-native rainbow trout and higher water temperatures are the two greatest threats most often reported for Westslope cutthroat trout persistence (Carscadden and Rogers 2011, Muhlfeld *et al.* 2009, Allendorf and Leary 1988). In this regard the upper Fording River could not be better suited. 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) and maximum water temperatures are well within species optimums (Bear *et al.* 2007, Oliver and Fidler 2001, Ford *et al.* 1995, Behnke and Zarn 1976).

Given the current population estimate (n=2,600 fish > 200 mm, *see Section 3.4.5.2 Population Estimates*) and the length of the main stem river (57.5 km available habitat) it appears that it is possible, if not probable, for the upper Fording River population, with suitable management strategies (*e.g.* habitat protection, angling restrictions), to achieve population objectives of a healthy, self-sustaining population capable of withstanding environmental change and accommodating stochastic population processes in perpetuity.

Based on prior use of the area, there are societal aspirations for recreational use (catch-and-release angling) and harvest activities within the upper Fording River watershed. To incorporate these aspirations into the future while maintaining long-term persistence of the population, the upper Fording River Westslope cutthroat trout population would likely need to be managed toward the higher end of the range suggested (*i.e.* greater than 470 adults, and likely much closer to 4,600 adults, Cleator *et al.* 2009, DFO 2009).

Within the species range, local/East Kootenay populations are generally considered relatively healthy and can support some level of recreational angling. It will be important over the remaining two years of planned population estimates to demonstrate the validity of the 2012 estimates through replication and to begin to understand the overall population trend (increasing, stable, decreasing). If it can be demonstrated the current population estimate is valid and increasing, then it could reasonably be anticipated that recreational angling would be reintroduced to the upper Fording River once population levels reach the higher end of the range identified as “viable” or “self-sustaining” in this literature review (470 to 4,600 adults).

Therefore the recommended approach for the upper Fording River watershed, rather than establishing a specific target number or population size (in the absence of stock-recruitment and productivity data for the population) to represent viability would be to take a conservative approach, identify key trends and opportunities using benchmarks, identify (and manage) key risks/threats, and develop a long term assessment strategy to track trends for Westslope cutthroat trout.

3.3. Population 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 (Carscadden and Rogers 2011, Allendorf and Leary 1988). Non-hybridized populations of Westslope cutthroat trout persist in only 20% of their range in Canada (COSEWIC 2006).

The upper Fording River Westslope cutthroat 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.

In addition, previous population genetic analyses indicate there is no genetic differentiation between Westslope cutthroat trout captured approximately 22.5 kilometres 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).

The current telemetry study has shown that the mean movement for the Aug 22, 2012 (summer rearing habitat) to January 15, 2013 (over-wintering habitat) period was 4.76 km with movements ranging between 0.00 km and 28.30 km (see Section 3.4.4.3 Migration and Movement, Figure 3.8). These results are consistent with other above barrier populations within the upper Kootenay River (Cope and Prince 2012, Prince and Morris 2003) that demonstrated migratory fluvial behaviour that would support genetic results showing no differentiation (*i.e.* mixing).

3.4. Radio Telemetry and Population Monitoring (Sub-adult and Adults)

3.4.1. Capture and Tagging

Angling for sub-adult and adult Westslope cutthroat trout was conducted August 22 to September 7, 2012. Mean daily water temperatures during capture and tag implantation ranged between 6.07 and 9.75 ^{o}C and spot measurements ranged from 6.0 ^{o}C to 14.5 ^{o}C. In total, 229 Westslope cutthroat trout ranging in size from 160 mm to 485 mm (fork length-FL) and between 55 g and 1,550 g were captured. Of these, 60 Westslope cutthroat trout were implanted with a radio tag and a green Floy tag was also applied. An additional 151 fish were tagged with white Floy tags. Eighteen juveniles less than 200 mm fork length were measured and released.

The application of 151 white Floy tags was 21 less than the target of 172. This was a direct result of the small stream size (low water volumes) and very low catch-per-unit-effort for fish meeting minimum size requirements above rkm 64.00. Above rkm 64.00 all fish captures except one were assessed as juveniles below the minimum size requirements (less than 200 mm). This assessment was based on the following; a) 60 radio tagged fish were examined internally and no Westslope cutthroat trout below 280 mm F.L. were sexually mature (n=11), including the seven fish examined within the uppermost section, b) smaller fish (< 200 g) had parr marks visible, and c) these results were consistent with the upper Bull River Westslope cutthroat trout telemetry study (Cope and Prince 2012).

After repeated sample attempts (n=3) traversing the river channel above Henretta Creek (i.e. rkm 63.0 to rkm 67.0), further sampling above rkm 63.0 was curtailed and the radio tags allocated to Section S11 (67.75 rkm to 76.75 rkm) were re-distributed among lower Henretta Creek and the remaining ten main stem river sections downstream. Since there were no Floy tags applied in Section S11, this reach was not included in the snorkel survey and the Year 1 (2012) population estimates are limited to fish greater than 200 mm within the main stem upper Fording River Sections S1 through S10 and lower Henretta Creek and Henretta Lake (approximately 49.5 river kilometres). As results are interim, and based on sampling restricted to the main stem upper Fording River and lower Henretta Creek, the alternative explanation that headwater sections may contain adults with smaller size-at-maturity and are less migratory has not yet been ruled out. In Year 2 (2013) additional effort has been allocated to sample the headwater Section S11 of the upper Fording River and tributaries in an effort to radio tag smaller sized fish (*e.g.* 200 g or approximately 230 to 280 mm F.L.) to confirm maturity status through increased sample size of internally examined fish and radio tagging results to demonstrate fluvial migratory or resident behaviour. These upper reaches will also be sampled to capture and tag (PIT Tag) smaller size classes through the juvenile recruitment study component (see Section 3.7).

3.4.1.1. Radio Telemetry

Radio tags and green Floy tags were applied to 60 sub-adult and adult fish ranging from 234 mm to 485 mm fork length. The corresponding weight ranged from 210 g to 1,400 g. Due to transmitter size restrictions (Winter 1983) the minimum fish size for radio tagging was 200 g or approximately 230 mm fork length. There were 21 males (35%), 33 females (55%) and 6 unidentified sex (10%) tagged. Fish life stage was classified based on gonad development during the internal exam and included; 11 sub-adults (18.3%), 7 maturing or first spawners next spring (11.7%), and 42 mature (70%). All fish less than 280 mm fork length or 300 g were classified as sub-adults (immature gonads). Fish greater than this size (280 mm fork length or 300 g) were classified as mature or maturing (mature, anticipated to spawn next spring).

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 3.4). Mean induction and recovery times were 3:52 and 6:06 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 this upper Fording River 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 3.4), while this recovery procedure was done, it was done on an informal basis and the time was not always recorded.

Table 3.4. Comparative summary of quality assurance parameters for the radio tag implantation procedure for upper Kootenay River Westslope cutthroat trout greater than 200 g; a) average anaesthetic exposure, b) surgery time, c) recovery to equilibrium, and d) time to release.

Exposure Time	Upper Fording River (mm:ss)	Bull River[1] (mm:ss)	Elk River[2] (mm:ss)	St. Mary River[3] (mm:ss)
Anaesthetic	3:52	4:12	4:26	3:10
Surgery	7:01	6:52	6:29	6:46
Recovery	6:06	7:50	7:08	8:25
Release	48:15	19:03	Not Recorded	Not Recorded

[1] Cope and Prince 2012
[2] Prince and Morris 2003
[3] Morris and Prince 2004

During snorkel surveys (54 of 60 radio tags relocated), a survival rate of 98.3% (1 mortality) was confirmed 22 days post-surgery by a combination of upstream movement and visual (snorkel) identification. While the mechanism of mortality was unknown, it was assumed capture and handling were directly or indirectly responsible for the one confirmed mortality during the three weeks following release. This mortality rate met expectations and compares to 96.7% for the Upper Bull River Westslope Cutthroat Trout Project that included the same quality assurance procedures (Cope and Prince 2012).

Figure 3.4 illustrates the distribution of radio tagged Westslope cutthroat trout within the study area. As described above, initial distribution targets of one radio tagged Westslope cutthroat trout per kilometer were achieved for Sections S1 through S10 and tagged fish were distributed between rkm 22.15 and rkm 65.00 of the upper Fording River main stem and the lowermost 1.0 km of Henretta Creek (including Henretta Lake).

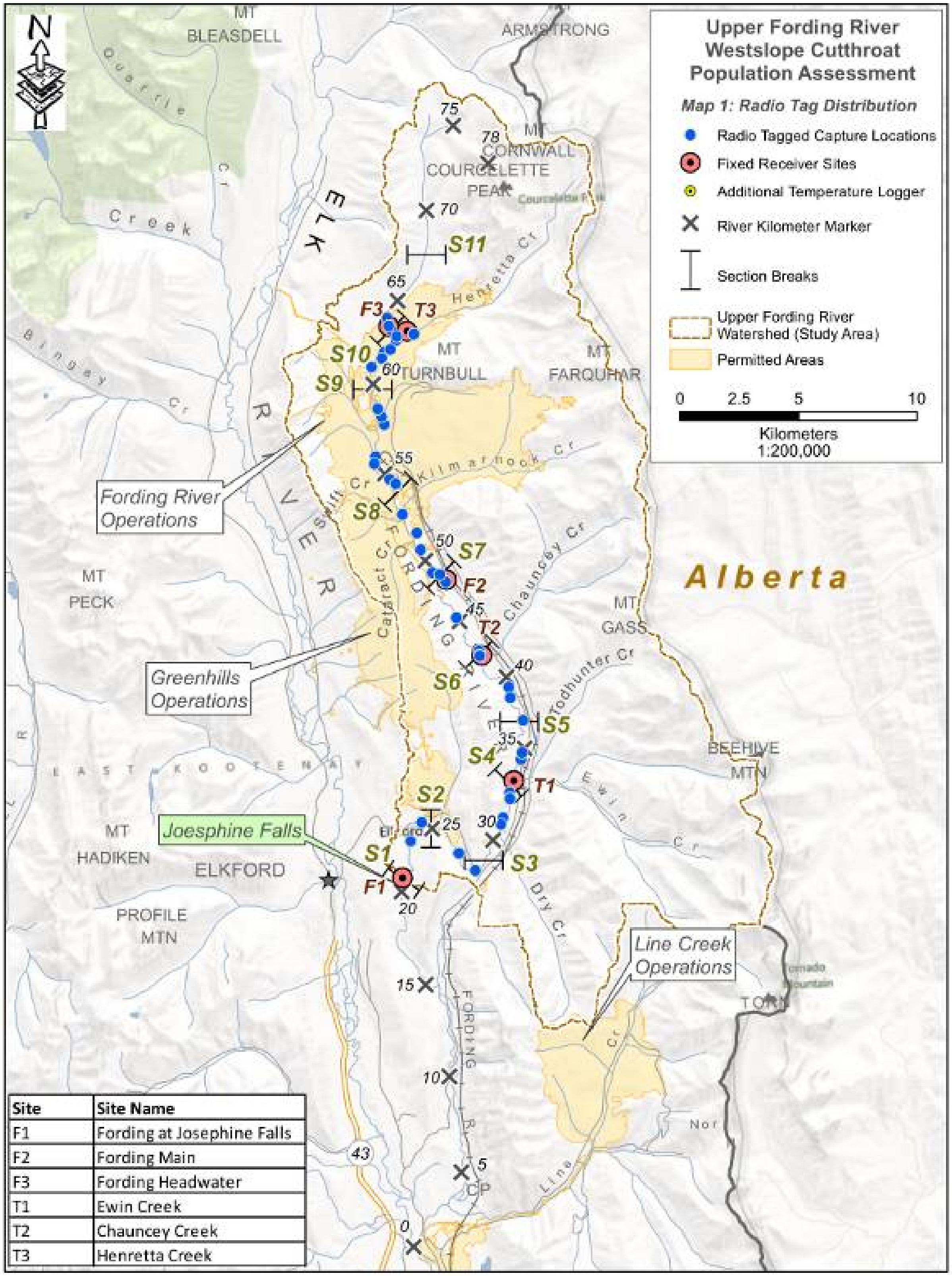


Figure 3.4. Distribution of radio tagged Westslope cutthroat trout captured and released in summer 2012, upper Fording River.

3.4.1.1. Population Monitoring

An additional 151 white Floy tags were applied to increase the total “marks” to 211 Westslope cutthroat trout greater than 200 mm fork length (size range 180 – 485 mm, 80 – 1,550 g). As previously described, the initial distribution target of four “marks” per kilometer was achieved for the main stem upper Fording River Sections S1 through S10 and the lowermost 1.0 km of Henretta Creek (including Henretta Lake). The results of the related snorkel surveys can be found in Section 3.4.5.

3.4.2. Life-history

Westslope cutthroat trout captured (n=229) ranged from 160 mm to 485 mm and averaged 289 mm fork length (Figure 3.5.). 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). The corresponding weight ranged from 55 g to 1,550 g and averaged 414 g.

Figure 3.5 illustrates the length frequency distribution and super-imposes estimated ages for life-history classes of interest (fry, juvenile, sub-adult, mature). These length-at-age estimates are a work in progress derived from scale ages at lower size ranges and ages (*i.e.* < 4 years old) and recently emerging otolith data were used to validate larger size classes and ages. These size ranges were then reviewed in the context of telemetry data illustrating alternate life-history strategies between life stages (*see Section 3.4.4 Radio Telemetry (Life-History) Monitoring)*.

This uncertainty in length-at-age data is owing to emerging evidence regarding the validity of scale age data for East Kootenay Westslope cutthroat trout (Cope and Prince 2012, Minnow Environmental *et al.* 2011, 2007, Wilkinson 2009, Robinson 2005). Using ages derived from otoliths (lethal sampling required), the Elk River population (includes upper Fording River samples) has been aged as old as 12 years (Wilkinson 2009) and 16 years (Minnow Environmental Inc. 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). Generally, scale aging is not recommended for any species which has the potential to be older than the scale growth pattern potential.

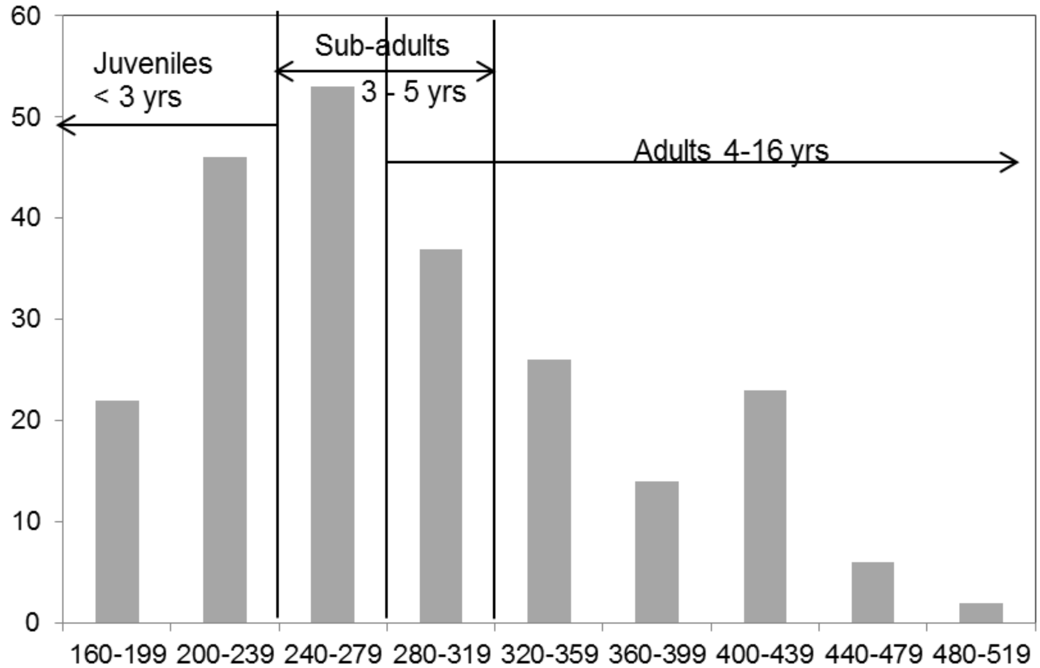


Figure 3.5. Length-frequency (n=229) and estimated lifestage and age intervals of Westslope cutthroat trout captured within the upper Fording River, 2012.

A number of upper Kootenay Westslope cutthroat trout populations monitored using radio telemetry have also been aged using scales (Cope and Prince 2012, Baxter 2004, Morris and Prince 2004, Prince and Morris 2003, Baxter and Hagen 2003). Although the maximum ages never exceeded 7 years and are therefore erroneous (Table 3.5), there are commonalities among these populations and the upper Fording River population that facilitate the estimation of size ranges for the four life-history stages (Figure 3.5). While the degree of overlap can be debated, it was clear that fry (young-of the-year) are less than 55 mm Fork Length. Juveniles are generally between one and three years old and range in size between 50 mm and 230 mm. Sub-adults are typically between three and five years old and range in size between 230 and 300 mm. Mature adults reach maturity between three and five years old and have been aged as old as 16 years. Gonadal maturity (*i.e.* fish will spawn the next spring) was identified in radio tagged upper Fording River Westslope cutthroat trout as small as 280 mm and ranged as large as 485 mm. The sub-adult and adult size range and life history stage are reviewed in the following sections in regards to Fulton's condition factor (*K*), population abundance, movement, distribution, and habitat utilization.

Table 3.5. Length-at-age estimated using the scale method for East Kootenay Region Westslope cutthroat trout telemetry projects.

Age Class	Upper Bull River (Cope and Prince 2012)	Upper Bull River (Baxter 2004)	Elk River (Prince and Morris 2003)	St. Mary River (Morris and Prince 2004)	Wigwam River (Baxter and Hagen 2003)
0+		52			24 (21 – 32)*
1+		91 (86 – 95)			73 (54 – 98)*
2+		135			133 (105 – 167)*
3+	260 (209 – 322)	220 (180 – 250)	325		224**
4+	286 (228 – 371)	319 (260 – 365)	343 (326 – 354)	349 (340 – 360)	373 (340 – 435)
5+	303 (237 – 383)	350 (300 – 410)	372 (331 – 415)	382 (350 – 405)	405 (365 – 450)
6+	386 (359 – 405)		393 (357 – 422)	400 (380 – 425)	410 (370 – 440)
7+	393 (329 – 431)			430	

* data from Cope 2007.
** data from Columbia Environmental Services 1996.

3.4.3. Fish Condition

Based on external visual examination (n=229) there were only four (1.7%) fish with observed deformities (shortened operculum, worn caudal fin, damaged eye). These were indicative of past injury rather than teratogenetic effects. 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 within fish greater than 150 mm fork length or at least two years age was also consistent with Clode Pond salvage reporting two out of 177 or 1.1% in 2005 (Interior Reforestation 2006).

Based on the internal visual examination there were zero reported deformities. The primary comment from the internal examine 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 evidence angling related injuries (Prince and Morris 2003).

Elevated rates of deformities in mature fish were not expected given that selenium toxicity is usually associated with teratogenic effects that primarily result in larval mortality (Elphick *et al.* 2009) as a result of maternal transfer of selenium in eggs (Orr *et al.* 2006). As a result, deformity and mortality occurs in the larval, early life stages and deformed fish are 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 3.6).

Table 3.6. 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	343	330	374	386	393
Min	234	251	325	342	340
Max	485	433	422	430	450
N	60	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.

Based on fork length, the mean size of upper Fording River Westslope cutthroat trout was larger than the upper Bull River (Cope and Prince 2012). Earlier telemetry studies (Elk, St. Mary and Wigwam Rivers) are 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).

Indices of condition, or well-being, have often been interpreted and compared in weight – length relationships. 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). 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):

$$K = (\textit{Weight g}/(\textit{Fork Length}^3\ \textit{mm})) * 100{,}000$$

However, comparisons are typically limited to fish of similar lengths and comparison between species is generally not possible (Murphy and Willis 1996).

The mean Fulton condition factor for the 2012 data (n= 229, FL 160 mm – 485 mm) was 1.41 (Table 3.7). In 1999, the mean Fulton condition factor for upper Fording River Westslope cutthroat trout was 1.18 (range 0.93 – 1.79, n= 95, FL between 74 mm and 250 mm) (Amos and Wright 2000). The 1999 condition factor was largely unchanged from twenty years previous (Norecol 1983; *K* = 1.15 (0.63 – 1.63). 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). This agrees closely with the current estimate for fish that include this size class.

Table 3.7 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 it's 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 are corroborated by the fish condition observations noting the robust nature of upper Fording River Westslope cutthroat trout that was evidenced by the very thick body wall and white muscle tissue.

Table 3.7. Comparative 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 Bull River (2010)[1]	Elk River (2000-01)[2]	St. Mary River (2001-02)[3]	Wigwam River (2001)[4]
Fulton K					
Average	1.41	1.18	1.44	1.28	1.14
Min	1.10	0.89	1.17	1.08	0.95
Max	1.80	2.14	1.84	1.89	1.40
N	229	65	40	40	31
Fork Length					
Average	289	316	374	386	393
Range	160 - 485	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.

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 Inc 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). Information on phosphorus for the upper Elk Valley is being researched and will be included in Interim Report 2.

3.4.4. Radio Telemetry Monitoring (sub-adults and adults)

Movement data will be analysed for home range, and life-history movement patterns that can then be compared to the regional reference populations that have had similar telemetry studies completed (upper Bull River, Elk River, Wigwam River, St. Mary River); 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 is anticipated that after three years (*i.e.* three replicate radio tag groups for a total of n=180 radio tagged Westslope cutthroat trout) if repeating patterns of movement and seasonal distribution can be identified then critical habitats necessary for the completion of life-history functions (*e.g.* spawning, over-wintering, rearing) can be identified with confidence. Mortality rates between habitats with multiple fish and repeating patterns of annual use (*i.e.* habitats categorized as “critical”, “limiting” or “important”) will be compared to those habitats with lower use categorized as “alternative” or “low utilization” habitats. If differences in mortality risk can be demonstrated this will support the designation of critical habitat.

Fish distribution and movement data will also be contrasted with the total available habitat documented using the low level aerial imaging. This would facilitate comparison of available habitat among river segments and enable statistical analysis using resource selection methods (Manly *et al.* 2002). Annual consultation with the Steering Committee as well as the AEMP and the HSI programs ensures coordination of habitat data collection among projects.

Due to the size restrictions of radio telemetry methods, only the sub-adult and adult life history stages (fish greater than 230 mm fork length or 200 g) are evaluated using these methods. The juvenile stages (fish less than 230 mm fork length or 200 g) utilize electro-fishing and angling mark-recapture methods (*see* Section 3.7 Recruitment and Juvenile Population Monitoring). Since Westslope cutthroat trout as small as 236 mm fork length were radio tagged, and no fish less than 280 mm was sexually mature, it is unlikely these results will be biased to characterize the habitat use and migratory life history of only the fastest-growing, larger individuals. In addition, the upper Bull River Westslope cutthroat trout telemetry study illustrated similar length-at-maturity and movement patterns to the current (preliminary) results and movement was not significantly correlated with body size (Cope and Prince 2012). This regression analysis (movement vs. body size) will be repeated using the larger upper Fording River dataset as it becomes available. Nevertheless, the alternative hypothesis that one or more headwater populations may exist with a smaller size-at-maturity and less migratory life history strategy has not been ruled out and additional effort has been allocated to sample headwater areas within the main stem and tributaries using radio-telemetry and electrofishing methods to further investigate this possibility.

3.4.4.1. Monitoring Interruptions

There have been no monitoring interruptions at any of the fixed receiver stations. Continuous monitoring at all six fixed receiver stations has been maintained from August 22, 2012 through January 15, 2013.

3.4.4.2. Survival

During snorkel surveys completed two weeks after tag implantation (September 16 - 22, 2012), the tagging success rate (survival) was assessed as 98.3% based on relocating 54 of 60 radio tags that included one confirmed mortality (tag recovered from carcass).

Currently, as of January 15, 2013, 131 days after the first radio tag release, 56 of 60 radio tagged fish (93.3%) have been relocated and assessed as alive based on a combination of visual confirmation and movement data. One fish was a recovered mortality and three fish were tagged and never seen again. Two of these fish were tagged in pools beside road pull-outs and could have been harvested (poached). Due to their short time at large or their disappearance, little or no movement was reported for these four fish. To eliminate this bias, these fish were not included in further movement analyses. As a result, there were a total of 56 radio tagged Westslope cutthroat trout confirmed alive and relocated at large for between 131 and 146 days of the 390 day tag lifespan. These fish form the basis for the following interim life-history evaluation.

Documentation of mortalities is an ongoing quality control process that is reported on an annual basis following 12 months of monitoring, therefore mortality rates will be reported on for the first time in early 2014. Movement patterns are reviewed on an ongoing basis to confirm fish status (*e.g.* upstream movement confirms alive) and ground-truthing sessions are scheduled to confirm fish status (*e.g.* visual confirmation or movement confirmation using receiver). Fish are confirmed mortalities through the recovery of the tag (or alternatively confirmation of the tag in an avian nest, animal den or buried in a logjam on land) and the documentation of the most plausible mechanism of mortality by an experienced tracking crew with detailed local knowledge. For example, over-wintering ice mortalities are typically documented as a tag recovered on a gravel bar or in a logjam where previous winter tracking sessions noted surface dewatering, ice accumulations, or an ice jam, no further movement noted after that time and tag signal strengths typical of an air tag. Similarly, predation mortality is typically documented as an air tag signal strength that results in a ground-truthing confirmation where the tag is recovered in bird droppings or beneath an avian roost.

3.4.4.3. Migration and Movement

There were no 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 two separate tracking sessions on the lower Fording River to ensure no “missing” tags managed to pass the receiver undetected.

Home range

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

Home range will be reported on an annual basis following 12 months of monitoring; therefore home range will be reported on for the first time in Interim Report 2 (early 2014). 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 represent largely migratory fluvial life-histories (Elk and St. Mary Rivers also include some adfluvial migratory). The home range of the upper Fording River Westslope cutthroat trout will be compared against these upper Kootenay River populations.

Seasonal movement patterns

Over-Wintering

The average distance moved for Westslope cutthroat trout between summer rearing habitat (August 22 – September 22) and over-wintering habitat (November 13 – January 15) was 4.76 km (range 0.00 – 28.30 km). This was within the range expected for a fluvial, above barrier, upper Kootenay River population of sub-adult and adult Westslope cutthroat trout.

The majority (67.9%) of the upper Fording River sub-adults and adults congregated in three notable habitat units (Figure 3.6). These locations were river Section S6 (42.0 rkm to 48.6 rkm) dominated by one deep pool location at 43.66 rkm (35.7%, although during periods of warming these fish would disperse up to 3.5 km within Section S6), the multi-plate culvert at 57.6 rkm (14.3%) and Henretta Lake (17.9%) 1.0 km upstream from the Henretta Creek confluence at rkm 62.8. These three habitats were slow, deep pools typical of over-wintering habitat reported for similar high elevation populations of Westslope cutthroat trout within the upper Kootenay River watershed that attain large size at maturity (> 300 mm) and experience dynamic ice environments (Cope and Prince 2012, Morris and Prince 2004, Prince and Morris 2003, Baxter and Hagen 2003). This over-wintering habitat preference for slow deep pools with possible groundwater influence has also been documented in Alberta (Cleator *et al.* 2009) and elsewhere (Schoby and Keeley 2011, Schmetterling 2001).

Four (7.1%) of the smallest fish (range 244 – 266 mm FL) were over-wintering within the headwaters above 62.00 rkm. Mobile tracking has confirmed these fish have been using over-wintering habitat more like that expected from juveniles such as small pools and sheltered waters with cover provided by boulders and other instream structures. Two of these fish were located at the base of gullies or avalanche chutes that may be contributing groundwater influence. These four fish were confirmed gonadally immature through internal examination.

The remaining 25.0% of the radio tags were documented within habitats represented by smaller logjam or bedrock control pools, and glides or runs with large cobble-boulder substrates. All of these habitats were associated with dynamic ice conditions that have been photo-documented. A final determination of the relative importance of these differing habitats within the upper Fording River (*i.e*. slow deep pools with possible groundwater influence and multiple fish versus so called “alternative” habitats with low utilization) cannot be made until the completion of over-wintering tracking in April, and the replication of the study design in years two and three. Confirmation of over-wintering mortality often requires snow and ice melt to facilitate tag retrieval and mortality confirmation. It is anticipated that after three years (*i.e.* three replicate radio tag groups for a total of n=180) if repeating patterns of movement and seasonal distribution can be identified then critical habitats necessary for the completion of life-history functions (*e.g.* spawning, over-wintering, rearing) can be identified with confidence. Mortality rates between habitats with multiple fish and repeating patterns of annual use (*i.e.* habitats categorized as “critical”, “limiting” or “important”) will be compared to

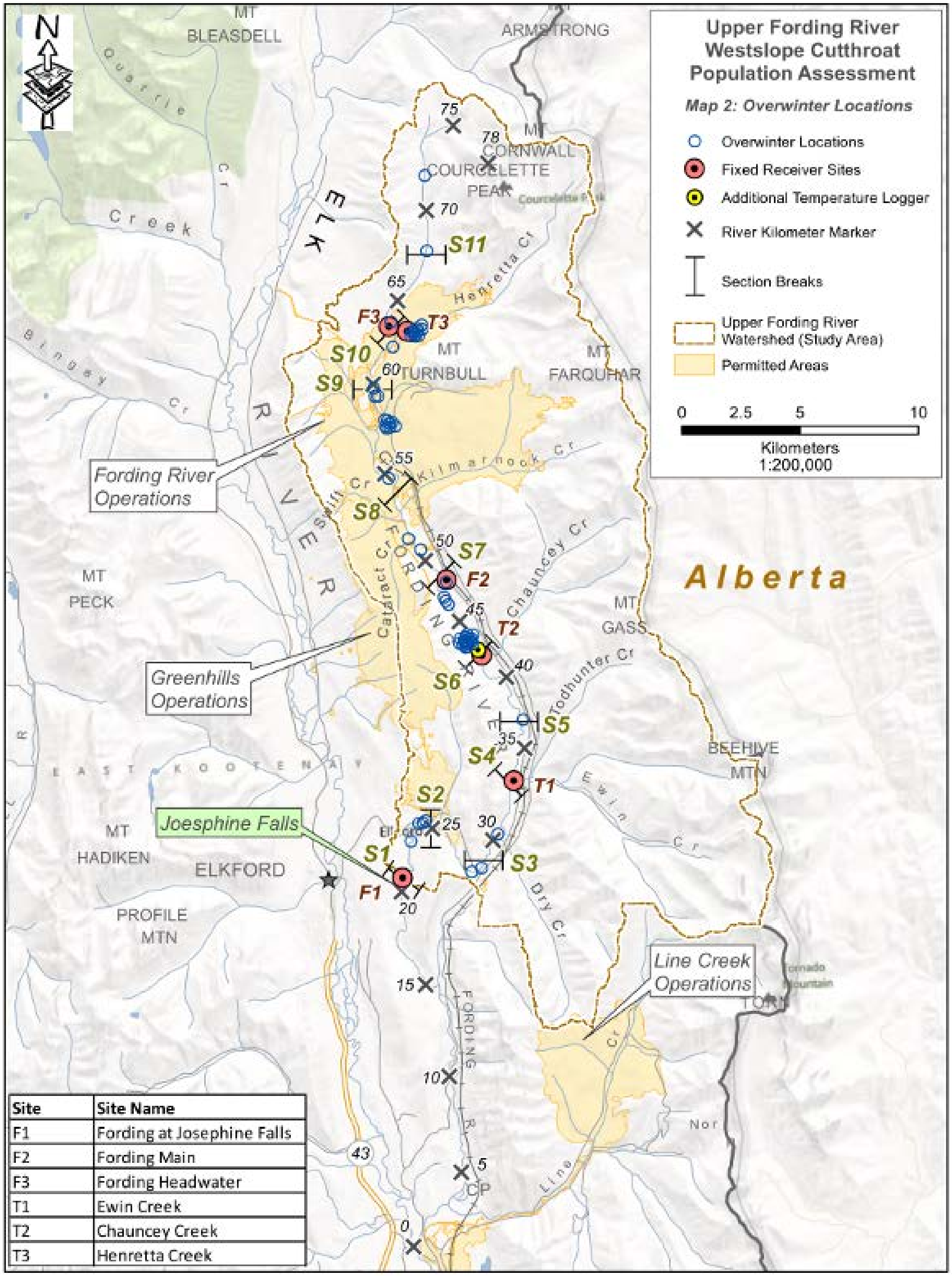


Figure 3.6. Overwinter locations of radio tagged Westslope cutthroat trout, January 15, 2013.

those habitats with lower use categorized as “alternative” or “low utilization” habitats. If differences in mortality risk can be demonstrated this will support the designation of critical habitat.

Figure 3.7 illustrates the change in distribution observed between summer rearing and over-wintering habitat. Not unexpectedly, the distribution of fish among summer rearing habitats was much broader than that observed for over-wintering habitat. 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).

Figure 3.8 illustrates the extent of movements exhibited by radio tagged Westslope cutthroat trout. Further movement is expected in spring and summer as fish move from over-wintering habitat to staging habitat, spawning and back to summer rearing habitat.

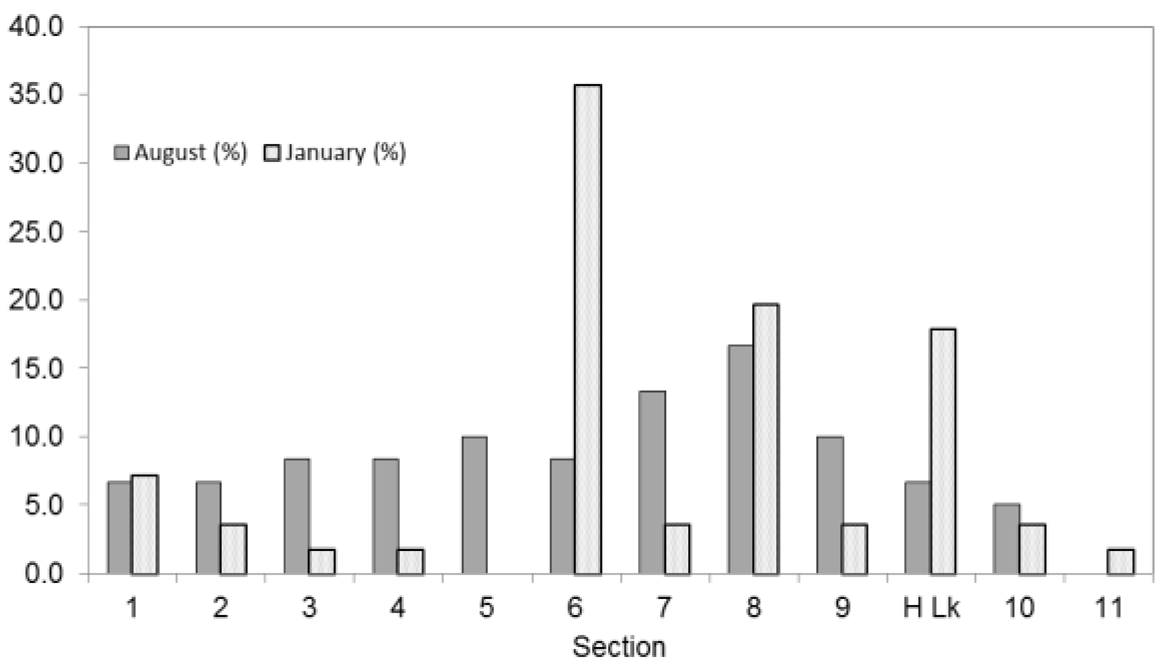


Figure 3.7. Change in distribution of radio tagged Westslope cutthroat trout (n=56) between summer rearing (August) and over-wintering (January) habitat.

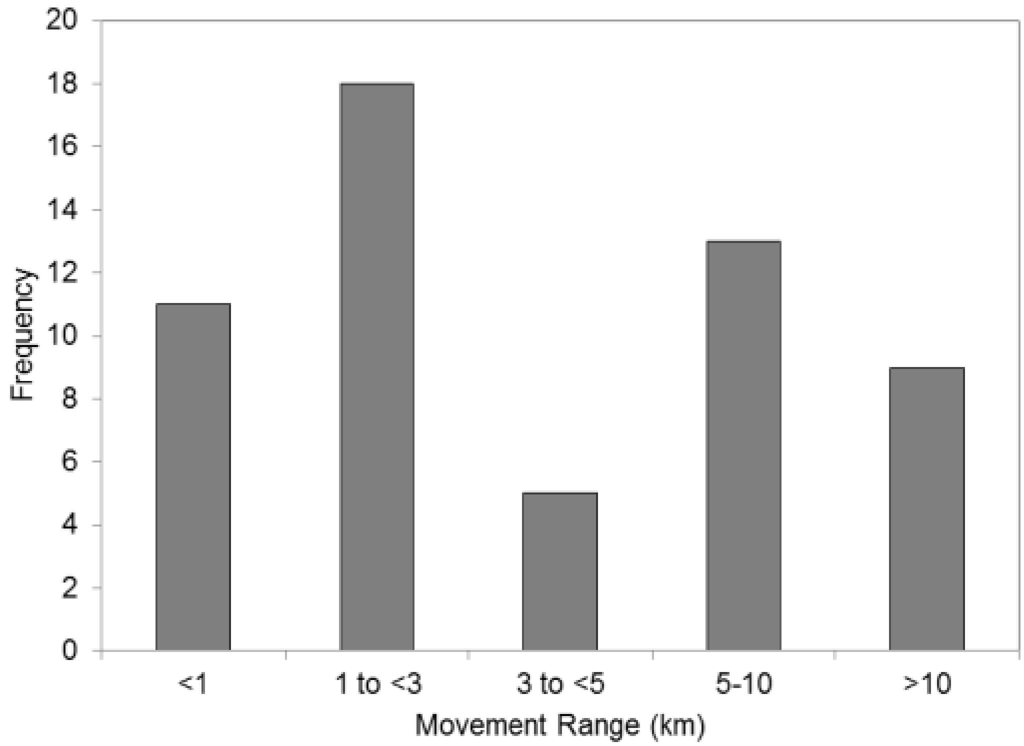


Figure 3.8. Frequency and extent of movements from late summer rearing habitat to over-wintering habitat by radio tagged Westslope cutthroat trout within the upper Fording River.

3.4.5. Population Monitoring

A total of 211 Westslope cutthroat trout were “marked” with radio tags (plus green Floy tag, n=60) and white Floy tags (n=151) between August 22 and September 7, 2012 for subsequent mark – re-capture snorkel surveys September 16 to 22, 2012. The mean daily water temperatures ranged between 5.5 ^{o}C and 7.91 ^{o}C during the snorkel survey. River discharge (as measured at the confluence, WSC Stn 08NK018) ranged between 4.0 m^3/s and 4.2 m^3/s.

Visibility during the snorkel survey was rated as excellent. There was no precipitation immediately preceding or during the snorkel period. The horizontal underwater Secchi visibility ranged between 7.0 m and 10.0 m; only one pool (Henretta Lake) within the enumeration sections was noted as being deeper than the visibility recorded for that section.

3.4.5.1. Snorkel Survey

A much higher proportion of the radio tagged (plus green Floy tag) fish were represented by larger mature fish than the white Floy tagged fish which had a higher proportion represented by the smaller juvenile and sub-adults (Figure 3.9). These life-stages have different habitat requirements and behaviours that result in differences in observer efficiencies and hence recapture rates. The large mature fish occupy the prime habitat within pools and have a higher observer efficiency. Smaller fish utilize higher water velocities over coarse substrate, interstices and woody debris for cover (Cope 2007, McPhail 2007, Ptolemy *et al.* 2006, Ford *et al.* 1995). These size related (*i.e.* life-stage) differences in habitat use patterns were observed within the upper Fording River by the snorkel crew in 2012 and were reflected in differences in observer efficiencies between the green and white Floy tagged fish (see following section 3.4.5.2 Population Estimates).

Differences in the proportion of smaller sized fish between the radio tagged (plus green Floy tag) and white Floy tagged fish resulted from the discrepancy between; a) the size category for snorkel surveys (> 200 mm) used to be consistent with reference populations so that results could be compared among these watersheds, b) the minimum size that can be radio tagged due to the 2% rule (*i.e.,* 200 g or 234 mm, Winters 1983), and c) low densities necessitate the application of Floy tags to all available captures that meet the minimum size requirements to meet the study design targets. As a result, there were more fish less than 200 g with white Floy tags than strict adherence to a random design would have applied. Ideal methods are to randomly select captures within each strata or river segment for radio tags so there is no bias. The 2012 results identify the need to try to do a better job in this regard in Years 2 and 3.

During the snorkel survey a total of 996 Westslope cutthroat trout greater than 200 mm were observed within Sections S1 through S10 and lower Henretta Creek including Henretta Lake (Table 3.8). In total 82.8% (47.62 km) of the entire main stem length was snorkeled. The uppermost 11 km of main stem river above 67.00 rkm (S11) was 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 above Josephine Falls was not snorkeled due to safety concerns.

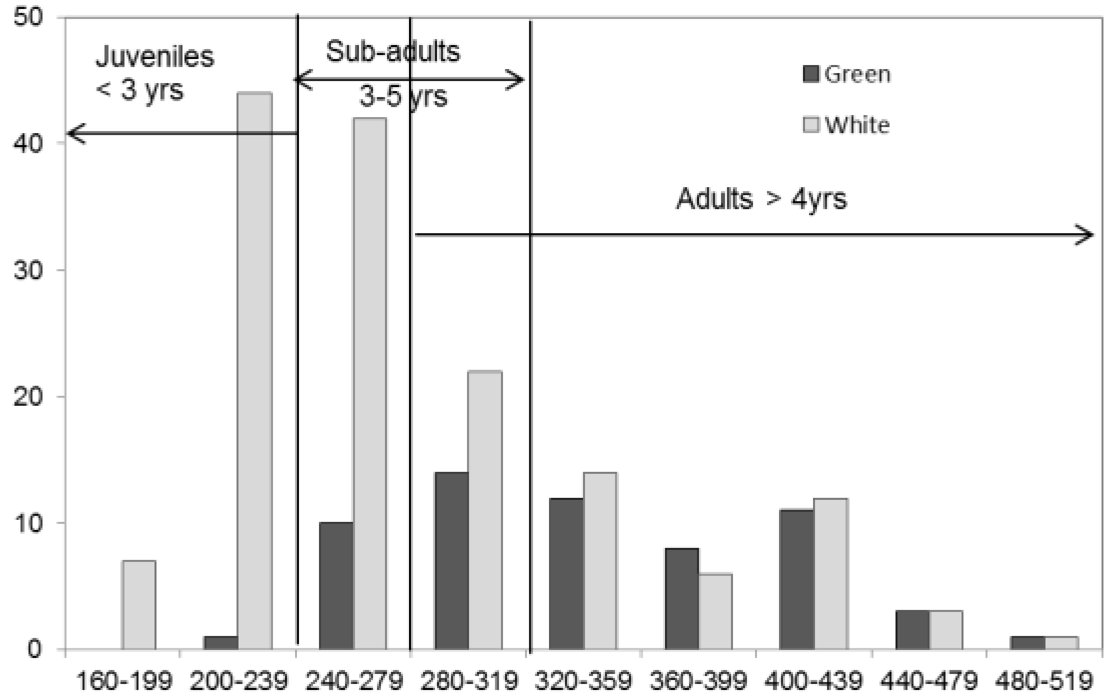


Figure 3.9. Length frequency of white Floy tagged fish (n=151) and radio tagged fish (plus green Floy tag, n=60) illustrating differences in representation of juvenile and sub-adult life-history stages.

Table 3.8. Snorkel count data for main stem river Sections S1 through S11 and lower Henretta Creek, upper Fording River September 16-22, 2012.

Upper Fording River Snorkel Survey Sept 2012

Section	River Km	Reach Length (km)	Section	Date	Water Temp. (°C)	Horizontal[1] Secchi Visibility (m)	Snorkel Length (km)	WCT (no Marks) 0-200	200-300	300-400	400+	WCT Recaptur White Floy	Green Floy	WCT White Floy at large[2]	WCT Green Floy at large[3]
1	20.51 - 25.00	4.49	Josephine Falls to GHO	22-Sep-12	7.0	8.0	4.12	0	17	24	5	1	3	11	4
2	25.00 - 29.00	4.00	GHO to above Fording Br.	21-Sep-12	8.0	9.0	4.00	81	208	111	10	5	1	10	1
3	29.00 - 33.16	4.16	Above Fording Br. to Ewin	21-Sep-12		9.0	4.16	1	16	18	3	1	3	14	3
4	33.16 - 37.56	4.40	Ewin Cr. To S-bends	20-Sep-12		9.0	4.40	20	25	30	13	6	4	22	4
5	37.56 - 41.96	4.40	S-bends to Chauncey Cr.	20-Sep-12		9.0	4.40	5	15	15	4	0	1	15	1
6	41.96 - 48.96	7.00	Chauncey Cr. to F2 sideroad	19-Sep-12	7.0	9.0	7.00	33	70	64	26	10	10	12	13
7	48.96 - 54.00	5.04	F2 sideroad to Diversion Rch	17-Sep-12	12.0	7.0	5.04	4	14	4	0	5	3	20	4
8	54.00 - 59.75	5.75	Diversion reach to Turnbull	18-Sep-12	7.0	9.0	5.75	1	13	13	7	9	7	17	10
9	59.75 - 63.40	3.65	Turnbull to above Henretta	17-Sep-12	7.0	9.0	3.65	39	70	10	2	3	2	9	3
10	63.40 - 67.75	4.35	Above Henretta	16-Sep-12		10.0	3.60	14	18	6	0	1	0	5	1
11[a]	67.75 - 76.75	9.00	Headwaters	17-Sep-12			0.00								
H2[b]	1.00 - 1.50	0.50	Henretta Lake	16-Sep-12		10.0[c]	0.50	7	41	100	24	13	1	14	9
H1[b]	0.00 - 1.00	1.00	Henretta Lake to Fording conf.	16-Sep-12		10.0	1.00	0	0	0	0	0	0	2	1
	56.24	57.74					47.62	205	507	395	94	54	35	151	54

[a] - Reach 11 not surveyed due to small stream size and lack of depth. Also no tags applied in reach.
[b] - Henretta Lake (H2) and Henretta Creek (H1) from Lake downstream to Fording confluence snorkeled.
[c] - Henretta Lake depth at West end greater than 10.0 m visibility and enumeration incomplete.
[1] - Visibility is recorded as undisturbed. If disturb bottom clarity can temporarily be as low as 1.5 m.
[2] - White Floy locations based on original capture and assumes no movement.
[3] - Green Floy locations confirmed independently during snorkel survey by tracking team. See tracking database for documentation of movement between capture and snorkel.

3.4.5.2. Population Estimates

1. Pooled Peterson Estimate

Three Pooled-Petersen estimates can be formed:

a. Based on radio-tagged fish (green Floy tags).

A total of 60 fish were radio-tagged (green tags), but one fish died and was removed between the time of marking and the snorkel surveys. This fish should be removed from the number of releases, and so the number of radio-tags released (and still alive at the time of the second survey) is $n_1 = 59$.

A total of $m_2 = 35$ radio-tagged (green tag) fish were seen during the snorkel surveys. The total number of unmarked fish >200 mm is found as 507 (200-300 mm) + 395 (300-400) + 94(400+) + 54 (white tags seen) = $u_2 = 1050$.

The estimated unmarked fish abundance is 1750 (SE 185) fish to which is added the 59 radio-tagged fish that are still alive for an estimate of the total population size >200mm of $\hat{N}_{PooledPetersen,Green,Chapman} = 1809$ (SE 185) fish.

The observed recapture rate of radio-tagged fish within the sections based on the known number of radio-tagged fish as detected by the shore crew, ranges from 100% (1 of 1 seen etc.) to 0% (0/1 seen on Henretta Creek) to 1/4 (seen on Henretta Lake). Note that while 9 fish were known to have moved into Henretta Lake (based on the fixed stations), only 4/9 radio tagged fish were detected by field crews during the snorkel surveys. It was assumed that the remainder of the radio-tagged fish were located in deep water (> 10.0 m) where there was no visibility and attenuation of the signal occurred.

b) Based on white Floy tagged fish (no radio tags).

A second estimate can be obtained by considering recapture of fish tagged with white tags (not radio tagged). There were $n_1 = 151$ fish initially tagged with white tags of which $m_2 = 54$ were recovered (relighted). The total number of unmarked fish > 200 mm is then found as 507 (200-300 mm) + 395 (300-400) + 94(400+) + 35 (green seen) = $u_2 = 1031$.

The estimate of total untagged (not white tagged) is 2851 (SE 310) unmarked fish to which is added the 151 initially white-tagged fish to give $\hat{N}_{PooledPetersen,White,Chapman} = 3002$ (SE 310). This estimate is almost 50% larger than from the radio-tagged fish which is not too surprising because the detection rate for the white tags is much lower (54/155 for white; 35/59 for radio tags (green tags)).

c) Pooling radio (green Floy tags) and Floy tagged (white) fish.

In this case, a total of $n_1 = 151 + 59 = 210$ fish were released with tags and $m_2 = 35 + 54 = 89$ fish were recovered (re-sighted). A total of $u_2 = 996$ untagged fish were seen during the surveys. The estimate of the total untagged (not white or radio) is 2336 (SE 194), and the estimate of the total population size is $\hat{N}_{PooledPetersen,White+Green,Chapman} = 2336$+ 210 = 2546 (SE 194) fish. This estimate is about half-way between the two estimates (not unexpectedly) obtained from radio-tag and white-tag groups only.

2. Stratified Pearson

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

a) Based on radio-tagged fish (green Floy tags).

The estimate of the total population is $\hat{N}_{Stratified,Green,Chapman} = 2026$ (SE 317). The estimate is slightly larger than the simple pooled-Petersen, but poorer in precision because, even after pooling the strata, the counts of radio-tagged fish are small.

A formal statistical test was conducted to test if the catchability was equal across all sections; this test indicated strong evidence (p=0.009) of a difference in catchability among sections driven basically by the low recovery rate in the Henretta sections where few radio tags were seen.

b) Based on white Floy tagged fish (no radio tags).

Estimate of total population size is $\hat{N}_{Stratified,White,Chapman} = 3073$ (SE 420) fish. Not surprisingly the estimate is larger than the stratified estimate from radio-tags because of lower recovery (re-sighting) rate of white-tagged fish.

A formal test for equality of the recovery (re-sighting) rates of the white tags across the 6 pooled strata provided good evidence that they are different (p=0.002). This is due to the high recovery rates of white tags in Section S6 and Henretta Lake.

c) Pooling radio (green Floy tags) and Floy tagged (white) fish.

If both types of tagged fish are combined, the estimate of total population size is $\hat{N}_{Stratified,White+Green,Chapman} = 2620$ (SE 280), which again is about half-way between the two stratified estimates.

Again, there was evidence (p=0.01) that the recovery (re-sighting) rates are not equal among the strata.

3. Hierarchical Model

Three estimates can once again be constructed using the same pooled strata.

a) Based on radio tagged fish (green Floy tags).

The hierarchical model when fit to the radio tag data only gave $\hat{N}_{Hierarchical,Green} = 1921$ (SD 254)[1]. The average recovery (re-sighting) rate was estimated to be 0.58 with a standard deviation over the strata of 0.05. The model had individual strata recovery rates ranging from 0.54 to 0.64. Notice that in one (pooled) strata, all of the radio tagged fish were sighted by the snorkelers, but the model estimated the recovery rate to be 0.64 (rather than 1.00) because the small sample size in that stratum implied that seeing all of the fish could have happened by chance even with a much lower actual recovery rate.

b) Based on white Floy tagged fish (no radio tags).

The hierarchical model when fit to the white-tags only, gave $\hat{N}_{Hierarchical,White} = 3022$ (SE 366). The average recovery (re-sighting) rate was 0.37 with a standard deviation of 0.06 and individual strata recovery rates ranging from 0.31 to 0.47. Not unexpectedly, the estimated individual recovery rates based on the white tags are all smaller than the comparable estimates based on the radio tags.

[1] 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.

c) Pooling radio (green Floy tags) and Floy tagged (white) fish.

The hierarchical model when fit to the white and green tags together, gave $\hat{N}_{Hierarchical,Green+White} = 2605$ (SE 240). The average recovery (re-sighting) rate was 0.43 with a standard deviation of 0.06 and individual strata recovery rates ranging from 0.38 to 0.48. Not unexpectedly, the estimates from the pooled data are between those from using each color separately.

4. Movement Model Combining Radio and White Floy tags

The estimate of total population size is $\hat{N}_{BayesianMovement} = 1896$ (SD 205).[2] Not surprisingly the estimate is similar to the estimates previously seen based on the radio tags or the pooled tags.

Average catchability was estimated at 55% (closer to the radio tagged numbers) as the white tags available have to be imputed and so aren't given as much weight, with individual estimates of catchability ranging between 52 and 59%. Most of the strata have a relatively small number of tags available and so the raw estimates of catchability are pulled towards the mean.

The estimated number of white tags available (after movement and leakage) is 14, 25, 24, 29, 15, 17 (total 124) which is close to 151 (90%) = 136 white tags assumed to be present assuming 10% leakage. This can be compared to the number of white tags originally applied in the reduced strata of 21, 36, 27, 37, 14, 16 and some movement upstream is imputed.

The estimated chance of staying in the (reduced) section is 59%;
The estimated chance of moving 1 (reduced) section (left- towards lower sections) = 6%;
The estimated chance of moving 1 (reduced) section (right - towards higher sections) 18%;
The estimated chance of moving 2 (reduced) sections (left) 5%;
The estimated chance of moving 2 (reduced) sections (right) 12%.

There is evidence that movement is not symmetric with more movement towards higher (upstream) sections (*i.e.* as seen by the radio tags where fish were detected to the right (in higher sections) rather than to the left of the original section).

[2] Recall that the equivalent to the SE from MLE is the SD of the posterior in a Bayesian analysis.

5. Synthesis of Population Estimate Results

A summary of the estimates is shown in Table 3.9. The estimates of population size based on the radio-tagged (green tags) fish are about 1/3 lower than those based on the white tagged fish. These lower estimates based on radio-tagged fish also include the movement model estimate as it is based on the radio-tagged fish movement data that provides information on the recapture rates by section and movement rates among sections. These differences are related to the size differential between radio and white tagged fish, with a greater proportion of larger fish 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 green and white tags are intermediate between the estimates based on each color separately.

Table 3.9. Summary of the estimates of population size (200+ mm) from the various approaches.

Method	Radio (Green) tags only	Floy (White) Tags Only	All Tags Combined	Key Assumption
Pooled Petersen	1809 (185)	3002 (310)	2546 (194)	Equal catchability in all sections
Stratified Petersen	2026 (317)	3073 (420)	2620 (280)	Fish stay in sections where tagged.
Hierarchical stratified Petersen	1921 (SD 254)	3022 (SD 366)	2604 (SD 240)	Fish stay in sections where tagged.
Movement model	1986 (SD 205)			White tagged and green (radio) tagged fish have the same movement pattern

There is good evidence that recovery rates (sightability) varied among the sections. It is known that the Pooled-Petersen is biased downwards in cases of heterogeneity in catchability, so it is not surprising that the estimates from the pooled-Petersen are smaller than corresponding estimates based on the stratified models. Similarly, it is known that heterogeneity leads to under-reporting of the SE in the pooled-Petersen, so it is again not surprising that the reported SE for the pooled-Petersen is consistently lower than those from the stratified models.

The estimates from the movement model are very similar to those from the radio-tag only scenarios run under the other three estimation methods. This indicates, that while movement did take place, and while the recovery rate (resighting rate) varied among strata, there was, in fact, very little difference in the recovery rates among strata.

Given the differential catchabilities of the white- and green-tagged fish, a reasonable choice for an estimate would be based on the combined tags, or around 2,600 fish greater than 200 mm. Estimates of the number of fish for other sizes will scale proportionately (*i.e.* to get estimates for > 300 mm multiply the population estimates in Table 3.9 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 may be problematic.

Using the estimated 2,600 Westslope cutthroat trout greater than 200 mm over the snorkel distance of 47.62 km yields a density estimate of 55 fish/km > 200 mm fork length and 27 fish/km > 300 mm fork length. The metric most often used for population estimation and comparison within the literature is fish density per lineal river kilometer. As previously outlined, the upper Bull River population has been 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 is a substantial difference in river size (volume). The mean annual discharge of the upper Fording River is approximately 25% that of the upper Bull River (Table 3.1). Michel Creek is another tributary to the Elk River of similar size (mean annual discharge) to the upper Fording River that can be 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 Westslope cutthroat trout (27.0 fish/km > 300 mm) was comparable to the overall mean density (28.9 fish/km > 300 mm) of estimates that have been collected for a number of high priority Westslope cutthroat trout streams in the upper Kootenay. These include the Elk main stem, Wigwam, Michel, St. Mary, White (Middle, East and North Forks) and Bull Rivers (Table 3.10). 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.*). By species standards within their worldwide distribution, the upper Fording River represents a large intact system (57.5 km main stem river) for a species that thrives in low productivity, high elevation, above barrier watersheds.

Table 3.10. Summary of recent density estimates (snorkel) for Westslope cutthroat trout greater than 300 mm in Classified Waters from the upper Kootenay River watershed.

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	**2012**	**27**	
Wigwam River	2008	12-24	Hagen and Baxter 2009
Upper St. Mary River	2011	19.0	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 is 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 are linked to the implementation of more conservative regulations (*e.g.* East Kootenay Angler management Plan ‘EKAMP’) in the spring of 2005 (Heidt 2007).

3.5. Habitat Characterization

The survival and recovery of Westslope cutthroat trout depends on the availability of habitat for key components of the life cycle; over-wintering, spawning, juvenile rearing and summer feeding. 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 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).

Summer Rearing Habitat

This subspecies thrives 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). Pool habitat dominated (91.7%) summer rearing habitat for sub-adult and adult Westslope cutthroat trout captures (Table 3.11). This result was not due to selective angling effort as the capture team moved upstream through the entire length of the river fishing all habitat types in an effort to randomly distribute tags among river sections and habitats. Typical pool habitat had a maximum depth of 3 m or greater, substrate was predominantly cobble-gravel (76.7% sites, Table 3.12) and the cover features of depth, large-woody-debris (LWD), cutbank, and boulder accounted for 90% of the capture locations dominant cover elements (Table 3.13). 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. These generalized summer rearing habitat features are illustrated in Figure 3.10. The distribution of summer rearing habitat was previously illustrated (Figure 3.4 *Initial Tag Distribution*).

Table 3.11. Meso-habitat classification for summer rearing habitat capture locations (n=60), upper Fording River, August 22 to Sept 7, 2012.

Meso-habitat	N	%
Lake	4	6.7
Pool	55	91.7
Run	1	1.6
Riffle	0	0
Off-channel	0	0
Total	60	100

Table 3.12. Dominant substrate for summer rearing habitat capture locations (n=60), upper Fording River, August 22 to Sept 7, 2012.

Substrate	N	%
Bedrock	6	10.0
Boulder	2	3.4
Cobble	26	43.3
Gravel	20	33.3
Fines	6	10.0
Total	60	100

Table 3.13. Dominant cover for summer rearing habitat capture locations (n=60), upper Fording River, August 22 to Sept 7, 2012.

Cover	N	%
Boulder	7	11.6
Cutbank	10	16.7
Depth	21	35.0
LWD	17	28.3
Nil	1	1.7
Overhanging Veg.	1	1.7
Turbulence	3	5.0
Total	60	100

Figure 3.10. Photographs illustrating typical summer rearing riffle-pool habitat features for mature Westslope cutthroat trout, upper Fording River. a) broader view of riffle-pool sequence and b) close-up view of fish position and pool features.

Over-wintering Habitat

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). Over-wintering adult Westslope cutthroat trout resident to East Kootenay streams similar to the upper Fording River (*i.e.* Bull, Elk, St. Mary and Wigwam Rivers) typically undertake seasonal migrations to preferred habitat with deep, slow moving water (Cope and Prince 2012, Prince and Morris 2003, Morris and Prince 2004, Baxter and Hagen 2003). These telemetry studies have illustrated alternate life-history strategies (fluvial, fluvial-adfluvial, and allucustrine) presumably depending on the presence of migration barriers, lacustrine habitat availability and environmental conditions.

All of the habitat units with over-wintering aggregations have been geo-referenced and photographed. Monthly tracking sessions relocate fish and these surveys facilitate the development of the seasonal Westslope cutthroat trout distribution through mapping and GIS functions. The distribution of this over-wintering habitat was previously illustrated for the November 2012 to January 2013 period (Figure 3.6 Overwinter Locations). Temperature is monitored continuously at seven separate locations (4 main stem, 3 tributary) throughout the study area; including one thermistor replicate located within the habitat of the largest aggregation of over-wintering Westslope cutthroat trout (upstream of Chauncey Creek confluence). This data will be presented in the year 2 Interim Report (Q2, 2014).

There were three notable over-wintering aggregations in 2012 that represented 67.9 % of the total population of radio tags (41 of 56 radio tags at large, Figure 3.6.). These were; 1) Section S6 (assumed groundwater influence) from 42.5 rkm upstream to 48.5 rkm, 2) the multi-plate culvert pool at 57.48 rkm, and 3) Henretta Lake. The majority of radio tagged fish monitored within Section S6 were in one large aggregation within a 200 m section at 43.66 rkm. The habitat associated with these aggregations was typical of those described in the literature; 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 1995b, Brown and Stanislawski 1996, Boag and McCart 1993). These over-wintering habitat features are illustrated in Figure 3.11. Ground-truthing of over-wintering habitat was still on-going at the time of this report.

a) Henretta Lake (62.8 rkm + 1.0 H)

b) Multi-plate Culvert (S8, 57.5 rkm)

c) Section S6 (43.66 rkm)

Figure 3.11. Photographs illustrating the three habitat units representing over-wintering habitat for 67.9% of radio tagged Westslope cutthroat trout, upper Fording River; a) Henretta Lake, b) Multi-plate culvert, and c) Section S6 42.5 – 48.5 rkm).

The high sinuosity Section S6 site was located downstream of FRO in the Fording Oxbow area and was bordered by wet open meadows, was ice free, and spot measurements indicated groundwater influx (Table 3.2). This area was previously identified as an important historical over-wintering area with groundwater influence (Fording Coal Limited 1985). However, there have also been changes from the historical availability and distribution of over-winter habitat. Prior to 1980, large aggregations of migratory (*i.e.* fluvial migratory) Westslope cutthroat trout were also identified within the similarly described ground-water influenced “Clode Flats” (currently referred to as Clode Pond) and Kilmarnock Creek (Fording Coal Limited 1985, Lister and Kerr Wood Leidal 1980).

Figure 3.12 illustrates the current Clode Ponds area that past reports refer to as either Clode Flats or Clode Ponds and these terms collectively refer to Clode Pond, East Pond, Main Pond, Clode Creek, West Exfiltration Creek and Grass Creek. Fish Pond Creek is not part of the Clode Ponds area (lies immediately upstream of the Clode Ponds area) but has not always been clearly differentiated in some earlier reports. The Clode Ponds were initially constructed as a treatment facility for water that was impacted by the mining of Clode Pit, which commenced in 1971. Westslope cutthroat trout utilized the ponds since installation and the area has been the subject of a number of fish compensation and mitigation works (Wood and Berdusco 1999, Berdusco and Wood 1993, Lister and Kerr Wood Liedal 1980). Fish moved freely between the Fording River and Clode Ponds area until 2004, at which time gates were installed in the culverts draining the ponds. A significant relocation effort at that time involved the capture and movement of approximately 5,956 fish from the ponds into the Fording River (Interior Reforestation 2006).

Kilmarnock Creek is no longer connected to the Fording River resulting in the isolation and loss of this over-wintering habitat from the main stem Fording River population. This permitted habitat loss occurred in the late 1980’s as part of the Eagle Mountain Project.

Amos and Wright (2000) reported large numbers (800 – 1,000 observed) of late summer Westslope cutthroat trout in the multi-plate culvert pool on September 22, 1999.

During the 1990’s, Henretta Creek was diverted through two large diameter steel culverts nearly 1 km long as part of the permitted Henretta Dragline Project. Henretta Lake was constructed to provide a large over-wintering habitat as part of the Henretta Creek Channel Reclamation Plan (1999) (Berdusco and Wood 1992, Interior Reforestation 2007). Over-

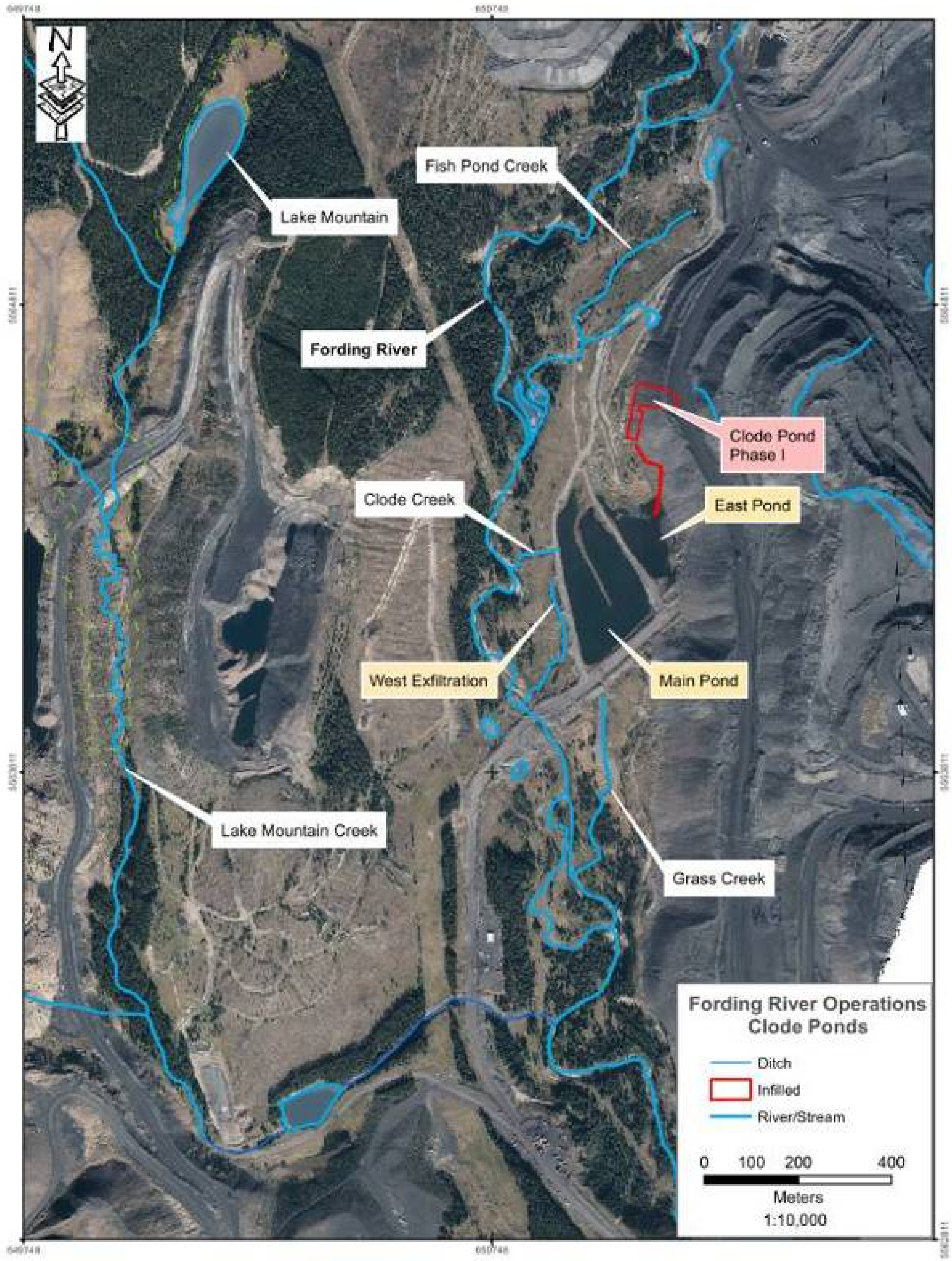


Figure 3.12. Aerial photograph illustrating the Clode Ponds area, Fording River Operations.

wintering use of Henretta Lake has been documented since shortly after initial construction (Interior Reforestation 2007, Wright *et al.* 2001).

Seasonal distribution and meso-habitat features will continue to be documented over the three replicate fish tagging periods and the remaining 30 months of radio telemetry monitoring.

3.6. Habitat Mapping

Aerial imagery was captured in September 2012 for the length of the main stem upper Fording River, the lower fish bearing reaches of tributaries and the associated riparian areas. A total area of 134.29 km^2 was captured on digital colour images with an image pixel size of 10 cm ground sampling distance (PHB Technologies, Broisbriand, Quebec, *memo proposal, 2012*).

The aerial photographs have been compiled into ortho-photographs for a watershed display with 10 cm resolution. Using this imagery, the meso-habitat will be classified and mapped using a standard suite of overview level habitat measurements derived from two primary sources; 1) Applied River Morphology (Rosgen 1996) and 2) Fish Habitat Assessment Procedures (Johnston and Slaney 1996).

The goal is to create a map containing all available fish habitat within the upper Fording River and the lower reaches of tributaries. The main stem river will be completed in 2013 (Year 2) and tributaries in 2014 (Year 3). Subsequently, this data could be used to contrast habitat availability with seasonal fish distribution (habitat utilization) and water quality gradients (*e.g.* aqueous selenium concentrations). Comparison of current habitat availability, seasonal fish distribution, and life-history patterns with reviews of historical habitat losses or impacts (via the Teck commissioned Pre-development Study that is currently underway) and historical air photographs (1950`s) should allow for documentation of historical impacts and identification of potential habitat limitations. Such an approach would facilitate the design and implementation of fish habitat mitigation and enhancement works to increase the productive capacity and hence the upper Fording River population of Westslope cutthroat trout.

Following receipt of the ortho-photographs, the development of the final meso-habitat data capture form will be completed in consultation with the Steering Committee. Measurements will be restricted to those that can be collected from aerial photographs. Ground truthing by field crews may be used to validate estimates (as necessary). It is anticipated measurements will include but not be limited to: stream type, habitat type, meso-habitat dimensions (bankfull channel width, wetted width, length), gradient, water depth (coarse scale; shallow or deep with deep being greater than maximum water visibility during image capture), dominant substrate, water velocity (slow, turbulence), available cover, large woody debris abundance, riparian vegetation and disturbance indicators. A draft of the form will also be provided to the HSI and AEMP teams, and potentially other related technical teams for review and comment to ensure coordination of habitat data collection among projects. A trial reach will be completed and reviewed with the Steering Committee before proceeding with the mapping of the remaining watershed.

3.7. Recruitment and Juvenile Population Monitoring

Data collection will begin August to October 2013. The study design for the 2013 recruitment and juvenile population monitoring is in the final stages of planning. As part of this planning a preliminary review of existing mark-recapture information and Fry (0^+) and juvenile (1^+, 2^+) density estimates was initiated.

Previously, juvenile recruitment and population monitoring has been completed on and adjacent to FRO property (current Sections 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 that proposed for this study (*i.e.* backpack electrofishing removal, each location includes at least one pool and riffle unit) and thus form a baseline for determination of possible trends in recruitment (Table 3.14). Table 3.14 will be updated following further review of the available upper Fording River monitoring reports prior to Interim Report 2 (Q2 2014). While this data will be examined 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 will however, form one of several lines of evidence that will be explored to determine if the upper Fording River population is limited by recruitment.

Table 3.14. 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, 1979-1999.

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

[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.

As part of the juvenile population monitoring, captured juveniles will be individually tagged, measured for length and weight and scale samples collected for length-at-age and growth rate determination. Although scale aging is not recommended for Westslope cutthroat trout due to limitations in scale growth potential, this is not a concern for fish that can reasonably be expected to be three years old or younger. Generally, scale aging is recommended for fish that are four years old or less. A review of existing length-at-age ranges for age classes less than four years old supports the use of scales for aging fish less than 250 mm FL. (Table 3.15). These data agree closely with the lower cut-off for sub-adults documented in the current study (smallest 234 mm).

Table 3.15. Summary of reported juvenile length-at-age (mm fork length) ranges for the upper Fording River and upper Wigwam River.

Age Class	Upper Fording[1] (mm FL)	Upper Fording[2] (mm FL)	Upper Fording[3] (mm FL)	Upper Wigwam[4] (mm FL)
0^+	20 - 39	30 – 39	-	21 – 32
1^+	40 – 139	50 – 129	61 – 85	54 – 98
2^+	100 – 179	110 – 189	71 – 175	105 – 167
3^+	140 - 259	180 - 250	121 - 223	-

[1] Amos and Wright 2000
[2] Oliver 1999
[3] Lister and Kerr Wood Leidal 1980.
[4] Baxter and Hagen 2003

4. Summary

It is generally recognized that 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, Muhlfeld *et al.* 2009):

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. Climate change could represent a significant challenge in the future for this cold-water dependent species.

The upper Fording River population represents the ideal research population in terms of evaluating resource development activities and Westslope cutthroat trout population dynamics, as three of the four general anthropogenic threats are not currently present within the upper Fording River.

1. Josephine Falls has isolated and protected the upper Fording River and non-native species and hybridization are not present;
2. The upper Fording River is currently closed to angling protecting the population from any additional mortality due to harvesting or catch and release angling. Angler harvest (17.5%) was the highest cause of mortality to radio tagged fish in the Elk River Westslope cutthroat trout telemetry study (Prince and Morris 2003); and
3. Cold water temperatures within the upper Fording River fall within species optima.

Surface coal mining and forest harvesting are the primary resource development concerns within the upper Fording River. These activities have resulted in a number of historic impacts that include;

1. Elevated concentrations of a number of metal and non-metal water quality variables notably selenium;

2. Fine sediment production (noting that Teck has comprehensive sediment control and re-vegetation plans in place to ensure compliance with water quality guidelines);

3. Habitat fragmentation and loss of groundwater influenced over-wintering habitat (Fording Coal Limited 1985, Norecol 1983, Lister Kerr Wood Leidal 1980). 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).

4. Fording River Road culvert crossings on Chauncey, Ewin and Dry creeks create barriers (at least during some flows) that cut off access to these watersheds that represent a significant portion of available tributary habitat within the upper Fording River;

5. Loss of riparian habitat and spawning habitat (Fording Coal Limited 1985, Norecol 1983, Lister Kerr Wood Leidal 1980);

6. Angling and over-exploitation may have contributed to population decreases as this population is easily accessible via Fording River Road which parallels the river and has been closed to angling due to uncertainties in population status; and

7. The historical use of bank armouring without current habitat mitigation techniques, thereby removing undercut banks, sweepers and log jams that provide Westslope cutthroat trout habitat.

On the other hand, the Year 1 interim results have illustrated a number of features that indicate it should be possible, if not probable, that with suitable management strategies (*e.g.* habitat protection, angling restrictions), the upper Fording River population of Westslope cutthroat trout can be maintained at a population level that represents a healthy, self-sustaining population capable of withstanding environmental change and accommodating stochastic population processes such as unpredictable events (*e.g.* several dry summers, or an exceptionally cold winter). A self-sustaining population is one that is expected to be present in perpetuity. Initial abundance estimates (2,600 fish > 200 mm fork length) for the main stem upper Fording River Sections S1 through S10 and lower Henretta Creek including Henretta Lake are encouraging in relation to the reported population viability range of between 470 and 4,600 mature fish required for population viability. Resulting densities were well within the range expected for a headwater population within the upper Kootenay River watershed.

This optimistic outlook for future population sustainability is based on the fact that this is an above barrier (genetically pure), headwater system (cold water species optima) with significant available habitat (57.5 km main stem river plus tributaries). In streams with high cutthroat trout abundance it has been estimated that about 9 km of stream is required to maintain a population (Hilderbrand and Kershner 2000a). In streams with low abundance, the length of stream needed was estimated to be about 28 km. In Alberta (not including the national parks), most remaining streams containing pure Westslope cutthroat trout average about 8 km in length and contain an average of 100 adults (Cleator *et al.* 2009).

While there has been loss of habitat related to mine operations and other development there have also been additions to habitat through reclamation, mitigation and compensation activities. These habitats continue to function and were noted for their numbers of adult fish in the current study. These constructed habitats located within Fording River Operations include;

1. Henretta Lake summer rearing and over-wintering habitat constructed as part of the Henretta Dragline reclamation plan (Wood and Berdusco 1999);
2. Fish Pond Creek has provided spawning and rearing habitat (Amos and Wright 2000, Oliver 1999);
3. The river diversion drop structures have consistently provided some of the highest density summer rearing habitat (Lister and Kerr Wood Leidal 1980); and
4. The multi-plate culvert pool represents high density summer and over-wintering habitat (Amos and Wright 2000).

Finally, initial observations by study team members have identified many degraded or simplified habitats, particularly on FRO property, that would most likely provide increased productive capacity through the application of current stream rehabilitation and habitat complexing techniques; especially as they relate to bank armouring using bio-engineering techniques designed to include-maintain habitat features within East Kootenay watersheds (*e.g.* Cope, 2008, 2005, 2003, 2000). It is anticipated these observations will be validated through the habitat mapping to be completed in 2013 and 2014.

The current state of knowledge, relating to the specific study questions identified by the project Steering Committee is:

1. *What is a viable Westslope cutthroat trout population?*

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 and stock productivity. Depending on the assumptions of the model, and the level of confidence desired, analyses for Westslope cutthroat trout have been reported between 470 and more than 4,600 adults (Cleator *et al.* 2009). Depending on the population characteristics (*i.e.* abundance, mortality, emigration), it has been estimated that between 9 and 28 km of stream is required to maintain an isolated population. The higher end of these ranges would likely better represent the upper Fording River population objective for a healthy, self-sustaining population capable of withstanding environmental change and accommodating stochastic population processes in perpetuity.

2. *Are the fish healthy?*

Mature (sub-adults and adults) upper Fording River Westslope cutthroat trout appear to be robust based on Fulton's condition indices. Only the Elk River had a higher condition factor among the upper Kootenay River populations examined. This assessment was corroborated by; a) the low incidence of deformities that were more indicative of injuries (<2%), 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 cutthroat trout and their very thick body wall and white muscle tissue.

This result was not unexpected given; 1) the primary adverse effect of Selenium concentrations that exceed concentration thresholds has been identified as larval mortality resulting from maternal transfer of Selenium to eggs (Elphick *et al.* 2009), 2) only mature fish were used for the condition indices, and 3) elevated levels of nitrates that can result in increased productivity have been associated with surface mining activities in the Elk Valley (Minnow Environmental Inc and PLA 2012).

3. *Is the Westslope cutthroat trout population sustainable?*

The 2012 (Year 1) population estimate of 2,600 Westslope cutthroat trout greater than 200 mm fork length over the snorkel distance of 47.62 km yields a density estimate of 55 fish/km > 200 mm and 27 fish/km > 300 mm. This preliminary population estimate is limited to fish within the main stem upper Fording River Sections S1 through S10 and lower Henretta

Creek and Henretta Lake. In Year 2 additional effort has been allocated to sample the headwater Section S11 of the upper Fording River and tributaries in an effort to tag and enumerate these habitats to provide a more complete population estimate for the upper Fording River.

Depending on the assumptions used in the model, and the level of confidence selected, literature on Population Viability Analyses (PVA) and Recovery Potential Assessments for Westslope cutthroat trout has shown that a viable population can range between 470 and 4,600 adults. Another approach to estimating population viability has been to estimate the amount of stream required to maintain a population. Depending on the population characteristics (*i.e.* abundance, mortality, emigration), it has been estimated that between 9 and 28 km of stream is required to maintain an isolated population.

Given the current population estimate (2,600 adults), and available habitat (57.5 km main stem river) it appears that it is possible, if not probable, for the upper Fording River population, with suitable management strategies (*e.g.* habitat protection, angling restrictions), to achieve population objectives of a healthy, self-sustaining population capable of withstanding environmental change and accommodating stochastic population processes in perpetuity. Based on prior use of the area, there are societal aspirations for recreational use (catch-and-release angling) and harvest activities within the upper Fording River watershed. To incorporate these aspirations into the future while maintaining long-term persistence of the population, the upper Fording Westslope cutthroat trout population would likely need to be managed toward the higher end of the range suggested (*i.e.* greater than 470 adults, and likely much closer to the 4,600 adults, Cleator *et al.* 2009, DFO 2009). It will be important over the remaining two years of planned population estimates to demonstrate the validity of the 2012 estimates through replication and to begin to understand the overall population trend (increasing, stable, decreasing).

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

There was no genetic differentiation among samples taken from the lower reaches of tributaries approximately 22.5 km apart within the upper Fording River (Carscadden and Rogers 2011). This indicates there is enough “mixing” among fish with connectivity to the main stem upper Fording River to be managed as one interconnected population. Initial telemetry data for the late summer and over-wintering periods supports the genetics illustrating movements of up to 28.3 km and substantial amount of mixing within the population.

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

At this time the evaluation of habitats in the study area is in the preliminary stages of investigation. Sampling has been limited to sub-adults and adults within the main stem upper Fording River Sections S1 through S10 and lower Henretta Creek and Henretta Lake. Study Years 2 through 4 have allocated additional effort to sample and evaluate smaller size classes (juveniles and possible alternative life history forms such as smaller size-at-maturity and less migratory population segments) within the main stem, main stem headwaters and tributaries.

6. *What are the movement patterns and why?*

At this time the evaluation of movement patterns is in the preliminary stages of investigation. The mean distance between summer rearing habitat (August 22 – September 22) and over-wintering habitat (November 13 – January 15) was 4.76 km (range 0.00 – 28.30, n=56 radio tagged fish). Movements of this scale were anticipated based on similar telemetry studies for headwater fluvial (migratory) populations. Dynamic ice conditions, the presence or absence of surface water, possible ground-water influence and water depths appear to be influencing over-winter habitat selection by sub-adult and adult fish.

7. *What is the distribution of Westslope cutthroat trout seasonally, considering life-history stage and upstream distribution limits?*

The preliminary results for Westslope cutthroat trout radio tagged within main stem upper Fording River Sections S1 through S10 and lower Henretta Creek and Henretta Lake are consistent with a migratory fluvial life-history strategy and seasonal distribution for these fish changed significantly since the start of the study. Currently the project is monitoring fish located between rkm 22.0 (lowermost Section S1 above Josephine Falls) and rkm 72.0 (headwaters Section S11). Results are in the preliminary stage of investigation (*e.g.* 6 months of a planned 36 months) and in Year 2 additional effort has been allocated to sample the headwater Section S11 of the upper Fording River and tributaries.

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Appendix A

Capture and Tagging Data

Table A1. Capture and tagging database for Westslope Cutthroat Trout, upper Fording River, August 22 – September 7 2012.

Rec. No.	Capture: Date	Capture: Time (hr:min)	Capture: UTM Northing	Capture: UTM Easting	Interim Locn. rkm	GPS Locn. rkm	River Section	Trans. Code	Floy Tag: 1st Floy Color	Floy Tag: 1st Floy No.	Floy Tag: 2nd Floy Color	Floy Tag: 2nd Floy No.	Wt (g)	Fork Length (mm)	Sex	Maturity Stage	Running Time: Anaesthesia (min:sec)	Running Time: Surgery (min:sec)	Running Time: Recovery (min:sec)	Running Time: Release (min:sec)
1	22-Aug	18:30					S1	n/a	W	1	W	3	100	207	U	Juvenile				
2	22-Aug	18:40					S1	n/a	W	4	W	5	155	220	U	Juvenile				
3	22-Aug	20:29					S1	n/a	W	50			170	242	U	Sub-adult				
4	22-Aug	20:30					S1	70	G	325			350	298	F	Maturing	2:45	8:50	12:57	20:00
5	23-Aug	13:20					S2	66	G	324			410	300	F	Maturing	4:10	9:40	14:30	31:05
6	23-Aug	13:25					S2	69	G	323			210	234	M	Sub-adult	4:37	10:08	13:43	32:16
7	23-Aug	13:15					S1	67	G	321			720	385	F	Mature	3:18	9:40	14:25	29:10
8	23-Aug	13:50					S1	68	G	320			750	394	F	Mature	4:01	10:50	17:20	66:12
9	23-Aug	14:20					S1	64	G	319			610	347	M	Mature	4:12	11:13	16:10	37:16
10	23-Aug	16:00					S1	n/a	W	25			360	294	U	Mature				
11	23-Aug	16:00					S1	n/a	W	24			500	316	U	Mature				
12	23-Aug	16:00					S1	n/a	W	23			750	370	U	Mature				
13	23-Aug	16:00					S1	n/a	W	22			910	410	U	Mature				
14	23-Aug	16:00					S1	n/a	W	21			500	321	U	Mature				
15	23-Aug	16:00					S1	n/a	W	20	W	19	960	400	U	Mature				
16	23-Aug	16:00					S1	n/a	W	18	W	17	420	315	U	Mature				
17	23-Aug	16:00					S1	n/a	W	16			460	317	U	Mature				
18	24-Aug	20:00					S2	n/a	W	15			110	202	U	Juvenile				
19	24-Aug	20:00					S2	n/a	W	14	W	13	180	229	U	Sub-adult				
20	24-Aug	20:00					S2	n/a	W	12			200	247	U	Sub-adult				
22	24-Aug	20:00					S2	n/a	W	11			145	211	U	Juvenile				
23	24-Aug	20:00					S2	n/a	W	10	W	9	340	290	U	Mature				
25	24-Aug	20:00					S2	n/a	W	8			130	212	U	Juvenile				
26	24-Aug	20:00					S2	n/a	W	7			350	285	U	Mature				
27	24-Aug	20:00					S2	n/a	W	276	W	277	240	260	U	Sub-adult				
28	24-Aug	14:10					S2	14	G	318			650	362	F	Mature	4:10	10:15	17:00	42:00
29	24-Aug	14:10					S2	65	G	317			540	337	U	Mature	4:10	12:00	18:00	29:00

Table A1. Continued.

Rec. No.	Fish Photo No.	Abnorml Photo No	Habitat Photo No.	Habitat Type	Dom. Substrate	Sub-Dom. Substrate	Dominant Cover	Sub-dom. Cover	Air Temp (oC)	Water Temp (oC)	Comments
1			1-14	Pool	Bedrock		Turbulence	Depth		11.5	
2			1-14	Pool	Bedrock		Turbulence	Depth		11.5	
3			1-14	Pool	Bedrock		Turbulence	Depth		11.5	
4	15		1-14	Pool	Bedrock		Turbulence	Depth	14.5	11.0	Maturing eggs - likely first spawn next spring.
5	17		18-19	Pool	Cobble		Depth		22.5	9.0	CPR Bridge - Maturing, under developed eggs - likely first
6	20		18-19	Pool	Cobble		Depth		22.5	9.0	Maturing, under developed eggs - likely first spawn next s
7	21		22-24, 26-27	Pool	Gravel	Cobble	Depth		22.5	10.5	Trib Confluence
8	25		22-24, 26-27	Pool	Gravel	Cobble	Depth		22.5	10.5	
9	28		22-24, 26-27	Pool	Gravel	Cobble	Depth		22.5	10.5	
10			22-24, 26-27	Pool	Gravel	Cobble	Overhanging Veg	Depth	22.5	10.5	Trib Confluence. Lots fish - all big.
11			22-24, 26-27								
12			22-24, 26-27								
13			22-24, 26-27								
14			22-24, 26-27								
15			22-24, 26-27								
16			22-24, 26-27								
17			22-24, 26-27								
18				pool	Gravel		LWD		21.0	8.5	parr marks fading
19											
20											
22											
23											
25											
26											
27											
28	44-46		29-35	Pool	Gravel		LWD	k, Over-hangi	15.0	8.5	Beautiful logjam hole with lots of depth and cover. U's riffle
29	47		29-35	Pool	Gravel		LWD	k, Over-hangi	15.0	8.5	Developing Female ? Not possitive

Table A1. Capture and tagging database for Westslope Cutthroat Trout, upper Fording River, August 22 – September 7 2012.

	Capture				Interim	GPS			Floy Tag					Fork			Running Time			
Rec.		Time	UTM		Locn.	Locn.	River	Trans.	1st Floy		2nd Floy		Wt	Length		Maturity	Anaesthesia	Surgery	Recovery	Release
No.	Date	(hr:min)	Northing	Easting	rkm	rkm	Section	Code	Color	No.	Color	No.	(g)	(mm)	Sex	Stage	(min:sec)	(min:sec)	(min:sec)	(min:sec)
30	24-Aug	19:00					S2	n/a	W	278			240	265	U	Sub-adult				
31	24-Aug	18:00					S2	n/a	W	279			175	221	U	Juvenile				
32	24-Aug	17:30					S6	62	G	316			300	285	M	Maturing	4:00	11:10	16:39	30:40
33	24-Aug	17:30					S6	63	G	315			350	291	F	Maturing	4:44	13:12	16:58	52:10
34	24-Aug	17:30					S6	13	G	326			300	275	M	Sub-adult	4:22	13:13	19:01	55:00
35	24-Aug	17:30					S6	n/a	W	280			180	242	U	Sub-adult				
36	24-Aug	17:30					S6	n/a	W	281			300	279	U	Sub-adult				
37	24-Aug	17:30					S6	n/a	W	282	W	283	210	251	U	Sub-adult				
38	25-Aug	11:55					S7	12	G	327			340	295	F	Mature	4:40	12:20	19:40	45:00
39	25-Aug	12:30					S7	61	G	328			500	336	M	Mature	4:10	11:09	15:55	180:00
40	25-Aug	13:00					S7	11	G	329			340	290	F	Maturing	4:10	10:33	15:09	60:00
41	25-Aug	13:40					S7	20	G	330			320	294	F	Mature	4:15	10:10	16:00	60:00
42	25-Aug	14:00					S7	n/a	W	284	W	285	250	252	U	Sub-adult				
43	25-Aug	14:00					S7	n/a	W	286			265	265	U	Sub-adult				
44	25-Aug	15:30					S5	17	G	331			330	294	F	Maturing	4:45	10:54	19:27	49:27
45	25-Aug	15:30					S5	16	G	332			320	280	F	Mature	4:15	10:08	18:00	45:00
46	25-Aug	15:30					S4	n/a	W	287			140	220	U	Juvenile				
47	25-Aug	17:30					S5	15	G	333			350	287	M	Maturing	4:00	10:16	15:56	35:00
48	25-Aug	17:30					S4	n/a	W	288			140	226	U	Sub-adult				
49	26-Aug	11:30					S7	19	G	334			920	403	F	Mature	6:10	13:36	21:20	77:09
50	26-Aug	12:10					S7	21	G	335			500	331	F	Mature	4:00	10:01	18:00	69:00
51	26-Aug	12:50					S6	25	G	336			930	410	M	Mature	4:00	10:45	17:14	57:00
52	26-Aug	13:10					S6	30	G	337			640	346	M	Mature	4:10	12:16	18:48	45:00
53	26-Aug	12:12					S5	n/a	W	289	W	290	530	330	U	Mature				
54	26-Aug	12:20					S5	n/a	W	291	W	292	460	324	U	Mature				
55	26-Aug	12:25					S5	n/a	W	293			420	322	U	Mature				
56	26-Aug	14:32					S5	n/a	W	294			520	328	U	Mature				
57	26-Aug	14:40					S5	n/a	W	295			205	258	U	Sub-adult				

Table A1. Continued.

Rec. No.	Fish Photo No.	Abnorml Photo No	Habitat Photo No.	Habitat Type	Dom. Substrate	Sub-Dom. Substrate	Dominant Cover	Sub-dom. Cover	Air Temp (oC)	Water Temp (oC)	Comments
30			29-35								
31			29-35								
32	51		48-50	Pool	Gravel		Cutbank	Depth	12.0	11.0	
33	54		48-50	Pool	Gravel		Cutbank	Depth	12.0	11.0	
34	57		48-50	Pool	Gravel		Cutbank	Depth	12.0	11.0	
35			48-50								
36			48-50								
37			48-50								
38	62		58-61	Pool	Gravel	Cobble	LWD		12.0	9.0	Lots of Fry in cobble-gravel margin habitat in tail-out.
39	65		58-61	Pool	Gravel	Cobble	LWD		12.0	9.0	
40	75		66-70,235	Pool	Gravel	Cobble	LWD		20.0	12.0	Beautiful spawning habitat in this meadow.
41	76		66-70,235	Pool	Gravel	Cobble	LWD		20.0	12.0	
42			66-70,235								
43			66-70,235								
44	83		78-82	Pool	Cobble	Gravel	Cutbank	LWD	18.0	10.0	Calcite in riffle, high fine (black) especially in slow water
45	84		78-82	Pool	Cobble	Gravel	Cutbank	LWD	18.0	10.0	Calcite in riffle, high fine (black) especially in slow water
46			78-82	Pool	Cobble	Gravel	Cutbank	LWD	18.0	10.0	Calcite in riffle, high fines (black) especially in slow water
47	88		85-87	Pool	Cobble	Gravel	Cutbank	Depth, LWD	17.0	10.0	
48			85-87	Pool	Cobble	Gravel	Cutbank	Depth, LWD	17.0	10.0	
49	89-90		106-108	Pool	Fines		Depth		24.0	7.0	Chauncey Creek Confluence U/S slow pool
50	92		106-108	Pool	Fines		Nil		24.0	7.0	Chauncey Creek Confluence U/S slow pool
51	99-102	101	91-96	Pool	Cobble	Gravel	Cutbank	ıanging veg.,	24.0	7.0	Chauncey Creek Confluence U/S slow pool. Badly worn l
52	105		91-96	Pool	Cobble	Gravel	Cutbank	ıanging veg.,	24.0	7.0	
53			106-108	Pool	Fines		Depth		24.0	10.0	
54			106-108	Pool	Fines		Depth		24.0	10.0	
55			106-108	Pool	Fines		Depth		24.0	10.0	
56			91-96	Pool	Cobble	Gravel	Cutbank	anging Veg.,	24.0	10.0	
57			91-96	Pool	Cobble	Gravel	Cutbank	anging Veg.,	24.0	10.0	

Table A1. Capture and tagging database for Westslope Cutthroat Trout, upper Fording River, August 22 – September 7 2012.

Rec. No.	Date	Capture Time (hr:min)	Capture UTM Northing	Capture UTM Easting	Interim Locn. rkm	GPS Locn. rkm	River Section	Trans. Code	Floy Tag 1st Floy Color	Floy Tag 1st Floy No.	Floy Tag 2nd Floy Color	Floy Tag 2nd Floy No.	Wt (g)	Fork Length (mm)	Sex	Maturity Stage	Running Time Anaesthesia (min:sec)	Running Time Surgery (min:sec)	Running Time Recovery (min:sec)	Running Time Release (min:sec)
58	26-Aug	15:01					S5	n/a	W	296			900	396	U	Mature				
59	26-Aug	15:45					S4	18	G	338			600	339	M	Mature	4:00	10:50	16:00	41:00
60	26-Aug	14:10					S4	29	G	339			860	394	M	Mature	4:20	9:16	15:00	35:00
61	26-Aug	14:20					S3	n/a	W	297	W	298	620	352	U	Mature				
62	26-Aug	17:00					S4	24	G	340			380	292	F	Mature	4:00	11:41	17:00	30:00
63	26-Aug	17:10					S3	n/a	W	299			180	241	U	Sub-adult				
64	26-Aug	17:11					S3	n/a	W	300			295	265	U	Sub-adult				
65	26-Aug	18:15					S4	n/a	W	251			100	209	U	Juvenile				
66	27-Aug	12:24					S7	23	G	341			1000	440	F	Mature	4:11	19:10	23:50	63:20
67	27-Aug	12:30					S7	22	G	342			1120	435	U	Mature	4:05	14:41	19:54	37:02
68	27-Aug	14:45					S8	28	G	343			920	422	M	Mature	4:00	8:26	13:53	57:00
69	27-Aug	15:30					S8	35	G	344			1400	443	F	Mature	3:30	8:57	13:20	46:23
70	27-Aug	16:00					S8	26	G	345			330	279	U	Sub-adult	3:00	8:26	14:00	45:00
71	27-Aug	16:16					S8	n/a	W	252	W	253	275	264	U	Sub-adult				
72	27-Aug	17:15					S8	n/a	W	254			840	386	U	Mature				
73	27-Aug	17:20					S8	n/a	W	255	W	256	550	329	U	Mature				
74	27-Aug	17:20					S8	n/a	W	257			1120	433	U	Mature				
75	27-Aug	17:25					S8	27	G	346			1000	420	F	Mature	3:30	8:15	13:53	37:55
76	27-Aug	17:50					S8	n/a	W	259			220	246	U	Sub-adult				
77	27-Aug	17:55					S8	n/a	W	260			260	261	U	Sub-adult				
78	27-Aug	17:58					S8	n/a	W	261	W	262	260	252	U	Sub-adult				
79	27-Aug	18:05					S8	n/a	W	263			280	265	U	Sub-adult				
80	27-Aug	18:10					S8	n/a	W	264	W	265	1080	440	U	Mature				
81	28-Aug	13:10					S8	34	G	347			640	353	F	Mature	3:00	8:32	14:25	47:31
82	28-Aug	13:30					S8	40	G	348			1080	423	F	Mature	3:00	8:33	14:45	60:00
83	28-Aug	13:00					S8	n/a	W	266			1080	422	U	Mature				
84	28-Aug	13:10					S8	n/a	W	267			700	362	U	Mature				

Table A1. Continued.

Rec. No.	Fish Photo No.	Abnorml Photo No	Habitat Photo No.	Habitat Type	Dom. Substrate	Sub-Dom. Substrate	Dominant Cover	Sub-dom. Cover	Air Temp (oC)	Water Temp (oC)	Comments
58	109, 111		91-96	Pool	Cobble	Gravel	Cutbank	anging Veg.,	24.0	10.0	
59	114		112-113	Pool	Gravel	Cobble	LWD	Depth	26.0	9.5	Below Ewin 800 m
60	115		112-113	Pool	Gravel	Cobble	LWD	Depth	26.0	9.5	Below Ewin 800 m
61	115		112-113	Pool	Gravel	Cobble	LWD	Depth	26.0	9.5	Below Ewin
62	116		116	Pool	Cobble	Gravel	LWD		20.0	10.0	
63			116								
64			116								
65				Pool	Gravel	Cobble	LWD	Cutbank	14.0	10.0	Juvenile - parr marks, Above Ewin
66	119	121	117-118	Pool	Bedrock	Gravel	Depth		20.0	13.0	Damage to right eye
67	122		117-118	Pool	Bedrock	Gravel	Depth		20.0	13.0	Codes 22, 23 - big fish, moving on table, not going down
68	124		125-127	Pool	Cobble	Gravel	Boulder	Turbulence	26.0	14.5	Caught in plunge pool below drop structure, Increase clov
69	129		125-127	Pool	Cobble	Gravel	Boulder	Turbulence	26.0	14.5	Caught in plunge pool below drop structure, Increase clov
70	132		133	Pool	Cobble		Boulder	Turbulence	26.0	14.5	Caught behind boulder in drop structure
71			133								
72			136-138								
73			136-138	ulder P	Cobble		Boulder		22.0	14.0	
74			136-138	ulder P	Cobble		Boulder		22.0	14.0	
75	145		141-143	Pool	Boulder	Cobble	Boulder	Turbulence	24.0	14.5	
76			141-143	ulder P	Cobble		Boulder		22.0	14.0	
77	147		146-147	ulder P	Cobble		Boulder		22.0	14.0	
78	146		146-147	ulder P	Cobble		Boulder		22.0	14.0	
79			146-147	ulder P	Cobble		Boulder		22.0	14.0	
80			146-147	Riffle	Cobble	Bedrock	Boulder		22.0	14.5	
81	151		152-154	Pool	Gravel		Depth		24.0	14.5	Multiplate culvert pool
82	155		152-154	Pool	Gravel		Depth		24.0	14.5	Multiplate culvert pool
83			152-154	Pool	Gravel		Depth		22.0	11.5	Multiplate culvert pool
84			152-154	Pool	Gravel		Depth		22.0	11.5	

Table A1. Capture and tagging database for Westslope Cutthroat Trout, upper Fording River, August 22 – September 7 2012.

Rec. No.	Date	Capture Time (hr:min)	Capture UTM Northing	Capture UTM Easting	Interim Locn. rkm	GPS Locn. rkm	River Section	Trans. Code	Floy Tag 1st Floy Color	Floy Tag 1st Floy No.	Floy Tag 2nd Floy Color	Floy Tag 2nd Floy No.	Wt (g)	Fork Length (mm)	Sex	Maturity Stage	Running Time Anaesthesia (min:sec)	Running Time Surgery (min:sec)	Running Time Recovery (min:sec)	Running Time Release (min:sec)
85	28-Aug	13:20					S8	n/a	W	268			190	246	U	Sub-adult				
86	28-Aug	13:30					S8	n/a	W	269	W	270	480	314	U	Mature				
87	28-Aug	13:40					S8	n/a	W	271			550	338	U	Mature				
88	28-Aug	16:30					S8	32	G	349			1050	422	M	Mature	3:00	8:22	19:58	45:22
89	28-Aug	17:30					S8	31	G	350			1120	440	F	Mature	3:10	10:11	16:32	43:18
90	29-Aug	13:30					S8	33	G	301			350	290	M	Mature	3:30	9:14	17:15	45:07
91	29-Aug	15:00					S8	39	G	302			240	266	F	Sub-adult	3:10	8:12	14:06	60:00
92	28-Aug	13:40					S8	n/a	W	272			700	350	U	Mature				
93	29-Aug	16:30					S9	n/a	W	273			100	190	U	Juvenile				
94	29-Aug	16:30					S9	n/a	W	274			125	202	U	Juvenile				
95	29-Aug	16:30					S9	n/a	W	275			135	212	U	Juvenile				
96	29-Aug	16:30					S9	n/a	W	150	W	149	135	219	U	Juvenile				
97	29-Aug	17:50					S9	37	G	303			650	342	F	Mature	3:00	8:51	16:59	55:00
98	30-Aug	11:30					H2	36	G	304			1340	485	F	Mature	3:50	8:23	17:15	50:00
99	30-Aug	12:20					H2	41	G	305			800	389	F	Mature	3:15	7:39	15:04	60:00
100	30-Aug	12:45					H2	43	G	306			900	400	F	Mature	3:15	7:40	17:31	58:30
101	30-Aug	13:15					H2	42	G	307			1000	425	F	Mature	3:30	9:33	20:55	41:50
102	30-Aug						H2	n/a	W	148	W	147	1200	435	U	Mature				
103	30-Aug						H2	n/a	W	146			195	244	U	Sub-adult				
104	30-Aug						H2	n/a	W	145			285	270	U	Sub-adult				
105	30-Aug						H2	n/a	W	144	W	143	920	400	U	Mature				
106	30-Aug						H2	n/a	W	141			420	290	U	Mature				
107	30-Aug	12:00					H2	n/a	W	140			1120	412	U	Mature				
108	30-Aug	12:00					H2	n/a	W	139	W	138	480	305	U	Mature				
109	30-Aug	12:00					H2	n/a	W	137			1100	400	U	Mature				
110	30-Aug	12:00					H2	n/a	W	136			980	425	U	Mature				
111	30-Aug	12:00					H2	n/a	W	135	W	134	1060	415	U	Mature				

Table A1. Continued.

Rec. No.	Fish Photo No.	Abnorml Photo No	Habitat Photo No.	Habitat Type	Dom. Substrate	Sub-Dom. Substrate	Dominant Cover	Sub-dom. Cover	Air Temp (oC)	Water Temp (oC)	Comments
85			152-154	Pool	Gravel		Depth		22.0	11.5	
86			152-154	Pool	Gravel		Depth		22.0	11.5	
87	156		152-154	Pool	Gravel		Depth		22.0	11.5	Damage to upper caudal
88	163		157-162	Pool	cobble		Cutbank	LWD	24.0	12.5	
89	164			Pool	Bedrock	Gravel	Turbulence	Depth	15.0	10.5	
90	181		179-180	Pool	Bedrock	Gravel	Depth	Turbulence	18.0	9.0	
91	185		182-184	Pool	Gravel	Cobble	LWD	k, Over-hangi	20.0	10.0	Mature - large well developed eggs, fish will spawn next s
92			152-154	Pool	Gravel		Depth		22.0	11.5	
93			165-167	Run	Boulder	Cobble	Boulder		22.0	11.5	In Turnbull Culvert
94			165-167	Run	Boulder	Cobble	Boulder		22.0	11.5	In Turnbull Culvert
95			165-167	Run	Boulder	Cobble	Boulder		22.0	11.5	In Turnbull Culvert
96			165-167	Run	Boulder	Cobble	Boulder		22.0	11.5	In Turnbull Culvert
97	189		186-188	Pool	Cobble	Gravel	LWD		11.0	9.0	
98	197		191-196	Lake	Fines		Depth		14.0	7.5	This fish has what looks like a healing muscle plug locate
99	198		191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake - fish are in 4 m water at inlet.
100	200		191-196	Lake	Fines		Depth		14.0	7.5	
101	201		191-196	Lake	Fines		Depth		14.0	7.5	
102			191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake
103			191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake
104	202		191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake
105	203		191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake
106	204		191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake
107	205		191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake
108			191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake
109			191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake
110			191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake
111			191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake

Table A1. Capture and tagging database for Westslope Cutthroat Trout, upper Fording River, August 22 – September 7 2012.

Rec. No.	Date	Capture Time (hr:min)	UTM Northing	UTM Easting	Interim Locn. rkm	GPS Locn. rkm	River Section	Trans. Code	Floy Tag 1st Floy Color	1st Floy No.	2nd Floy Color	2nd Floy No.	Wt (g)	Fork Length (mm)	Sex	Maturity Stage	Running Time Anaesthesia (min:sec)	Surgery (min:sec)	Recovery (min:sec)	Release (min:sec)
112	30-Aug	12:00					H2	n/a	W	133			1320	475	U	Mature				
113	30-Aug	12:00					H2	n/a	W	132	W	131	1550	485	U	Mature				
114	30-Aug	12:00					H2	n/a	W	130			480	314	U	Mature				
115	30-Aug	12:00					H2	n/a	W	129			520	327	U	Mature				
116	30-Aug	15:30					H1	n/a	W	128			130	215	U	Juvenile				
117	30-Aug	16:00					H1	n/a	W	127			172	223	U	Juvenile				
118	30-Aug	17:00					S10	44	G	308			255	271	F	Sub-adult	3:30	8:40	12:30	61:15
119	30-Aug	17:45					S9	45	G	309			305	278	M	Sub-adult	3:20	8:17	11:38	45:00
120	31-Aug	18:00					S10	49	G	310			240	256	U	Sub-adult	3:30	10:54	15:05	45:00
121	31-Aug	11:45					S10	46	G	311			200	244	U	Sub-adult	3:20	8:45	14:40	60:00
122	31-Aug	11:50					S10	n/a	W	47			130	205	U	Juvenile				
123	31-Aug	11:50					S10	n/a	W	49	W	48	150	217	U	Juvenile				
124	31-Aug	11:50					S10	n/a	W	46			125	200	U	Juvenile				
125	31-Aug	11:50					S10	n/a	W	45			115	204	U	Juvenile				
126	31-Aug	12:30					S10	n/a	W	44	W	43	145	231	U	Sub-adult				
127	31-Aug	14:00					S9	48	G	312			205	252	F	Sub-adult	4:00	9:03	15:10	60:30
128	31-Aug	14:10					S9	n/a	W	42	W	41	125	224	U	Juvenile				
129	31-Aug	16:30					S5	50	G	313			280	271	M	Sub-adult	3:15	8:00	11:35	61:29
130	31-Aug	16:35					S5	n/a	W	40			145	224	U	Juvenile				
131	31-Aug	16:38					S5	n/a	W	39			130	214	U	Juvenile				
132	31-Aug	16:44					S5	n/a	W	38		37	135	214	U	Juvenile				
133	31-Aug	18:15					S5	38	G	314			740	376	M	Mature	4:37	13:07	18:40	45:00
134	01-Sep	11:30					S6	47	G	315			820	392	F	Mature	3:15	7:58	17:53	45:00
135	01-Sep	11:35					S6	n/a	W	36			1020	415	F	Mature				
136	01-Sep	11:45					S6	n/a	W	35		34	1040	404	F	Mature				
137	01-Sep	17:15					S6	52	G	316			670	357	M	Mature	4:05	10:17	15:49	45:00
138	02-Sep	18:00					S6	n/a	W	33			250	266	U	Sub-adult				

Table A1. Continued.

Rec. No.	Fish Photo No.	Abnorml Photo No	Habitat Photo No.	Habitat Type	Dom. Substrate	Sub-Dom. Substrate	Dominant Cover	Sub-dom. Cover	Air Temp (oC)	Water Temp (oC)	Comments
112			191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake
113	206		191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake
114			191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake
115			191-196	Lake	Fines		Depth		14.0	7.5	Henretta lake
116				Riffle	Boulder		Boulder		18.0	8.5	parr marks
117				Cascade	Cobble		Depth	Turbulence	18.0	8.5	Below culvert. Parr marks
118	208		207	Pool	Cobble		Boulder		14.0	9.5	
119	209		210-211	Pool	Cobble		Overhanging Veg.		14.0	9.5	
120	212-213		218-219	Pool	Cobble	Bedrock	Turbulence		11.5	6.5	
121	216		218-219	Pool	Boulder	Bedrock	Boulder		16.0	10.0	
122			218-219	Pool	Boulder	Bedrock	Boulder		16.0	10.0	
123			218-219	Pool	Boulder	Bedrock	Boulder		16.0	10.0	
124			218-219	Pool	Boulder	Bedrock	Boulder		16.0	10.0	
125			218-219	Pool	Boulder	Bedrock	Boulder		16.0	10.0	
126			218-219	Pool	Boulder	Bedrock	Boulder		16.0	10.0	
127	220			Pool	Cobble		LWD		16.0	10.0	
128	221			Pool	Cobble		LWD		16.0	10.0	Shortened left opercule
129	222			Pool	Cobble		LWD	Cutbank	18.0	8.0	Fines present
130				Pool	Cobble		LWD	Cutbank	18.0	8.0	parr marks
131				Pool	Cobble		LWD	Cutbank	18.0	8.0	parr marks
132				Pool	Cobble		LWD	Cutbank	18.0	8.0	parr marks
133	224		225-226	Pool	Cobble	Gravel	LWD	Depth	18.0	8.0	
134	227		228	Pool	Fines		Depth		18.0	8.0	
135				Pool	Cobble		Depth	Turbulence	18.0	10.0	
136				Pool	Cobble		Depth	Turbulence	18.0	10.0	
137	229		230	Pool	Gravel	Cobble	LWD		18.0	8.0	
138			231	Pool	Gravel	Cobble	LWD		18.0	8.0	

Table A1. Capture and tagging database for Westslope Cutthroat Trout, upper Fording River, August 22 – September 7 2012.

Rec. No.	Capture Date	Capture Time (hr:min)	Capture UTM Northing	Capture UTM Easting	Interim Locn. rkm	GPS Locn. rkm	River Section	Trans. Code	Floy Tag 1st Floy Color	Floy Tag 1st Floy No.	Floy Tag 2nd Floy Color	Floy Tag 2nd Floy No.	Wt (g)	Fork Length (mm)	Sex	Maturity Stage	Running Time Anaesthesia (min:sec)	Running Time Surgery (min:sec)	Running Time Recovery (min:sec)	Running Time Release (min:sec)
139	02-Sep	18:00					S6	n/a	W	32		31	340	295	U	Mature				
140	02-Sep	18:00					S6	n/a	W	30			400	302	U	Mature				
141	02-Sep	18:00					S6	n/a	W	29			340	278	U	Sub-adult				
142	02-Sep	18:00					S6	n/a	W	28		27	350	292	U	Mature				
143	02-Sep	18:00					S6	n/a	W	51			670	345	F	Mature				
144	02-Sep	18:00					S6	n/a	W	52			750	384	M	Mature				
145	02-Sep	13:30					S7	55	G	317			480	320	U	Mature	3:00	9:03	12:08	46:15
146	02-Sep	13:35					S7	n/a	W	125		124	450	315	U	Mature				
147	02-Sep	16:30					S4	n/a	W	122			100	192	U	Juvenile				
148	02-Sep	16:32					S4	n/a	W	123			80	180	U	Juvenile				
149	02-Sep	16:25					S4	53	G	318			1060	431	F	Mature	4:37	10:47	16:10	45:10
150	02-Sep	16:25					S4	51	G	319			1060	438	F	Mature	4:04	9:52	16:16	45:05
151	03-Sep	16:10					S4	n/a	W	121		120	610	335	U	Mature				
152	03-Sep	16:12					S4	n/a	W	119		118	570	339	U	Mature				
153	03-Sep	16:16					S4	n/a	W	117			500	314	U	Mature				
154	03-Sep	16:23					S4	n/a	W	116			775	370	U	Mature				
155	03-Sep	17:00					S4	n/a	W	68			210	255	U	Sub-adult				
158	03-Sep	14:30					S7	n/a	W	53			290	284	U	Mature				
159	03-Sep	14:30					S7	n/a	W	54			175	238	U	Sub-adult				
160	03-Sep	14:30					S7	n/a	W	56	W	57	530	331	F	Mature				
161	03-Sep	14:30					S7	n/a	W	58			180	239	U	Sub-adult				
162	03-Sep	13:00					S7	n/a	W	59			135	228	U	Sub-adult				
163	03-Sep	13:00					S7	n/a	W	60			200	244	U	Sub-adult				
164	03-Sep	13:00					S7	n/a	W	61	W	62	250	264	U	Sub-adult				
165	03-Sep	13:00					S7	n/a	W	63			215	259	U	Sub-adult				
166	03-Sep	13:00					S7	n/a	W	64			165	234	U	Sub-adult				
167	03-Sep	13:00					S7	n/a	W	65	W	66	175	238	U	Sub-adult				

Table A1. Continued.

Rec. No.	Fish Photo No.	Abnorml Photo No	Habitat Photo No.	Habitat Type	Dom. Substrate	Sub-Dom. Substrate	Dominant Cover	Sub-dom. Cover	Air Temp (oC)	Water Temp (oC)	Comments
139			231	Pool	Gravel	Cobble	LWD		18.0	8.0	
140			231	Pool	Gravel	Cobble	LWD		18.0	8.0	
141			231	Pool	Gravel	Cobble	LWD		18.0	8.0	
142			231	Pool	Gravel	Cobble	LWD		18.0	8.0	
143			232	Pool	Gravel	Cobble	LWD		18.0	8.0	
144			232	Pool	Gravel	Cobble	LWD		18.0	8.0	
145	233		234	Pool	Cobble		Depth	Turbulence	18.0	10.0	
146			234	Pool	Cobble		Depth		18.0	10.0	
147			238	Pool	Cobble		Depth		18.0	8.0	
148			238	Pool	Cobble		Depth		18.0	8.0	
149	236		238	Pool	Cobble		Depth	LWD	18.0	8.0	Recap of G0333&W0020
150	237		238	Pool	Cobble		Depth	LWD	18.0	8.0	
151			238	Pool	Cobble		Depth		18.0	8.0	
152			238	Pool	Cobble		Depth		18.0	8.0	
153			238	Pool	Cobble		Depth		18.0	8.0	
154			238	Pool	Cobble		Depth		18.0	8.0	
155			239	Pool	Cobble		LWD		16.0	8.0	
158				Glide	Cobble		LWD		18.0	10.0	
159				Glide	Cobble		LWD		18.0	10.0	
160				Glide	Cobble		LWD		18.0	10.0	
161				Glide	Cobble		LWD		18.0	10.0	
162			66-70,235	Pool	Cobble		LWD		18.0	10.0	
163			66-70,235	Pool	Cobble		LWD		18.0	10.0	
164			66-70,235	Pool	Cobble		LWD		18.0	10.0	
165			66-70,235	Pool	Cobble		LWD		18.0	10.0	
166			66-70,235	Pool	Cobble		LWD		18.0	10.0	
167			66-70,235	Pool	Cobble		LWD		18.0	10.0	

Table A1. Capture and tagging database for Westslope Cutthroat Trout, upper Fording River, August 22 – September 7 2012.

	Capture				Interim	GPS			Floy Tag					Fork			Running Time			
Rec.		Time	UTM		Locn.	Locn.	River	Trans.	1st Floy		2nd Floy		Wt	Length		Maturity	Anaesthesia	Surgery	Recovery	Release
No.	Date	(hr:min)	Northing	Easting	rkm	rkm	Section	Code	Color	No.	Color	No.	(g)	(mm)	Sex	Stage	(min:sec)	(min:sec)	(min:sec)	(min:sec)
168	03-Sep	13:00					S7	n/a	W	67			135	220	U	Juvenile				
169	04-Sep	11:00					S9	60	G	320			520	327	M	Mature	4:06	10:16	19:10	60:00
170	04-Sep	13:00					S9	n/a	W	115			180	234	U	Sub-adult				
171	04-Sep	15:15					S9	n/a	W	114	W	113	240	248	U	Sub-adult				
172	04-Sep	16:00					S9	n/a	W	112			90	192	U	Juvenile				
173	04-Sep	16:00					S9	n/a	W	111			120	197	U	Juvenile				
174	04-Sep	18:00					S7	56	G	321			420	300	M	Mature	4:00	8:52	12:15	45:10
175	04-Sep	18:05					S7	n/a	W	110			220	234	U	Sub-adult				
176	04-Sep	18:09					S7	n/a	W	109	W	108	280	261	U	Sub-adult				
177	04-Sep	18:15					S7	n/a	W	106	W	105	420	299	U	Mature				
178	04-Sep	18:20					S7	n/a	W	104			105	206	U	Juvenile				
179	04-Sep	18:35					S7	n/a	W	103			180	240	U	Sub-adult				
180	04-Sep	18:42					S7	n/a	W	102	W	101	275	266	U	Sub-adult				
181	05-Sep	11:00					S8	58	G	322			650	337	M	Mature	4:30	12:46	17:58	45:00
182	05-Sep	11:18					S8	n/a	W	226			220	246	U	Sub-adult				
183	05-Sep	12:09					S8	59	G	323			750	372	F	Mature	4:00	9:54	14:30	45:00
184	05-Sep	13:30					S8	n/a	W	227			180	240	U	Sub-adult				
185	05-Sep	19:30					S3	n/a	W	228	W	229	210	247	U	Sub-adult				
186	05-Sep	18:25					S3	54	G	324			340	273	M	Sub-adult	4:15	10:09	18:11	45:00
187	05-Sep	19:05					S3	n/a	W	230			150	228	U	Sub-adult				
188	05-Sep	19:10					S3	n/a	W	231			145	222	U	Juvenile				
189	05-Sep	19:12					S3	n/a	W	232	W	233	185	245	U	Sub-adult				
190	05-Sep	19:25					S3	n/a	W	234			100	200	U	Juvenile				
191	05-Sep	19:23					S3	n/a	W	235			100	199	U	Juvenile				
192	05-Sep	19:45					S3	57	G	325			400	291	F	Mature	4:00	9:10	15:55	45:00
193	05-Sep	19:39					S3	n/a	W	236			100	202	U	Juvenile				
194	05-Sep	19:41					S3	n/a	W	237			150	230	U	Sub-adult				

Table A1. Continued.

Rec. No.	Fish Photo No.	Abnorml Photo No	Habitat Photo No.	Habitat Type	Dom. Substrate	Sub-Dom. Substrate	Dominant Cover	Sub-dom. Cover	Air Temp (oC)	Water Temp (oC)	Comments
168			66-70,235	Pool	Cobble		LWD		18.0	10.0	
169	241	240		Pool	Cobble		LWD		18.0	8.0	1st pool u/s culvert at Turnbull. Caudal fin deformity
170				Pool	Cobble	Gravel	Turbulence	LWD	17.0	8.0	
171				Pool	Cobble	Gravel	LWD		17.0	8.0	
172			186-188	Pool	Cobble		LWD		18.0	8.0	
173			186-188	Pool	Cobble		LWD		18.0	8.0	
174	242			Pool	Gravel	Cobble	Cutbank	Turbulence	14.0	13.0	
175				Pool	Gravel	Cobble	Cutbank	Turbulence	14.0	13.0	
176				Pool	Gravel	Cobble	Cutbank	Turbulence	14.0	13.0	
177				Pool	Gravel	Cobble	Cutbank	Turbulence	14.0	13.0	
178				Pool	Gravel	Cobble	Cutbank	Turbulence	14.0	13.0	
179				Pool	Gravel	Cobble	Cutbank	Turbulence	14.0	13.0	
180				Pool	Gravel	Cobble	Cutbank	Turbulence	14.0	13.0	
181	243		244-245	Pool	Cobble		LWD	Depth	13.5	10.0	
182			247	Pool	Cobble		LWD	Depth	13.5	10.0	
183	246		247	Pool	Cobble	Gravel	Boulder	Turbulence	13.5	10.0	Bridge providing cover
184			248-249	Cascade	Cobble	Gravel	Turbulence		13.5	10.0	
185				Run	Cobble		Turbulence	Depth	13.0	8.0	
186	250		251-252	Pool	Bedrock	Gravel	Depth		13.5	8.0	
187	254-255		253	Pool	Cobble	Fines	LWD	Depth	12.0	8.0	
188			253	Pool	Cobble	Fines	LWD	Depth	12.0	8.0	
189	256		253	Pool	Cobble	Fines	LWD	Depth	12.0	8.0	
190			253	Pool	Cobble	Fines	LWD	Depth	12.0	8.0	
191			253	Pool	Cobble	Fines	LWD	Depth	12.0	8.0	
192	258		257	Run	Gravel	Cobble	Depth	LWD	10.0	8.0	Fines present
193			257	Run	Gravel	Cobble	Depth	LWD	10.0	8.0	Fines present
194			257	Run	Gravel	Cobble	Depth	LWD	10.0	8.0	

Table A1. Capture and tagging database for Westslope Cutthroat Trout, upper Fording River, August 22 – September 7 2012.

Rec. No.	Date	Capture Time (hr:min)	UTM Northing	UTM Easting	Interim Locn. rkm	GPS Locn. rkm	River Section	Trans. Code	Floy Tag 1st Floy Color	1st Floy No.	2nd Floy Color	2nd Floy No.	Wt (g)	Fork Length (mm)	Sex	Maturity Stage	Running Time Anaesthesia (min:sec)	Surgery (min:sec)	Recovery (min:sec)	Release (min:sec)
195	05-Sep	19:44					S3	n/a	W	238			135	210	U	Juvenile				
196	05-Sep	19:49					S3	n/a	W	239	W	240	150	224	U	Juvenile				
197	05-Sep	19:53					S3	n/a	W	241	W	243	145	233	U	Sub-adult				
198	06-Sep	11:30					S5	n/a	W	244			280	263	U	Sub-adult				
199	06-Sep	11:30					S5	n/a	W	245	W	246	320	266	U	Sub-adult				
200	06-Sep	11:30					S5	n/a	W	247			220	241	U	Sub-adult				
201	06-Sep	12:50					S5	n/a	W	248			170	235	U	Sub-adult				
202	06-Sep	17:30					S5	n/a	W	249	W	250	370	287	U	Mature				
203	06-Sep	17:35					S5	n/a	W	98			400	290	U	Mature				
204	06-Sep	19:00					S4	n/a	W	97			230	260	U	Sub-adult				
205	06-Sep	19:00					S4	n/a	W	96			100	185	U	Juvenile				
206	06-Sep	19:00					S4	n/a	W	95	W	94	250	266	U	Sub-adult				
207	06-Sep	19:00					S4	n/a	W	93			210	252	U	Sub-adult				
208	06-Sep	19:00					S4	n/a	W	92			250	271	U	Sub-adult				
209	06-Sep	19:00					S4	n/a	W	91	W	90	270	277	U	Sub-adult				
210	06-Sep	19:00					S4	n/a	W	89			460	300	U	Mature				
211	06-Sep	19:00					S4	n/a	W	88			410	299	U	Mature				
212	06-Sep	19:00					S4	n/a	W	87	W	86	440	290	U	Mature				
213	06-Sep	19:00					S4	n/a	W	85			100	205	U	Juvenile				
214	06-Sep	19:00					S4	n/a	W	84			130	224	U	Juvenile				
215	06-Sep	19:00					S4	n/a	W	72	W	71	1050	440	U	Mature				
216	24-Aug	20:00					S2	n/a	n/a				105	187	U	Juvenile				
217	24-Aug	20:00					S2	n/a	n/a				110	202	U	Juvenile				
218	30-Aug	16:25					S10	n/a	n/a				105	180	U	Juvenile				
219	30-Aug	16:25					S10	n/a	n/a				100	180	U	Juvenile				
220	30-Aug	16:25					S10	n/a	n/a				90	181	U	Juvenile				
221	30-Aug	16:25					S10	n/a	n/a				90	182	U	Juvenile				

Table A1. Continued.

Rec. No.	Fish Photo No.	Abnorml Photo No	Habitat Photo No.	Habitat Type	Dom. Substrate	Sub-Dom. Substrate	Dominant Cover	Sub-dom. Cover	Air Temp (oC)	Water Temp (oC)	Comments
195			257	Run	Gravel	Cobble	Depth	LWD	10.0	8.0	
196			257	Run	Gravel	Cobble	Depth	LWD	10.0	8.0	
197			257	Run	Gravel	Cobble	Depth	LWD	10.0	8.0	
198				Pool	Cobble	Gravel	Depth	LWD	13.0	9.0	Fines present
199				Pool	Cobble	Gravel	Depth	LWD	13.0	9.0	
200				Pool	Cobble	Gravel	Depth	LWD	13.0	9.0	
201				Pool	Cobble	Gravel	Depth	LWD	13.0	9.0	
202				Pool	Cobble	Bedrock	Boulder	Turbulence	10.0	9.0	
203				Pool	Cobble	Bedrock	Boulder	Turbulence	10.0	9.0	
204			259	Pool	Cobble		LWD				
205			259	Pool	Cobble		LWD				
206			259	Pool	Cobble		LWD				
207			259	Pool	Cobble		LWD				
208			259	Pool	Cobble		LWD				
209			259	Pool	Cobble		LWD				
210			259	Pool	Cobble		LWD				
211			259	Pool	Cobble		LWD				
212			259	Pool	Cobble		LWD				
213			259	Pool	Cobble		LWD				
214			259	Pool	Cobble		LWD				
215			259	Pool	Cobble		LWD				
216											released
217		36									missing back half opercular plate; released unmarked
218				Pool	Cobble		LWD	Turbulence	11.5	6.5	too small to tag, Juveniles, parr marks
219				Pool	Cobble		LWD	Turbulence	11.5	6.5	too small to tag, Juveniles, parr marks
220	214			Pool	Cobble		LWD	Turbulence	11.5	6.5	too small to tag, Juveniles, parr marks
221				Pool	Cobble		LWD	Turbulence	11.5	6.5	too small to tag, Juveniles, parr marks

Table A1. Capture and tagging database for Westslope Cutthroat Trout, upper Fording River, August 22 – September 7 2012.

Rec. No.	Capture Date	Capture Time (hr:min)	Capture UTM Northing	Capture UTM Easting	Interim Locn. rkm	GPS Locn. rkm	River Section	Trans. Code	Floy Tag 1st Floy Color	Floy Tag 1st Floy No.	Floy Tag 2nd Floy Color	Floy Tag 2nd Floy No.	Wt (g)	Fork Length (mm)	Sex	Maturity Stage	Running Time Anaesthesia (min:sec)	Running Time Surgery (min:sec)	Running Time Recovery (min:sec)	Running Time Release (min:sec)
222	30-Aug	16:25					S10	n/a	n/a				95	182	U	Juvenile				
223	31-Aug	11:50					S10	n/a	n/a				80	175	U	Juvenile				
224	31-Aug	11:50					S10	n/a	n/a				95	187	U	Juvenile				
225	02-Sep	16:37					S4	n/a	n/a				55	160	U	Juvenile				
226	03-Sep	13:00					S7	n/a	n/a				55	168	U	Juvenile				
227	03-Sep	17:00					S4	n/a	n/a				220	258	U	Sub-adult				
228	03-Sep	17:00					S4	n/a	n/a				425	295	U	Mature				
229	04-Sep	16:00					S9	n/a	n/a				70	170	U	Juvenile				
21	05-Sep	19:14					S3	n/a	n/a				65	162	U	Juvenile				
24	05-Sep	19:00					S3	n/a	n/a				80	177	U	Juvenile				
156	05-Sep	19:20					S3	n/a	n/a				99	186	U	Juvenile				
157	06-Sep	19:00					S4	n/a	n/a				90	195	U	Juvenile				

Table A1. Continued.

Rec. No.	Fish Photo No.	Abnorml Photo No	Habitat Photo No.	Habitat Type	Dom. Substrate	Sub-Dom. Substrate	Dominant Cover	Sub-dom. Cover	Air Temp (oC)	Water Temp (oC)	Comments
222				Pool	Cobble		LWD	Turbulence	11.5	6.5	too small to tag, Juveniles, parr marks
223			218-219	Pool	Boulder	Bedrock	Boulder		16.0	10.0	
224	217		218-219	Pool	Boulder	Bedrock	Boulder		16.0	10.0	Left Eye deformed
225			238	Pool	Cobble		Depth		18.0	8.0	
226			66-70,235	Pool	Cobble		LWD		18.0	10.0	
227			239	Pool	Cobble		LWD		16.0	8.0	
228			239	Pool	Cobble		LWD		16.0	8.0	
229			186-188	Pool	Cobble		LWD		18.0	8.0	
21			253	Pool	Cobble	Fines	LWD	Depth	12.0	8.0	
24			253	Pool	Cobble	Fines	LWD	Depth	12.0	8.0	
156			253	Pool	Cobble	Fines	LWD	Depth	12.0	8.0	
157			259	Pool	Cobble		LWD				

Appendix B

Westslope cutthroat Trout Radio Tracking Summary

Table B1. Tracking summary for radio tagged Westslope Cutthroat Trout, upper Fording River, August 22, 2012 – January 15, 2013.

Radio Code	Len (mm)	Wt (g)	Sex	Capture (RKM)	Download 13-Sep	Dir (U/D)	Grnd 22-Sep	Download 4-Oct	Dir (U/D)	Grnd 16-Oct	Download 24-Oct	Dir (U/D)	**Flight** 13-Nov	Download 23-Nov	Dir (U/D)	Flight 10-Dec	Download 12-Dec	Dir (U/D)	Download 9-Jan	Dir (U/D)	Flight 15-Jan-13	Comments
11	290	310	F	49.37			59.90			60.00			59.89								59.30	
12	295	340	F	49.10	F2	D	31.70			26.20			54.50			26.65					28.52	
13	275	300	M	48.56	F2	D	48.40	F2	D	48.20	F2	D	47.00			46.85					46.85	
14	362	650	F	26.98			26.20			26.20			26.07								28.00	
15	287	350	M	34.76			36.90			36.40			36.80			37.79					37.12	
16	280	320	F	34.47			36.90			41.96	T2	D	43.4			42.87					43.66	
17	294	330	F	34.47	T2	D	42.50														43.66	
18	339	600	M	32.34			36.90			42.20			43.40			43.66					43.66	
19	403	920	F	41.97	T2	D	41.97	T2	D				43.40			43.66					43.66	
20	294	320	F	49.37			57.60			58.00			59.89			58.92					59.30	
21	331	500	F	41.97			42.50						43.40			43.66					43.66	
22	435	1120	U	52.46			52.46						57.47			57.50					57.48	
23	440	1000	F	52.46			52.46			54.50			54.50			56.30					54.75	
24	292	380	F	32.61	T2	D	42.50						43.40			43.66					43.66	
25	410	930	M	41.93	T2	D	42.00	T2	D		T2	D	43.40								43.66	
26	279	330	U	54.37			49.20														57.48	Mortality
27	420	1000	F	54.66			54.66			57.60			57.47								57.48	
28	422	920	M	54.30			54.30			54.50			57.47								57.48	
29	394	860	M	32.34			42.20						43.40			42.87					43.66	
30	346	640	M	41.93			42.20			42.80			43.40								43.66	
31	440	1120	F	57.88	T3	U	1.00H			1.00H			1.00H								1H	
32	422	1050	M	58.30			58.50	T3	U	1.00H											1H	
33	290	350	M	60.82	F3	D	60.90			59.00			59.5			57.48					57.48	
34	353	640	F	57.50			57.60			57.60			57.47			57.48					57.48	
35	443	1400	F	54.30			54.30			57.60			57.47			57.6					57.48	
36	485	1340	F	1.00H			1.00H			1.00H											1H	
37	342	650	F	62.70	T3	U	1.00H														1H	
38	376	640	M	39.50	T2	D	42.10			42.80			43.4			43.66					43.66	
39	266	240	F	61.54			63.60	F3	U				66.64			57.48					68.00	
40	423	1080	F	57.50			57.60						57.47								57.48	
41	389	750	F	1.00H			1.00H			1.00H			1.00H								1.00	
42	425	1000	F	1.00H			1.00H			1.00H			1.00H								1.00	
43	400	900	F	1.00H			1.00H			1.00H			1.00H								1.00	
44	271	255	F	63.42	T3	U	1.00H														1.00	
45	278	305	M	62.98	T3	U	1.00H														1.00	
46	244	200	U	64.06												71.77					71.77	

Table B1. Continued.

Radio Code	Len (mm)	Wt (g)	Sex	Capture (RKM)	Download 13-Sep	Dir (U/D)	Grnd 22-Sep	Download 4-Oct	Dir (U/D)	Grnd 16-Oct	Download 24-Oct	Dir (U/D)	**Flight** 13-Nov	Download 23-Nov	Dir (U/D)	Flight 10-Dec	Download 12-Dec	Dir (U/D)	Download 9-Jan	Dir (U/D)	Flight 15-Jan-13	Comments
47	392	820	F	42.19	T2	D	42.10			42.40			43.4			43.66					43.66	
48	252	205	F	62.10			62.50			62.50			62.07			62.36					62.36	
49	256	240	U	63.64	F3	D	0.05H			62.90			63.42	F3	U/D	63.45	F3	D	F3	D	63.84	
50	271	280	M	38.93																		
51	438	1060	F	37.10	T2	D	42.10	T2	D	42.10	T2	D	43.4			43.66					43.66	
52	357	670	M	45.34									47.0			51.1					51.10	
53	431	1060	F	37.10	T2	D	42.10	T2	D	30.90			43.4			43.66					43.66	
54	273	340	M	31.15						42.00	T2	D	36.8			42.87					43.66	
55	320	680	U	50.52			54.20			51.00			50.5			49.08					50.51	
56	300	420	M	51.28			51.30			57.60			59.9			59.73					59.73	
57	291	400	F	31.40			31.90			41.96	T2	D	43.4			43.66					43.66	
58	337	650	M	55.66			55.70															
59	372	750	F	55.98			56.00			57.60			57.5								57.48	
60	327	520	M	61.80	T3	U	1.00H			1.00H			1.00H								1.00	
61	336	500	M	49.10	F2	D	39.60	T2	D	44.30			43.4			43.66					43.66	
62	285	300	M	48.56	F2	D	48.30			48.20			47.0								47.00	
63	291	350	F	48.56	F2	D	48.30	F2	D	48.56	F2	D	48.6	F2	U	48.66	F2	D	F2	D	48.55	
64	347	610	M	24.46			24.46			26.20			26.1			26.08					24.50	
65	337	540	U	26.98						29.58			29.4			30.43					30.33	
66	300	510	F	28.25			36.90			41.96	T2	D	47.0			47.7					47.70	
67	385	720	F	24.46			24.46			24.46			24.5								24.50	
68	394	750	F	24.46			24.46			24.46			24.5			24.58					24.50	
69	234	210	M	28.25																		
70	298	250	F	22.93			22.93			23.00			22.6								22.95	