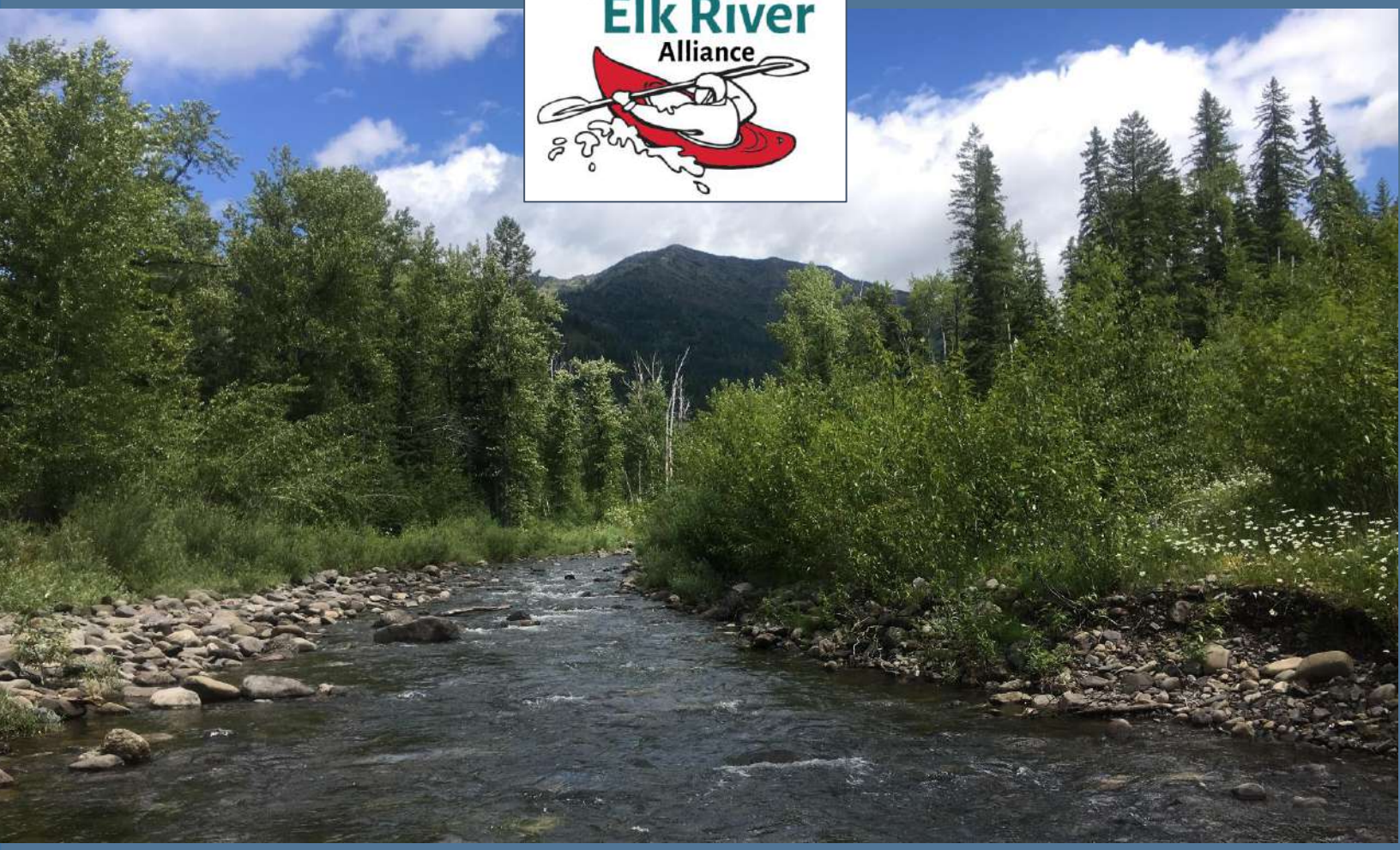

Elk River Westslope Cutthroat Trout (WCT) Research Initiative: 2019 Report

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Prepared with financial support from Habitat Conservation Trust Foundation (HCTF), the Patagonia Environmental Grants Fund of Tides Foundation and public stakeholders.

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Executive Summary

The Elk River and its tributaries are home to the only interior subspecies of Cutthroat Trout in Canada, Westslope Cutthroat Trout (WCT; *O. clarkii lewisi*), and is recognized as a stronghold for the species (McPhail 2007; COSEWIC 2016). WCT have experienced dramatic population declines throughout their historic range due to habitat loss and degradation, overexploitation, competition, predation by non-native salmonids, and introgressive hybridization with other trout species (Shepard *et al.,* 1997; COSEWIC, 2016). The Elk River watershed also faces some unique threats such as degraded water quality from coal mining, logging, riparian clearing due to industrial and community development, and an increase in angling pressure (Tepper, 2008; British Columbia Ministry of Environment, 2014).

The Elk River Cutthroat Trout Research Initiative was designed to address concerns surrounding WCT populations in the Elk Watershed through WCT habitat evaluation, identification of restoration opportunities, and the communication of easily understood and current WCT information to the community. The project aims to: review and distill information from reports, GIS layers, and knowledgeable community members to identify key habitat and restoration opportunities, and; conduct redd surveys, habitat assessments, and restoration plans for future WCT habitat improvements. A public outreach component includes: educating the community on WCT health, habitat, and threats through the creation of educational materials, social media posts, and workshops/community events that discuss project results and address community concerns for WCT.

From May to November of 2019 ERA carried out redd surveys and habitat assessments throughout the Elk River watershed. In the spring, a total of 62 WCT redds were identified on the following four tributaries of the Elk River: Lizard Creek, Morrissey Creek, Coal Creek, and Forsyth Creek. Data collected provides valuable baseline population data for WCT that fills knowledge gaps and aids in prioritizing restoration and conservation efforts in key streams. Twenty-eight areas of concern were identified during redd surveys and through consultations with members of the public, industry, and government via one-on-one conversations and public engagement sessions. In the fall, 11 habitat assessments were completed at sites of concern to evaluate habitat health and restoration needs. Habitat Assessments focused restoration and enhancement work in areas where improvements will create the greatest positive impact to the aquatic environment. From these habitat assessments, three restoration plans were developed for high priority sites. The information collected during this project addressed information gaps allowing fisheries managers, industry, and community members to be better able to work towards reducing threats and ensuring a sustainable and healthy WCT population for future generations.

Table of Contents

List of Figures

List of Tables

List of Appendices

Acknowledgements

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Introduction

Organization Background

Operating since 2010, the Elk River Alliance (ERA) is a community-based water group that aims to connect people to the Elk River ensuring it is drinkable, fishable, and swimmable for future generations. ERA aims to improve and preserve watershed health through projects that raise watershed literacy, inform sustainable water decision-making, collect scientific data to prioritize restoration opportunities, and promote safe and sustainable river recreation. ERA is a registered charity that is governed by a volunteer board consisting of board members from various backgrounds.

ERA has four guiding principles: (1) Stimulate conversation, share information, and facilitate community input to encourage sustainable water decision-making in the Elk Valley; (2) Promote a new era in watershed thinking by coordinating a community voice to contribute to watershed planning and management activities, regulatory processes, and other regional water initiatives; (3) Bring together diverse points of view and offer a safe place to dialogue about the Elk River, and; (4) Unite not divide.

Alongside members of the community, ERA has successfully monitored and assessed aquatic health over the course of nine years through the community-based water monitoring program. Using this knowledge, ERA has designed and managed numerous restoration projects to improve the health of the watershed. Stewardship and restoration work includes bank stabilization and habitat enhancement projects on Alexander Creek, Lizard Creek, and the Beaver Wetland in Sparwood, wetland construction in an abandoned gravel pit working alongside world renowned biologists, and ongoing stewardship initiatives throughout the Elk River watershed including nine years hosting an annual river cleanup on the Elk River and its tributaries. ERA previously developed a Flood Strategy that provides decision makers and the public information and data analysis recommending long, medium, and short-range solutions to flooding impacts in the Elk River watershed. ERA is committed to enhancing and restoring aquatic ecosystems, wetlands, and riparian areas, and has a proven track record of providing professional results.

Project Background

The Elk River and its tributaries are home to the only interior subspecies of cutthroat trout in Canada: Westslope Cutthroat Trout (WCT; McPhail 2007). WCT have experienced dramatic population declines throughout their historic range due to habitat loss and degradation, overexploitation, competition, predation by non-native salmonids, and introgressive hybridization with introduced Rainbow Trout (*O. mykiss*) and Yellowstone Cutthroat Trout (*O. clarkii bouvieri*; Allendorf and Leary 1988; Liknes 1988; Shepard et al. 1997). Non-hybridized populations of WCT exist in less than 20% of their historic range in Canada (Environment and Climate Change Canada 2016). The Elk River is one of seven streams designated as Class II Classified Waters and is recognized as a stronghold with limited introgression for WCT across its populations (Rubidge 2003; Rubidge and Taylor 2005; Lamson 2018). The Elk River watershed faces multiple threats such as degraded water quality from coal mining, riparian clearing due to industrial and urban development, and an increase in angling pressure (B.C. Ministry of Environment 2014; Tepper 2008). From 2009 to 2013, the Elk River averaged approximately 2,000 guided angler days annually and approximately 10,500 total angler days (Heidt 2014). Fisheries biologists in the region are worried that the unknown state of WCT populations, paired with an increase in anglers, could lead to decreased recruitment and reduced population sizes (Environment and Climate Change Canada 2016). While the provincial government has made efforts to estimate catch per unit effort through angler creel surveys

(Heidt 2003; 2007; 2014), a complete census of WCT populations in the Elk River have not been completed. Ongoing monitoring of WCT populations in the Elk River system would an ideal, but formidably complex and expensive undertaking. Evaluations of WCT populations by Tech Resources LTD are intensive, but focus on the Upper Fording River rather than the Elk River system as a whole. Some work has been done to identify habitat use in the Elk River watershed through telemetry studies (Prince and Morris 2003; Cope et al. 2016); however, further investigation (with current, up to date information) into the use of tributaries for spawning and rearing habitat is needed in order to determine priority areas for conservation. Additionally, local community members and Elk River users are concerned about the health of WCT but lack current, accurate information necessary to help them make informed decisions to support a healthy WCT population. Ongoing, comprehensive monitoring of WCT populations (whether by direct measurement or a proxy such as redd surveys) requires large degree of effort not currently achievable under the current system of private and governmental investment of expertise and resources.

The Elk River Cutthroat Trout Research Initiative aims to begin to address concerns surrounding WCT populations in the Elk Watershed from a community perspective through habitat surveys, identification and evaluation of restoration opportunities, and communication of easy-to-understand, current WCT information to the community. By addressing information gaps, fisheries managers, industry, and community members will be better able to actively work towards reducing threats and ensuring a sustainable and healthy WCT population.

Objectives

Objective 1*: Identify and map important habitat for WCT including spawning and rearing habitat.*

Community was engaged in identifying important WCT habitat through a review of existing literature on previous spawning and rearing research, coupled with discussions with local experts and knowledgeable community members. Data was compiled into a series of maps to illustrate locations of important habitat and areas of concern. Maps provide baseline information that help guide future WCT projects, informing research, habit restoration, and ultimately improved fisheries management.

Objective 2*: Increase community awareness and understanding of WCT health indicators, habitat threats, and possible actions to ensure sustainability of the population.*

This project aims to increase community awareness and promote conservation of WCT through better understanding and education of the community's concerns surrounding WCT in the Elk Valley. Awareness is achieved through: one-on-one meetings, community engagement events, and the creation of educational materials.

Objective 3*: Evaluate the quality of identified WCT habitats and highlight habitat restoration opportunities for future years.*

Finally, the Fish Research Initiative aims to identify and prioritize degraded habitat, and provide recommendations for future restoration efforts. Restoration opportunities were determined from community and industry input, and during redd surveys. As the presence of redds is a strong indication of habitat utilization and importance for WCT, a degraded site with the potential to negatively affect redds would be given preference when selecting sites for restoration activities. In 2019 ERA focused on initiating redd surveys and habitat assessments on key Elk River Tributaries, aiming to develop the basis for a long-term monitoring of redd distribution.

Study Area

Redd Surveys

The study area for this project encompasses the Elk River catchment, located within the East Kootenay region of British Columbia, however only a handful were selected for redd surveys. Tributaries were selected based on consultations with fisheries biologists and members of the community providing historical and first-hand accounts (See Methods). Selected tributaries included: Lizard Creek, Coal Creek, Morrissey Creek, and Forsyth Creek (Figure 1).

Habitat Assessments

Habitat Assessments were conducted on sites in the Elk River catchment on Andy Goode, Morrissey, Coal, Hartley, and Lizard Creeks, and on the main stem of the Elk River. These areas of concern were identified during redd surveys and through a series of consultations and workshops with members of the public, industry, and government and workshops.

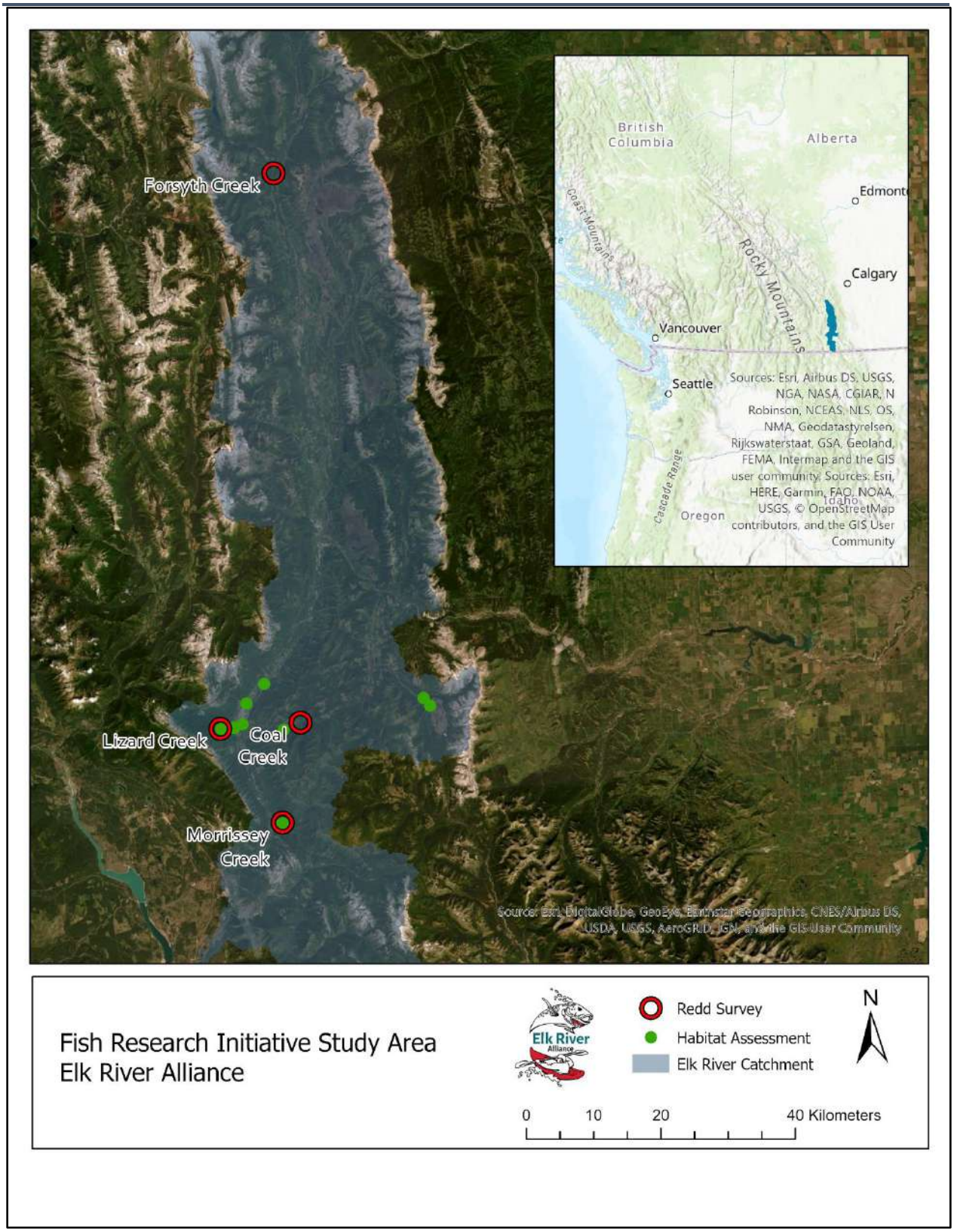

Figure 1: Elk River catchment study area (British Columbia) and location of redd survey and habitat assessment locations.

Background Information

Summary

The Elk River is one of seven watercourses designated as Class II Classified Waters and is recognized as a stronghold for Westslope Cuthroat Trout (WCT; *Oncorhynchus clarkii lewisi*) across its populations (McPhail 2007; Isaak et al. 2012). The Elk River and its tributaries are known to provide quality habitat to all life stages of WCT. Although there are many healthy populations of WCT in the East Kootenay region, WCT are a blue-listed species (i.e. species of concern) in B.C. (B.C. Ministry of Environment 2014; Government of Canada 2016). WCT have experienced dramatic population declines throughout their historic range due to habitat loss and degradation, overexploitation, competition, predation, and introgressive hybridization with introduced species (Allendorf and Leary 1988; Liknes 1988; Shepard et al. 1997). The Elk River WCT population in particular is threated by hybridization with non-native salmonids, overexploitation, and down-stream impacts from land use activities (particularly coal mining and forest harvesting; Rubidge 2003; Tepper 2008; B.C. Ministry of Environment 2014). Work has been done to assess WCT in the Elk River watershed, though existing research has information gaps resulting in an inability to properly evaluate the health of WCT populations (Prince and Morris 2003; Cope et al. 2016). This review summarizes existing threats to the WCT population in the Elk Valley, knowledge gaps, and recommendations for future work. Much of this information does not immediately impact the current project, but provides a useful context for WCT in the Elk Valley and is critical in communicating species concerns with members of the community.

Management of WCT in British Columbia

WCT are protected under both provincial and federal legislation. The British Columbia population is currently listed as Special Concern under Schedule 1 of the federal Species at Risk Act (SARA). As of 2006, the species is provincially blue-listed as Special Concern according to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), an independent advisory panel to the Federal government. Fisheries protection and pollution prevention provisions of the federal Fisheries Act provide protection to WCT as well. If a project is subject to an assessment under the Canadian Environmental Assessment Act, measures must be taken to avoid or reduce adverse effects on the species. WCT have also been identified as a priority native sport fish species by the B.C. Freshwater Fisheries Program and therefore in need of a provincial fisheries management plan.

In 2013, the British Columbia Ministry of Environment produced a species-specific management plan for WCT outlining a list of management objectives that aim to protect the species (updated 2014, adopted federally in 2017). The overarching management goal is “long-term persistence of the species within its native range at abundance levels capable of providing sustainable benefits to society, within the context of broader ecosystem values” (B.C. Ministry of Environment 2014). Management objectives include: (1) Maintain the native distribution and genetic diversity of populations, (2) Maintain wild populations at abundance levels that prevent at-risk status assessment so that the populations can provide sustainable societal benefits, (3) Maintain, or rehabilitate, the capacity of natural habitat to meet abundance tar gets for populations, and; (4) Optimize sustainable recreational benefits (B.C. Ministry of Environment 2014). However, management objective targets are not being met for the Elk Valley population, largely due to lack of research leading to numerous information gaps (B.C. Ministry of Environment 2014).

WCT in the Elk River Watershed

The Elk River and its tributaries have some of the most diverse and pristine landscapes within the WCT range, and are recognized as a stronghold for the species (Isaak et al. 2012). Migratory WCT populations are distinguished from resident populations by home range and distance traveled over an individual's lifespan. Resident WCT can have a home range as small as 1.8 km, whereas others may migrate up to 35.9 km (Prince and Morris 2003). Upper Elk River WCT have a mean home range of 22.87 km, whereas lower Elk River WCT have a mean home range of 4.5 to 8.8 km (Prince and Morris 2003). WCT subpopulations within the Elk Valley have been found to be genetically differentiated, containing characteristics of both resident and migratory populations (Prince and Morris 2003; Taylor et al. 2003; Muhlfeld et al. 2009).

In a telemetry study conducted by Prince and Morris (2003), it was found that WCT in the upper and lower Elk River had varying home ranges due to the lack of suitable overwintering habitat. WCT in the upper river utilized over twice the habitat (mean home range of 22.87 km) compared to WCT in the lower river (mean home range of 4.5 to 8.9 km; Prince and Morris 2003). Other research in the upper Fording River found that WCT had an average home range of 13.3 km (Cope et al. 2016). A range of overwintering and spawning migrations, short and long distance, occur in the Elk River depending on available habitat in subpopulation home range. WCT either overwinter in deeper river sections or migrate to lakes, depending on their life history strategy. Presence of surface water, groundwater influence, number and extent of large pools, water temperature, ice conditions, and the availability and depth of spawning habitat all influence the seasonal distribution of WCT (Cope et al. 2016).

WCT use a range of spawning habitats depending on their environment and life history characteristics, but have similar traits. Optimal WCT habitat can be found in unaltered streams with cold (7-11°C; Prince and Morris 2003; Cope et al. 2016), clean water and varied forms of cover (i.e. undercut banks, pool-riffle habitat, riparian vegetation, etc.). Spawning occurs in streams that have a low-gradient, well oxygenated waters, clean un-silted gravels, and a good variety of cover (Brown and Mackay 1995a). Spawning often occurs in the tailout of deep pools, triggered by the descending limb of the hydrograph in the spring (Brown and Mackay 1995a). In the Elk River watershed, previous research has identified important spawning and rearing habitat in a variety of locations including the mainstem of the Elk River, perennial, ephemeral, and off-channel tributaries (Prince and Morris 2003). While the majority of fish spawned in the mainstem, some spawned in Morrissey, Lizard, Hartley, Michel, and Fording creeks, as well as the outlet of lower Elk Lake (Prince and Morris 2003). These spawning habitats were all found to have similar characteristics; redds were found in clumped gravel areas (1.8-3.3 cm diameter) with an abundance of undercut banks, large woody debris, and dominant gravel substrate (Prince and Morris 2003). Spawning also occurred in late May and June when temperatures reached 7-11°C, which is similar to spawning timing and temperatures reported for WCT in the Fording River (Prince and Morris 2003; Cope et al. 2016), and Prince and Morris (2003) found 25% of WCT in the study exhibited site fidelity to spawning areas. Historically, Forsyth and Coal Creek were found to have WCT spawning activity in the 2001 and 2002 spawning seasons (Prince and Morris 2003), and community consultations indicated moderate spawning activity in Forsyth Creek. Data from historical redd surveys is scant and Prince and Morris' (2003) is not publicly available, and in general is advised against releasing location specific data of listed species such as WCT. Varying water temperatures (resulting from either climate change or land use activities) have been identified as a substantial threat to WCT in the elk valley (Davidson et al. 2018).

While some research exists on habitat use in the Elk River watershed, less effort has been allocated towards estimating WCT population abundance. In 2008, Hagen and Baxter (2009) conducted snorkel surveys to estimate WCT abundance in the Elk River and Michel Creek. Population abundance estimates

for fish with a fork length > 300 mm on the Elk River and Michel Creek were 39 fish/km and 46 fish/km, respectively (Hagen and Baxter 2009). The Elk River estimation was conducted to assess the feasibility of future studies as too few snorkelers were used (only 2 were utilized, recommended 7-8), which may have led to inaccurate estimates (Hagen and Baxter 2009). Creel surveys have been conducted for a number of years to estimate the effects associated with angling; however, the only consistent mechanism currently available for fisheries managers to monitor populations is by comparing the catch per unit effort (CPUE) taken from River guardian surveys (Heidt 2009). Fish collection permits can provide an idea of important areas for WCT juvenile rearing; however, these samples are taken without proper study design that would enable fisheries managers to draw conclusions from the data. This data does, however, function as an indicator of important habitat for juvenile rearing. Publicly available fish sampling data was compiled (but not included in this report, in an effort to avoid releasing WCT location data public). For the purpose of future monitoring of WCT population status it has been recommended that baseline and monitoring methods need to be established for the Elk River (Hagen and Baxter 2009; Heidt 2009; B.C. Ministry of Environment 2014).

A population study estimating the abundance and health of an entire subpopulation was completed in the upper Fording River by (Cope et al. 2016) from 2012 to 2015. Cope et al. (2016) found approximately 2,552 to 3,874 fish with a fork length > 200 mm in approximately 57.5 km of mainstem and 59 km of available tributary habitat. The average fish abundance estimate for the upper Fording River was 28.2 fish/km for fish with a fork length > 300 mm (Cope et al. 2016). Research also concluded that the genetic integrity of the population was strong (pure strain) and population characteristics were indicative of a "healthy" population (Cope et al. 2016). However, a number of localized effects were identified in conjunction with mining activity adjacent the Fording River (see 'Negative Impacts Affecting WCT'). The 2012 to 2015 study was feasible as the population was isolated in a smaller system. The potential for similar population abundance estimates on the Elk River has been assessed; however, given the size and complexity of the system would be extremely difficult (Westslope Fisheries Ltd. 2016). Despite the challenges involved, a measurement of WCT population dynamics in the Elk River is considered important to properly manage the fishery and fill knowledge gaps, particularly given the recent population crashes being reported by Teck Resources LTD in the Upper Fording River, Harmer, and Grave Creeks. The cause of these crashes is unclear, but these events highlight the need for baseline WCT population data in the Elk Valley.

Negative Impacts Affecting WCT in the Elk Valley

WCT have experienced dramatic population decline throughout their historic range due to degradation and loss of habitat, overexploitation, competition, predation by non-native salmonids, and introgressive hybridization with introduced rainbow trout (RBT; *O. mykiss*) and Yellowstone cutthroat trout (*O. clarkii bouvieri*; Allendorf and Leary 1988; Liknes 1988; Shepard et al. 1997). According to the British Columbia Ministry of Environment (2014), the Elk River WCT population faces cumulative threats, including: hybridization with non-native salmonids, coal mining, forest harvesting, and increased angling pressure (Rubidge 2003; Tepper 2008; B.C. Ministry of Environment 2014).

Hybridization

Hybridization with non-native salmonids leading to introgression has been identified as one of the greatest threats to WCT populations in North America (Trotter 2008; B.C. Ministry of Environment 2014). It is estimated that non-hybridized populations of WCT persist in less than 10% of their historic range (Trotter 2008). Research in the upper Kootenay drainage has found genetically-pure WCT populations in

only 22% of their original range (Rubidge 2003). These genetically-pure populations are often restricted to isolated headwater systems making them highly vulnerable to extirpation.

The Elk River is part of the heart of WCT distribution in the East Kootenay and is thought to be one of the few remaining areas with genetically pure populations (Rubidge and Taylor 2005). Although Rainbow Trout (RBT) are native to many of B.C.'s watersheds, they are not native to the Elk River. RBT have been introduced to the Elk River, and small populations are now found throughout the watershed. For example, there is evidence of a WCT-RBT hybrid swarm in the Lodgepole Creek subpopulation (tributary of the Wigwam River in the Elk River drainage) with advanced hybridization (37.5% heterospecific alleles; Rubidge, 2003). In 2005, Rubidge and Taylor measured the presence of RBT alleles in the Elk River watershed. They found the percentage of RBT alleles was 13.1% in Michel Creek, 1.5% in Morrissey Creek, 1.3% in Coal Creek, 0% in Fording River and 0% in the upper Elk River (Rubidge and Taylor, 2005; Figure 2). Higher RBT presence in Michel Creek in relation to other sites suggests it is a source of RBT alleles in the Elk River system. It is likely that some RBT have been swept downstream into Michel Creek from nearby Summit Lake during high water events (Rubidge and Taylor, 2005). Summit Lake has been historically stocked with RBT and found to contain RBT hybrids (Rubridge, 2003). Michel Creek has also been categorized as a "hotspot" for RBT hybridization by the British Columbia Ministry of Environment (2014). Given these identified areas of potential RBT introduction and the isolation of the Elk River population thanks to a natural 12 m waterfall downstream from the Elko hydroelectric dam, management efforts to limit RBT introgression would be more effective here than in other systems with greater connectivity. Additionally, the spread of hybridization may remain limited in the Elk River watershed by ecological barriers including temperature and elevation (Paul and Post 2001; Rubidge and Taylor 2005; Taylor et al. 2003).

WCT prefer colder temperature to RBT, and pure WCT subpopulations exist in higher elevation headwater streams (Paul and Post 2001). Continuing hybridization could have a negative effect on high elevation WCT leading to greater levels of isolation and susceptibility to extirpation. Additionally, if temperatures continue to warm due to climate change, RBT and hybrids may encroach on higher elevation WCT habitat. WCT-RBT hybrids and RBT have been found to be competitively superior to genetically-pure WCT in warmer waters (Paul and Post 2001; Rasmussen et al. 2010; Rubidge and Taylor 2005).

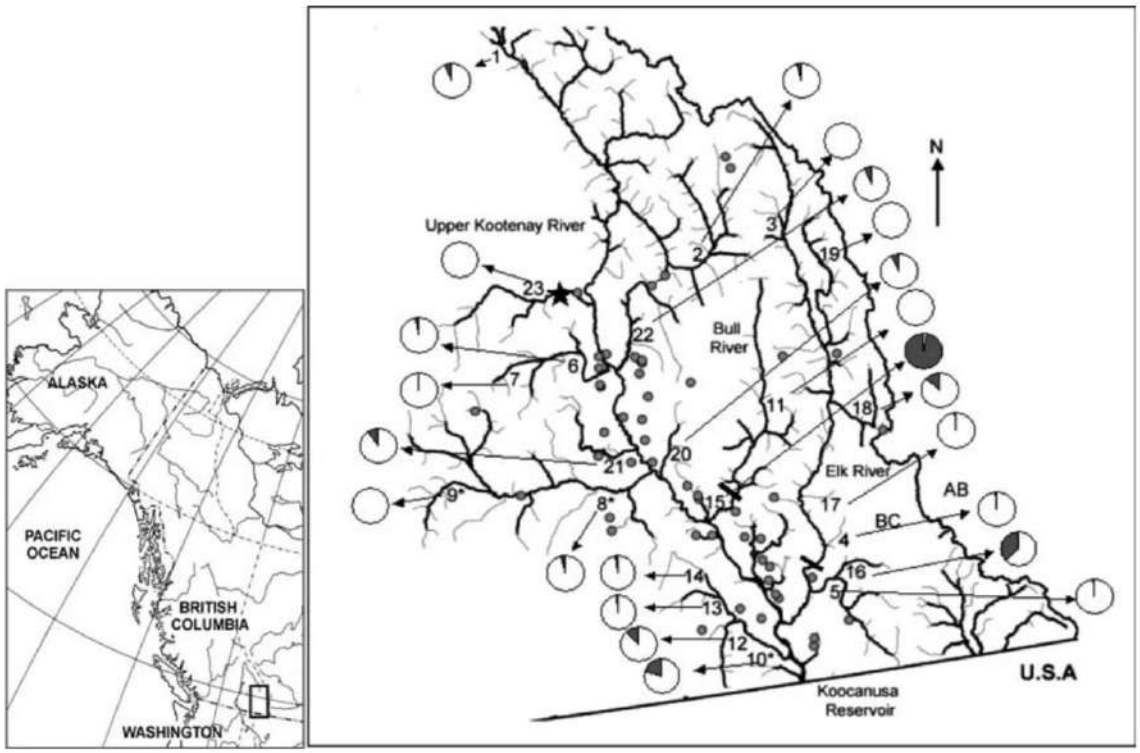

Figure 2. Sample localities examined for the presence of westslope cutthroat trout, rainbow trout, and their hybrids in the upper Kootenay River drainage.

Note: Elk Valley populations: (3) upper Elk River; (4) Morrissey Creek; (16) Lodgepole Creek; (17) Coal Creek; (18) Michel Creek; (19) Fording River. Note: Each grey dot represents a locality where rainbow trout were stocked between 1915 and 1998 (data from BC MWLAP stocking records); one locality may have been stocked numerous times. Pie charts represent the proportion of species alleles at each site; shaded area indicates % RBT alleles, white area indicates % WCT alleles. Black bars represent hydro dams and the star represents a canyon, both barriers to upstream fish migration. Inset shows study area in western North America. BC–British Columbia, AB– Alberta, USA–United States of America. From Rubidge and Taylor (2005).

Coal Mining

There are currently five current and defunct coal mines in the Elk Valley, with a proposed two to three scheduled to begin extraction in the next 5-10 years. Mining operations are known to have adverse direct and indirect effects on aquatic health. In some tributaries of the Elk River, entire headwater reaches have been disrupted by coal mining and subpopulations of WCT have been fragmented, some of which are genetically-pure (Government of Canada 2016). Impacts from coal mining include: increased water temperature, loss of tributary habitat, and water contamination; the Elk Valley Water Quality Plan has been developed by Teck to address some of these issues (Teck Resources Ltd. 2015).

Water temperature can increase when riparian vegetation is removed allowing greater sun exposure, while water withdrawal for mining activities can reduce the natural cooling effect of headwater tributary inflow (Nelson et al. 1991). For example, segments of the Fording River have been found to have daily temperatures exceeding water quality guidelines for WCT spawning, incubation, and rearing (Cope *et al.,* 2016; Figure 3). Increased water temperature can also limit the amount of suitable habitat for WCT, as they cannot tolerate high water temperatures (Haas 1998).

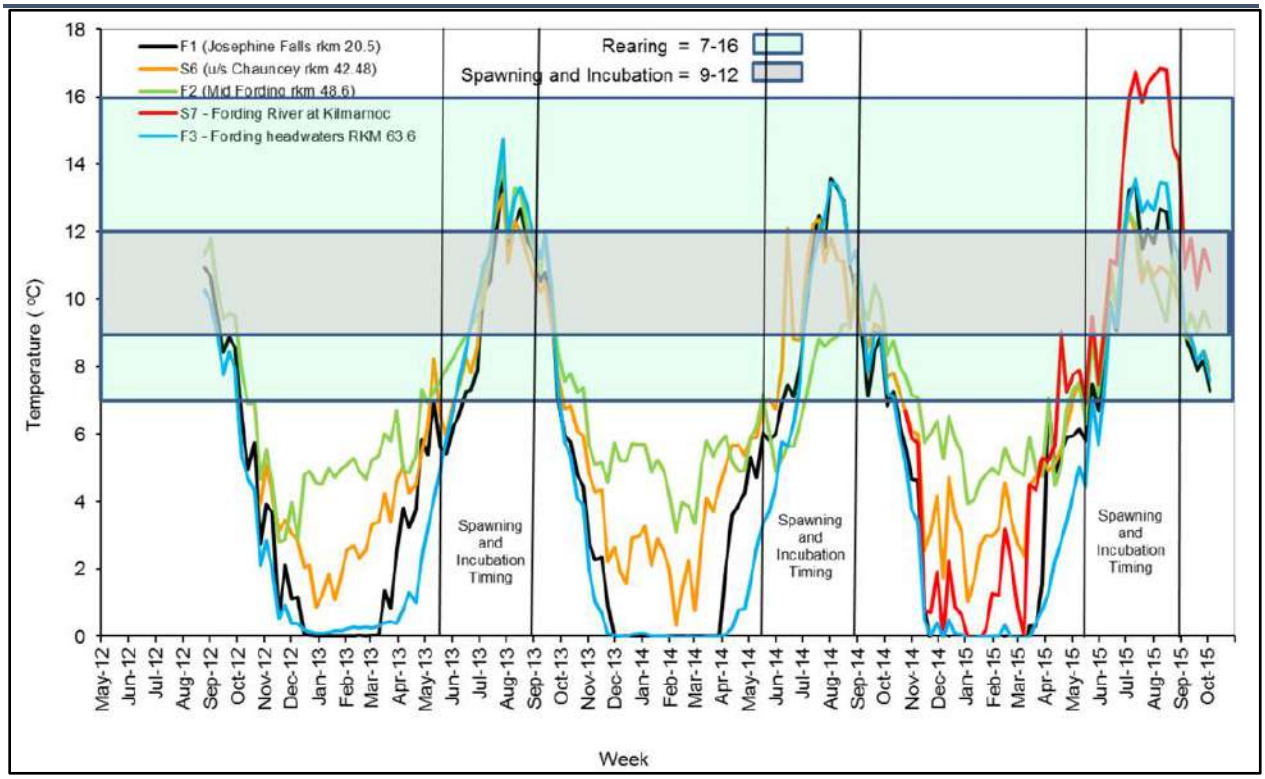

Figure 3. Mean weekly maximum water temperature for the five mainstem upper Fording River locations.
Note: Figure indicates recommended guidelines for WCT, August 22, 2012 to October 7, 2015. From Cope et al. (2016).

Tributary habitat can be lost due to a variety of mining-related activities, principally construction of rock drains, and installation of culverts. Rock drains destroy habitat directly through valley infilling, and inadequate culvert design and placement can limit habitat connectivity (Cope et al. 2016). This loss and fragmentation of tributary habitat can reduce population resiliency and limit productivity. In the upper Fording River, it has been estimated that approximately 59% of all historically available tributary habitat has been lost or fragmented from the mainstem (Cope et al. 2016).

An increasingly negative impact on freshwater habitat and aquatic health is water contamination as a result of mining activity. Selenium and calcite are naturally occurring elements in the Elk River and its tributaries at low concentrations; however, mining processes can elevate levels, resulting in harmful effects on aquatic health. Elevated levels of selenium can result in reproductive impairment, and reduced growth and mortality in WCT (Hilton and Hodson 1983; Lemly 1993; 2014). The most sensitive toxicity endpoints are reproductive effects that occur through the maternal transfer of selenium to eggs, causing larval deformities and/or death upon hatching (Lemly 1993; Janz et al. 2010). In 2008, (Rudolph et al. 2008) collected eggs from 12 female WCT in streams affected by mining activities in the Elk Valley and 16 from a reference site. Fish egg selenium concentrations ranged from 12.3 to 16.7 µg/g dry weight (dw) from the reference site and from 11.8 to 140 µg/g dw in exposed sites (Rudolph et al. 2008). A correlation between fish egg selenium concentration and alevin mortality was observed (Rudolph et al. 2008). Additional research in the Fording River, which is adjacent to two large coal mines, has found evidence of elevated levels of selenium in important WCT spawning and overwintering habitat (Windward Environmental et al. 2014). WCT in these areas have been found to have high selenium bioaccumulation within tissue samples, with potential negative effects on species recruitment (McDonald 2013; Minnow Environmental Inc. et al. 2011).

Water quality monitoring conducted in the Fording River indicates selenium levels are increasing in the area. For example, from 2004 – 2009 selenium levels increased by 13% in the Fording River with a mean concentration of 31 mg/L (McDonald 2013; Minnow Environmental Inc. et al. 2011). In 2012, the British Columbia Ministry of Environment undertook independent sampling and found average selenium concentrations of 52.9 mg/L in the upper Fording River (Lemly 2014). More recently, the median selenium concentration from upper Fording River monitoring stations was between 7.9 and 72 mg/L, representing a trend increase of 10 to 43% (Windward Environmental et al. 2014). Additionally, WCT captured during spawning season within areas with high selenium have been found to contain high levels of selenium bioaccumulation in their tissues (McDonald 2013; Minnow Environmental Inc. et al. 2011). Earlier work indicated that tissue samples taken between 1996 and 2009 in the Fording River from benthic invertebrates, bird eggs, and fish muscle showed no signs of increasing selenium levels (Orr et al. 2012).

The impact of selenium is somewhat debated. Elevated selenium levels in surface water did not appear to be adversely impacting fish and water bird populations (Minnow Environmental Inc. et al. 2011; Chapman et al. 2008). In contrast to these findings, Environment Canada, which sampled the area between 2011 and 2014, concluded that current surface water selenium concentrations were having an impact on fish populations in the Fording and Elk Rivers (Lemly 2014). This could be the result of increasing effects, as bioaccumulation often takes many years or decades to become apparent, or it could be the result of variations in sampling. Past research has found selenium tissue concentrations in WCT caught at exposure locations can be highly variable, with this variation partially attributed to fish movements through areas of exposure (Holm et al. 2005). While the impacts of selenium on aquatic and terrestrial life in the Elk Valley have been studied, the effects of selenium on fish and wildlife combined with other stressors are less clear. Loss of habitat and degrading water quality and changes to temperatures from land use activities and climate change can have confounding effects and reduce species resiliency, and it is difficult to separate a single variable from a dynamic, complex system such as the Elk River.

Another concern for water contamination from mining activities is calcite precipitation and deposition. While calcite deposition occurs naturally within the Elk River Watershed, it is commonly observed downstream of mining activities, particularly downstream of waste rock piles. Calcite deposition in the Fording River was found to alter aquatic invertebrate communities, shifting the dominant taxa away from important WCT prey items towards more unfavorable species (Interior Reforestation Co. Ltd. 2010). This can result in reduced food availability for WCT, impacting habitat utility. Areas of high calcite deposition have also been found to impact channel morphology, riparian vegetation, and fish habitat directly including spawning potential through deposition of calcite on gravel beds (Interior Reforestation Co. Ltd. 2011; 2012). However, the mechanisms of calcite precipitation and rate of deposition are not well understood. Teck is evaluating calcite deposition and the effects of calcite on biota, and has looked at its impact on aquatic insects and fish eggs. The current data is confounded somewhat, as high levels of calcite are often found in conjunction with high levels of selenium and other constituents that indicate poor water quality. Preliminary data suggests that calcite may affect redd densities and percent mayfly larva (Environmental Monitoring Committee 2019); however, further research on calcite deposition and its potential impact to aquatic health is needed.

Forest Harvest

Lumber harvest can have adverse effects on fish populations by changing hydrological regimes and temperatures within streams. Two logging activities that cause a major impact to fish and aquatic health are the removal of riparian vegetation and the creation of forest service roads.

The removal of riparian vegetation can increase water temperature, reduce stability of stream banks, and increase surface run-off by decreasing buffer capacity (with regard to water retention), altering hydrologic regimes (Keim et al. 2006). Timber harvest can also impede the recruitment of large woody debris (Bragg 2000). Increased runoff also increases turbidity and sedimentation which can degrade spawning and rearing habitat by filling pool habitat and interstitial spaces with gravel, reduce recruitment by smothering incubating eggs and alevin (juvenile fish), reduce and impede WCT feeding abilities by clogging and abrading fish gills, and reduce available food by smothering aquatic insects (Reiser and White 1988; Weaver and Fraley 1991; Anderson 1996; USFWS 1999). Previous research has also demonstrated that reduced emergence success from high sedimentation can result in low juvenile densities and adult recruitment (Scrivener and Brownlee 1989).

Increasing surface run-off as a result of riparian vegetation loss can alter water velocity leading to a change in stream bank morphology and issues associated with increased stream discharge (Weaver and Fraley 1991). If changes in water velocity are substantial, they can act as a barrier for spawning fish during annual spring runoff, preventing populations from accessing key habitat (McIntyre and Rieman 1995).

Increasing water temperatures can give non-native fish a competitive advantage over WCT in marginal habitats; while RBT and WCT both have similar optimal growth temperatures (4-15°C, and 0-4°C for overwintering), WCT have an upper lethal temperature of 19.6°C 4.7°C lower than RBT (24.3°C), indicating increased water temperatures favor RBT competition (Bear et al. 2007; Fisheries and Oceans Canada 2019). In addition to promoting competition, in the Rocky Mountain region it has been estimated that an increase of as little as 1°C in mean July air temperatures could reduce the geographic area of suitable trout habitat by 16.8% (Keleher and Rahel 1996). In addition to this, Temperature and flow provide the physical triggers required to migrate for spawning and overwintering (Oliver 2009). The negative effects of higher stream temperature on WCT will likely become more noticeable as climate change increases atmospheric temperatures.

Logging requires an elaborate road network for vehicle and heavy machinery access. While new regulations for road development are more sensitive to fish passage, a number of historic railway crossings in the Elk Valley are of concern (Oliver 2009). In Southeastern B.C., previous research found a significant negative relationship between the cumulative effects of forestry-related activities and WCT density, as measured by roads on erodible soils, roads within near-stream zones, and road density (Valdal and Quinn 2011). Valdal and Quinn (2011) also found that logging of non-fish bearing streams can still negatively impact downstream WCT abundances.

The construction of culverts during road development at stream crossings can limit fish passage and access to spawning areas (Fisheries and Oceans Canada 2019). Furthermore, the isolation of subpopulations can compromise gene flow and negatively affect long-term persistence of the species (Allendorf and Leary 1988; McIntyre and Rieman 1995). Many culverts are not designed to accommodate fish passage at high flows and the lost habitat is potentially significant if impassable culverts prevent completion of WCT life history. For example, in Alberta a partial survey of 167 culverts in Banff National Park found 55% were full barriers, 33% were partial barriers and 12% were passable to trout species (Mayhood and Taylor 2009). The dramatic decline of migratory WCT subpopulations seen in the area was attributed to barriers created by culverts (Mayhood and Taylor 2009). This loss of migratory forms of WCT can also limit recolonization of areas where resident subpopulations are in danger (Mayhood and Taylor 2009). In some cases, barrier culverts actually protect isolated strains of genetically-pure WCT from non-native species, limiting hybridization and preserving gene flow. It is estimated that 50% of existing culverts in the region would likely pose a barrier to fish passage (Mount, 2011, unpublished data). In the Elk Valley,

a 2012 technical report evaluating culverts associated with resource roads on Morrissey Creek, Lizard Creek, and Michel Creek found that the majority of culverts assessed were a barrier to fish movement and need to be addressed (Grainger 2012).

Overexploitation

The Elk River and its tributaries are a popular fishing destination for WCT. The Elk River WCT population felt the effects of overharvesting between the 1960s and 1980s, leading to dramatic declines in WCT subpopulations (Heidt 2002). This led to more restrictive fishing regulations and river closures in the 1980s; by the 1990s, many WCT populations were rebounding. This rebound resulted in a renewed increase in angling pressure, leading to the implementation of a new river classification system in 2004, which required additional licensing for anglers (Heidt 2014). From 2009 to 2013, the Elk River averaged approximately 2,000 guided angler days annually and approximately 10,500 total angler days (Heidt 2014). Over the past two decades, fishing regulations have become more restrictive and many populations have recovered without long-term effects (Ministry of Environment 2006; Heidt 2007; 2014). Most subpopulations of WCT in the Elk River have been identified as abundant and able to support a quality fishery though there is significant concern regarding localized habitat impacts and hybridization (B.C. Ministry of Environment 2014).

One of the major concerns for increasing overexploitation of WCT in the Elk Valley is the development and expansion of industry related resource roads. The expanding road network allows anglers access to sensitive WCT habitat and the potential introduction of non-native species (Government of Canada 2016). It is believed that many of the threats facing the Alberta WCT subpopulations could be reduced through the restoration of right of ways to natural conditions and removal of unnecessary resource roads (Mayhood and Taylor 2009). An increase in resource road networks in developing watersheds could also increase illegal angling. With significant guided and tourist recreational fishing occurring in the watershed, an expansion into previously isolated habitat could increase angling pressure (Heidt 2014). WCT are particularly sensitive to angling pressure as they are easily caught (Haas 1998; Paul and Post 2001). Research has found that the catchability of WCT is 2.5 fold greater than other salmonids such as Brook Trout (Cleator et al. 2009). Over a 3.5-month fishing season, studies have shown that WCT were caught an average of 9.7 times in a heavily fished catch-and-release river in Yellowstone National Park (Schill et al. 1986). Over a summer season in the Elk River some WCT have been caught up to 11 times (Mayhood and Taylor 2009). In areas where WCT fishing pressure may increase, risks associated with catch and release mortality may become a greater concern (Government of Canada 2016). Catch and release is currently believed to result in low mortality (< 5%); however, since WCT are easily angled the cumulative effects of multiple catch and release incidents could be more significant (Mayhood and Taylor 2009). Increases in angling pressure could also increasingly affect overwintering WCT. As WCT congregate in large numbers and are relatively sedentary during winter when they congregate deeper pools, increased angling pressure could result in higher mortality during winter harvest (Brown and Mackay 1995b). Although overexploitation is a concern for the Elk River watershed, WCT subpopulations have been identified to be in relatively good health.

Research Gaps and Future Research

While some work has been done to assess WCT in the Elk River watershed, current information gaps impede a comprehensive evaluation of WCT population health. Reference points for population abundances do not exist, and it is unclear if threats such as angling-related mortality are a significant issue in the fishery (B.C. Ministry of Environment 2014). While the provincial government has made efforts to

estimate catch per unit effort through angler creel surveys (Heidt 2003; 2007; 2014), direct monitoring of the fish populations in the Elk River has not been accomplished and accurate population estimates do not exist. While research by Teck Resources LTD has produced a wealth of information regarding WCT in the upper Fording River, this data does not provide sufficient data on the entire Elk River system. It is also worth stating that private industry alone should not be the driving force for population management. While continuing research is needed monitor the severity of various impacts (mining, logging, harvest etc.) in the Elk Valley, more important is the need for unbiased, comprehensive, and ongoing assessment of the Elk River WCT population as a whole in order make sound management decisions.

One principal issue related to gathering research on these topics is the complexity of the Elk River system. Westslope Fisheries determined there are limited options that would be feasible for implementing a population abundance monitoring project and the cost would be high (2016). Alternative methods to evaluate the population need to be addressed using collaborative efforts between the government, industry, and non-profit sectors. One method includes focusing on juvenile abundance assessments, and another is to build a database for redd surveying.

While redd counts do not give an absolute measure of a population, redd surveys could provide a measure of WCT reproduction/recruitment utilization within tributaries, and therefore measure population presence over time and space. Over time, redd survey data could be used to track changing utilization of streams and provide a relative assessment of population size (relative to prior survey data).

Comprehensive WCT redd survey data for the Elk River catchment isn't currently publicly available in order to protect spawning areas from recreational fishing activity. However this results in fragmentation of data and restricts professionals from utilizing important information. Redd surveys do not directly measure population, but could allow for long term monitoring of WCT utilization of streams, and may be a reliable method of recording year-to-year recruitment potential of individual tributaries or river sections. The principal limitation of redd surveys being that they can only be performed on smaller tributaries as the main stem of the Elk River is too turbid to reliably see redds during spawn times. Despite this, redd surveys have the advantage of being relatively simple and safe to perform both for surveyors and fish. Redd survey can be competed with minimal equipment, training or impacts on fish compared to direct population estimates such as electrofishing or snorkel surveys.

There is currently ongoing research to assess the extent of hybridization in Elk River population groups, which addresses objectives 1 and 2 from the British Columbia Ministry of the Environment's management plan. For hybridization concerns, it would be more effective to locate and protect non-hybridized populations to ensure they remain genetically pure instead of focusing on populations where hybridization has already been identified (Rubidge and Taylor 2005). A focus on hybridization is a high priority action item in the 'Management Plan for the Westslope Cutthroat Trout (Oncorhynchus Clarkii Lewisi), British Columbia Population, in Canada' (B.C. Ministry of Environment 2014).

Objective 3 from the British Columbia Ministry of the Environment's management plan has a number of different focuses, and outlines several information gaps, many of which apply to the Elk Valley (B.C. Ministry of Environment 2014). These gaps include the need for watershed level analysis of land use and its impacts on riparian habitats, studies on baseflow requirements for WCT in the Elk Valley, the effects of road densities on fish populations, and how selenium and calcite from coal mining is impacting WCT in the Elk Valley (B.C. Ministry of Environment 2014). Monitoring stream volume and temperatures throughout the Elk Valley has also been identified as a desirable actions by the Cumulative Effects Management Framework (Davidson et al. 2018). Monitoring physical parameters offer the dual benefit of

observing the potential effects of land use, as well as identifying steams that will become refuges for WCT as the effects of climate change increase water temperatures.

The cumulative effects of some impactors have been assessed in the Aquatic Ecosystems Cumulative Effects Assessment Report (Davidson et al. 2018), and Teck is investing heavily into investigating the impacts of calcite and selenium on WCT in mine impacted tributaries in the Elk Valley (Environmental Monitoring Committee 2019). However, due to the scale of these issues, more work could be done on a larger scale assessment that specifically considers habitat availability and quality for WCT. To date, some work has been done to identify habitat use in the Elk River watershed through telemetry studies (Prince and Morris 2003; Cope et al. 2016), and to evaluate the impact of land use activities (Valdal and Quinn 2011; Cope et al. 2016). Further investigation into important areas of WCT habitat use would be useful to determine priority areas for conservation and restoration.

Objective 4 of the management plan focuses on optimizing sustainable recreation benefits. Since the 1980s, stricter fishing regulations have benefitted fish populations and maintained a 'very good' to 'high' quality of angling experience (Heidt 2014; B.C. Ministry of Environment 2014). However, the extent to which harvest can be maintained is unknown, which is of concern as angling pressure increases and compliance decreases (B.C. Ministry of Environment 2014). Frequent monitoring of the Elk River fishery is needed to determine if angling pressure is in fact increasing year-to-year and, if so, what regulations could be changed and/or implemented to maintain healthy fish populations. The British Columbia Ministry of the Environment's *Management Plan for the Westslope Cutthroat Trout (Oncorhynchus clarkii lewisi) in British Columbia* outlines a number of potential projects and initiatives that should be considered for future research (Appendix B).

Summary

The Elk River watershed is an important system for WCT, providing an abundance of important habitat to the species. WCT are a blue-listed species in B.C. due to threats facing the species across B.C. which include: habitat loss and degradation, competition, overexploitation, competition, predation by non-native salmonids, and introgressive hybridization with RBT and Yellowstone cutthroat trout (Allendorf and Leary 1988; Liknes 1988; Shepard et al. 1997). In the Elk River watershed specifically, populations are threatened by: hybridization with non-native salmonids; negative impacts resulting from coal mining and forest harvesting, the effects of climate change and; overexploitation (Rubidge 2003; Tepper 2008; B.C. Ministry of Environment 2014). Certain populations of WCT in the Elk River watershed have been analyzed, but research and data is limited by the complexities of assessing WCT populations in this system. Hybridization is a significant threat to WCT due to the high level of genetic purity in the Elk River watershed. While some areas of the watershed see WCT hybridized with RBT, the majority of subpopulations remain genetically pure. Hybridization may continue as the valley sees the ongoing effects of industry and climate change. Climate change has the potential to alter stream temperatures as well as broader effects on surrounding vegetation. The impacts of coal mining on WCT include: increased water temperature from riparian clearing; loss of tributary habitat from valley infilling, and; water contamination from constituents such as selenium and calcite. The effects of coal mining on downstream processes relating to WCT are not fully understood and need to be further studied. The major impacts from forest harvesting include: the removal of riparian vegetation leading to changes in stream morphology and temperature, and issues associated with the construction of forest service roads. Forestry-related activities can have direct effects on WCT populations, but may also have negative cumulative effects on critical downstream habitat, particularly spawning grounds. Lastly, the expansion of land use activities in the Elk Valley can lead to increased access to previously isolated fish populations and habitat, amplifying

angler pressure and associated negative effects on WCT populations. Although some work has been done to identify habitat use in the Elk River watershed, direct monitoring of WCT populations in the Elk River watershed have not been accomplished and comprehensive evaluations of WCT habitat do not exist. Fisheries biologists in the region are worried that the unknown state of WCT populations, paired with increasing threats may lead to negative impacts on the population. Further research is needed to assess the health of the Elk River WCT populations to ensure the population remains sustainable and viable in the years to come.

Methods

Desktop study

Prior to field surveys, a desktop study of relevant information was compiled. This review examined factors influencing WCT distribution and population dynamics in the Elk River and its tributaries. Reviewed materials include but are not limited to: historical surveys; mapping; literature detailing WCT life history, habitat requirements, and land uses that impact WCT in the Elk Valley including forest harvest, exploitation of fisheries, and coal mining, and; a review of WCT in British Columbia.

Redd Surveys

Redd surveying was completed following the peak of spring freshet, during the declining limb of the hydrograph. The declining limb varies according to yearly climatic conditions, but typically occurs between May and July (Figure 4). Work was conducted in small, narrow tributaries; therefore, the only feasible survey method was physical observation for redds traveling by foot. Access to stream sections was limited, and travel was limited to in-stream and on top of the banks.

Due to timing, manpower, and budgetary constraints four tributaries were surveyed for redds during the 2019 spawning season. Tributaries were selected based on prior telemetry work conducted by Prince and Morris (2003), input from community members, and consultation with regional biologists. Morrissey and Lizard Creeks are known spawning locations. Historically, Forsyth and Coal Creek were found to have a small amount of WCT spawning activity in the 2001 and 2002 spawning seasons (Prince and Morris, 2003). Coal Creek has a high gradient relative to other surveyed creeks, and while there are exceptions, high gradient watercourses are generally considered less suitable for spawning. Despite this, Coal Creek was selected as it is a Creek of community concern, and consultations with biologists and the public suggested the presence of redds. Forsyth Creek was selected to increase the spatial reach of the surveys, and was considered a strong candidate for redd suitable habitat. Specific tributary sections were selected based ease of access and perceived likelihood of suitable spawning habitat ascertained through local knowledge. Redd databases are generally not publicly available as this may encourage overfishing of important spawning grounds. As a publicly available redd database for the Elk River catchment is nonexistent, these four streams are considered a ‘good start’ for this project’s redd surveys. Generation and maintenance of a comprehensive and up to date database will require ongoing future effort. It is important to note that any database containing redd locations should not be made publicly available, but rather exist for WCT monitoring and management purposes. Location data would be made available to those requiring access in a professional capacity.

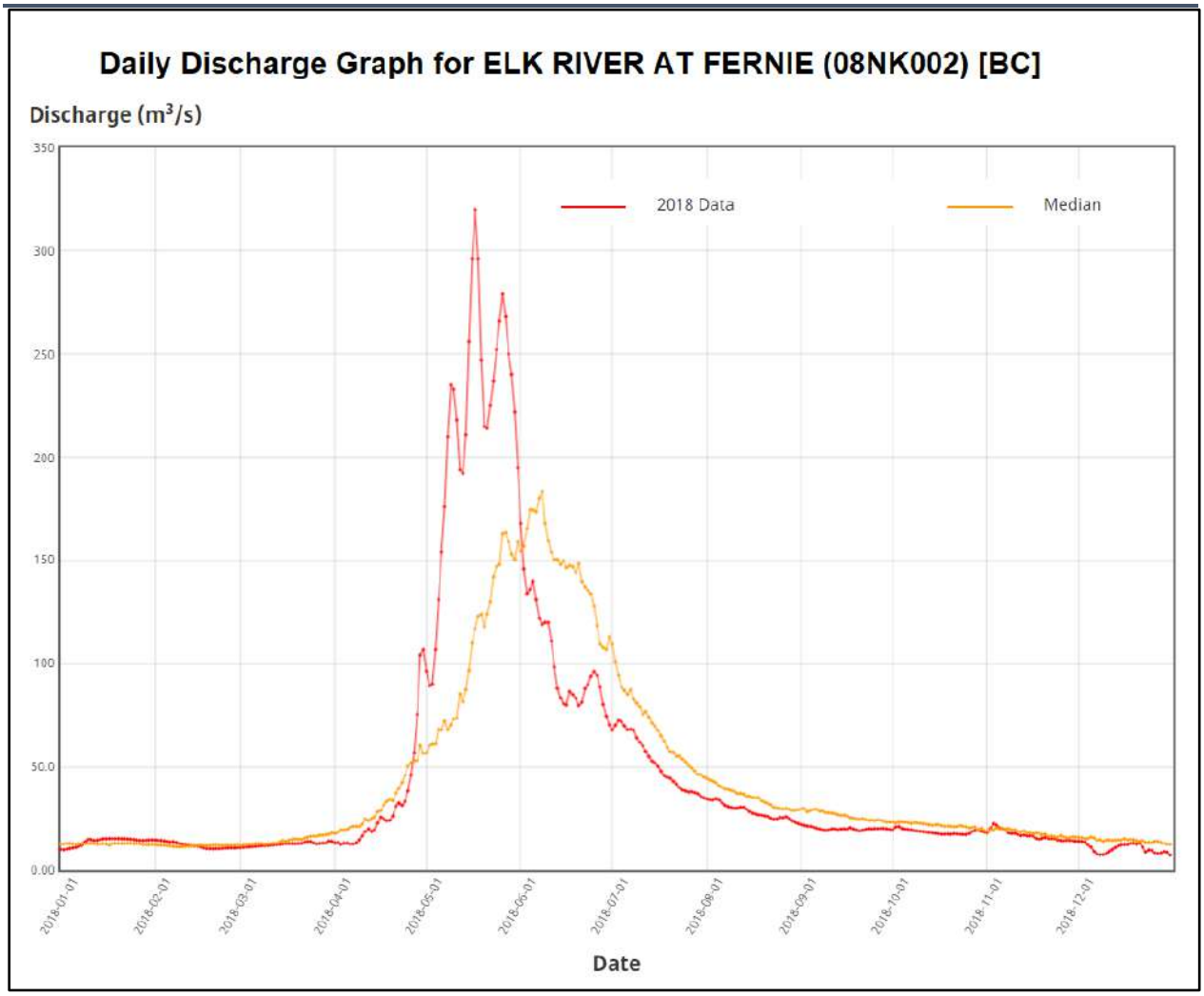

Figure 4: Mean Daily Discharge Graph for the Elk River at Fernie (Station: 08NK002) [BC] (Government of Canada, 2020)
Note: 2018 data is also shown here. 2019 data not available at time of writing; however, this illustrates variability of flow.

Redds are identified within the streambed as oval patterns of clean, well sorted bed material, with a depression at the upstream extent of the oval (Burner 1951). Redds were counted and locations recorded using a Garmin GPS unit. Communal versus individual redds were not differentiated during this survey; however, estimates on redd numbers within communal areas were made.

Ingress and egress locations were chosen based on ease of access, presence/absence of redds, and available time. Two consecutive reaches were selected on Lizard Creek spanning a total of 2.4 km (Figure 5). Two reaches were selected on Coal Creek, the first spanning 0.47 km and the second spanning 0.78 km (Figure 6). Two reaches were selected on Morrissey Creek, the first spanning 1.85 km and the second spanning 1.7 km (Figure 7). One reach was selected on Forsyth Creek spanning 1.0 km (Figure 8).

Habitat features were recorded when redds were encountered, or opportunistically if redds were not recorded. If no redds were recorded, fewer habitat features were recorded; however, surveyors noted Coal Creek had fewer habitat features and a more channelized stream than other watercourses such as Lizard Creek (Appendix C). This oversight should be reviewed to ensure future survey methodologies consistently record habitat features across surveyed streams.

Figure 5. *Sections of Lizard Creek redd surveyed in 2019 by ERA contractors.*
Note: The sections of creek that were surveyed are indicated by the red lines (A = Start of reach 1; B = End of Reach 1 and start of reach 2; C = End of reach 2).

Figure 6*. Sections of Coal Creek redd surveyed in 2019 by ERA contractors.*
Note: *The sections of creek surveyed are indicated by the red lines (A = Start of reach 1; B = End of Reach 1; C = Start of reach 2; D = End of reach 2).*

Figure 7. Sections of Morrissey Creek redd surveyed in 2019 by ERA contractors.
Note: Surveyed creek sections are indicated by red lines (A = Start of reach 1; B = End of Reach 1; C = Start of reach 2; D = End of reach 2).

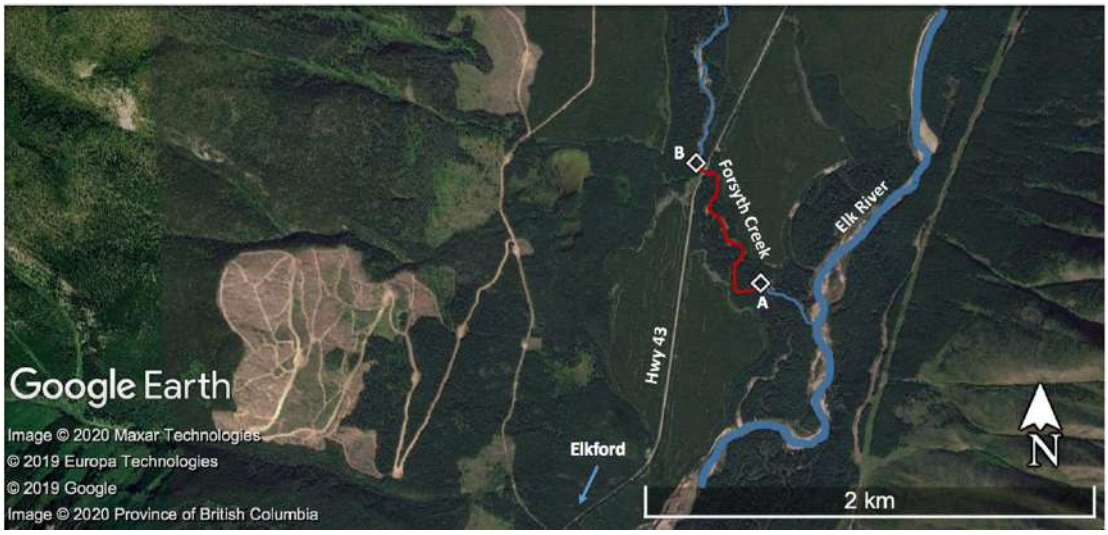

Figure 8. The section of Forsyth Creek that was redd surveyed in 2019 by ERA contractors.
Note: Surveyed creek sections are indicated by red lines Section of Forsyth Creek surveyed is indicated by the red line (A = Start of reach 1; B = End of Reach 1).

In addition, at representative sites, habitat information was recorded, including: fish presence, temperature, elevation (m), holding cover and dominant substrate (See appendix A). Reference photos were taken at each site to document size and position. Other relevant information regarding redds and/or spawning habitat was recorded in the comments.

Table 1. Description of cover type codes.

Cover Type Code	Description
LWD	Large Woody Debris
SWD	Small Woody Debris
UB	Undercut Bank
B	Boulders
DP	Deep Pools
OV	Overhanging Vegetation
IV	In-stream Vegetation

Table 2. Description of substrate codes.

Substrate Code	Description
S	Sands, silts, clay or fine organic material (< 2 mm diameter)
G	Gravels (2 - 64 mm)
C	Cobbles (64 - 256 mm)
B	Boulders (256 - 4000 mm)

Habitat Assessments

Habitat assessments were completed during late summer and fall (August – November) during low flow when streams could be safely accessed. Late season timing also allowed the evaluation of stream features, the identification of seasonal water levels and identify preliminary restoration activities (N. T. Johnston and Slaney 1996). Habitats were initially surveyed using the adapted schematic from Johnston and Moore (1995; Figure 9) to identify stream degradative factors related to surrounding areas connected to the site, including: hillslope and gully instability and erosion; riparian factors such as structure, bank instability, and large woody debris availability, and; in-stream issues such as channel or fish habitat problems. If concerns were identified an overview habitat assessment was conducted.

Habitat assessments were conducted using a standard suite of habitat feature measurements derived from Streamkeepers Module 2 – Advanced Stream Habitat Survey (Murdoch *et al.,* 1996), the Canadian Aquatic Biomonitoring Network (CABIN) Field Manual (Reynoldson et al. 2003), and the Overview Fish Habitat Assessment Guidelines (N. Johnston and Slaney 1996) outlined in Appendix A. The assessment quantifies a number of variables related to fish habitat into a single score, allowing for a rapid, quantitative assessment of the relative habitat values of the site.

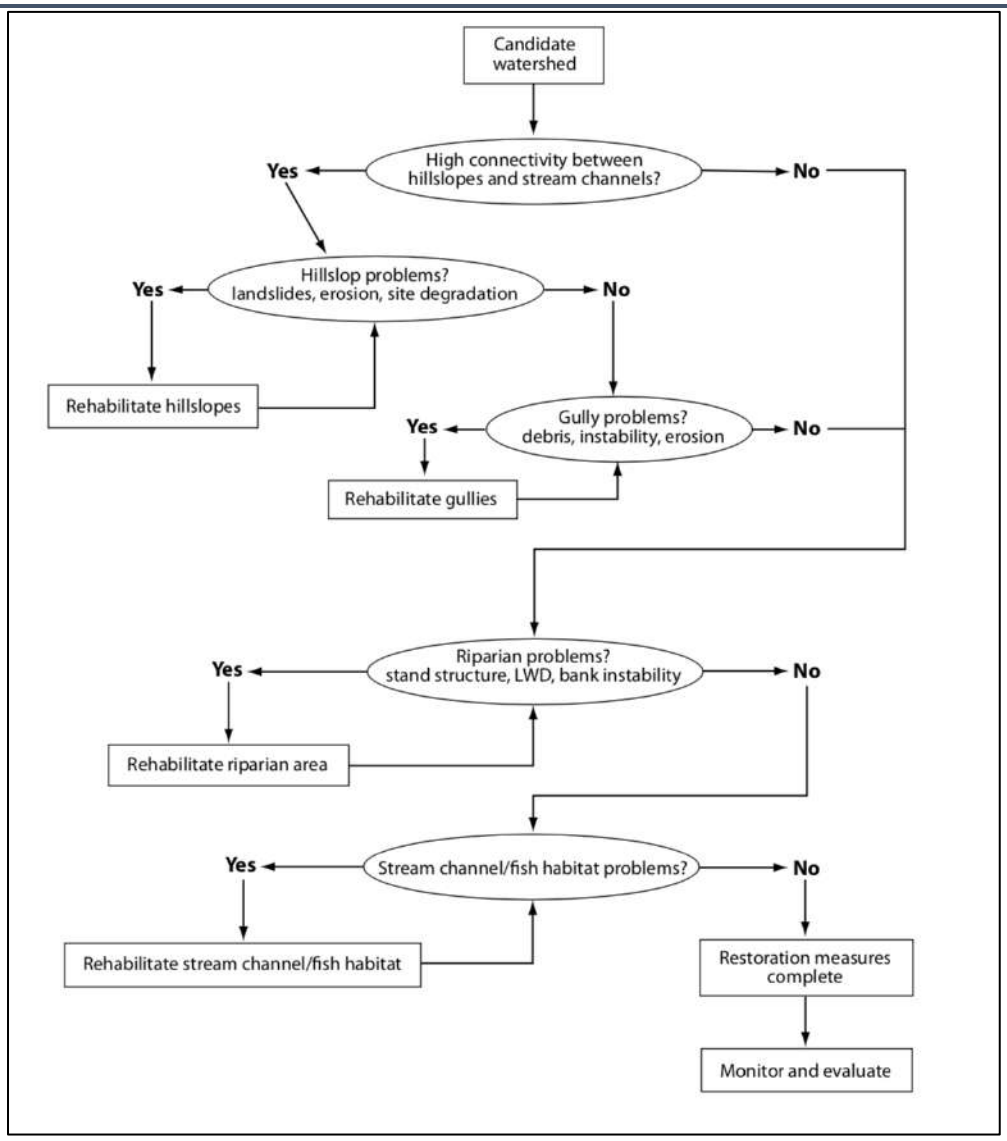

Figure 9. Overview of watershed restoration Johnston and Moore (1995)

Public Outreach

A public outreach component was developed to create education and engagement opportunities within the community. A series of educational materials were developed to increase public education on WCT health, habitat, and threats. A local graphic designer was hired to create a poster summarizing information on WCT in the Elk Valley, an infographic summarizing the WCT lifecycle, and a pamphlet summarizing the overall project and results. Educational materials will continue to be utilized at community events and are available digitally on ERA's website for public use following project completion. Additional public outreach activities included: a WCT workshop for direct public engagement; project updates on ERA's Facebook page and website; published articles in the Fernie Free Press newspaper and the website e-know.ca, and; a community night to summarize project results.

Habitat Evaluations

Habitat evaluations combined the single score from habitat assessments with prioritization criteria scores to rank degraded site for potential restoration activities (Table 3). This score was designed to provide a 'quick and dirty' assessment of restoration potential, and is not intended to, and shouldn't be used to compare sites in a wider context. Prioritization criteria scores ranged from 9 to 36, with higher prioritization score indicating a higher value rehabilitation project. Habitat evaluation scores were calculated by multiplying the habitat assessment score with the prioritization score. A high value indicated a restoration project that, in addition to having positive impacts on WCT, would also be achievable, cost effective, and have direct and indirect long-term benefits to both WTC and the community. Habitat evaluations also outlined measures required to remediate the site with a basic rehabilitation plan. Habitat prioritization scores are relative values and used to compare sites within this project only.

Table 3. Prioritization Criteria used when assessing habitat restoration potential and priority.

Prioritization Criterion	Considerations	Scoring Breakdown
One or more life stages	Expected or observed use of the surrounding habitat or tributary by 1 of more life stages of WCT? Used by other Blue-listed species (i.e. Bull Trout)?	4 = Creek used by all WCT life stages and Bull Trout 3 = Adults and spawning or rearing juvenile present with other blue-listed species observed 2 = One life stage and/or other blue listed species observed 1 = No life stages or other blue-listed species observed
Spawning or overwintering habitat	Has there been previously observed use of the surrounding habitat or tributary by WCT for spawning or overwintering?	4 = Both are confirmed to have been present 3 = Either spawning or overwintering present 2 = High potential for either spawning and/or overwintering 1 = Low potential for either spawning or overwintering
Technical difficulty	Is restoration feasible? What would it require? Higher priority given to restoration habitat which have been degraded by factors that can be addressed using the resources and skills available to ERA	4 = Project achievable in house by ERA 3 = Most of project achievable by ERA 2 = Some of project achievable by ERA 1 = None of project achievable by ERA
Complementary restoration	Would restoration or enhancement complement other projects in the stream or near-by streams? (Score 4-1)	4 = High level of complementary restoration 1 = Low level of complementary restoration
Accessibility	Is the site easily accessible? Accessible for restoration/enhancement equipment?	4 = Easily accessible from highway and within 30 minutes from Fernie 3 = Rough forestry road or more than 30 minutes from Fernie 2 = Rough forestry road and more than 30 minutes from Fernie 1 = No vehicle access within 50m or very difficult to access
Opportunities for partnership	Is there potential for partnering with other groups/organizations for this site? (Score = 4-1)	4 = High potential for partnership 1 = Low potential for partnership
Cost	Given the scope of restoration/enhancement work that would suit this site, what would the associated cost for the project look like?	4 = < $5000 3 = $5000 - $20,000 2 = $20,000 - $50,000 1 = > $50,000
Project longevity potential	Is there high potential for the project to remain intact? What factors will ensure it doesn't degrade again? How many years is the project likely to remain intact?	4 = 20 + years 3 = 10 - 20 years 2 = 5 - 10 years 1 = < 5 years
Contribution to species awareness	Would this restoration/enhancement work contribute to species awareness?	4 = High public visibility, volunteer and educational opportunities 3 = Moderate visibility or educational opportunities 2 = Low visibility or educational opportunities 1 = No visibility, volunteer or educational opportunities

Results

Redd Surveys

A total of 62 redds were observed in 8.2 km of surveyed stream sections in Lizard, Coal, Morrissey, and Forsyth Creeks. Table 4Table 5 summarize relevant information recorded during redd surveys. Raw data can be seen in Appendix C.

Table 4. Summary of data from 2019 redd surveys (Tributary data).

Tributary Surveyed	Average Approx. Gradient (%)	Average of Temp (°C)	Count of LWD	Count of SWD	Count of UB	Count of B	Count of DP	Count of OV	Count of IV
Coal Creek	4.9	8.7			1	4		4	
Forsyth Creek	1.5	4.0							
Lizard Creek	1.1	8.0	4	10	14	2	5	11	1
Morrissey Creek	1.9	7.2		1		1	1	1	1
TOTAL	**2.1**	**7.5**	**4**	**11**	**15**	**7**	**6**	**16**	**2**

Table 5: Summary of data from 2019 redd surveys (Redd data).

Tributary Surveyed	# of redds identified	Km Surveyed	Redds/km
Coal Creek	0	1.3	0
Forsyth Creek	0	1.0	0
Lizard Creek	55	2.4	22.9
Morrissey Creek	7	3.6	1.9
TOTAL	**62**	**8.3**	**7.5**

Lizard Creek

Lizard Creek contained the highest number of redds with a total of 55 redds observed within 2.4 km of stream, giving it a concentration of 22.9 redds/km (Table 4, Table 5). Lizard creek had gravel as the dominate substrate and there were diverse and abundant habitat features near redd locations, in order from most abundant to least abundant, including: undercut banks, overhanging vegetation, small woody debris, deep pools, large woody debris, boulders, and in-stream vegetation (Appendix C). The average temperature and approximate gradient of Lizard Creek was 8°C and 1.1%, respectively. Two adult WCT were visually identified near redd locations during the survey.

Coal Creek

No redds were identified on the 1.3 km of surveyed sections of Coal Creek (Table 4, Table 5, Figure 6). Coal Creek substrate was comprised of a gravel and cobble mix, with slightly more cobble. The average temperature and approximate gradient of Coal Creek was 8.7°C and 4.9%, respectively. In the lower reach 8 visually identified WCT juveniles were observed to be holding in a small, well covered side channel of Coal Creek. Several cascading waterfalls were observed, but determined not to be a barrier to fish passage at the time of survey.

Morrissey Creek

Morrissey Creek contained the second highest number of redds with a total of 7 redds observed within 3.6 km of stream giving it a concentration of 1.9 redds/km (Table 4, Table 5). Morrissey Creek had a substrate comprised of a gravel and cobble mix, with cobble being slightly more dominant. Given that fewer redds were observed, limited habitat features were recorded (see above). Overall, there appeared to be more habitat features than on Coal Creek and less than on Lizard Creek (Appendix C). The average temperature and approximate gradient of Morrissey Creek was 7.2°C and 1.9%, respectively. A few small groups of fry were observed near redd locations but were too small to visually confirm to the species level.

Forsyth Creek

No redds were identified on the surveyed sections of Forsyth Creek (Table 4, Table 5). A total of 1.0 km was surveyed on Forsyth Creek, which had substrate comprised of a near equal gravel and cobble mix. Given the lack of redds recorded, less habitat features were recorded (see Creek Creek, above). This stream reach was observed to have the least number of habitat features of all streams surveyed and higher stream channelization compared to Lizard Creek and Morrissey Creek (Appendix C). Stream channelization appeared to decrease closer toward the confluence with the Elk River. The average temperature and approximate gradient of Forsyth Creek was 4.0°C and 1.5%, respectively. No fish were visually observed during this survey.

Habitat Assessments

Habitat assessments were conducted on Elk River tributaries in a variety of locations throughout the Elk Valley, encompassing areas effected by a variety of degradative driving factors. There was a focus on Michel Creek and the Fernie area, as these areas encompassed the majority of community complaints and feedback. Habitat assessments were conducted on: Lizard Creek, Morrissey Creek, Coal Creek, Andy Goode Creek, Corbin Creek, and side channels of the Elk River. Areas of concern were identified during redd surveys, through consultations with members of the public, industry, and government, and at the first WCT workshop. Identified habitat locations and their associated concerns are listed in Table 6.

Table 5.

Table 6: Habitat sites identified for assessment and their associated concerns.

Site Number	Stream Name	GPS Coordinates (°)		Site Description/notes	Habitat Assessment Completed?
		Latitude (N)	Longitude (W)		
1	Elk River	49.52277	-115.04388	Manmade habitat above the golf course was washed away by the 2013 flood and has not been rebuilt.	NO
2	Elk River	49.46583	-115.07222	Manmade habitat below the ski hill was washed away by the 2013 flood and has not been rebuilt.	NO

3	Elk River	49.41250	-115.03500	Erosion approximately 200m above the Morrissey sawmill cutting into the highway bank.	NO
4	Elk River	49.55750	-114.99166	Hosmer subdivision approved south of Hosmer destroying riparian habitat; community concerns that Dike will likely need to be built resulting in future habitat loss.	NO
5	Elk River	49.58333	-114.96833	Cattle crossings near Hosmer resulting in damage to riparian zone and stream bed.	NO
6	Elk River	49.49100	-115.07870	Section of river near James White Park with eroded banks increasing turbidity and collapsing walking path.	YES
7	Elk River	49.49137	-115.08082	Large section of bank erosion adjacent to highway 3.	YES
8	Elk River	49.66888	-114.90222	Concerns that the riprap by Garrett Ready Mix is has been damaged.	NO
9	Elk River	49.55438	-115.00550	Dicken road access to Elk River is very steep and becoming degraded due to increased river usage. Building a dedicated launch point could improve erosion and reduce safety risks.	NO
10	Hartley Creek	49.54851	-115.01525	Dicken Road culvert at highway 3 becoming a problem for flooding on highway and potential barrier for fish on Hartley Creek.	YES
11	Elk River	49.52321	-115.05245	Side channel identified by multiple local fisherman who observed approximately 200 juvenile mountain whitefish and WCT that appeared to be trapped. Concern this is not viable overwintering habitat.	YES
12	Lizard Creek	49.48348	-115.08906	Community concerns regarding new residential development currently underway along Lizard Creek. Septic beds will be near creek.	NO
13	Lizard Creek	49.49010	-115.10577	Road 1.2 km past provincial park entrance actively eroding bank into Lizard Creek. Concern regarding stream sedimentation.	YES
14	Coal Creek	49.49722	-115.07000	Numerous banks throughout Coal Creek collapsing and depositing coal dust into the stream.	NO
15	Coal Creek	49.48750	-114.99583	People are constructing weirs near the mouth that can act as traps for fish and/or cause stream warming.	NO

16	Coal Creek	49.49540	-115.06190	Area between mouth and barn severely channelized with riprap - community would like to see some habitat development done through enhancement work as significant fish presence in this reach.	YES
17	Coal Creek	49.486641	-114.97745	Area where old bridge has collapsed into stream and metal debris has accumulated in-stream and on river banks. Lots of invasive plants present.	YES
18	Morrissey Creek	49.36212	-114.98454	Actively eroding bank on gas line, identified during redd surveys.	YES
19	Morrissey Creek	49.35920	-114.98930	Actively eroding and sliding bank, increasing turbidity and severely changing stream morphology.	YES
20	Michel Creek	49.68833	-114.81361	Hanging culvert East of Sparwood on tributary to Michel Creek. Potential to impede fish passage.	NO
21	Michel Creek	49.51999	-114.68611	Logging near Michel Headwaters between Corbin and Andy Goode creeks. Potential logging activity in riparian zone, minimal cover remaining on old reclaimed spoils from original mine site.	NO
22	Michel Creek	-	-	Bridge of concern located approx. 6 or 7 km south of cabin on the Barnes Lake Road. Residents unsure if their silt control barriers are up to code and worry that sedimentation may be an issue (road only accessible by 4x4 – not accessible in fall)	NO
23	Michel Creek	49.57297	-114.78721	From the Coal-Leach bridge, upstream to where the stream departs from Corbin Road (second rail crossing): Erosion and slope failure.	NO
24	Michel Creek	49.53527	-114.71583	Water quality concerns from tributaries below Tent Mountain. Canwel removed trees on slopes where old spoils exist from a historical mining operation on Tent Mountain. There is very little cover left and residents are concerned about the runoff from that area passing the two settling ponds and draining into the Michel Creek.	NO
25	Corbin Creek	49.51500	-114.67111	Bridge of concern – located approx. 1 km N of Corbin. North Coal is calling the road the Michel Head Road: Erosion and sedimentation concerns	NO

26	Corbin Creek	49.51334	-114.67554	Stream widening, substrate disturbance, and potential siltation resulting from ATV's or trucks driving through the creek	YES
27	Andy Goode Creek	49.52368	-114.68877	Significant logging in the area raising concerns over water quality; area near bridge with extensive erosion; falling trees and logjams forming	YES
28	Barnes Lake	49.44499	-114.70391	OHV trail development near Corbin around lake might be affecting tributaries flowing into lake (only accessible by 4 x 4)	NO

A total of 11 habitat assessments were conducted with scores ranging between 36 and 72 (Table 7). Of these, 8 sites were found to have marginal health and 3 sites were found to have acceptable health. 'Acceptable' and 'marginal' are relative judgments in the context of this project only, and should not be considered in relation to the wider region.

The average habitat assessment score was 58 out of a possible 135. Commonalities between sites that were of acceptable health, if any, included boulder & cobble dominant substrate, abundant in-stream cover, vegetated stream banks, and mild bank instability. Commonalities between sites that scored in the marginal health range included minimal habitat features (i.e. in-stream cover and pools), a limited riparian zone, and more extensive bank erosion. The majority of habitats that were found to have marginal health had more than one identified concern, according to the Johnston and Moore (1995) schematic (Figure 9). Figures 12-16 illustrate the location of each identified habitat of concern corresponding to Table 7.

Table 7: Summary of habitat assessments completed

Site code	Tributary	Latitude	Longitude	Summary of Degradative Factors and Proposed Restoration Efforts	Habitat Assessment Score	Priority Score	Evaluation Score
HAMOR1	Morrissey Creek	49.36212	-114.98454	Actively eroding bank is increasing sediment load with potential to impact fish downstream/reducing habitat connectivity. Trees are actively falling into stream off bank. High priority site for restoration given use of Morrissey Creek by WCT, adjacent land uses (gas line/active logging in catchment). Easily accessible from road via right of way. Rehabilitation requirements: bank realignment and stabilization (likely require revegetation); addition of LWD at tow slope to prevent further erosion and improve habitat.	61	22	36.07
HAMOR2	Morrissey Creek	49.35920	-114.98930	Actively eroding bank is increasing sediment load. Rehabilitation efforts would require significant work to stabilize the bank as well as either armour the eroding bank or redirect the current stream through the old stream channel to bypass the eroding sections. Rehabilitation requirements: bank realignment and stabilization (likely require revegetation); addition of LWD at tow slope to prevent further erosion and improve habitat.	62	14 to 16	23-26
HACOL01	Coal Creek	49.48668	-114.77630	Infestation of invasive plants in parts of riparian zone. Site well suited for weed pulls and mechanical removal. Large pieces of metal debris on shoreline and embedded in streambed. Site requires a shoreline and stream cleanup, approx. 3 days worth of effort for a small team of volunteers. Rehabilitation requirements: planting on right side of bank may halt erosion; large concrete block removal requiring heavy machinery or may be unfeasible to remove; weedpulls over a few seasons would be beneficial for surrounding vegetation; a shoreline cleanup to remove metal debris not embedded in the streambed.	65	24	37
HACOL02	Coal Creek	49.49540	-115.06190	Severely channelized site with an eroding bank that lacks riparian vegetation and habitat for WCT use. Moderate improvements in bank stability could be achieved with planting and hand tools. One section at the downstream area of the reach could benefit from earthmoving equipment. Rehabilitation requirements: Bank realignment and stabilization (likely require revegetation); site would benefit from low level habitat enhancement to increase habitat availability and connectivity.	36	28	78
HACOR1	Corbin Creek	49.51334	-114.67554	ATV crossing through stream. Eroding historical bridge abutments. Debris in area (large metal, wooden palates, etc.). Rehabilitation requirements: Restoration involves cleanup (2 days) and remediation of ATV tracks. This could involve restricting access (unlikely to have long term compliance without enforcement) or addition of a bridge or other crossing to alleviate sedimentation. Adding concrete or large rocks to create a more durable crossing may result in least impact to environment and local stream users. Long term planning required to address erosion of abutments into stream.	65	25	38

Site code	Tributary	Latitude	Longitude	Summary of Degradative Factors and Proposed Restoration Efforts	Habitat Assessment Score	Priority Score	Evaluation Score
HAAG01	Andy Goode Creek	49.52368	-114.68877	Actively eroding bank is increasing sediment load. Large log jam created in-stream from failed bank affecting stream morphology and potential stream widening.	50	22	44
HALIZ01	Lizard Creek	49.49010	-115.10577	Steep eroded bank adjacent to road. Rehabilitation requirements: requires bank realignment and stabilization of toe slope to prevent erosion; revegetation and addition of large woody debris would improve habitat and stabilize banks. Lizard Creek is a very significant stream for WCT recruitment.	72	26	36
HAELK01	Elk River (side Channel)	49.52321	-115.05245	Relatively small (10-20 m long) eroded bank adjacent to walking path. Rehabilitation requirements to improve habitat and stabilize banks: requires bank realignment and stabilization of toe slope to prevent erosion; revegetation with native riparian species, and; addition of large woody debris. Any rehabilitation work is within Elk River flood channel and will be affected by yearly freshet flow and intermittent flooding. Over 200 juvenile mountain whitefish and WCT observed in shallow side channel. May not be suitable habitat to support fish, and mortality during winter freeze may occur, possibly preventable by fish salvage. However, groundwater influence may be sufficient for survival.	36	25	69
HAELK02	Elk River (side Channel)	49.49100	-115.07870	Eroding bank is contributing to the undercutting of a walking trail used by recreationalists. The undercutting appears to be worsening and may be dangerous to the safety of users. Eroding banks may increase sedimentation in high flow. Rehabilitation required: restoration of the bank with some vegetation and large woody debris may provide additional pool and habitat in the main stem during high water. Any rehabilitation work is within Elk River flood channel will be affected by yearly freshet flow and intermittent flooding.	71	22	31
HAELK03	Elk River (side Channel)	49.491374	-115.080825	Large eroded bank. Rehabilitation, enhancement, and stabilization would be a large undertaking due to the extensive area, large size of banks, and size of river. Rehabilitation requirements: riprap, technical expertise, and heavy equipment to achieve satisfactory results. Vegetative riprap methodology could be used. Rehabilitation work is within Elk River flood channel and will be affected by yearly freshet flow and intermittent flooding.	53	16	30
HAHAR01	Hartley Creek	49.54861	-115.01510	Culvert at site is collapsing and may pose a barrier to fish passage while being a potential hazard to the creek/highway. Rehabilitation requirements: Replacement of culvert. This would have to be done in conjunction with Ministry of Transportation/Main Roads to rectify constricted culvert.	67	23	34

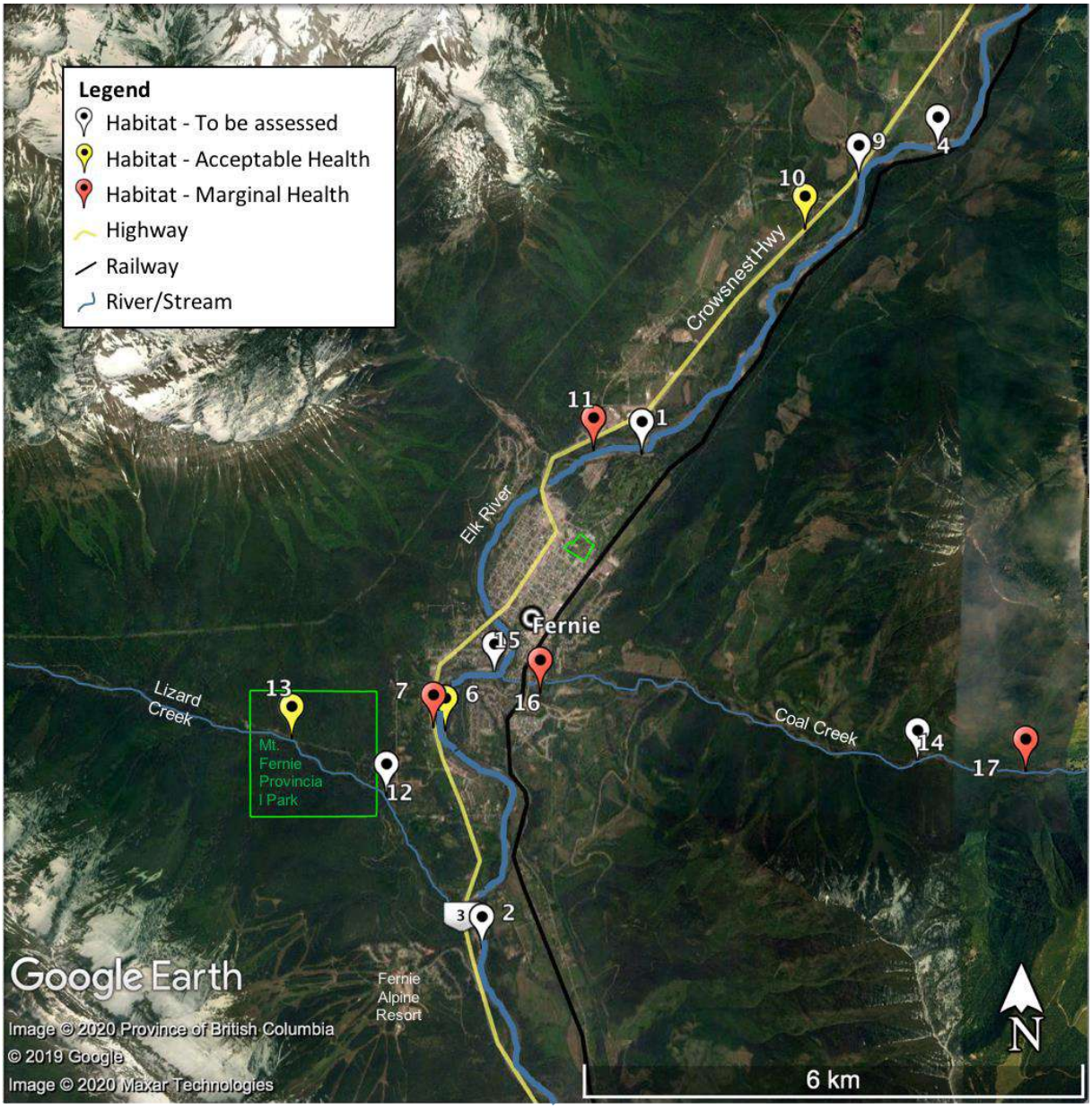

Figure 10. Identified habitat of concern in the Fernie, B.C. area.
Assessed habitats found to have marginal health are indicated by red points, assessed habitats found to have acceptable health are indicated by yellow points, and identified habitats that require future assessments are indicated by white points.

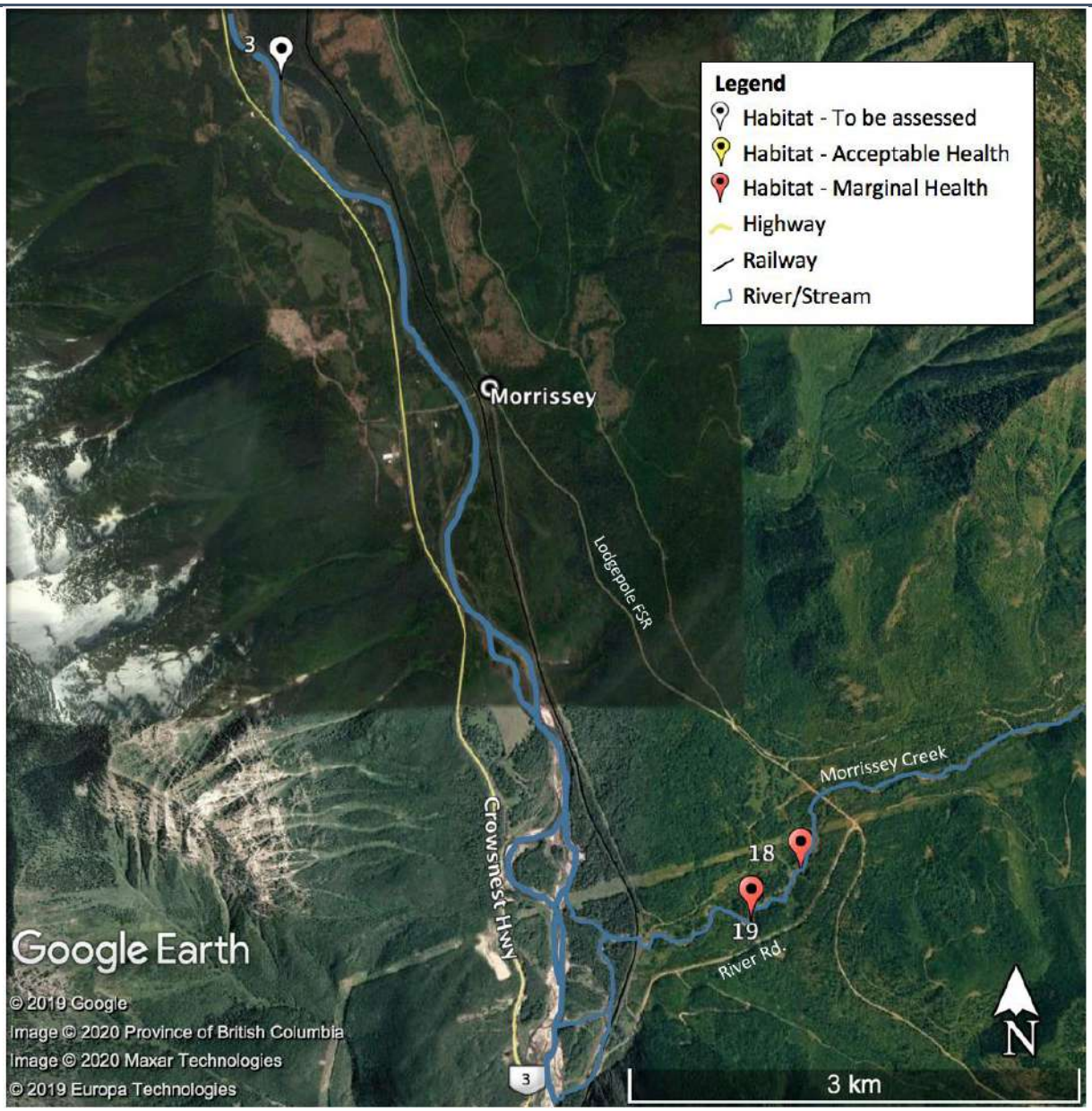

Figure 11. Identified habitat of concern in the Morrissey, B.C. area.
Assessed habitats found to have marginal health are indicated by red points, assessed habitats found to have acceptable health are indicated by yellow points, and identified habitats that require future assessments are indicated by white points.

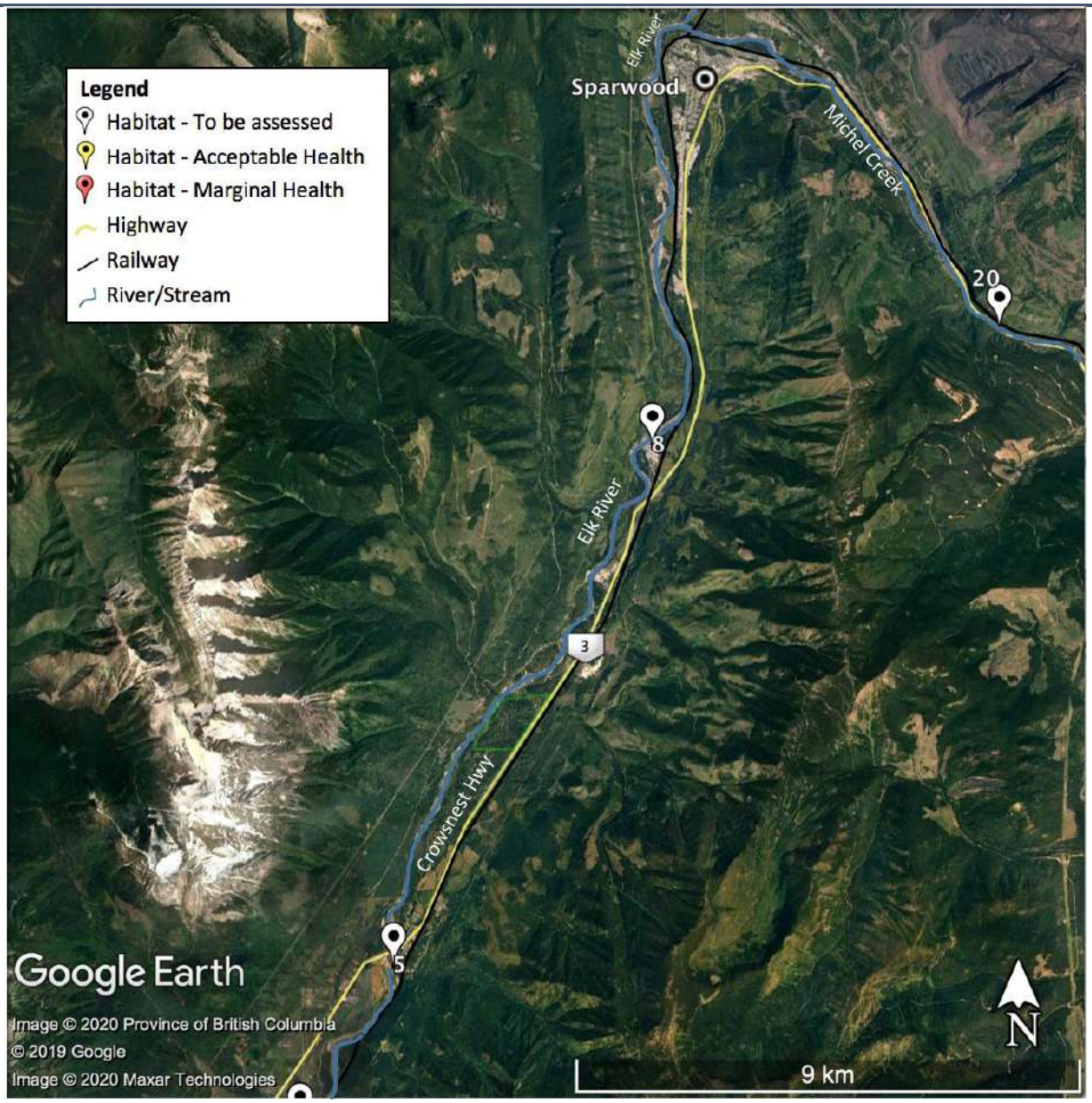

Figure 12. Identified habitat of concern in the Sparwood, B.C. area.
Assessed habitats found to have marginal health are indicated by red points, assessed habitats found to have acceptable health are indicated by yellow points, and identified habitats that require future assessments are indicated by white points.

Figure 13. Identified habitat of concern in the Corbin, B.C. area.
Assessed habitats found to have marginal health are indicated by red points, assessed habitats that were judged to be in better health are indicated by yellow points, and identified habitats that require future assessments are indicated by white points.

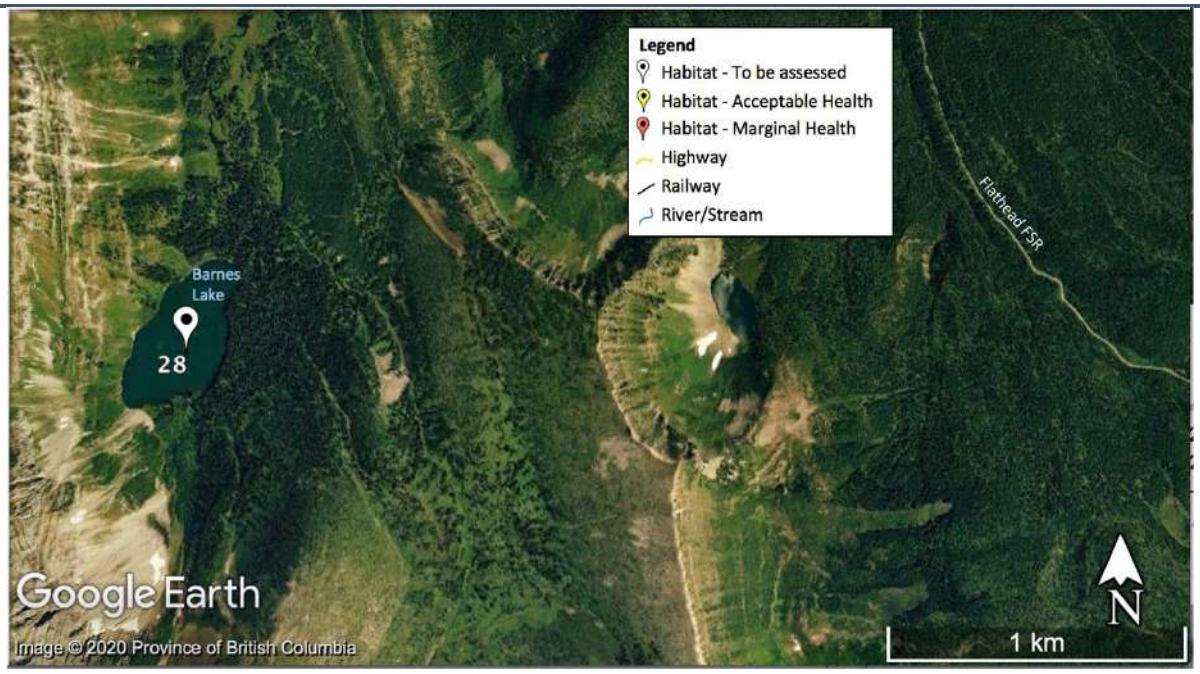

Figure 14: Identified habitat of concern in the area surrounding Barnes Lake, Southwest of Corbin, B.C. Assessed habitats found to have marginal health are indicated by red points, assessed habitats found to have acceptable health are indicated by yellow points, and identified habitats that require future assessments are indicated by white points.

Public Outreach

Table 8 outlines the volunteer contributions to different components of the project and the number of online and print articles that were produced. A series of educational materials were published in print and online form to help educate the public on WCT health, habitat, threats, and conservation (Appendix D).

Table 8: Volunteer contributions and outreach metrics for the WCT Research Initiative.

Component	# volunteers	Volunteer hours	# participants	# Articles
Redd Surveys	9	56		
Habitat Assessments	26	79		
Workshop 1	3	5	17	
Workshop 2	10	40	75	
Online Articles				1
Print articles				2

Survey Constraints and Limitations

A breakdown of some of the potential limitations impacting redd surveys is detailed in Table 8 and habitat assessments in Table 9.

Table 8: Potential limitations of redd surveys

Aspect	Project Constraint	Comments Regarding Redd Surveys
Competency/experience of surveyors	Yes/Maybe	Surveyors consisted of a project lead and a team of volunteers. ERA surveyors were new to redd surveying this year but received training from experienced fisheries biologists. A lack of experience would have affected redd observations. ERA continues to work with regional biologists to refine skills and methodology
Objectives	No	The objectives were clearly defined and realistically achievable within the designated timeframe.
Timing / weather / seasonality	Yes	There is a very narrow and variable window for WCT spawning, dependent on a variety of factors that change from year to year. It's possible redd surveys did not coincide with peak spawning periods leading to skewed results. Forsyth Creek in particular was likely surveyed too early for spawning activity as stream temperature at the time of survey was too low for spawning WCT (4°C, WCT typically spawn at 7°C).
Proportion of task achieved/further work needed	Maybe	The proposed activities were achieved based on the objectives. However, the entirety of potential redd habitat on each tributary was not surveyed, and many Elk River tributaries were not surveyed in 2019 due to funding and timing restraints. Ongoing survey effort is needed to evaluate the continual use of these streams by WCT.
Completeness	Yes	Priority sections of tributaries were surveyed given the objectives and project feasibility. However, fish may have spawned in other sections of the stream that were not surveyed (See 'Proportion of task achieved/further work needed'). Further, available resources only allowed for each stretch to be surveyed once during the spawning season. Therefore, evidence of spawning may have been missed in those stretches if they occurred significantly before or after the survey date.
Resources	Yes/Maybe	Existing resources were adequate, additional resources could have improved data and information recorded. SOKKIA unit, drone, and flow meter are examples of resources that could have increased the data and/or parameters collected. Increased budget/survey time would have corresponding improvements in survey completeness.

Aspect	Project Constraint	Comments Regarding Redd Surveys
Remoteness/access Issues	Yes	Sections of some tributaries are remote and difficult to access, restricting the section of stream that can be surveyed and limiting the collection of data.

Table 9: Potential limitations of habitat assessments.

Aspect	Project Constraint	Comments regarding habitat assessments
Competency/experience of field staff	Partial	Surveyors were trained in CABIN and Streamkeepers protocols and have the competency to execute outlined work. A lack of in-depth experience was mitigated in part by consulting with regional fish experts and professionals.
Objectives	No	The objectives were clearly defined and realistically achievable within the designated timeframe.
Timing / weather / seasonality	No	Habitat assessments were not constrained by timing, weather or seasonality
Proportion of task achieved/further work needed	Maybe	The task was achieved based on the objectives. However, further habitat assessments need to be conducted to enable a more comprehensive understanding of WCT habitat health.
Completeness	Yes/Maybe	Only selected sites were surveyed given the objectives and feasibility of the project. Additional time/resources required to assess additional identified sites of concern.
Resources	Yes	Refined parameters and habitat health evaluation tools would improve the quantitative and qualitative data collected during habitat assessments.
Remoteness/access Issues	Yes	Sites were chosen in part by accessibility, limiting ERA's ability to assess some locations.

Discussion and Recommendations

Redd Surveys

Discussion

Lizard Creek had the highest number of redds of the sections of tributaries surveyed. Lizard Creek is well known locally as being an important tributary for WCT recruitment, and previous research has identified redds in the same vicinity as this study and in other parts of Lizard Creek. Lizard Creek has ideal conditions for WCT spawning given its undisturbed condition, gravel substrate, average stream temperature of 7°C, low gradient (1.2%) and abundance of habitat features. Typically, WCT seem to select redd locations with similar characteristics throughout the Elk river watershed (Prince and Morris 2003).

In comparison to Lizard Creek, the surveyed stretches of Morrissey Creek, Coal Creek, and Forsyth Creek had relatively fewer WCT spawning features, which may be the reason why few or no redds were observed in these locations. The surveyed sections of Morrissey Creek appeared to have an optimal temperature (7.2°C) and gradient (1.9%) for WCT spawning, along with favorable habitat features including sections of gravel deposits. A small number of redds and usage by WCT were observed. Previous research has identified WCT spawning activity in the 2001 and 2002 spawning seasons on sections of Morrissey Creek that appeared to overlap with the second reach ERA surveyed (Prince and Morris 2003). This previous research also saw spawning activity closer to the confluence of the Elk River, downstream of the train tracks, which is an area just outside of the scope of this study (Prince and Morris 2003). WCT spawning in the reaches surveyed are likely limited by the availability of suitability spawning habitat. Given observations by Prince and Morris (2003) and visual assessment of current aerial photography, it is likely that suitable spawning habitat exists downstream of the train tracks and future redd surveys should target this area.

The lack of redds identified on the surveyed stretches of Forsyth and Coal Creeks could be due to a number of reasons which include: inadequate habitat in surveyed stretches (further surveying required to assess habitat quality in additional stream stretches); sub-optimal temperature for fish spawning during the 2019 season, and; poor timing of redd surveying. Both tributary stretches surveyed were found to lack characteristics of streams that are usually selected for by spawning WCT, had fewer habitat features, and had average substrates with bed material that is typically too large for WCT to dig redds.

Historically, Forsyth and has been found to be the site of a small amount of WCT spawning activity in the 2001 and 2002 spawning seasons (Prince and Morris 2003). However, the section of stream surveyed (identified by members of the community and regional biologists as a potential site for spawning) lacked ideal spawning habitat, and it is possible WCT utilized other sections of the stream for spawning. Further, it is possible that the narrow window when redds can be easily observed was missed by surveyors. WCT spawning is largely determined by the hydrograph and weather patterns, and the window for identifying redds can easily be missed if weather patterns shift. Forsyth is higher in the watershed, both in terms of elevation and up valley, and at the time of survey water temperatures averaged around 4.0°C which is outside of the optimal range for spawning (Brown and Mackay 1995a). Future redd surveys should be repeated over a larger window of time to properly catch the spawning window. Future redd surveys should also focus on downstream sections of the tributary closer to the confluence where there appears to be more variation in stream morphology and has the potential for greater spawning habitat. Surveys will be difficult due to the local environment and impediments to access that limited the extent of surveys

on Forsyth Creek.

Coal Creek is another tributary that community input and historical studies have suggested is used by WCT during spawning season (Prince and Morris 2003). Coal Creek had an average temperature within the optimal range (8.7°C) during surveys, although temperature is not the sole indicator of spawning conditions. The average gradient of the surveyed stretch of coal creek was relatively high at 4.9%, more than double the gradient of the other tributaries surveyed. Previous research has found the majority of WCT spawning occurs in streams with a gradient between 0.5% and 3.8%, with no spawning typically occurring at gradients greater than 4% (Magee et al. 1996). WCT may be spawning elsewhere in Coal Creek given the presence of WCT juveniles observed holding in side channels of the stream (a good indicator that spawning occurred within the past few seasons), it's possible the shallower gradient sections in the downstream reaches of Coal Creek are more productive in terms of spawning habitat. Downstream areas have been more heavily impacted by human and industrial activity and have seen greater riparian habitat degradation, and are therefore potentially critical areas for habitat restoration given the reduced spawning habitat available in the upstream sections of Coal Creek.

Beyond the potential study design constraints that may have impact redd surveys, it is important to note the possibility that conditions were not optimal for trout to utilize these streams this year and trout spawned in other areas, for example, in side-channels of the Elk River mainstem instead, which has been known to occur in lower flow years (Prince and Morris 2003). Coal Creek in particular is impacted by a number of factors that could limit current spawning potential, particularly sedimentation stemming from logging and road development. Further, community comments and discussions with Teck environmental personnel indicate that 2019 was a poor season with less than normal redd numbers (pers. com. Allie Ferguson, Teck Resources LTD, 2020). The timing of fish spawning is not inherently consistent, and it can be difficult to identify spawn time and location based on the multitude of variables that exist within a stream in terms of both physical and seasonal conditions. Any assumption made on the subject of timing and location contain a level of uncertainty.

The limitations mentioned above and in Table 8 and Table 9 are relevant for all tributaries surveyed, particularly in terms of timing and resource constraints. WCT redd utilization is subject to many variables and therefore creates opportunity for human error. However, they do serve as a simple and minimally intrusive method of gathering baseline population information. Ultimately the value of redd surveys lies in long-term monitoring to track changes over time and space to give a relative measure of population changes. Further survey effort is required on these streams to determine their level of importance for WCT recruitment and to help track changes.

Finally, it is worth noting that around the time of writing Teck Resources LTD indicated that the Upper Fording River, Harmer, and Grave Creeks experienced significant declines in both adult and juvenile populations. The extent, causes, and potential downstream effects of these discoveries are unclear. Likewise, should the findings prove verified, it is unclear if these declines are appearing elsewhere in the watershed given the limited surveying. These events highlight the need for greater understanding of WCT population dynamics in the Elk Valley.

Recommendations

The Elk River has a large number of tributaries with the majority not comprehensively and/or recently surveyed for redd presence or concentration. Given the numbers of redds identified in the four creeks surveyed in 2019, it is recommended future survey efforts concentrate on tributary segments with strong

habitat values such as those found in Lizard Creek. Particular focus should be made on creek segments with low gradients, suitable temperature and substrate, and habitat complexity; most of these characteristics are relatively easy to identify using GIS data and subsequently ground truth. Surveys in future years should continue to include informative input from community, government, and private sector contributors.

The creeks surveyed in 2019 would benefit most from additional search efforts. Both upstream and downstream of the 2019 Lizard Creek survey area likely house additional redd habitat, including areas outside the Mount Fernie Provincial Park that should be investigated. The lower reaches of Morrissey would benefit most from additional effort, as this area is under explored compared to Lizard Creek and would confirm if spawning locations are static in this area. Upstream of the Morrissey survey area has higher gradients and is not likely to house significant redd locations, if at all. Surveys in the lower sections of Forsyth and Coal Creeks would have merit in the future given the potential for better spawning habitat. Given the lack of redds in the surveyed sections of Forsyth and Coal Creeks, a review of redd survey timing and methodology has merit. In the future, either multiple redd surveys should occur over the spawning season, or surveys should be limited to optimal spawning conditions.

Habitat Assessments

Habitat assessments were conducted to evaluate areas of concern, determine the nature of degradation, and avenues for restoration. This information will allow ERA to focus restoration and enhancement work in areas where improvements will create the greatest positive impact to the aquatic environment, WCT populations, and the local community. Habitat site sheets can be found in Appendix E and provide the rational for the site-specific discussions. Habitat assessments are discussed individually below.

Discussion and Recommendations

Habitat assessment discussions and their subsequent recommendations for the 11 sites selected are provided for the individual sites below. Site numbers are included for each habitat assessed, which corresponds to Table 7 and Figures 12-16. Of these, three were identified as particularly viable for restoration work. Restoration plan proposals for these three are included in Appendix F. A number of sites identified in Table 7 were not assessed in 2019.

HAMOR1 (Site #18) – Morrissey Creek Habitat Assessment 1

HAMOR1 is an identified site on Morrissey Creek located at 49.36212, -114.98454 that received a habitat assessment score of 61, priority score of 22, and evaluation score of 36.7 (Table 7). This site is centered around a 37 m long failing bank along a FortisGas gas line right of way that was witnessed washing sediment into the stream during a high rainfall event and increasing downstream turbidity. Site concerns include undercut trees falling into water way, increased sedimentation, low habitat values, and channelization (Figure 15). While erosion is a natural feature, in this case the erosion may impact a gas line, and arresting erosion now will save the necessity of more invasive realignment or armouring of the line in the future.

Morrissey Creek provides spawning and rearing habitat for WCT (Prince and Morris, 2003), and while redds were not observed during ERA's 2019 redd surveys the creek provides important fish habitat and may be utilized by WCT for spawning in areas with appropriate features, thus increasing the priority of restoring this site. While the site has low off-channel and pool habitat, the site has the appropriate

gradient (1.1%) and bed composition to provide rearing habitat, particularly if restoration works were to include large woody debris as toe anchors of the eroding slope that would subsequently create pool habitat.

The surrounding riparian zone was noted to be in generally acceptable health, and there was some instream cover within the reach. Downstream of the site off channel habitat was observed. Overall, the site provided some fish habitat but the eroding bank was greatly reducing habitat and water quality.

This site could be rehabilitated through the use of bioengineering techniques. Rehabilitation would entail re-shaping the stream bank, adding/repositioning LWD at the toe of the slope, and planting/seeding/staking native riparian vegetation on the bank. The end goals would be to stabilize the bank, limit erosion to decrease sedimentation and turbidity, promote restoration of the riparian zone, and create in-stream habitat for WCT. Project design and costs would be similar to restoration work in the past (i.e. Elk River Alliance's 2014 Alexander Creek Restoration). The Alexander Creek restoration site has proven stable to 2020, indicating long term viability. As redds have been observed both downstream and upstream of this site (ERA redd surveys, 2019), increasing the habitat value here could increase connectivity and productivity in the stream.

Given the location of the site on private land and the presence of Fortis gas line, cooperation and additional permits would be necessary. Project partners would likely include Canwel (donating logs for LWD implementation) and Fortis (providing project support and access).

Should restoration efforts take place a complementary public outreach initiative should be implemented. This would engage community volunteers with hands-on restoration and riparian planting work, as well as provide an opportunity for environmental education for volunteers on the importance in conserving WCT habitat.

Figure 15. Photos of HAMOR1 (Site #18) on Morrissey Creek.
Trees are seen falling into bank along a large section where the slope as failed.

HAMOR2 (Site #19) – Morrissey Creek Habitat Assessment 2

HAMOR2 is an identified site on Morrissey Creek located at 49.3592, -114.9893 that received a habitat assessment score of 62, priority score of 14-16, and evaluation score of 23-26 (Table 7). This site is centered on a large, approximately 100 m long, steep failing bank and slopes in a tight bend in Morrissey

Creek. The site hydrology is complicated and includes several springs that have caused slumping and ongoing, near-continuous sedimentation of the slope into Morrissey Creek, visibly increasing downstream turbidity (Figure 16).

Morrissey Creek provides spawning and rearing habitat for WCT (Prince and Morris, 2003), and while redds were not observed during ERA's 2019 redd surveys the creek provides important fish habitat and may be utilized by WCT for spawning in areas with appropriate features, thus increasing the priority of restoring this site. On the survey date Rocky Mountain Whitefish were observed 18 m upstream of the site. The site has numerous concerns for WCT including a large eroding slope causing sedimentation and water quality concerns, and a lack of overhead canopy. However, the site has the appropriate gradient (1.1%), relatively acceptable pool habitat, and an ideal bed composition with 44% gravel to provide rearing habitat to WCT. The site also has off-channel habitat providing potential rearing habitat.

Given the location of the site on private (Canwel) land, partnership with the landowner and additional permits would be necessary. Canwel may be willing to donate logs for LWD implementation and be interested in partnering on the project.

Restoration efforts at this site would be complicated and challenging given its difficulty in access, scale of the project required, and associated costs. As such it is beyond the capacity of ERA to execute. Rehabilitation efforts would require significant in-stream work to mitigate bank erosion, either armour the eroding bank with riprap or large woody debris, or redirecting the current stream through an older stream channel to bypass the eroding sections. Additionally, significant earthworks and realignment would be required. Furthermore, springs throughout the slope may hinder the efficacy of restoration efforts. A professional geomorphologist and hydrologist would need to be consulted in assessing the feasibility of restoration and developing field plans for this site. This restoration project could benefit from a collaboration with multiple partners, such as ERA, FLNRORD, Canwel, Lotic Environmental, and KNC. Restoration may be most feasible via work by hand or through the use of a spyder hoe. A project at this site could also include a research and monitoring component to assess benthic invertebrates and fish densities before and after restoration work.

Similar to HAMOR02, while the site is not near main roads and out of public view, restoration should include a complementary public outreach component. This could involve community in hands-on restoration and riparian planting work, as well as provide an opportunity for contractors to educate these volunteers on the importance in conserving WCT habitat.

Figure 16. Photos of HAMOR2 (Site #19) on Morrissey Creek.
A large section of the stream bank that has failed can been seen depositing sediment and vegetation into the stream.

HACOL01 (Site #17) – Coal Creek Habitat Assessment 1

HACOL01 is an identified site located at 49.48664, -114.97745 that received a habitat assessment score of 65, priority score of 24, and evaluation score of 37 (). HACOL01 is centered around the remains of an old bridge, with remnants of large concrete embankments that have fallen into the creek over time. The cement embankments have altered the streams morpholdogy, but do not appear to be causing further degradation and their removal may cause more disruption to stream health than improvement (Figure 17).

The site was found to have a generally healthy riparian zone with large species diversity and good overhead and instream cover. However, there is approximately 70 m long eroding slope with invasive plant (Common Tansy, Spotted Knapweed, Burdock, Hound's Tongue) colonization on the slope and nearby that is reducing the riparian and habitat quality of this site. Minus the stretch along the eroded bank, the area has good spawning habitat with a decent substrate composition in favour of cobbles and gravels, and a slope of 2.9%, along with significant LWD, rooted cutbanks, and 33% pool habitat providing year-round fish habitat.

Despite redds not being observed at the site during the surveying period, the site has relatively decent spawning habitat aside from the stretch of bank erosion into the stream. The stretch lacks overhead cover and could be a contributing reason why WCT were not observed using the site for spawning in the 2019 season. WCT have historically been observed both spawning in and utilizing Coal Creek for habitat, though the creek has many historical and contemporary impacts including coal mining, logging, and public use of forestry roads.

The primary concern for the site is the eroding slope, resulting lack of vegetation overhead, and presence of invasive species that are reducing the successful colonization of the slope by native plant species. The site is littered with metal debris both on the shoreline and in-stream (likely from the old mine and township). Restoration work could be relatively straightforward as the site has good accessibility and could be done without heavy machinery to reshape the slope. Reshaping the slope would increase the likelihood of success of the project marginally, but the increased damages and risks associated with mobilizing heavy machinery do not make it worth it.

The recommended restoration activities for this site include implementing clean-up efforts to remove metal debris and invasive plants and planting native vegetation and live stakes along the eroded slope to help stabilize it and provide overhead coverage. Restoration should be paired with public outreach involving volunteers and/or school groups to assist with enhancement activities. Involving community members and youth promotes understanding of conservation activities and enhances stewardship of Coal Creek. Volunteer involvement at this site, particularly weed pulls with school groups, is achievable given site proximity to Fernie, ease of access, and relative simplicity of restoration requirements.

Figure 17. Photos of HACOL01 (Site #17) on Coal Creek.
A historic bridge that collapsed into the stream can be seen altering the surrounding stream morphology. A slumping bank can also be seen with invasive plants growing on it.

HACOL02 (Site #16) – Coal Creek Habitat Assessment 2

HACOL02 is an identified site located at 49.49540, -115.06190 extending approximately 250 upstream from the Cokato Rd bridge. This site received a habitat assessment score of 36, priority score of 28, and evaluation score of 78 (Table 7). HACOL02 is a section of stream that has been severely channelized and lacks suitable habitat for fish (Fig. 20). There are no pools or rooted cutbanks, and minimal large woody debris and overhanging vegetation; 80-85% of the bank is devoid of vegetation and consists of large boulders. The riparian zone has been heavily impacted by human activity and is constrained between a logging road and urban development. Coal Creek has historical impacts stemming from an abandoned township, defunct coal mine and logging, while contemporary impacts include ongoing logging and public use of forestry roads, all of which have had a negative impact on WCT.

The gradient is 2.98% and the bed composition consists of gravel, cobbles and boulders, with 50% embeddedness, allowing for the potential creation of spawning habitat. However, the lack of cover and instream habitat features makes this site an unlikely location for spawning activity.

This site would be suitable for riparian plantings to improve instream cover. The addition of LWD would improve habitat complexity, connectivity, and potential rearing/spawning opportunities. However, by first improving the riparian zone, LWD will naturally be added to the site and will provide long-term benefits (Hartman et al. 1996). Given the extensive disturbance to the area, improving the riparian zone should be the focus of restoration efforts.

Improvements to the riparian zone and moderate improvements in bank stability could be achieved with planting live stakes using hand tools. One section of eroding bankside at the downstream end of the reach

could benefit from earthmoving equipment, though this section is located on bedrock so erosion is not as severe as other sites. Given ongoing cumulative impacts on Coal Creek (particularly sedimentation from ongoing logging, among other factors), restoration and habitat enhancement would help offset upstream effects. Creating deeper pools with LWD habitat will slow down flow, allowing suspended sediments to settle from the water column. Additionally, given the high level of existing rip-rap throughout the site it may be an ideal location for a vegetated riprap pilot project. This may be a project the City of Fernie would be interested in partnering on.

This reach is easily accessible from town and could provide an opportunity for a high visibility restoration and community outreach program. Enhancement work could involve community in hands-on restoration and riparian planting, as well as provide an opportunity for contractors to educate these volunteers on the importance in creating WCT habitat. Sign placement would provide ongoing educational opportunities.

Figure 18. Photos of HACOL02 (Site #16) on Coal Creek.
A heavily rip-rapped and channelized section of Coal Creek that has few habitat features and cover for inhabiting fish.

HACOR01 (Site #26) - Corbin Creek Habitat Assessment 1

HACOR01 is an identified site of concern located at 49.51334, -114.67554, approximately 50 m upstream of the Corbin-Michel Creeks confluence. The site received a habitat assessment score of 65, priority score of 25, and evaluation score of 38 (Table 7).

HACOR01 provides relatively good fish habitat and potential rearing habitat, with a gradient of 1.14%, and a substrate composition of 44% gravel and 56% cobble with 30% embeddedness. There are a number of large woody debris in the stretch surveyed, 13% pool presence, and a nearby wetland and off channel habitat that would provide year-round coverage to WCT. The riparian zone is healthy with good coverage of grasses, shrubs, and trees, though there is low (7%) overhead canopy coverage and no rooted cutbanks.

This site is the location of a decommissioned bridge embankment with some resulting erosion issues along 10 m of bank. The site also has a notable invasive plant presence (i.e. Blueweed, Mullein), particularly along the eroding slope, and large debris on stream banks and nearby, likely the result of the historical bridge access. According to local residents of Corbin, B.C., the abutments are comprised of clinker, or coal combustion waste products; this may be reducing the water quality of the site.

An uncontrolled, unmarked ATV crossing below the embankment is likely causing the stream to widen and encourages irresponsible recreational use through gravel beds that would otherwise provide good rearing habitat (Fig. 21). Juvenile trout have been found near this site and in-stream which would be adversely affected by ATV use of the stream.

HACOR01 is downstream from the Coal Mountain coal mine that may be contributing to lower habitat value. Coal fines have been documented settling on the streambed and were observed during habitat inspections likely having a negative affect on WCT and aquatic health. Further, Corbin Creek has been found to have elevated levels of calcite, poor water quality, and a poor benthic invertebrate community (Windward Environmental et al. 2014). However, Corbin Creek feeds into Michel Creek, home to important spawning and rearing habitat for WCT (B.C. Ministry of Environment 2014). Both Michel Creek and Corbin Creek have been exposed to ongoing anthropogenic influences, including: logging, coal mining, and road works, and it is therefor important to do all that is possible to help remediate fish habitat in the area to help WCT.

One of the primary recommendations for this site would be addressing the ATV crossing and education for trail users. The crossing is not part of a known ATV trail and may infrequently be used by larger vehicles. Restricting access with a gate and providing signage may get long term compliance with minimal effort, though the trail will need to be decommissioned to ensure full compliance. Installing a bridge would be a more likely manner to receive compliance, but would have prohibitive cost. A middle ground solution would be to install a rock/concrete instream crossing that would effectively reduce sedimentation. Adding concrete or large rocks to create a more durable crossing may result in least impact to environment and local stream users. Teck Resources LTD, local conservation officers, and regional ATV clubs would need to be consulted regarding the appropriate actions to be taken, and any project implementation should include an education component on better educate trail users.

Further restoration activities should include removing surrounding debris and invasive plants from the site through a series of cleanup events, and planting native shrubs and grasses along the eroded bank to reduce erosion. This will reduce issues of bank destabilization and erosion resulting in sedimentation, though a proper reclamation of the eroding abutments would be preferred.

This site exists on crown land but access may require partnership with local landowners. To access the site from highway 3, turn onto Corbin Rd, approximately 7.5 km west of the Alberta/BC boarder. Take Corbin Rd for approximately 22 km and turn south onto Barnes Rd and travel another 500 m to the site.

Figure 19. Photos of HACOR01 (Site #26) on Corbin Creek.
A section of stream that has been driven through by vehicles can be seen here alongside a failing bank that is just upstream from vehicle crossing.

HAAG01 (Site #27) – Andy Goode Creek Habitat Assessment 1

HAAG01 is an identified site of concern located at 49.52368, -114.68877, approximately 40 m downstream of the bridge on Corbin Rd. HAAG01 received a habitat assessment score of 50, priority score of 22, and evaluation score of 44 (Table 7). This site is subject to slope failure and stream widening creating shallow stream morphology and sedimentation concerns.

While WCT were seen at the nearby bridge, HAAG01 does not provide ideal fish habitat due to the active erosion and limited cover. 50% of the reach surveyed lacks riparian vegetation, with 45 m of the bank exhibiting active erosion. There is one 12 m cutbank and a logjam providing some habitat, but the stream is very shallow in this stretch on account of the river widening. However, if not for this the streambed substrate is ideal for fish spawning with 56% gravel and 44% cobble, and the gradient is 0.36%. Further, previous studies have found that the site has good water quality and benthic invertebrate communities (Windward Environmental et al. 2014). WCT have also been captured in Andy Good Creek (Interior Reforestation 2011) and approximately 1 km upstream of the site has been reported as having ideal riffle habitat, gradient, and riparian vegetation (Minnow Environmental Inc 2014). Andy Goode Creek is a tributary of Michel Creek, home to important spawning and rearing habitat for WCT. Land use in the surrounding area includes logging activities upstream of HAAG01 which may have increased surface flows, resulting in the degradation of this site.

This site would benefit from rehabilitation through the use of bioengineering techniques. A combination of LWD, re-shaping the stream bank and planting native riparian vegetation on the bank would be beneficial. The site is adjacent to a highway with easy access.

Rehabilitation would entail reshaping and stabilizing the eroded bank, planting a series of brush layers containing native shrubs (red osier dogwood, black cottonwood), and the placement of rootwads at the toe of bank to help armour the slope. This would help limit sedimentation and turbidity, promote restoration of the riparian zone, and create new in-stream habitat for WCT. Project design and costs would be similar to restoration work completed by ERA in the past (i.e. Elk River Alliance's 2014 Alexander Creek Restoration). The Alexander Creek restoration site has proven stable to 2020, indicating long term viability.

Upstream of the highway/bridge is crown land and downstream is privately owned land. Cooperation and additional permits may be necessary depending on scope of works. Teck Coal Ltd. may be interested in partnering on a restoration project given the proximity to their land. Guiding outfitters and independent environmental agencies may also be interested in partnering given the importance of this system and its exposure to anthropogenic influence.

The road adjacent HAAG01 is not frequented by the general public aside from trout fishers and back country enthusiasts; however, if restoration efforts took place a complementary public outreach initiative could be implemented. This could involve community volunteer assistance in hands-on restoration and riparian planting work, as well as provide an opportunity for contractors to educate volunteers on the importance in conserving WCT habitat.

Figure 20. Photos of HAAG01 (Site #27) on Andy Goode Creek.
A section of stream consists of a slope failure and stream widening creating shallow stream morphology and sedimentation concerns.

HALIZ01 (Site #13) - Lizard Creek Habitat Assessment 1

HALIZ01 is an identified site of concern located at 49.49010, -115.10577 that received a habitat assessment score of 72, priority score of 26, and evaluation score of 36 (Table 7). The site includes a steep, eroding slope that threatens to undercut the adjacent access road. Despite this, the site provides good fish habitat with a 31 m cutbank, 11 pieces of LWD and several small pools. 27% of the surveyed reach includes overhanging vegetation and good overhead cover. Gradient of the site is 2.05% and the substrate consists of 16% gravel and 84% cobble.

The unstable slope is 22.7 m long and is immediately adjacent to a road. This is of immediate concern as the erosion is threatening to undercut the road, which risks eventually failing into the stream (Fig. 23). The lack of space between road and stream could complicate re-vegetating and re-shaping the slope. The road lies within the provincial park boundaries, and will likely be a project of interest to them as this is a critical piece of infrastructure on their land. Further, Island Lake Lodge may also be interested in partnering on this project as the road is necessary for accessing the property. Consultation with environmental restoration experts including geomorphologists and engineers will be required to assess what can be done to accommodate the restoration of the site given the steep pitch of the eroding slope and proximity to the road. Likely the road would need to be moved or narrowed in order to accommodate reshaping the slope and placing LWD instream to deflect erosional forces. A combination of adding/repositioning LWD, re-shaping the stream bank and planting native riparian vegetation on the bank would be effective. This would stabilize the bank, limit sedimentation and turbidity, promote vegetation of the riparian zone and create in-stream habitat for WCT. A smaller scale, less costly, and shorter-term fix would be to plant a number of native shrubs such as willows along the eroding slope to help stabilize the soil and reduce sedimentation into the stream. This would provide benefit unless a larger scale flood should occur and wash out the vegetation before it becomes established.

Figure 21. Photos of HALIZ01 (Site #13) on Lizard Creek.
These photos illustrate the steep stream bank erosion and its concerning proximity to the adjacent road.

HAELK01 (Site #11) - Elk River Habitat Assessment 1

HAELK01 is an identified site of concern located at 49.52321, -115.05245 that received a habitat assessment score of 36, priority score of 25, and evaluation score of 69 (Table 7). The site consists of a 200 m long shallow side/back channel of the Elk River that, on the date of surveying, was holding an estimated 200+ juvenile Westslope cutthroat trout and mountain whitefish (Figure 22). The site also includes a steep eroding section of bank that is cutting into a walk path creating sedimentation and community safety concerns.

The site received a modified habitat assessment due to its presence on the main stem of the Elk River and a desire to not disturb the juvenile fish sheltering in the side channel. 50 m of the surveyed reach was armoured with riprap and 10 m of contained bank erosion. There was good pool habitat, but the pools were not deep and had lost connection to the main stem. The pools were likely too shallow to provide overwintering habitat, though there is the potential that it may provide overwintering habitat given the presence of groundwater inflow. Limited overhead canopy and bank vegetation existed, and the riparian zone extended only 1 to 2 m.

Community members expressed concerns over fish mortality if the channel froze during winter and fish were unable access the main channel. After discussion with a local environmental consultant, it appears that the fish may be able to exit the channel through dense aquatic vegetation to the main channel. Small groundwater springs were visible at the time of habitat assessment which may prevent freezing and providing fish suitable overwintering habitat. The professional recommendation was to not apply for permitting to perform a fish salvage and to “let nature run its course.”

To address the bank failure, it is recommended to at the minimum plant native shrubs along the bank after spring freshet. As the bank exists on City of Fernie land it is likely that, should the erosion get worse, the City would armour the slope with riprap (as has been done upstream of the eroding bank). In this instance it would be suggested that vegetated riprap be use to provide additional overstory and shade to fish utilizing the side channel, and help create habitat features.

There is good opportunity for partnership at this site given the number of stakeholders that may be interested, including: The City of Fernie, Fernie Trails Alliance, Fish Guiding Outfitters and the nearby RV

park. The site is adjacent to a well used trail, presenting a good opportunity to publicise restoration work and educational signage placement. Community involvement should include volunteer rehabilitation and planting and an opportunity for contractors to educate volunteers.

Figure 22. Photos of HAELK01 (Site #11) on the Elk River.
These photos illustrate side channel that was of concern and the steep stream bank erosion that is almost undercutting the adjacent walkway.

HAELK02 (Site #6) - Elk River Habitat Assessment 2

HAELK02 is an identified site of concern located at 49.4910, -115.0787 that received a habitat assessment score of 71, priority score of 22, and evaluation score of 31 (Figure 7). The site is centered around a 16 m long, 2.5 m tall eroded bank undercutting a footpath, (Figure 23) similar to at HAELK01.

The site received a limited habitat assessment due to its presence on the main stem and the time of year (late fall) when the channel was already dry. The site likely provides good habitat during high water due to the overhanging vegetation and pools, though was dry during the survey. Given substrate characteristics and seasonal flow in this particular channel it is unlikely that this site is utilized for spawning, however the side channel may be utilized by juvenile fish. A handful of dead and living juvenile fish were observed under ice in small pools near the site that likely freeze solid during winter.

The eroded bank is undercutting a footpath posing a safety hazard to recreational users. The lack of space between the walking path and bank could complicate re-vegetating and re-shaping the slope. The site lies within the City of Fernie boundaries, and would likely be an area that they consider armouring with riprap as a lower investment option. In this instance we would suggest vegetating the riprap to provide improved habitat values through overhanging vegetation. A smaller scale, less costly, and short-term fix would be planting/live staking native shrubs along the eroding slope to help stabilize the soil and reduce sedimentation into the stream. The site is easily accessed from the trail making it a good candidate for small scale rehabilitation. Alternatively, bioengineering, including the placement of LWD, re-shaping the eroding bank, and planting native riparian vegetation on the bank to protect both bank and trail, would help to stabilize the bank, limit sedimentation and turbidity, promote restoration of the riparian zone and create new in-stream habitat for WCT.

Restoration on the main stem introduces the potential damage during spring freshet and high-water events and would likely be exposed to high water events within a 5 to 10 year timespan. Durable

restoration options could be explored including heavy duty LWD anchoring could be a viable option to improve restoration longevity.

There is good opportunity for partnership at this site given the number of stakeholders that may be interested, including: The City of Fernie and Fernie Trails Alliance. The site is adjacent to a well used trail, presenting an opportunity to publicize restoration work. This site presents an opportunity for educational signage, increasing species and environmental awareness. Community involvement should include volunteer rehabilitation and planting and an opportunity for contractors to educate volunteers.

Figure 23. Photos of HAELK02 (Site #6) on the Elk River.
These photos illustrate the stream bank erosion that is undercutting the adjacent walkway and the associated vegetation that has fallen into the seasonal streambed.

HAELK03 (Site #7) - Elk River Habitat Assessment 3

HAELK03 is an identified site of concern located at 49.491374, -115.0808255 that received a habitat assessment score of 53, priority score of 16, and evaluation score of 30 (Table 7), though the site did not receive a full habitat assessment due to its presence on the mainstem and the lack of wadable waters. HAELK03 comprises a steep, eroded bank on the outside bend of the stream between the Elk River and Hwy 3 (Fig. 26). The site easily accessible, however it may not be an ideal candidate for the use of bioengineering techniques. The most feasible and effective stabilization method which will likely be selected due to its proximity to the highway. This method will not result in the creation of fish habitat and will result in changes to stream morphology. If this method is chosen by the City of Fernie then it is recommended to install vegetated riprap to provide a degree of habitat value, stream shading, and cover for WCT. This method is not the preferred method for restoration, it would protect critical infrastructure, increase the longevity of the site providing greater long-term benefits, and still create some in-stream habitat for WCT. A project of this magnitude would require extensive consultation from environmental and industry professionals.

There is potential opportunity for partnership at this site, including: The City of Fernie, Fernie Trail Alliance, RDEK, and Main roads/Ministry of Transportation. The site is adjacent to a recreational trail, presenting an opportunity for educational signage or species and environmental awareness. Restoration could involve community in hands-on restoration and riparian planting work, as well as provide an opportunity for contractors to educate these volunteers. However, given the scope of the project it would likely be undertaken solely by the Ministry. Despite this, ERA could contribute a community awareness

and public outreach component. The City of Fernie may be interested in partnering on this project as a pilot project to test the viability of vegetative riprap along the Elk River.

Figure 24. Photos of HAELK03 (Site #7) on the Elk River.
These photos illustrate the long section of stream bank that is eroding into the river.

HAHAR01 (Site #10) – Hartley Creek Habitat Assessment 1

HAHAR01is an identified area of concern located at 49.54861, -115.01520 and received a habitat assessment score of 67, priority score of 23, and evaluation score of 34 (Table 7). The principal concern at HAHAR01 is a collapsing/undersized culvert at the intersection of Hartley Creek and Highway 3. The site did not receive a full habitat assessment due to the culvert.

Hartley Creek is an important tributary for spawning and rearing. WCT redds have historically been found downstream from this site. Overwintering is unlikely given the streams morphology and low flow characteristics. In previous surveys, Westslope Cutthroat Trout, Bull Trout, and Mountain Whitefish have also been found utilizing the stream (Interior Reforestation Co Ltd. 2007).

In October 2019 site visit the culvert was identified as a potential barrier for fish movement and a danger to the creek/highway. Numerous citizens have brought this site to ERA's attention as it cannot support the flow of water from Hartley Creek and consistently floods, often overflowing the highway during spring freshet. Over time the culvert has been blocked/constricted compressed and is no longer suited to handle high flow events (Fig. 27). The narrowed culvert is easily blocked by debris restricting natural water movement, leading to altered stream morphology and inhibiting fish movement. Given the importance of Hartley Creek for spawning and rearing WCT it is important that this culvert is addressed to prevent restrictions to natural fish movement and concerns related to altered stream morphology. This culvert was replaced and the stream restored/rehabilitated in 2007 (Interior Reforestation Co Ltd. 2007).

Culvert replacement is the responsibility of the Ministry of Transportation, and ERA will advocate for WCT conservation by notifying the Ministry of Transportation of the problem culvert and offering rehabilitation guidance. The restoration activities would provide an opportunity for partnerships and improved education for community and youth on fish conservation.

Figure 25. Comparison of the Hartley Creek culvert at Highway 3 between 2007 and 2019.
(A) 2007 (photo taken by Interior Reforestation Co. Ltd.) and (B) 2019. Note compression and infilling this culvert has undergone over the 12-year period.

Restoration Plans

Restoration plans and recommendations for HACOR01, HACOL01 and HACOL02 are included in Appendix F.

Conclusion

As part of the Westslope Cutthroat Trout Research Initiative, ERA worked with community members and regional biologists to identify potential rearing habitat and areas of concern for WCT. Based on these recommendations, ERA surveyed stretches of four Elk River tributaries as identified for potential redd presence, and conducted habitat assessments on 11 sites on Andy Goode, Coal, Corbin, Hartley, Lizard and Morrissey Creeks, and on side channels of the main stem of the Elk River. Of the four tributaries, Lizard Creek and Morrissey Creek contained 55 and 7 redds respectively. The majority of habitat assessments conducted were on sites identified to be currently or historically utilized by Cutthroat Trout.

In general, redds were located on low-slope stretches of creeks with abundant habitat features such as large woody debris, undercut banks, and well-developed gravel deposits. Future surveys will focus on similar tributary stretches during optimal spawning conditions in order to more efficiently utilize resources, though it is still valuable to obtain community input into project directions.

Restoration activities on identified stretches of Coal and Corbin Creeks was recommended as a result of redd surveys in 2019. In 2020, additional redd surveys and site assessments are planned to further investigate potential breeding sites and restoration opportunities on additional tributaries.

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Appendix A: Habitat assessment template

Appendix A: Habitat Assessment Template

Tributary:	Surveyors:				Date:
Rationale:					
Weather (Circle One):	Clear	Overcast	Showers (1-2.5cm in 24 hrs)	Storm (>2.5cm in 24hrs)	

	Northing	Easting	Elevation (m)
GPS Coord. (at Benchmark)			

Bankfull Width: (m)	Wetted Stream Width: (m)
Bankfull-Wetted Width (height from water surface to bankfull): (cm)	

	1	2	3	4	5	6	AVG
Distance from Shore (m)							
Depth (D) (cm)							
Flowing Water Depth (D1) (cm)							
Depth of Stagnation (D2) (cm)							
Change in Depth (ΔD=D2-D1) (cm)							
Velocity (V) (m/s)							

	Downstream elevation (m)	Upstream elevation (m)	Change in elevation (m)	Distance between (m)
Clinometer Measurement				
% gradient = (change in elevation (downstream-upstream) / distance between (m)) x 100				

% gradient of site	

Notes:

send the data to the Streamkeepers Database

Advanced Stream Habitat Survey Field Data Sheet

(use a new data sheet for each reference site surveyed) **Module 2**

Stream Name	Date
Organization Name	Stream Seg # Section#
	Map Sheet #

STEP 4.1 LONGITUDINAL SURVEY, MEASUREMENTS

		Photos (yes, no)
Length of survey site (minimum 12 times the bankfull width)	Minimum _____ (m) Actual_____(m)	
Upstream survey boundary (m upstream of benchmark)	Minimum _____ (m) Actual _____ (m)	
Downstream boundary (m downstream of benchmark)	Minimum _____ (m) Actual _____ (m)	

* distance **upstream** (Up) of benchmark

habitat unit type (pool or riffle)	bottom of habitat unit*	top of habitat unit*	length of habitat unit (m)	% slope	Photo Frame #
	Up	Up			
	Up	Up			
	Up	Up			
	Up	Up			
	Up	Up			
	Up	Up			
	Up	Up			

* distance **downstream** (Dn) of benchmark in metres

habitat unit type (pool or riffle)	top of habitat unit*	bottom of habitat unit*	length of habitat unit (m)	% slope	Photo Frame #
	Dn	Dn			
	Dn	Dn			
	Dn	Dn			
	Dn	Dn			
	Dn	Dn			
	Dn	Dn			
	Dn	Dn			

send the data to the Streamkeepers Database

Advanced Stream Habitat Survey Field Data Sheet

(use a new data sheet for each reference site surveyed) **Module 2: (con't)**

Stream Name	Date
Stream segment and section #'s	

STEP 4.2 LONGITUDINAL SURVEY, HABITAT QUALITY

1. Streambed material Collect 25 samples 1 8 15 22 2 9 16 23 3 10 17 24 4 11 18 25 5 12 19 6 13 20 7 14 21	% fines (<0-2cm) - ladybug size and smaller % gravel(0.2-5 cm) - ladybug to tennis ball % cobble (5·25cm) - tennis ball to basketball % boulder (>25cm) – bigger then a basketball with definable edges % bedrock - slab of rock	*Fines* = _____% *Gravel* = _____% ***Cobble*** = _____% ***Boulder*** = _____% *Bedrock* = _____% ***Cobble + Boulder*** *Total* = _____%
2. % embeddedness - cover of gravel and cobble by fine sediment		_____%
3. Instream cover LWD _____ Rooted cutbank	_____ # pieces LWD + _____ # rooted cutbanks = _____ ÷ _____ = _____ total cover (length of reference site ÷bankfull width) instream cover	
4. Percent pool habitat survey site slope total length of reference site (m)	total length of pools (m) % pool habitat	
5. Off channel habitat (if present, describe habitat type, size, and whether it is seasonal or year-round)	description	PRESENT ABSENT
6. Bank stability (left or right bank facing downstream)	*# of sites and length of bank affected (m)* LEFT BANK RIGHT BANK	
# active bank erosion	_____ _____	
bank stabilization	_____ _____	
# slides reaching the channel	_____ _____	
7. Length of bank with no vegetation (m)	LEFT BANK _____	RIGHT BANK _____
8. Overhead canopy	% bankfull channel covered by overhanging branches	
9. Riparian zone type and amount of vegetation	# of channel widths coniferous trees deciduous trees shrubs grasses	_____ none ❑ few ❑ many ❑ none ❑ few ❑ many ❑ none ❑ few ❑ many ❑ none ❑ few ❑ many ❑
Adjacent land use and impacts		

send the data to the Streamkeepers Database

Advanced Stream Habitat Survey Field Data Sheet

(use a new data sheet for each reference site surveyed) **Module 2 (con't)**

Stream Name	Date
Stream segment and section #'s	

STEP 5 HABITAT ASSESSMENT ***(the score in bold, estimate a value within the range listed)***

Characteristic	Results	Good	Acceptable	Marginal	Poor	Score
1: Streambed material:		**15 - 20**	**10 - 15**	**5 - 10**	**0 - 5**	
% boulder and cobble		50%	30-50%	10-30%	<10%	
2: Embeddedness:		**15 - 20**	**10 - 15**	**5 - 10**	**0 - 5**	
		25–0%	50-25%	75-50%	>75%	
3: Instream cover:		**15 - 20**	**10 - 15**	**5 - 10**	**0 - 5**	
		>3	2 to 3	1 to 2	<1	
4: % Pool Habitat		**11 - 15**	**7 - 11**	**3 - 7**	**0 - 3**	
<2% stream slope		>60% pool	50-60%	40-50%	<40%	
2-5% stream slope		>50% pool	40-50%	30-40%	<30%	
>5% stream slope		>40% pool	30-40%	20-30%	<20%	
5: Off-channel habitat:		**11 - 15**	**7 - 11**	**3 - 7**	**0 - 3**	
ponds, side channels with		year	seasonal,	seasonal,	little or	
protection from flood flows		round,	good	minimal	none, no	
		good	protection	protection	protection	
		protection				
6: Bank stability		**11 - 15**	**7 - 11**	**3 - 7**	**0 - 3**	
stability		stable	moderately	moderately	unstable	
			stable	unstable		
evidence of erosion or bank		none	some	some	lots	
failure ***(see note 1)***						
7. Bank vegetation: %		**8 - 10**	**5 - 8**	**2 - 5**	**0 - 2**	
stream bank covered by		>90%	70-90%	50-70%	and <50%	
vegetation						
8. Overhead canopy: %		**8 - 10**	**5 - 8**	**2 - 5**	**0 - 2**	
bankfull channel overhung						
by trees and shrubs		>30%	20-30%	10-20%	0-10%	
9. Riparian zone:		**8 - 10**	**5 - 8**	**2 - 5**	**0 - 2**	
# bankfull channels wide		2 or more	1 to 2	<1	0	
trees and shrubs		abundant	good	common,	sparse or	
		on whole	species mix	few species	absent	
		floodplain				
TOTAL						
SCORE		**102 - 135**	**66 - 102**	**30 - 66**	**0 - 30**	

Note 1: The evidence of erosion or bank failure changes from **Good** (intact banks) to **Acceptable** (healed or banks stabilized) to **Marginal** (active erosion or extensive bank stabilization) to **Poor** (many actively eroding areas or upslope slides reaching channel).

Appendix B: Summary of recommended Actions considered critical in implementing the WCT management plan (British Columbia)

Appendix B: Summary of recommended Actions considered critical in implementing the WCT management plan (British Columbia). Appendix adapted from Table 10 in Ministry of Environment (2014).

Recommended Actions	Objective[a] and Concern Addressed	Priority[b]
Population Conservation		
Define population using predictive models: • Confirm status in unknown areas including peripheral areas • Consider data on range of movement, barrier data, hydrological units, genetics, threats, stocking records • Ground-truth species composition, logical hydrological units, genetics, demography, barrier surveys, habitat disturbances using standardized approaches	1; Knowledge Gap	Essential
Describe genetic structure of B.C. WCT populations.	1; Knowledge Gap	
Ground Establish status of introgression in WCT populations: • Complete a genetic inventory update and gap analysis • Where hybridization is occurring, determine direction and rate of change	1; Knowledge Gap	Essential
Identify naturalized Rainbow Trout spawning locations focusing on locations where they are likely to concentrate (e.g., in lower elevation creeks), prioritize areas where there is potential cross-breeding with WCT.	1; Threat: Introgression	
Identify naturalized Eastern Brook Trout populations.	1; Threats: Altered Community Dynamics	Necessary
Monitor upstream movement of U.S. hybrids within Flathead Population Group.	1; Threat: Introgression	Necessary
Determine if kokanee enhancement in Kookanusa could be a detriment to WCT production.	1; Threats: Altered Community Dynamics	Beneficial
Define “pure WCT population” and establish thresholds to trigger appropriate management responses.	1; Threat: Introgression	Necessary
Prioritize WCT populations for restoration action based on genetic purity.	1; Threats: All	Necessary
Gather aboriginal traditional knowledge, and other historic accounts of occurrence and unique characteristics to help clarify historical distribution, relative abundance, and fish community structure	1, 2; Knowledge Gap	Necessary

Develop policy and regulations for protection and restoration of wild WCT populations including consideration of: • Regulations: opportunistic removal in areas of high hybridization and naturalize Rainbow Trout populations (listed in Appendix 4) • Policies: refugium/transplantation; barrier use; nutrient supplementation; and hatchery supplementation. Note that B.C. currently does not use hatchery supplementation to restore salmonid populations thus it would first have to be considered in an experimental/evaluation context (Province of British Columbia 2005). • "Habitat banking" – explore as a compensation option and determine if/when using this might be appropriate.	1; Threats: Introgression; Fish passage; large-scale habitat modifications	Essential
Review recreational stocking programs for WCT, Rainbow Trout, and Eastern Brook Trout to ensure risks to WCT are minimized: • WCT stocking in Connor Lake – review stocking plan to ensure no stocking into wild WCT waters • Eastern Brook Trout stocking – confirm plan meets current stocking policy • Rainbow Trout stocking – confirm all current stocking in WCT range is in isolated lakes and uses sterile fish; reduce Rainbow Trout stocking in key WCT range and consider stocking with native species as an alternative	1; Threat: Introgression	Necessary
Support stewardship initiatives by local governments, angling groups, and stream stewardship groups, by helping prepare the following for a wider distribution than the regulations synopsis: • species identification tools; • education material to reduce hooking injury mortality; • education materials for schools/angling clubs on biology, threats (especially invasive species and introgression), such as brochures, Powerpoint presentations, and relevant signage; and • promote stewardship agreements/conservation covenants.	1-4; All	Beneficial
Develop Whiteswan Lake management plan for WCT due to confirmed hybrid status (WCT x RBT) in watershed. Plan should include stocking recommendations, naturalized Rainbow Trout population management, barrier use, etc.	1, 2; Threats: Introgression	Essential
For wild, unexploited WCT populations, use threat analysis to identify at risk populations and assess carrying capacity of a random subset of these populations.	1, 2; Knowledge Gap	Beneficial
Identify wild, exploited stream and lake WCT populations (include subgroups if necessary) for individual stock assessment including Classified Waters and non-Classified Waters: • Classified Waters: Bull, Wigwam, Elk, St. Mary, Skookumchuck, White, and Upper Kootenay rivers • Non-Classified Waters: Flathead, Akolkolex, Goat, Findlay, and Lussier rivers • Other small populations	2; Knowledge Gap	Essential

Develop a measure of carrying capacity for each exploited WCT population using: • the empirical approach (preferred) on as many populations as possible to measure total abundance and harvest rate; or • the modeling approach (as needed) which requires considerable demographic information.	2; Knowledge Gap	Necessary

Develop and implement standard protocols to determine WCT total abundance.
• Consider the following methods:
  • Snorkeling – adult count of entire river
  • Mark recapture – watershed or reach scale
  • Catch per unit effort (could be hyper-stable, needs investigation before use)
  • Genetic analysis (needs investigation to determine if plausible).
• Determine fry/parr densities (e.g., night-time snorkeling).
• Determine if the different methods produce equivalent results.
• Document, test, and prioritize each protocol. • Develop long-term sampling strategy to obtain data for carrying capacity.
	2; Knowledge Gap	Essential

Establish a periodic schedule of WCT stock re-assessments that is prioritized around relative threat risk and availability of occurrences	2; Knowledge Gap	Necessary
Determine if a single $N_{equilibrium}$ value for large, productive systems and its associated WCT Objective 2 target is appropriate given variability in productivity observed even among Classified Waters rivers.	2; Knowledge Gap	Necessary
Based on application of abundance-related reference points, develop a summary of WCT manage actions for each management zone (as adapted from Johnston *et al*. 2002).	2; Knowledge Gap	Necessary
For wild, unexploited WCT populations manage threats to keep populations above the Limit Reference Point (0.2 equilibrium or higher in very small populations).	2; Threats: All	Beneficial
Determine if the "persistence" goal for wild, unexploited (headwater) WCT populations of 0.2·Nequilibrium (Limit Reference Point) needs adjusting (may not be high enough). Adjust as needed.	2; Knowledge Gap	Necessary
Determine how to assess angling mortality, and obtain direct measures of catch and release mortality for each fishery (e.g., fly fishing only in catch and release zone, gear in catch and release zone, fly fishing in kill zone, gear in kill zone).	2; Knowledge Gap; Threat: Direct Mortality	Necessary
Evaluate physiological impacts of catch and release: condition factor, age at size, post-release mortality (24- to 48-hr mortality standard).	2; Knowledge Gap; Threat: Direct Mortality	Necessary
Habitat Protection/Restoration		
Identify key habitats for migratory and resident WCT populations.	3; Knowledge Gap	Necessary
Review fish barrier information and further investigate to confirm significance of threat (e.g., reduction in carrying capacity) to WCT.	3; Threats: Fish passage; Small-scale habitat modifications	Essential

Support *Water Act* modernization including: • establishing fish flow needs for WCT and identify priority watersheds with persistent deficiencies, • strengthen provisions regarding release of damaging substances to high risk streams, and • support/develop water management plans in priority streams.	3; Knowledge Gap; Threat: Altered flow regime	Beneficial
Explore the possibility of extending Riparian Area Regulations in Kootenays beyond Revelstoke, toward the goal of identify opportunities for regulating minimum riparian protection widths in areas of the province where they do not currently exist.	3; Threats: Small/large-scale habitat modifications	Beneficial
Complete stream restoration activities in streams with identified habitat deficiencies, impacts, or high fishing pressures	1-4; all; Threats: riparian alteration, altered flow regimes, instream habitat modifications	Essential
Sustainable And Diverse Recreational Opportunities		
Obtain use information for priority non-Classified Waters: Goat, Lussier, Findlay, and Wildhorse rivers.	4; Knowledge Gap	Beneficial
Determine linkage between catch per unit effort and fish abundance.	4; Knowledge Gap	Necessary
Determine advantage of a catch per unit effort target for Classified Waters.	4; Knowledge Gap	Beneficial
Determine if commercial activities are adequately regulated on non-Classified Waters.	4; Knowledge Gap	Necessary
Determine benefits of small lakes recreation associated with WCT and consider ways to optimize sustainable recreation including stocking, lake enrichment, etc.	4; Knowledge Gap	Beneficial
Determine information needed to better understand and define WCT harvest opportunities. Develop a plan to explore potential harvest opportunities.	4; Knowledge Gap	Beneficial
Expand the River Guardian program to priority non-Classified Waters, including data gathering on compliance monitoring (including small streams), and harvest rate determination.	4; Threats: several	Beneficial
Consider Skeena approach (Dolan 2008) to deal with oversubscription issues for Wigwam River and Elk River.	4; Threat: Direct mortality	Necessary
Advertise WCT status via appropriate bulletin/poster program to educate public on its conservation status and required management.	1, 2, 3, 4; Threats: several	Beneficial

[a] Objectives are described in Section 6.

[b] Essential (urgent and important, needs to start immediately); Necessary (important but not urgent, action can start in 2–5 years); or Beneficial (action is beneficial and could start at any time that was feasible).

Appendix C: Redd surveying data

Appendix C: Redd surveying data - Fish Research Initiative - 2019 Redd Survey Data *Location specifc data removed*

									GPS Coordinates	
Site #	Site	Date	Surveyors	SamplingMethod	Tributary	Lower Elevation (m)	Upper Elevation (m)	Approx. Gradient (%)	Latitude	Longitude
1	RED 1	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
2	RED 2	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
3	RED 3	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
4	RED 4	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
5	RED 5	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
6	RED 6	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
7	RED 7	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
8	RED 8	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
9	RED 9	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
10	RED 10	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
11	RED 11	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
12	RED 12	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
13	RED 13	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
14	RED 14	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
14-2	RED 14-2	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
16	RED 16	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
17	RED 17	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
18	RED 18	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
19	RED 19	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
20	RED 20	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
21	RED 21	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
23	RED 23	June 7/19	Brett Elmslie, Jon Bisset	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1.2	[data removed]	[data removed]
3	CC FISH 3	June 12/19	Brett Elmslie, Steve Marlboro	Redd Surveying	Coal Creek	[data removed]	[data removed]	5.4	[data removed]	[data removed]
4	CC FISH 4	June 12/19	Brett Elmslie, Steve Marlboro	Redd Surveying	Coal Creek	[data removed]	[data removed]	5.4	[data removed]	[data removed]
5	CC FISH 5	June 12/19	Brett Elmslie, Steve Marlboro	Redd Surveying	Coal Creek	[data removed]	[data removed]	5.4	[data removed]	[data removed]
6	CC FISH 6	June 12/19	Brett Elmslie, Steve Marlboro	Redd Surveying	Coal Creek	[data removed]	[data removed]	5.4	[data removed]	[data removed]
7	CC FISH 7	June 12/19	Brett Elmslie, Steve Marlboro	Redd Surveying	Coal Creek	[data removed]	[data removed]	5.4	[data removed]	[data removed]
8	CC FISH 8	June 12/19	Brett Elmslie, Steve Marlboro	Redd Surveying	Coal Creek	[data removed]	[data removed]	5.4	[data removed]	[data removed]
9	CC FISH 9	June 12/19	Brett Elmslie, Steve Marlboro	Redd Surveying	Coal Creek	[data removed]	[data removed]	5.4	[data removed]	[data removed]
10	CC FISH 10	June 12/19	Brett Elmslie, Steve Marlboro	Redd Surveying	Coal Creek	[data removed]	[data removed]	5.4	[data removed]	[data removed]
1	MC 01	June 20/19	Brett Elmslie, Jon Bisset	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	2.5	[data removed]	[data removed]
2	MC 02	June 20/19	Brett Elmslie, Jon Bisset	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	2.5	[data removed]	[data removed]
3	MC 03	June 20/19	Brett Elmslie, Jon Bisset	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	2.5	[data removed]	[data removed]
4	MC 04	June 20/19	Brett Elmslie, Jon Bisset	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	2.5	[data removed]	[data removed]
5	MC 05	June 20/19	Brett Elmslie, Jon Bisset	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	2.5	[data removed]	[data removed]
6	MC 06	June 20/19	Brett Elmslie, Jon Bisset	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	2.5	[data removed]	[data removed]
1	0	June 21/19	Brett Elmslie, Brooke Hall	Redd Surveying	Forsyth Creek	[data removed]	[data removed]	N/A	[data removed]	[data removed]

Appendix C: Redd surveying data - Fish Research Initiative - 2019 Redd Survey Data *Location specifc data removed*

									GPS Coordinates	
Site #	Site	Date	Surveyors	SamplingMethod	Tributary	Lower Elevation (m)	Upper Elevation (m)	Approx. Gradient (%)	Latitude	Longitude
1	RED 24	June 25/19	Brett Elmslie, Beth Millions	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1	[data removed]	[data removed]
2	RED 25	June 25/19	Brett Elmslie, Beth Millions	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1	[data removed]	[data removed]
3	RED 26	June 25/19	Brett Elmslie, Beth Millions	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1	[data removed]	[data removed]
4	RED 27	June 25/19	Brett Elmslie, Beth Millions	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1	[data removed]	[data removed]
5	RED 28	June 25/19	Brett Elmslie, Beth Millions	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1	[data removed]	[data removed]
6	RED 29	June 25/19	Brett Elmslie, Beth Millions	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1	[data removed]	[data removed]
7	RED 30	June 25/19	Brett Elmslie, Beth Millions	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1	[data removed]	[data removed]
8	RED 31	June 25/19	Brett Elmslie, Beth Millions	Redd Surveying	Lizard Creek	[data removed]	[data removed]	1	[data removed]	[data removed]
1	FC ACCESS 4	June 28/19	Brett Elmslie, Brooke Hall	Redd Surveying	Forsyth Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
1	N/A	June 28/19	Brett Elmslie, Brooke Hall	Redd Surveying	Forsyth Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
2	FC 7	June 28/19	Brett Elmslie, Brooke Hall	Redd Surveying	Forsyth Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
3	FC 8	June 28/19	Brett Elmslie, Brooke Hall	Redd Surveying	Forsyth Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
4	FC 9	June 28/19	Brett Elmslie, Brooke Hall	Redd Surveying	Forsyth Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
5	FC 10	June 28/19	Brett Elmslie, Brooke Hall	Redd Surveying	Forsyth Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
0	N/A	June 28/19	Brett Elmslie, Brooke Hall	Redd Surveying	Forsyth Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
1	N/A	July 11/19	Brett Elmslie, Emily Tidman	Redd Surveying	Coal Creek	[data removed]	[data removed]	4.1	[data removed]	[data removed]
2	CC 16	July 11/19	Brett Elmslie, Emily Tidman	Redd Surveying	Coal Creek	[data removed]	[data removed]	4.1	[data removed]	[data removed]
3	CC 17	July 11/19	Brett Elmslie, Emily Tidman	Redd Surveying	Coal Creek	[data removed]	[data removed]	4.1	[data removed]	[data removed]
4	CC 18	July 11/19	Brett Elmslie, Emily Tidman	Redd Surveying	Coal Creek	[data removed]	[data removed]	4.1	[data removed]	[data removed]
5	CC 19	July 11/19	Brett Elmslie, Emily Tidman	Redd Surveying	Coal Creek	[data removed]	[data removed]	4.1	[data removed]	[data removed]
1	MC 08	July 18/19	Brett Elmslie, Emma	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
2	MC 09	July 18/19	Brett Elmslie, Emma	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
3	MC 10	July 18/19	Brett Elmslie, Emma	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
4	MC 11	July 18/19	Brett Elmslie, Emma	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
5	MC 12	July 18/19	Brett Elmslie, Emma	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
6	MC 13	July 18/19	Brett Elmslie, Emma	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
7	MC 14	July 18/19	Brett Elmslie, Emma	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
8	MC 15	July 18/19	Brett Elmslie, Emma	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]
9	MC 16	July 18/19	Brett Elmslie, Emma	Redd Surveying	Morrissey Creek	[data removed]	[data removed]	1.5	[data removed]	[data removed]

Appendix C: Redd surveying data - Fish Research Initiative - 2019 Redd Survey Data *Location specifc data removed*

					Holding Cover								
Site #	Site	# of redds	Fish Presence (Y/N)	Temp (C)	LWD	SWD	UB	B	DP	OV	IV	Dominant Substrate	Comments
1	RED 1	2	N	0	0	0	0	0	0	0	0	G	Just below waterfall; waterfall has previously been designated as a barrier, but not the case i.e. fish spawning above barrier; re-record this elevation point
2	RED 2	4	N	7	0	0	0	0	0	0	0	G	At the tail end of a glide
3	RED 3	4	N	0	X	0	X	0	0	0	0	G	0
4	RED 4	1	Y	0	0	0	X	0	0	X	0	G	0
5	RED 5	1	N	0	0	0	0	0	0	0	0	G	0
6	RED 6	2	N	0	0	0	0	0	0	X	0	G	0
7	RED 7	3	N	0	0	X	0	0	0	0	0	G	0
8	RED 8	2	N	0	0	0	0	0	0	0	0	G	0
9	RED 9	1	N	0	0	X	X	0	X	X	0	G	0
10	RED 10	2	N	0	X	0	0	0	0	0	0	G	0
11	RED 11	1	N	0	0	0	X	0	0	X	0	G	0
12	RED 12	2	N	7	0	0	X	0	0	X	X	G	0
13	RED 13	1	N	0	0	0	X	0	0	X	0	G	Channelization in the stream
14	RED 14	1	N	0	0	X	0	0	0	X	0	G	0
14-2	RED 14-2	3	N	0	0	0	0	0	0	0	0	G	14-2 = mis-labeled in the field (14 was used twice); most upstream redd very unsure about
16	RED 16	1	N	0	0	0	0	0	0	0	0	G	0
17	RED 17	2	N	0	0	X	X	0	0	X	0	G	0
18	RED 18	2	N	0	0	0	0	0	0	0	0	G	0
19	RED 19	2	Y	0	0	X	X	0	X	X	0	G	0
20	RED 20	4	N	0	X	X	X	0	0	0	0	G	0
21	RED 21	2	N	0	X	0	X	0	0	0	0	G	0
23	RED 23	2	N	0	0	0	X	0	X	0	0	G	Total diastance walk = 1420m; total redds spotted = 45; time = approx. 2.5hrs of walking
3	CC FISH 3	0	N	0	0	0	0	0	0	0	0	G/C	0
4	CC FISH 4	0	Y	7.5	0	0	X	0	0	0	0	G/C	0
5	CC FISH 5	0	Y	9	0	0	0	0	0	0	0	G/C	channelized, lots of worms, OLD CULVERT
6	CC FISH 6	0	Y	0	0	0	0	X	0	X	0	G/C	side channel, 4-5" WCT juvenile fish, visible parr marks, holding in small pool
7	CC FISH 7	0	Y	0	0	0	0	X	0	X	0	G/C	side channel, 4" WCT juvenile fish holding in small pool
8	CC FISH 8	0	Y	9.5	0	0	0	X	0	X	0	G/C	side channel, 2 small WCT, 3-5", holding in small pool
9	CC FISH 9	0	Y	0	0	0	0	X	0	X	0	G/C	side channel, 4 small WCT, 2 fry? (2-3"), 2 juvenile (3-4"), holding in small pool, parr visible on juvenile
10	CC FISH 10	0	N	0	0	0	0	0	0	0	0	G/C	end of extent, bridge, distance walked = 466m, total # of juveniles seen = 8 - time of redd surveying = 3.5 hrs approx.
1	MC 01	0	N	0	0	0	0	0	0	0	0	C	start of reach, bridge, lodgepole/river road, Creek looks bony (large cobble)
2	MC 02	3	N	8	0	X	0	0	0	0	X	G/C	Channelized, redds in side channel
3	MC 03	0	Y	0	0	0	0	0	0	0	0	C	small juvenile rescued from a puddle (3 inches), healthy looking WCT - channelized, bony substrate
4	MC 04	0	N	8	0	0	0	0	0	0	0	C	0
5	MC 05	0	N	8.5	0	0	0	0	0	0	0	C	0
6	MC 06	0	N	0	0	0	0	0	0	0	0	C	bridge, end of extent, total distance walked = 1853m, total # of juvenile = 1, total # of redds = 3, redd surveying 5.5hrs
1	0	0	0	4	0	0	0	0	0	0	0	0	Snowing and raining. Weather prevented succesful survey. Water temp taken from bridge, In the field for 5 hrs

Appendix C: Redd surveying data - Fish Research Initiative - 2019 Redd Survey Data *Location specifc data removed*

					Holding Cover								
Site #	Site	# of redds	Fish Presence (Y/N)	Temp (C)	LWD	SWD	UB	B	DP	OV	IV	Dominant Substrate	Comments
1	RED 24	0	0	9	0	0	0	0	0	0	0	G/C	start of reach
2	RED 25	1	N	0	0	0	0	X	X	0	0	G/C	0
3	RED 26	2	N	9	0	X	X	X	X	X	0	G	photo #1
4	RED 27	1	N	0	0	X	0	0	0	0	0	G/C	0
5	RED 28	1	N	0	0	X	X	0	0	0	0	G	photo #2
6	RED 29	3	N	0	0	0	0	0	0	X	0	G	not much holding cover, exposed area
7	RED 30	2	N	0	0	X	X	0	0	0	0	G	0
8	RED 31	0	N	0	0	0	0	0	0	0	0	G	end of reach, total distance walked = 967m, total # of redds = 10, reddu surveying for 3 hrs
1	FC ACCESS 4	0	0	0	0	0	0	0	0	0	0	0	0
1	N/A	0	N	0	0	0	0	0	0	0	0	C	start of reach, as determined by google earth
2	FC 7	0	N	0	0	0	0	0	0	0	0	0	GPS waypoint glitch, on ATV pathed used for acces
3	FC 8	0	N	0	0	0	0	0	0	0	0	C/G	channelized section of stream. Gravel deposits, possible suitable habitat for spawning
4	FC 9	0	N	0	0	0	0	0	0	0	0	G	Channelized in treed area, rgavel dominate - possible suitable habitat for spawning
5	FC 10	0	N	0	0	0	0	0	0	0	0	C/G	gravel bed by log jam, possible spawning area in main stem of river - on inside bank of river bed
0	N/A	0	N	0	0	0	0	0	0	0	0	C	bridge - end of reach, total distance walked = 1002m, NO redds/fish
1	N/A	0	N	0	0	0	0	0	0	0	0	C	Car location - GPS glitched out, recorded CC 15 wrong, way of course
2	CC 16	0	N	0	0	0	0	0	0	0	0	C	Start of reach
3	CC 17	0	Y	0	0	0	0	0	0	0	0	C	2 teir waterfall - American Mink with juvenile cutthroat in it's mouth! Spat it out when it saw us, juveinle was about 5" - visible parr parks
4	CC 18	0	N	0	0	0	0	0	0	0	0	C	3 teir waterfall - cascading waterfalls, first 2 were 2-3 ft, 3rd one was 4-5 ft - potential barrier in lower water years?
5	CC 19	0	N	0	0	0	0	0	0	0	0	C	end of reach, total distance walked = 780m, total # of redds = 0, total # of juveniles = 1, redd suerveying 3.5hrs
1	MC 08	0	0	0	0	0	0	0	0	0	0	0	car parked at turn of Morrissey road, temporary
2	MC 09	0	0	0	0	0	0	0	0	0	0	0	Turn off from road to cut over to creek
3	MC 10	0	0	0	0	0	0	0	0	0	0	0	Start of Morrissey Creek reach by train track bridge
4	MC 11	1	Y	0	0	0	0	X	0	X	0	G	potential redd location, potential for future years spawning, few small fry noticed - in side channel of creek. More fry noticed further up same side channel
5	MC 12	3	Y	0	0	0	0	0	X	0	0	G/C	pobable patch of 3 redds, some fry noticed swimming, in side channel
6	MC 13	0	0	5	0	0	0	0	0	0	0	0	temp taken - recent heavy rain and cool temps could be a abnormal low in river temp
7	MC 14	0	0	0	0	0	0	0	0	0	0	0	small creek flowing into MC, ideal substrate for future/past years of spawning, lots of habitat features
8	MC 15	0	0	6.5	0	0	0	0	0	0	0	0	gant eroded bank, looks lie a clay deposit- clay washing into stream, stagnent pools observed throughout the creek turbid with clastic material
9	MC 16	0	0	0	0	0	0	0	0	0	0	0	End of reach, total distance walked = 1702m, total # of redds = 4, total # of juvenile = multiple fry, redd surveying for 4.5hrs

Appendix D: Educational materials produced

Westslope Cutthroat Trout in the Elk River Watershed

Westslope Cutthroat Trout (WCT)

The westslope cutthroat trout or *Oncorhynchus clarkii lewisi* is one of two native subspecies of cutthroat trout in British Columbia. Cutthroat trout get their common name from a distinctive red slash that occurs just below both sides of the lower jaw. Colouration ranges from silver to yellow green with red on the front and sides of the head. Overall, body colour can vary widely and often reflects the colour of the substrate and water that the trout inhabits. Spawning trout often develop a bright red colouration over the entire body. WCT are primarily insectivorous, feeding on drifting macroinvertebrates, such as: caddisflies, mayflies and stoneflies. WCT are typically small in size ranging from 150 - 230 mm in length; larger individuals rarely exceed 460 mm.

WCT typically reflect one of three life history forms: **stream-resident**, **fluvial** or **adfluvial**.

Stream-resident WCT live within a very restricted distribution. Typical of headwater populations, movement is restricted by natural barriers and they remain small in length (< 200 mm).

Fluvial WCT move between tributaries and larger, more productive rivers. They are generally larger as adults (>400mm).

Adfluvial WCT move between tributaries and lakes if productivity is high, resulting in large adults (can exceed 450mm).

WCT in the Elk River Watershed

In the Elk River watershed, all 3 of these life history forms exist. WCT inhabit the mainstem of the Elk River and many of its tributaries. The Elk River and its tributaries are optimal habitat for WCT because of their structural variability, low-gradient flow and clean, cold water. The abundance of riffles and pools, undercut banks, log jams, boulders, and deep pools provide WCT with everything they need to thrive.

WCT habitat on the Fording River. Photo: Westslope Fisheries

Elk River tributaries that provide important habitat for WCT include: **Lizard Creek**, **Morrissey Creek**, **Fording River**, **Coal Creek**, **Michel Creek** and **Hartley Creek**. Some of these tributaries are home to small isolated headwater populations whose movement is restricted because of natural barriers, like waterfalls.

REDD ALERT

What is a redd?

- Depressions in river gravels that trout make to lay their eggs.
- Redds appear on pea to golfball sized rocks that look lighter or cleaner than the rest of the river bed.
- They can be found in slow, shallower water, often at the downstream end of a pool or along point bars.

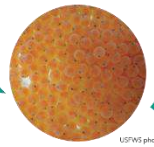
Photo Chris Bangay

WCT LIFECYCLE

DIGILOYD INC photo

Spawning

Spawning can occur from April through August, but tends to peak in late May through to mid-June. Female westslope cutthroat trout dig a nest or redd in small, well-oxygenated rivers with gravel bottoms. As the female deposits the eggs in the nest, they are fertilized by the male and covered with gravel.



USFWS photo

Eggs

Eggs incubate in the gravel for a few months before hatching into alevins. The timing of the hatch is dependent on temperature. Eggs produced by larger females are bigger and produce larger alevins, increasing their chances for survival.

NANFA photo

Adults

Adult trout have a territory that gives them a good supply of food and a place to hide from predators. The extent of their territory and age at sexual maturity can vary greatly and is dependent on their habitat and life history. They overwinter in deep pools or lakes and begin migrating to their spawning grounds in early spring.

D-Loop Outfitters photo

Alevins

After hatching, alevins stay in the gravel for an additional few weeks living off their yolk sac. They then emerge from the gravel as fry, usually between July and August.

NPS photo

Fingerlings

Fingerlings, or juvenile trout, are simply one step larger than fry and are typically about the size of a finger. Fingerlings may reside in natal streams from one to four years. Trout begin to acquire the characteristic body markings of westslope cutthroat trout.

Joel Sartore photo

Fry

Fry disperse generally into lower velocity habitats with sufficient cover, foraging for small insects and larvae. Fry often look similar to adult trout, but have light coloration and non distinct spots. Once trout begin to develop scales and working fins they are known as fingerlings.

Threats to the Elk Valley Population

The WCT is provincially blue-listed, meaning that the species may become a threatened or endangered species because of a combination of biological characteristics and identified threats. **Some of the main threats that are present in the Elk Valley include:**

Logging

Photo Wildsight

Some of the negative impacts associated with logging include:

- Increased surface run-off, resulting in increased turbidity, which can degrade spawning and rearing habitat, smother incubating eggs and impede WCT feeding abilities.
- Increased water velocities, stream channelization and the presence of culverts, creating barriers that prevent WCT from accessing key habitats.
- Reduced riparian vegetation, increasing water temperature and reducing the stability of stream banks.

Mining

Photo Garth Lenz

Impacts include the construction of rock drains on creeks (typically the infilling of valley bottoms and related habitat destruction), chemical loading (e.g., selenium) and stream diversion. Impacts are primarily physical and chemical impacting upstream fish passage, resulting in habitat loss, increased nutrient loading and contamination. Selenium has been linked to defects in reproduction and growth, deformities and increased mortality in WCT.

Overexploitation

Photo Tourism Fernie

The increase in the number of resource roads being built is of concern because they are allowing anglers access to sensitive WCT habitat. WCT are particularly sensitive to angling pressure because they are easily caught, even by novice anglers. As fishing pressure continues to increase, the risk associated with catch and release mortality may become a greater concern.

What YOU Can Do to Help

- Use the river responsibly
- Follow all fishing regulations
- DO NOT FISH where fish are holding during spawning
- DO NOT FISH over redds
- AVOID WADING OR ANCHORING in redds

Protect the next generation of trout and your fishing opportunity!

MIND THE REDD

Elk River Alliance

The Elk River Alliance is committed to protecting and preserving Westslope Cutthroat Trout and their habitat through various environmental initiatives.To learn more about our organization visit our website at www.elkriveralliance.ca.

www.elkriveralliance.ca

Teck

HABITAT CONSERVATION TRUST FOUNDATION

Poster highlighting information on Westslope Cutthroat Trout (WCT), including: species information, life history forms, habitat preference, and threats facing the population. Poster was presented at the first workshop held.

What is a Redd?

Depressions in river gravels that trout make to lay their eggs

Redds appear on pea to golfball sized rocks that look cleaner than the rest of the river bed

They can be found in slow, shallower water, often at the downstream end of a pool or along point bars

Elk River Alliance

Info-graphic created to help people identify WCT redds. This info-graphic was presented during the first workshop and was shared via social media channels. It is also available on ERA's website.

WHAT CAN YOU DO TO HELP?

In an effort to protect Westslope Cutthroat Trout during spawning season, you can:

- Use the river responsibly
- Follow all fishing regulations
- Avoid fishing over redds
- Avoid wading or anchoring in redds

Elk River Alliance

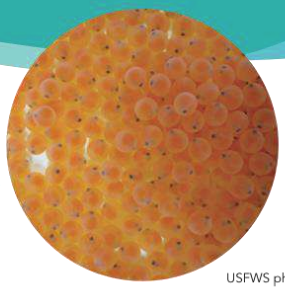
Info-graphic created to educate people on what hey can do to help protect WCT. This info-graphic and information was presented at both workshops and was shared via social media channels. It is also available on ERA's website.

The Westslope Cutthroat Trout Lifecycle

DIGLLOYD INC photo

Spawning

Spawning can occur from April through August, but tends to peak in late May through to mid-June. Female westslope cutthroat trout dig a nest or redd in small, well-oxygenated rivers with gravel bottoms. As the female deposits the eggs in the nest, they are fertilized by the male and covered with gravel.



USFWS photo

Eggs

Eggs incubate in the gravel for a few months before hatching into alevins. The timing of the hatch is dependent on temperature. Eggs produced by larger females are bigger and produce larger alevins, increasing their chances for survival.

NANFA photo

Adults

Adult trout have a territory that gives them a good supply of food and a place to hide from predators. The extent of their territory and age at sexual maturity can vary greatly and is dependent on their habitat and life history. They overwinter in deep pools or lakes and begin migrating to their spawning grounds in early spring.

D-Loop Outfitters photo

Alevins

After hatching, alevins stay in the gravel for an additional few weeks living off their yolk sac. They then emerge from the gravel as fry, usually between July and August.

NPS photo

Fingerlings

Fingerlings, or juvenile trout, are simply one step larger than fry and are typically about the size of a finger. Fingerlings may reside in natal streams from one to four years. Trout begin to acquire the characteristic body markings of westslope cutthroat trout.

Joel Sartore photo

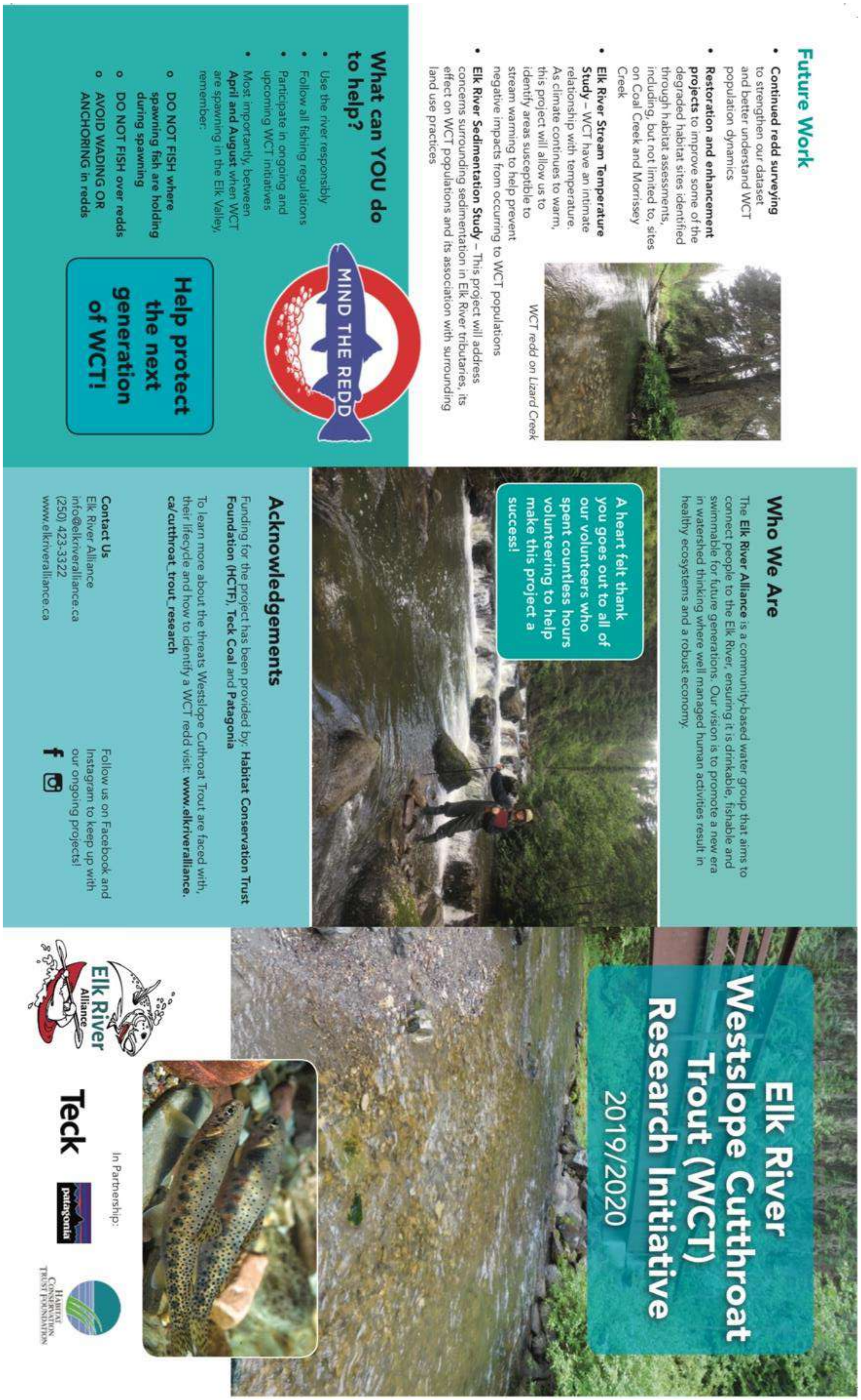
Fry

Fry disperse generally into lower velocity habitats with sufficient cover, foraging for small insects and larvae. Fry often look similar to adult trout, but have light coloration and non distinct spots. Once trout begin to develop scales and working fins they are known as fingerlings.

Elk River Alliance

www.elkriveralliance.ca

Info-graphic created to educate people on the WCT lifecycle. This info-graphic was presented during the first workshop and was shared via social media channels. It is also available on ERA's website.



Future Work

- **Continued redd surveying** to strengthen our dataset and better understand WCT population dynamics
- **Restoration and enhancement projects** to improve some of the degraded habitat sites identified through habitat assessments, including, but not limited to, sites on Coal Creek and Morrissey Creek
- **Elk River Stream Temperature Study** – WCT have an intimate relationship with temperature. As climate continues to warm, this project will allow us to identify areas susceptible to stream warming to help prevent negative impacts from occurring to WCT populations
- **Elk River Sedimentation Study** – This project will address concerns surrounding sedimentation in Elk River tributaries, its effect on WCT populations and its association with surrounding land use practices

WCT redd on Lizard Creek

What can YOU do to help?

- Use the river responsibly
- Follow all fishing regulations
- Participate in ongoing and upcoming WCT initiatives
- Most importantly, between **April and August** when WCT are spawning in the Elk Valley, remember:
  - **DO NOT FISH where spawning fish are holding during spawning**
  - **DO NOT FISH over redds**
  - **AVOID WADING OR ANCHORING in redds**

MIND THE REDD

Help protect the next generation of WCT!

Who We Are

The **Elk River Alliance** is a community-based water group that aims to connect people to the Elk River, ensuring it is drinkable, fishable and swimmable for future generations. Our vision is to promote a new era in watershed thinking where well managed human activities result in healthy ecosystems and a robust economy.

A heart felt thank you goes out to all of our volunteers who spent countless hours volunteering to help make this project a success!

Acknowledgements

Funding for the project has been provided by: **Habitat Conservation Trust Foundation (HCTF)**, **Teck Coal** and **Patagonia**

To learn more about the threats Westslope Cuthroat Trout are faced with, their lifecycle and how to identify a WCT redd visit: **www.elkriveralliance.ca/cutthroat_trout_research**

Contact Us
Elk River Alliance
info@elkriveralliance.ca
(250) 423-3322
www.elkriveralliance.ca

Follow us on Facebook and Instagram to keep up with our ongoing projects!

Elk River Westslope Cutthroat Trout (WCT) Research Initiative

2019/2020

Elk River Alliance

In Partnership:

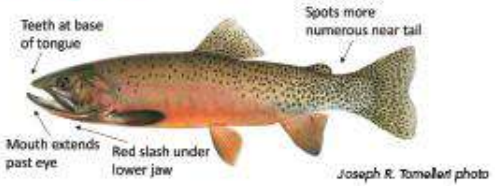
Teck patagonia Habitat Conservation Trust Foundation

Pamphlet created to educate people on the Elk River WCT Research Initiative (Page 1). This pamphlet was available in paper form at the 2nd workshop. Paper copies are available at ERA's office and digital copies are available for download on ERA's website.

WCT in the Elk Valley

Westslope Cutthroat Trout (WCT) are a species of great ecological, social and economic importance in the Elk River watershed. The Elk River is considered a stronghold for WCT. The Elk River and its tributaries are optimal habitat for WCT because of their structural variability, low-gradient flow and clean, cold water. Even though the Elk has so much to offer this species, WCT have been designated as a species of special concern under the Federal Species at Risk Act and are blue-listed in British Columbia. WCT have experienced severe restrictions in their distribution and abundance due to a combination of biological characteristics and identified threats.

How to identify a WCT:



Joseph R. Tomelleri photo

Threats to WCT in the Elk River watershed include:

- hybridization with non-native salmonids
- resource exploitation
- increased angling pressure

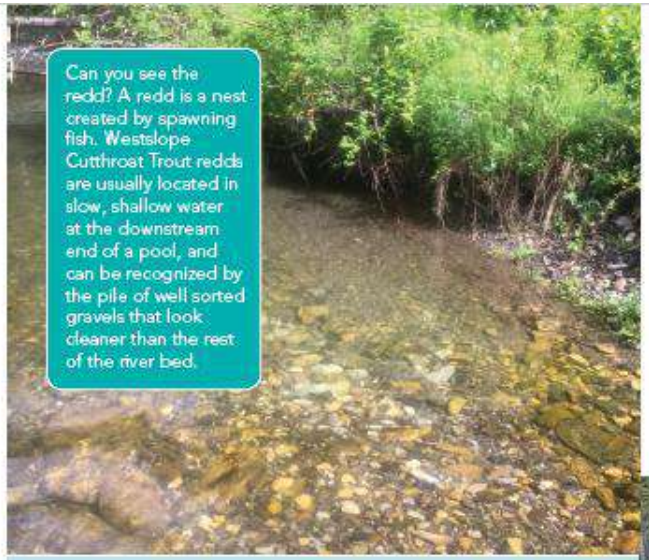
Garth Lenz photo

Elko Jones photo

Tourism Fernie photo

The Elk River WCT Research Initiative

There have been few studies on the Elk River WCT population leaving gaps in our understanding regarding key habitat, restoration priorities and population estimates. Without this data it is difficult to manage the population effectively or implement projects that enhance WCT habitat. The Elk River WCT Research Initiative aims to address existing knowledge gaps surrounding WCT populations in the Elk River watershed through WCT habitat identification using two different methods: redd (spawning) surveys and habitat assessments. By addressing these gaps, fisheries managers, industry and community members will be better able to actively work towards reducing threats and ensuring a sustainable and healthy WCT population.



Can you see the redd? A redd is a nest created by spawning fish. Westslope Cutthroat Trout redds are usually located in slow, shallow water at the downstream end of a pool, and can be recognized by the pile of well sorted gravels that look cleaner than the rest of the river bed.

Redd Surveys

- Redd surveys or spawning surveys involve visually identifying the nests (redds) of spawning salmonids during their spawning season
- Redd surveys are a simple and minimally intrusive method of gathering baseline population information

2019 Results

- In spring 2019, we surveyed reaches of Lizard Creek, Morrissey Creek, Forsyth Creek and Coal Creek for WCT redds
- We walked a total of 8.2 km's and observed a total of 62 redds
- No redds were identified on the reaches walked in Forsyth and Coal Creek, however we found 55 redds on Lizard Creek and 7 redds on Morrissey Creek
- This was the 1st year of study - continued redd surveying in future years will allow us to evaluate population trends and potential stressors influencing WCT spawning
- Other important WCT spawning streams identified by previous research, include: Hartley Creek, Michel Creek and Fording River
- Knowing the importance of these tributaries for WCT recruitment will aid in prioritizing restoration and conservation efforts in key streams/areas

Habitat Assessments

- Areas of degraded WCT habitat were identified by members of the community, government and industry
- Habitat assessments were conducted to comprehensively evaluate habitat health using protocols derived from the Pacific Streamkeepers Federation (Streamkeepers) and the Canadian Aquatic Biomonitoring Network (CABIN)
- Evaluating habitat health allows us to determine areas in need of restoration and assists in prioritizing future work

Volunteers conducting a habitat assessment

Degraded habitat assessed on Andy Goode Creek

2019 Results

- In fall 2019, we conducted a total of 11 habitat assessments on multiple different tributaries, including: Lizard Creek, Morrissey Creek, Coal Creek, Andy Goode Creek, Corbin Creek and side channels of the Elk River
- We found that 73% of habitats assessed had marginal health, meaning they are below the acceptable level to support a healthy and diverse ecosystem
- This information will allow ERA to focus restoration and enhancement work in areas where improvements will create the greatest positive impact to the aquatic environment

Pamphlet created to educate people on the Elk River WCT Research Initiative (Page 2). This pamphlet was available in paper form at the 2nd workshop. Paper copies are available at ERA's office and digital copies are available for download on ERA's website.

Appendix E: Habitat site sheets

HAAG01

Site Habitat Evaluation and Restoration Assessment

Tributary:	Andy Goode (Michel)	Site code:	HAAG01
Lat:	49.52368	Date:	2019-11-08
Long:	-114.68877	Surveyors:	Brett E, Kate M., Scotia B.

1) Identified Concerns **(Watershed Restoration Implementation Sequence - Johnston and Moore 1995)**

Hillslope (Y/N):	N	Riparian (Y/N):	Y
Gully (Y/N):	N	Channel/habitat (Y/N):	Y
Proceed with Habitat Assessment and Evaluation (Y/N):		Y	

Comments: Large eroded bank has collapsed into stream from LB (approx 45m). Bank eroding into stream feeding logjam spanning stream width, chanign stream morphology. Trees activly falling into stream indicating ongoing erosion. 40m downstream from bridge. Good spawning habitat, however minimal cover.

2) Habitat Assessment **(Streamkeepers handbook, module 2)**	Result	Score	Comments
1. % boulder & cobble	44%	14	
2. % Embededness	25%	15	
3. Instream Cover	1.57	8	
4. % Pool Habitat	10.50%	1	
5. Off-channel habitat	none	0	
6. Bank stability	unstable	2	
7. Bank Vegetation (%)	50%	2	
8. Overhead Canopy (%)	5%	1	
9. Riparian Zone	1 to 2	7	
Habitat Assessment Score		50	

Description of degratative factors and Rehabilitation requirements:

Large eroded bank influencing stream morphology and causing stream widening. Rehabilitiation requirements: Requires bank realignment and stabilization of toe slope to prevent erosion. Revegetation and addition of Large woody debris would improve habitat and stabilize banks. Could also benefit from incorporating vegetetation in areas of rip rap.

HAAG01

3) Prioritization Criteria (subjective assesment)	Score **1 to 4**
1. One or more life stages?	3
Fish spotted udring survey (visually identified as a WCT). Evidence of WCT juvenile presence in the creek from previous juvenile abundance assessments.	
2. Spawning or overwintering Habitat?	3
No Redds observed however reach has high potential for spawning/rearing with ideal cover and substrate characteristics. Possible overwintering habitat, as there are a few deeper pools.	
3. Technical difficulty?	2
Similar bank stabilization projects have been conducted by ERA in the past. Heavy machinery and some specialist input is required.	
4. Complementary Restoration?	4
Several other restoration and habitat enhancements have been planned for the Michel creek system.	
5. Accessibility?	3
The site is approximatly one hour from Fernie, and easily accessable via vehicle and heavy equipment.	
6. Opportunities for Partnership?	2
There is a moderate chance of partnership with guiding companies, local environmental consultancies and the coal mine directly upstream of the site.	
7. Cost	1
Cost to complete rehabilitation work would likely be around $50,000-$60,000.	
8. Project longevity potential	2
Given the stream morphology at this site and soil dynamics, this bank stabilization project is likely to last between 5- 10 years if implemented correctly.	
9. Contribution to species awareness?	2
The site itself is some distance from commonly accessed areas and therefore unlikely to be seen by most members of the public, however volunteer and public outreach events will allow some degree of public awareness on the project and Western Cutthroat trout.	
Prioritization score	22
Habitat Assessment Score	50
Habitat Evaluation Score	44

HAAG01

Comments and recommendations:

Andy Goode Creek feeds into Michel Creek, which is home to important spawning and rearing habitat for WCT. Andy Goode Creek has not been studied as extensively, however juvenile WCT have been found rearing in the area in previous juvenile assessments and visually observed at the time of the site assessment.

Some of the upstream mining and logging activities on Andy Goode Creek, may have resulted in changes in water velocity resulting in the degradation of this site. Given the location of the site on private land (believed to be owned by Teck) cooperation and additional permits would be necessary. However, Teck may be interested in partnering on the restoration project. Guiding outfitters and independent environmental agencies may also be interested in partnering given the importance of this system and its exposure to a high level of anthropogenic influence.

This site is almost immediately adjacent to the highway making it easily accessible and a good candidate for rehabilitation through the use of bioengineering techniques. A combination of adding/repositioning LWD, re-shaping the stream bank and planting native riparian vegetation on the bank could be used. This would help to stabilize the bank, limit sedimentation and turbidity, promote restoration of the riparian zone and create new in-stream habitat for WCT. Project design and costs would be similar to restoration work in the past (Alexander Creek Restoration). This previous work would also provide evidence in longevity. The large logjam that has resulted from the collapse of the bank could cause further bank erosion and stream widening. Therefore, part of restoration plans should include adjusting these logs. They could even be used in restoration efforts (i.e .as footer logs), which would help cut project costs. Furthermore, the project could also incorporate environmental elements into the already rip-rapped stream banks, this may help to create more fish habitat and alleviate the negative effects of channelization through this section. Alternatively, a lower level restoration approach could be to just incorporate environmental elements in the rip-rapped areas.

The site is not near any main roads to showcase in the public eye, however if restoration efforts took place a complementary public outreach initiative could be implemented. This could involve community in hands-on restoration and riparian planting work, as well as provide an opportunity for contractors to educate these volunteers on the importance in conserving WCT habitat.

HACOL01

Site Habitat Evaluation and Restoration Assessment

Tributary:	Coal Creek	Site code:	HACOL01
Lat:	49.4866416	Date:	2019-10-16
Long:	-114.9774527	Surveyors:	Brett E, Chad H

1) Identified Concerns **(Watershed Restoration Implementation Sequence - Johnston and Moore 1995)**

Hillslope (Y/N):	N	Riparian (Y/N):	Y
Gully (Y/N):	N	Channel/habitat (Y/N):	Y
Proceed with Habitat Assessment and Evaluation (Y/N):		Y	

Comments: Human disturbance indicators: Concrete supports from hisotrical bridge. Multiple large metal debris in and around stream. Several failing streambanks. Concrete blocks influencing stream morphology and bank stabilty.

2) Habitat Assessment **(Streamkeepers handbook, module 2)**	Result	Score	Comments
1. % boulder & cobble	96%	20	
2. % Embededness	20%	16	
3. Instream Cover	1.22	5	
4. % Pool Habitat	33%	4	
5. Off-channel habitat	none	0	
6. Bank stability	unstable	3	Minimal erosion on both sides
7. Bank Vegetation (%)	86%	7	
8. Overhead Canopy (%)	22%	5	
9. Riparian Zone	1 to 2	5	
Habitat Assessment Score		65	

Description of degratative factors and Rehabilitation requirements:

Infestation of invasive plants in parts of riparian zone. Site well suited for a weed pull. Large pieces of metal debris on shoreline and embedded in streambed. Site requires a shoreline and stream cleanup, Around 3 days worth of effort for small team of volunteers. Rehabilitation requirements: Planting on right side of bank may halt erosion. Large concrete block removal requires heavy machinery, or may be unfeasible to remove. Weedpull would be beneficial for surrounding vegetation and a shoreline cleanup.

HACOL01

3) Prioritization Criteria (subjective assesment)	Score **1 to 4**
1. One or more life stages?	2
Adult and juvenile WCT are known to inhabit Coal Creek. Juvenile WCT were visually observed during 2019 redd surveys holding upstream from this site.	
2. Spawning or overwintering Habitat?	3
No spawning or overwintering has been identified in coal creek, however a small amount of viable spawning locations were identified. And given the presence of holding juvenile's approximately a few km's upstream it is likely that WCT are spawning in Coal Creek. There is also potential for WCT to overwinter in Coal Creek and previous indications from fly fisherman confirm WCT presence in the winter.	
3. Technical difficulty?	3
Aside from large block removal (heavy machinery needed), cleanup and remediation are achievable with ERA resources.	
4. Complementary Restoration?	3
ERA has several other project in Coal Creek. Current: Community based Water Monitoring. Proposed: Sedimentation and land use study, Habitat improvement (downstream).	
5. Accessibility?	4
The site is within 20 minutes drive of Fernie, and very close to a well developed forestry road.	
6. Opportunities for Partnership?	2
The city of Fernie as well as several local clubs (Fernie Trails Alliance, Fernie Rifle Range, Local Guiding companies) would likely be interested in partnering to improve the local amenities.	
7. Cost	2
Costs for rehabilitation would likely be around $30-40,000.	
8. Project longevity potential	2
Removal of large debris would be permanent. Invasive plants may need to be removed a few years in a row to allow for native plants to re-establish. Bank restabilization would likely have 5-10 year viability.	
9. Contribution to species awareness?	3
The moderate visibility of the site coupled with community involvment would allow moderate community education and awareness oppertunities.	
Prioritization score	24
Habitat Assessment Score	65
Habitat Evaluation Score	37

HACOL01

Comments and recommendations:
Coal Creek is known to be an important system from WCT and has come into the public eye with all of the logging that is happening upstream. Although, minimal research has bee conducted on WCT in Coal Creek, WCT are known to inhabit the stream as many fishermen claim there is abundant opportunities to catch WCT throughout the creek. It is thought to be an important system for both spawning and overwintering. This site appears to showcase the remains of an old bridge, with remnants of large concrete embankments that have fallen into the creek over time. The removal of these embankments could potentially cause more damage than improvement given the machinery that would be required to move them. Additionally, the cement embankments have altered the streams morphology, but appear to be causing no further degradation to the site. This site is also littered with metal debris on the shoreline and in-stream (possibly from the old mine) and has portions of its riparian zone that is abundant in higher priority invasive plants (i.e. Common Tansy, Spotted Knapweed). Implementing a clean-up effort including cleaning up metal debris and pulling weeds is the recommended enhancement approach for this site. This could be paired with a public outreach component where volunteers or school groups are brought to the site to assist with enhancement activities. This would involve the community and youth in restoring the stream and promote the understanding of the importance in stewardship activities. This would be an appropriate site for volunteer involvement with school groups given tis proximity to Fernie and ease of access.

HACOL02

Site Habitat Evaluation and Restoration Assessment

Tributary:	Coal Creek	Site code:	HACOL02
Lat:	49.4954	Date:	2019-11-19
Long:	-115.0619	Surveyors:	Brett E, Chad H

1) Identified Concerns **(Watershed Restoration Implementation Sequence - Johnston and Moore 1995)**

Hillslope (Y/N):	N	Riparian (Y/N):	Y
Gully (Y/N):	N	Channel/habitat (Y/N):	Y
Proceed with Habitat Assessment and Evaluation (Y/N):		Y	

Comments: Stream is long, straight, heavily channelized and lacking in complexity. Riparian habitat is lacking in places with riprap on left side and bank instability/erosion on both sides. Minimal fish habitat but has potential with some restoration work. Good candidate for enhancement.

2) Habitat Assessment **(Streamkeepers handbook, module 2)**	Result	Score	Comments
1. % boulder & cobble	84%	18	
2. % Embededness	50%	10	
3. Instream Cover	0.102	0	
4. % Pool Habitat	0%	0	
5. Off-channel habitat	none	0	
6. Bank stability	unstable	2	
7. Bank Vegetation (%)	17.50%	1	
8. Overhead Canopy (%)	11%	2	
9. Riparian Zone	>1	3	
Habitat Assessment Score		36	

Description of degratative factors and Rehabilitation requirements:

Habitat enhancement would involve large woody debris placement to improve complexity, connectivity and potentiallt rearing/spawning oppertunities. Moderate improvements in bank stability could be achived with planting and hand tools. One section at the downstream area of the reach would require earchmoving equipment. This is located on some bedrock so erosion isn't a great as it otherwise would be. Rehabilitation requirements: Bank realignment and stabilization (likely require revegetation). Site would benefit from low level habitat enhancement to increase habitat availability and conectivity.

HACOL02

3) Prioritization Criteria (subjective assesment)	Score **1 to 4**
1. One or more life stages?	2
Adult and juvenile WCT are known to inhabit Coal Creek. Juvenile WCT were visually observed during 2019 redd surveys holding upstream from this site.	
2. Spawning or overwintering Habitat?	3
No spawning or overwintering has been identified in coal creek, however a small amount of viable spawning locations were identified. And given the presence of holding juvenile's approximately a few km's upstream it is likely that WCT are spawning in Coal Creek. There is also potential for WCT to overwinter in Coal Creek and previous indications from fly fisherman confirm WCT presence in the winter.	
3. Technical difficulty?	4
Rehabilitation is easilly achevable with ERA's rescources.	
4. Complementary Restoration?	4
ERA has several other project in Coal Creek. Current: Community based Water Monitoring. Proposed: Sedimentation and land use study, Habitat improvement (upstream).	
5. Accessibility?	4
The site is within/adjacent Fernie township and alongside a footpath that could be accessed via vehicle.	
6. Opportunities for Partnership?	3
The city of Fernie would likely be interested in partnering to improve the local amenities.	
7. Cost	2
While a larger scale restoration project would cost around $50,000, significant improvements could be achieved with a moderate budget of around $20,000.	
8. Project longevity potential	2
Bank restabilization would have 5-10 year viability and in-stream large woody debris improvements would have a similar lifespan.	
9. Contribution to species awareness?	4
The site itself is on a well used footbath and likely to be highly visible to members of the public. Volunteer and public outreach events will allow a higher degree of public awareness on the project and Western Cutthroat trout.	
Prioritization score	28
Habitat Assessment Score	36
Habitat Evaluation Score	78

HACOL02

Comments and recommendations:
Coal Creek is known to be an important system from WCT and has come into the public eye with all of the logging that is happening upstream. Although, minimal research has bee conducted on WCT in Coal Creek, WCT are known to inhabit the stream and many fishermen fish the reach from the Montane bridge down to the confluence with the Elk River, which encapsulates this site. It is thought to be an important system for both spawning and overwintering. This would be an opportune site for habitat enhancement activities as it would involve easy access, low cost, and has potential for partnership with the City of Fernie. Habitat enhancement would involve large woody debris placement to improve complexity, connectivity and potentially rearing/spawning opportunities. Moderate improvements in bank stability could be achieved with planting and hand tools. One section at the downstream area of the reach would require earthmoving equipment. This is located on some bedrock so erosion wouldn't be as severe as in other locations. Given the ongoing sedimentation of Coal Creek from logging it is important we restore and enhance habitats where we can to help offset any upstream effects. Additionally, creating more pool and LWD habitat will help remove some of these suspended sediments from the water column through settlement and capture. Additionally, given the presence of rip-rap throughout the majority of this site it could be an ideal location for a vegetative rip=rap pilot project. This may be a project the City of Fernie would be interested in partnering on. The site is near main roads and a walking path walks alongside it, therefore it would be a great location to showcase enhancements to the community. Enhancement work could involve community in hands-on restoration and riparian planting, as well as provide an opportunity for contractors to educate these volunteers on the importance in creating WCT habitat.

HACOR01

Site Habitat Evaluation and Restoration Assessment

Tributary:	Corbin Creek	Site code:	HACOR01
Lat:	49.51334	Date:	2019-11-20
Long:	-114.67554	Surveyors:	Brett E, Kate M., Scotia B.

1) Identified Concerns **(Watershed Restoration Implementation Sequence - Johnston and Moore 1995)**

Hillslope (Y/N):	N	Riparian (Y/N):	Y
Gully (Y/N):	Y	Channel/habitat (Y/N):	Y
Proceed with Habitat Assessment and Evaluation (Y/N):			

Comments: Stream crossing by ATV's, possibly larger vehicles with likely inrease in sedimentation. Lots of metal and other debris in area. A few cascades in stream, not likely barries to fish. Good stream for fish habitat (aside from erosion).

2) Habitat Assessment **(Streamkeepers handbook, module 2)**	Result	Score	Comments
1. % boulder & cobble	56%	16	
2. % Embededness	30%	13	
3. Instream Cover	0.88	4	
4. % Pool Habitat	13%	1	
5. Off-channel habitat	year-round	8	
6. Bank stability	unstable	6	
7. Bank Vegetation (%)	92%	8	
8. Overhead Canopy (%)	7%	1	
9. Riparian Zone	>2	8	
Habitat Assessment Score		65	

Description of degratative factors and Rehabilitation requirements:

ATV crossing through stream. Debris in area (large metal etc). Rehabilitation requirements: Restoration involves cleanup (2 days) and remediation of ATV tracks. This could involve restricting access unlikely to have long term compliance) or addition of a bridge or other crossing to aleviate sedimentation. A bridge would have prohibitive cost. Adding concrete or large rocks to create a more durable crossing may result in least impact to environment and local stream users.

HACOR01

3) Prioritization Criteria (subjective assesment)	Score **1 to 4**
1. One or more life stages?	2
While no trout were observed during habitat assessment there is a high liklyhood the area contains viable habitat for multiple life stages.	
2. Spawning or overwintering Habitat?	3
Michel creek is a known, high quality tributary for spawning and rearing WCT. The area surrounding the site appears to have high quality spawning characteristics with pools suitible for overwintering.	
3. Technical difficulty?	4
Remediation is relatively simple if cleanup and rock/concrete crossing option is taken.	
4. Complementary Restoration?	4
Several other restoration and habitat enhancements have been planned for the Michel creek system.	
5. Accessibility?	3
The site is approximatly one hour from Fernie, but easily accessable via vehicle and heavy equipment.	
6. Opportunities for Partnership?	2
There is a moderate chance of partnership with local trails users and/or clubs (i.e. Sparwood ATV club, Elkford ATV club) and the coal mine directly upstream of the site.	
7. Cost	3
Significant improvements could be made to the site for under $20,000.	
8. Project longevity potential	2
Clean-up would have long term longevity potential (assuming no further debris is dumped). Re-enforcement of the stream crossing would likely remain functional for 5-10 years depending on materials used and maintenance.	
9. Contribution to species awareness?	2
The site itself is some distance from commonly accessed areas and therefore unlikely to be seen by most members of the public, however volunteer and public outreach events will allow some degree of public awareness on the project and Westslope Cutthroat Trout.	
Prioritization score	25
Habitat Assessment Score	65
Habitat Evaluation Score	38

HACOR01

Comments and recommendations:
Corbin Creek feeds into Michel Creek, which is home to important spawning and rearing habitat for WCT. Minimal research is publically available for Corbin Creek, however there is evidence that juvenile WCT have been found rearing in its reaches. Michel Creek and Corbin Creek have been exposed to anthropogenic influences, including: logging and coal mining. This site on Corbin Creek is just downstream from an old coal mine that may be contributing to its lowered habitat value. Coal fines have been documented settling on the streambed and were observed at the time of the site visit, which could be having multiple negative effects on WCT and aquatic health. The site also has a decommissioned bridge embankment that is slowly eroding into the stream, some invasive plant presence and large metal debris on stream banks. Remediating the issue of coal fines may be difficult and provide minimal habitat benefit, given the proximity to coal mining activities. Additionally, the eroding bridge embankment appears to be relatively stable, given the presence of low priority invasive plants inhabiting it (mainly Mulen). However, there is an uncontrolled, unmarked ATV crossing at this site that could be addressed. The ATV crossing is causing the stream to widen and encourages irresponsible recreational use. Juvenile trout have been found near this site and any disturbance from an ATV in stream could have adverse effects on incubating and rearing WCT. This site is likely on private property owned by Teck, which would further complicate the permitting process and partnership for any earthmoving activities. Therefore, enhancement may have to remain less invasive and complex. Teck may be interested in partnering on this project. The best recommendation for this site would be to address this ATV crossing and educate trail users. The crossing is not part of a known ATV trail and appears to may have had use by larger vehicles when the coal mine was in operation. Addressing this ATV crossing may be as simple as restricting access, however that is unlikely to have long term compliance. The better option may be to install a bridge or other crossing to alleviate sedimentation. However, a bridge would have prohibitive cost. Adding concrete or large rocks to create a more durable crossing may result in least impact to environment and local stream users. This installation could be paired with a public outreach component to educate trial users. This could involve posting signage, educating trail users on why the bridge was installed. ERA could also attend ATV club meetings and present on the importance of keeping ATVs out of streams. These groups could also volunteer to come out and help clean up the metal and debris at the site. Overall, the site is in relatively good condition and remediation would have moderate benefits to fish populations, given lack in ability to remediate the influence of upstream mining activities. Although, given the low cost of rehabilitation work is recommended pending engineering/specialist consultation.

HAELK01

Preliminary Site Habitat Evaluation and Restoration Assessment

Tributary:	Elk River	Site code:	HAELK01
Lat:	49.52321	Date:	2019-10-16
Long:	-115.05245	Surveyors:	Brett E, Chad H

1) Identified Concerns **(Watershed Restoration Implementation Sequence - Johnston and Moore 1995)**

Hillslope (Y/N):	N	Riparian (Y/N):	Y
Gully (Y/N):	N	Channel/habitat (Y/N):	Y
Proceed with Habitat Assessment and Evaluation (Y/N):		Y	

Comments: Riprap/bank armouring negativly impacts habitat values. Side channel appears constricted with estimated 200+ juvenile mountain whitefish and cutthroat trout in long shallow side channel. May result in significant mortality post freeze, likely natural mortality. Bank not riprap'd failing into river. Some possible groundwater influence. See site sheet for further information.

2) Habitat Assessment **(Streamkeepers handbook, module 2)**	Result	Score	Comments
1. % boulder & cobble*	0%	0	Substrate composed of fines
2. % Embededness*	0%	0	
3. Instream Cover*	0	4	Some semi-aquatic macrophytes. No large habitat features
4. % Pool Habitat	57.50%	12	
5. Off-channel habitat	0	0	
6. Bank stability	Mod/some	10	
7. Bank Vegetation (%)	66%	4	
8. Overhead Canopy (%)	1%	1	
9. Riparian Zone	1 to 2	5	sparse, common/good trees and shrubs
Habitat Assessment Score		36	**Note:** A full habitat assessment was not conducted to limit the level of disturbance to the large school of fish in the channel. Some Habitat Assessment parameter scores were based on visual estimates. Estimated values are indicated with an asteriks.

Description of degratative factors and Rehabilitation requirements:

Relatively small eroded bank adjacent to walking path that is beginning to erode. May not be suitable habitat to support fish and fish mortality may result over winter. Rehabilitation requirements: Requires bank realignment and stabilization of toe slope to prevent erosion. Revegetation and addition of large woody debris would improve habitat and stabilize banks. Fish mortality during winter freeze may be possible, may only be preventabe by fish salvage. However, may be enough groundwater influence for them to survive if fish move slightly downstream. Any rehabilitation work is within Elk River flood channel and will be effected by yearly freshet flow and intermittant flooding.

HAELK01

3) Prioritization Criteria (subjective assesment)	Score
	1 to 4
1. One or more life stages?	3
Juvenile WCT were present at the site during time of assessment. However, may be utilized by other life stages given its connected to the Elk River, which is home to all WCT life stages. Additionally, large number of juvenile whitefish were identified at the site during time of assessment.	
2. Spawning or overwintering Habitat?	2
Uncertainities exist around whether this side channel is suitable for overwintering habitat. May be suitable given groundwater influence, however may be too shallow in low flow conditions. Unsuitable spawning habitat.	
3. Technical difficulty?	2
Heavy equipment will be required tro remediate failing banks. Fish specialists will be required to salvage fish if required.	
4. Complementary Restoration?	3
This restoration would compliment the adjacent recreation trail, preventing it from eroiding further and mitigating assocaited dangers.	
5. Accessibility?	4
The site is readily accessible via the adjacent walking trail and near downtown Fernie.	
6. Opportunities for Partnership?	4
Oppurtunities for partnership exist including: City or Fernie, Fernie Trails Alliance, Fish Guiding Outfitters and adjacent RV park.	
7. Cost	2
Fish salvage would have a relativly low cost if performed in-kind by local registered professionals. Rehabilitation of the stream/bank would require approximatly $20,000 to $50,000.	
8. Project longevity potential	1
Vegetative riprap would have longer longevity than biological techniques. However, either way there is a good chance that restoration efforts may be destroyed within the next flood event (2-5 years). Fish salvage would vary yearly, possibly requiring yearly salvages.	
9. Contribution to species awareness?	4
As the site is well used by a wide spectrum on the community (tourists, locals, fishers, bikers, walkers etc). Therefore, action could have a high degree of visibility if combined with volunteer oppurtunities and signage.	
Prioritization score	25
Habitat Assessment Score	36
Habitat Evaluation Score	69

HAELK01

Comments and recommendations:

The Elk River is a stronghold WCT within its natural range. It provides important spawning and rearing habitat as WCT have been found spawning in side channels of the Elk River mainstem. There is also abundant overwintering in deep pools of the Elk River.

At this site there was estimated to be 200+ juvenile Westslope cutthroat trout and mountain whitefish in the long shallow side channel/back channel. After discussion with a local environmental consultant, it appears that the fish may be able to exit the channel, which appeared to be dense with semi-aquatic macrophytes to the main channel to evade freezing mortality. Furthermore, the small groundwater springs were visible at the time of habitat assessment, which may prevent freezing and providing fish with good overwintering habitat. Suggestions were made to not apply for permitting to perform a fish salvage and to let nature run its course. However, this may be a site to monitor in the future to see if fish left the channel in the winter or not and if the channel does freeze solid in the winter or not.

Aside from the present fish, there is evidence of bank erosion at this site as well. The erosion is beginning to erode the walking path, which could pose a large safety hazard for recreational users. The site could be accessed easily from this trail making it a good candidate for rehabilitation through the use of bioengineering techniques. A combination of adding/repositioning LWD, re-shaping the stream bank and planting native riparian vegetation on the bank could be used. This would help to stabilize the bank, limit sedimentation and turbidity, promote restoration of the riparian zone and create new in-stream habitat for WCT. Project design and would be similar to restoration work in the past (Alexander Creek Restoration) and costs would be less given the smaller size. This rehabilitation work would also help to improve the current and worsening danger of the walking trail to recreation users. One set back for any restoration work carried out would be the lack of likely longevity because of the power of the Elk River waters during spring freshet and high water events. There is a good chance that the restoration work would be destroyed during such events. However, perhaps other restoration options could be explored or more heavy duty anchoring tactics could be used to help increase the restorations longevity. That being said, another option for bank restoration would be via vegetative riprap, which could be run as a pilot project with potential partnership with the City of Fernie. This would increase the likelihood of longevity, however would not be as beneficial for in-stream habitat features.

There is good opportunity for partnership at this site given the number of stakeholders that may be interested, including: The City of Fernie, Fernie Trails Alliance, Fish Guiding Outfitters and the nearby RV park. The site is adjacent to a well used trail, presenting a good opportunity to showcase the restoration work. This would present a good opportunity to place educational signage at the site of restoration, increasing species awareness. This could also involve community in hands-on restoration and riparian planting work, as well as provide an opportunity for contractors to educate these volunteers on the importance in conserving WCT habitat.

The Elk River is a stronghold WCT within its natural range. It provides important spawning and rearing habitat as WCT have been found spawning in side channels of the Elk River mainstem. There is also abundant overwintering in deep pools of the Elk River.

At this site there was estimated to be 200+ juvenile Westslope cutthroat trout and mountain whitefish in the long shallow side channel/back channel. After discussion with a local environmental consultant, it appears that the fish may be able to exit the channel, which appeared to be dense with semi-aquatic macrophytes to the main channel to evade freezing mortality. Furthermore, the small groundwater springs were visible at the time of habitat assessment, which may prevent freezing and providing fish with good overwintering habitat. Suggestions were made to not apply for permitting to perform a fish salvage and to let nature run its course. However, this may be a site to monitor in the future to see if fish left the channel in the winter or not and if the channel does freeze solid in the winter or not.

HAELK01

Aside from the present fish, there is evidence of bank erosion at this site as well. The erosion is beginning to erode the walking path, which could pose a large safety hazard for recreational users. The site could be accessed easily from this trail making it a good candidate for rehabilitation through the use of bioengineering techniques. A combination of adding/repositioning LWD, re-shaping the stream bank and planting native riparian vegetation on the bank could be used. This would help to stabilize the bank, limit sedimentation and turbidity, promote restoration of the riparian zone and create new in-stream habitat for WCT. Project design and would be similar to restoration work in the past (Alexander Creek Restoration) and costs would be less given the smaller size. This rehabilitation work would also help to improve the current and worsening danger of the walking trail to recreation users. One set back for any restoration work carried out would be the lack of likely longevity because of the power of the Elk River waters during spring freshet and high water events. There is a good chance that the restoration work would be destroyed during such events. However, perhaps other restoration options could be explored or more heavy duty anchoring tactics could be used to help increase the restorations longevity. That being said, another option for bank restoration would be via vegetative riprap, which could be run as a pilot project with potential partnership with the City of Fernie. This would increase the likelihood of longevity, however would not be as beneficial for in-stream habitat features.

There is good opportunity for partnership at this site given the number of stakeholders that may be interested, including: The City of Fernie, Fernie Trails Alliance, Fish Guiding Outfitters and the nearby RV park. The site is adjacent to a well used trail, presenting a good opportunity to showcase the restoration work. This would present a good opportunity to place educational signage at the site of restoration, increasing species awareness. This could also involve community in hands-on restoration and riparian planting work, as well as provide an opportunity for contractors to educate these volunteers on the importance in conserving WCT habitat.

HAELK02

Preliminary Site Habitat Evaluation and Restoration Assessment

Tributary:	Elk River main Side Channel	Site code:	HAELK02
Lat:	49.491	Date:	2019-11-07
Long:	-115.0787	Surveyors:	Brett E, Chad H

1) Identified Concerns **(Watershed Restoration Implementation Sequence - Johnston and Moore 1995)**

Hillslope (Y/N):	N	Riparian (Y/N):	Y
Gully (Y/N):	N	Channel/habitat (Y/N):	Y
Proceed with Habitat Assessment and Evaluation (Y/N):	Y		

Comments: Active erosion on bank. Existing vegetation not sufficent to prevent erosion. Depth of bank ~2.5m. Trees fallen into streambed. Undercut pathway falling into channel. Several discontinuous pools with live fish indicate seasonal connectivity to main stem. May be an important area for juvenile fish.

2) Habitat Assessment **(Streamkeepers handbook, module 2)**	Result	Score	Comments
1. % boulder & cobble*	60%	19	
2. % Embededness*	30%	12	
3. Instream Cover*	1.6	7	
4. % Pool Habitat*	25%	1	
5. Off-channel habitat*	seasonal	9	seasonal, some protection
6. Bank stability*	unstable	7	
7. Bank Vegetation (%)*	90%	8	
8. Overhead Canopy (%)*	10%	2	
9. Riparian Zone*	1 to 2	6	
Habitat Assessment Score		71	**Note:** A full habitat assessment was not conducted to due to the lack of flow in the ide channel at the time of assessment. Some Habitat Assessment parameter scores were based on visual estimates. Estimated values are indicated with an asteriks.

Description of degratative factors and Rehabilitation requirements:

Eroding bank is contributing to the undercutting of a walking trail used by recreationalists. The undercutting appears to be worsening and may be dangerous to the saftey of users. Eroding banks may increase sedimentation in high flow, however given generally high turbidity and sediment transfer in the Elk River during high water the impacts of this small stretch of bank are negilible. Rehabilitation required: Restoration of the bank with some vegetation and large woody debris may provide additional pool and habitat in the main stem during high water. However, any rehabilitation work is within Elk River flood channel and will be effected by yearly freshet flow and intermittant flooding.

HAELK02

3) Prioritization Criteria (subjective assesment)	Score **1 to 4**
1. One or more life stages?	1
While trout are likely existent in adjacent stretch of the Elk River they are not present during normal flow conditions. Habitat may be utilized by juvenile fish.	
2. Spawning or overwintering Habitat?	1
Not sutiable trout spawning or overwintering habitat given its seasonal nature.	
3. Technical difficulty?	3
Restoration would be relatively easy, and ERA has completed similar work in the past.	
4. Complementary Restoration?	3
This restoration would compliment the adjacent recreation trail, preventing it from eroiding further and mitigating assocaited dangers.	
5. Accessibility?	4
The site is readily accessible via the adjacent walking trail and near downtown Fernie.	
6. Opportunities for Partnership?	3
Oppurtunities for partnership exist including: City or Fernie and Fernie Trails Alliance.	
7. Cost	2
Rehabilitation of the stream/bank would require approximatly $30,000.	
8. Project longevity potential	2
There is a chance that restoration efforts may be destroyed within the next flood event (2-5 years). The bank is situated in an area that powerful flow could undercut the bank again. Vegetative riprap may be the better solution, which would increase longevity (5-10 years).	
9. Contribution to species awareness?	3
As the site is well used by a wide spectrum on the community (tourists, locals, fishers, bikers, walkers etc) action could have a high degree of visability if combined with volunteer oppertunities and signage.	
Prioritization score	22
Habitat Assessment Score	71
Habitat Evaluation Score	31

HAELK02

Comments and recommendations:

The Elk River is a stronghold WCT within its natural range. It provides important spawning and rearing habitat as WCT have been found spawning in side channels of the Elk River mainstem. There is also abundant overwintering in deep pools of the Elk River. Given substrate characteristics and seasonal flow in this particular channel it is unlikely that this side channel is utilized for spawning and or overwintering. However, the side channel may be utilized by rearing juvenile fish. A few dead and living juvenile fish were observed in small pools near the site that will likely freeze solid this winter.

There is an eroded bank that requires rehabilitation at this site. The erosion is beginning to erode the adjacent walking path, which could pose a large safety hazard for recreational users. The site could be accessed easily from this trail making it a good candidate for rehabilitation through the use of bioengineering techniques. A combination of adding/repositioning LWD, re-shaping the stream bank and planting native riparian vegetation on the bank could be used. This would help to stabilize the bank, limit sedimentation and turbidity, promote restoration of the riparian zone and create new in-stream habitat for WCT. Project design and would be similar to restoration work in the past (Alexander Creek Restoration) and costs would be less given the smaller size. This rehabilitation work would also help to improve the current and worsening danger of the walking trail to recreation users. One set back for any restoration work carried out would be the lack of likely longevity because of the power of the Elk River waters during spring freshet and high water events. There is a good chance that the restoration work would be destroyed during such events. However, perhaps other restoration options could be explored or more heavy duty anchoring tactics could be used to help increase the restorations longevity. The restoration of this site could include addressing areas where small pools of water formed and trapped juvenile fish to prevent future fish kills in the fall/winter.

There is good opportunity for partnership at this site given the number of stakeholders that may be interested, including: The City of Fernie and Fernie Trails Alliance. The site is adjacent to a well used trail, presenting a good opportunity to showcase the restoration work. This would present a good opportunity to place educational signage at the site of restoration, increasing species awareness. This could also involve community in hands-on restoration and riparian planting work, as well as provide an opportunity for contractors to educate these volunteers on the importance in conserving WCT habitat.

HAELK03

Preliminary Site Habitat Evaluation and Restoration Assessment

Tributary:	Elk River main Side Channel	Site code:	HAELK03
Lat:	49.491374	Date:	2019-11-07
Long:	-115.080825	Surveyors:	Brett E, Chad H

1) Identified Concerns (Watershed Restoration Implementation Sequence - Johnston and Moore 1995)

Hillslope (Y/N):	N	Riparian (Y/N):	Y
Gully (Y/N):	N	Channel/habitat (Y/N):	N
Proceed with Habitat Assessment and Evaluation (Y/N):		Y	

Comments: Oppertunistic observation on south/west side of Elk river. Long section of failing bank. Bank will likely require stabilization at some point in future to avoid encroachment onto highway. May be opportunity to proactivly enhance bank.

2) Habitat Assessment (Streamkeepers handbook, module 2)	Result	Score	Comments
1. % boulder & cobble*	60%	19	
2. % Embededness*	30%	12	
3. Instream Cover*	1.4	6	
4. % Pool Habitat*	25%	1	
5. Off-channel habitat*	none	1	
6. Bank stability*	unstable	2	
7. Bank Vegetation (%)*	60%	4	
8. Overhead Canopy (%)*	10%	2	
9. Riparian Zone*	1 to 2	6	
Habitat Assessment Score		53	**Note:** A full habitat assessment was not conducted to due dangers associated with high water velocity and channel depth. Some Habitat Assessment parameter scores were based on visual estimates. Estimated values are indicated with an asteriks.

Description of degratative factors and Rehabilitation requirements:

Large eroded bank. Rehabilitation, enhancement and stabilization would would be a large undertaking due to the extensive area, large size of banks and size of river. Rehabilitation requirements: Would likely require riprap and high degree of technical expertise, plus heavy equipment to achive satisfactory results. Vegetative riprap methodology could be used. However, any rehabilitation work is within Elk River flood channel and will be effected by yearly freshet flow and intermittant flooding.

HAELK03

3) Prioritization Criteria (subjective assesment)	Score **1 to 4**
1. One or more life stages?	3
It's more than likley the stretch of the river is utilized by several life stages and potentially Bull Trout.	
2. Spawning or overwintering Habitat?	2
The area is possible spawing habitat, but more likely utilized as overwintering habitat.	
3. Technical difficulty?	1
Would likely require riprap and high degree of technical expertise plus heavy equipment to achieve satisfactory results.	
4. Complementary Restoration?	2
Not a great deal of complimentary retoration oppurtunities.	
5. Accessibility?	2
The site is easily accessible as it is along highway 3. However, it is close enough to the highway that this may complicate access. Traffic regulation would be necessary.	
6. Opportunities for Partnership?	2
Main roads/Ministry of Transportation and the City of Fernie could be effective partners. Although, it is likely that a project of this caliber would be undertaken solely by the Ministry. That being said, ERA could contribute in community awareness and public outreach component of the project.	
7. Cost	1
Project would cost $100,000+ given the length and severity of the site.	
8. Project longevity potential	1
Properly executed vegetative riprap would have a longer life than biological techniques. However, given the exposure of this site in high flooding events the longevity may be reduced. There is a chance that restoration efforts may be destroyed within the next flood event (2-5 years).	
9. Contribution to species awareness?	2
The site is adjacent to a trail used by some recreationalists. Restoring this site could help to effectively engage with the public, as well as have a significant volunteer and education component.	
Prioritization score	16
Habitat Assessment Score	53
Habitat Evaluation Score	30

HAELK03

Comments and recommendations:
The Elk River is a stronghold WCT within its natural range. It provides important spawning and rearing habitat as WCT have been found spawning in side channels of the Elk River mainstem. There is also abundant overwintering in deep pools of the Elk River. Given substrate characteristics in this particular stream section it is unlikely that it is utilized for spawning; however, fish may utilize the deeper pools and faster flowing water for overwintering. There is an eroded bank that requires rehabilitation at this site. The site could be accessed easily from adjacent highway 3 making it a good candidate for rehabilitation, however it may not be an ideal candidate for the use of bioengineering techniques. The most feasible and effective restoration method would be through the use of vegetative riprap. Although this not the most environmentally friendly method for restoration, it would increase the longevity of the site providing greater long-term benefits while still creating in-stream habitat for WCT. A project of this magnitude would require extensive consultation from environmental and industry professionals. The cost of this project would be quite expensive given the scope of the work and third party consultation needed. There is potential opportunity for partnership at this site, including: The City of Fernie, Fernie Trail Alliance and Main roads/Ministry of Transportation. The site is adjacent to a recreational trail, presenting a good opportunity to showcase the restoration work. This would present a good opportunity to place educational signage at the site of restoration, increasing species awareness. This could also involve community in hands-on restoration and riparian planting work, as well as provide an opportunity for contractors to educate these volunteers on the importance in conserving WCT habitat. However, given the scope of the project it is likely that a project of this caliber would be undertaken solely by the Ministry. That being said, ERA could contribute in community awareness and public outreach component of the project. The City of Fernie may be interested in partnering on this project as a pilot project for testing the success of vegetative riprap along the Elk River, which may open the door for further opportunities.

HAHAR01

Preliminary Site Habitat Evaluation and Restoration Assessment

Tributary:	Hartley Creek	Site code:	HAHAR01
Lat:	49.54861	Date:	2019-10-03
Long:	-115.015	Surveyors:	Brett E, Chad H

1) Identified Concerns **(Watershed Restoration Implementation Sequence - Johnston and Moore 1995)**

Hillslope (Y/N):	N	Riparian (Y/N):	N
Gully (Y/N):	N	Channel/habitat (Y/N):	Y
Proceed with Habitat Assessment and Evaluation (Y/N):		Y	

Comments: Culvert brought to our attention is at the interection of Hartley Creek and Highway 3 (Culvert 1). Underside of culvert appears to be collapsing, could be barrier to fish movement. Another culvert upstream (Culvert 2) was assessed as it is a hanging culvert, but was deterined to not be a barrier for fish. Assessment can be found in **Appendix III**. See field data sheet for more comments.

2) Habitat Assessment **(Streamkeepers handbook, module 2)**	Result	Score	Comments
1. % boulder & cobble*	50%	15	
2. % Embededness*	30%	13	
3. Instream Cover*	1	5	instream cover is greater U/S of culvert vs. D/S
4. % Pool Habitat*	30%	3	
5. Off-channel habitat*	none	1	
6. Bank stability*	stable	8	
7. Bank Vegetation (%)*	80%	6	
8. Overhead Canopy (%)*	30%	8	U/S of culvert overhead canopy much thicker
9. Riparian Zone*	1 to 2	8	
Habitat Assessment Score		67	**Note:** A full habitat assessment was not conducted due to the presence of a culvert. Some Habitat Assessment parameter scores were based on visual estimates. Estimated values are indicated with an asteriks.

Description of degratative factors and Rehabilitation requirements:

Culvert at site is collapsing and may pose as a barrier to fish and is a potential hazard to the creek/highway. Rehabilitation requirements: Replacement of culvert. This would have to be done in conjunction with Ministry of Transportation/Main Roads to rectify constricted culvert.

HAHAR01

3) Prioritization Criteria (subjective assesment)	Score **1 to 4**
1. One or more life stages?	4
Hartely Creek is known to be home to all life stages of WCT. Bull Trout and Mountain Whitefish have also been found utilizing the stream.	
2. Spawning or overwintering Habitat?	3
Hartley Creek is an important tributary for spawning and rearing WCT. WCT redds have previously been found downstream from this site. Overwintering is unlikely given the streams morphology and low flow characteristics.	
3. Technical difficulty?	1
The rehabilitation of this site would require the closure or traffic alteration of highway 3, which would pose some difficulty. Removing and replacing the culvert would be technically difficult and would require extensive consultation.	
4. Complementary Restoration?	1
This restoration would not compliment other restoration in the area.	
5. Accessibility?	4
The site is easily accessible for the required heavy equipment for site rehabilitation and is close to downtown Fernie.	
6. Opportunities for Partnership?	2
There is oppurtunity for partnership with Main Roads/Ministry of Transportation. Although, it is likely that a project of this caliber would be undertaken solely by the Ministry. That being said, ERA could contribute in community awareness and public outreach component of the project.	
7. Cost	1
Project would cost $100,000+ given the nature of the work and machinery required.	
8. Project longevity potential	4
The implementation of a properly sized culvert would have 20+ years longevity. Built with proper characteristics to withstand flooding (every 2-5 years) and high water events.	
9. Contribution to species awareness?	3
The site itself is located along the highway and would be seen by many menerbs of the public. However not an area that experiences much foot traffic so interactive signage would not be useful, alternatively a large sign of some kind could be useful. A comination of volunteer and public outreach events would help to increase public awareness of the project and promote the conservation of WCT.	
Prioritization score	23
Habitat Assessment Score	67
Habitat Evaluation Score	34

HAHAR01

Comments and recommendations:

Hartley Creek is known to be home to all life stages of WCT and is an important tributary for spawning and rearing WCT. WCT redds have previously been found downstream from this site. Overwintering is unlikely given the streams morphology and low flow characteristics. In previous surveys, Bull Trout and Mountain Whitefish have also been found utilizing the stream.

The main issue that needs to be addressed at this site is the collapsing/undersized culvert at the intersection of Hartley Creek and Highway 3. When the site was visited in October This culvert is a potential barrier for fish movement and a danger to the creek/highway. Numerous citizens have brought this site to ERA's attention as it cannot support the flow of water from Hartley Creek and consistently floods, sometimes flowing over the highway during spring freshet. Over the past 12 years, it can be seen that the culvert has compressed **(See Figure X)** and is no longer suited to handle the flow that it once once. The smaller culvert is more likely to become blocked by debris and restrict natural water movement, leading to altered stream morphology and fish movement. Given the importance of Hartley Creek for spawning and rearing WCT it is important that this culvert is addressed to prevent restrictions to natural fish movement and concerns related to altered stream morphology. Given the scope of the work and involved costs, ERA does not have the resources and experience to replace this culvert. However, ERA could advocate for WCT conservation by notifying the Ministry of Transportation of the problem culvert and offer support in any way necessary. The Ministry of Transportation would be responsible for the work related to replacing this culvert.

There is potential opportunity for partnership at this site with the Ministry of Transportation/Main Roads and the City of Fernie. As previously mentioned, the Ministry of Transportation would likely be responsible for undertaking the majority of the work, however ERA could offer supporting in the form of on-site work, volunteer involvement, community awareness and public outreach related to the project.

*Need figure comparing culvert photo from interior reforestation September 2017 to our photo of culvert from October 2019.

HALIZ01

Site Habitat Evaluation and Restoration Assessment

Tributary:	Lizard Creek	Site code:	HALIZ01
Lat:	49.4901	Date:	2019-10-17
Long:	-115.10577	Surveyors:	Brett E, Chad H

1) Identified Concerns **(Watershed Restoration Implementation Sequence - Johnston and Moore 1995)**

Hillslope (Y/N):	N	Riparian (Y/N):	Y
Gully (Y/N):	N	Channel/habitat (Y/N):	Y
Proceed with Habitat Assessment and Evaluation (Y/N):		Y	

Comments: Area of concern due to active erosion of steep slope into stream with potential for trees to enter channel. Erosion adjacent existing roadway, potenial danger and remediation required.

2) Habitat Assessment **(Streamkeepers handbook, module 2)**	Result	Score	Comments
1. % boulder & cobble	84%	18	
2. % Embededness	35%	12	
3. Instream Cover	3.36	17	
4. % Pool Habitat	11%	1	
5. Off-channel habitat	none	0	
6. Bank stability	unstable	2	
7. Bank Vegetation (%)	94%	9	
8. Overhead Canopy (%)	27%	7	
9. Riparian Zone	1 to 2	6	
Habitat Assessment Score		72	

Description of degratative factors and Rehabilitation requirements:

Steep eroded bank adjacent to road that may begin to erode if nothing is done. Rehabilitation requirements: Requires bank realignment and stabilization of toe slope to prevent erosion. Revegetation and addition of Large woody debris would improve habitat and stabilize banks. Lizard Creek is a very sugnificant stream for WCT recruitment.

HALIZ01

3) Prioritization Criteria (subjective assesment)	Score **1 to 4**
1. One or more life stages?	4
Lizard Creek is known to be one of the most significant tributiaries for WCT recruitment and juvenile rearing in the Elk River watershed. All WCT lifestages are found in abundance.	
2. Spawning or overwintering Habitat?	3
Lizard Creek is one of the most highly utilized tributaries by spawning WCT in the Elk River watershed. Approximately 50 WCT redds were identified on Lizard Creek by ERA in 2019, downstream from this site. WCT have also been known to overwinter in some of the deep pools in Lizard Creek.	
3. Technical difficulty?	2
Similar bank stabilization projects have been conducted by ERA in the past. However, this is a steep slope, which may complicate any re-vegetative planting. The top of the slope is joined the road, which may also complicate restoration efforts. Heavy machinery and some specialist input is required.	
4. Complementary Restoration?	4
ERA has performed similar projects downstream of this site. Furthermore ERA monitors Lizard Creek as part of it's Community Based Water Monitoring program and ERA conducted redd surveys on Lizard Creek in 2019.	
5. Accessibility?	3
The site is approximatly twenty minutes from Fernie, and easily accessable via vehicle and heavy equipment.	
6. Opportunities for Partnership?	3
Island Lake Lodge as well as British Columbia Parks may be interested in partnering on this project.	
7. Cost	2
Cost to complete rehabilitation work would likely be between $20,000 and $50,000.	
8. Project longevity potential	2
Given the stream morphology and slope of the bank at this site, restoration efforts are likely to be viable for 5-10 years, if implemented correctly.	
9. Contribution to species awareness?	3
Mewmebers of the public frequently drive and cycle past this site providing high visibility, particularly with signage. Volunteer and public outreach events will allow some degree of public awareness on the project and Western Cutthroat trout.	
Prioritization score	26
Habitat Assessment Score	72
Habitat Evaluation Score	36

HALIZ01

Comments and recommendations:
Lizard Creek is known to be one of the most significant tributaries for WCT recruitment and juvenile rearing in the Elk River watershed. Approximately 50 WCT redds were identified on Lizard Creek by ERA in 2019, downstream from this site. WCT have also been known to overwinter in some of the deep pools in Lizard Creek. This site is immediately adjacent to the road making it easily accessible and a good candidate for rehabilitation through the use of bioengineering techniques. A combination of adding/repositioning LWD, re-shaping the stream bank and planting native riparian vegetation on the bank could be used. This would help to stabilize the bank, limit sedimentation and turbidity, promote restoration of the riparian zone and create new in-stream habitat for WCT. Project design and costs would be similar to restoration work in the past (Alexander Creek Restoration). This previous work would also provide evidence in longevity. However, the erosion at this site is beginning to eat away at the road and the slope that has failed is quite steep. This could complicate restoration efforts, causing issues with re-vegetating or re-shaping the slope. That being said, since the erosion is beginning to eat away at the road it also increases the need for restoration. This could entice Island Lake Lodge (the property owners) to become more interested in partnering on this project and possibly offering some funding to complete the project. Consultation with environmental consultants will be required to assess what can be done to accommodate the restoration of this steeper pitch. The site is near a well trafficked road, presenting a good opportunity to showcase the restoration work. This could also involve community in hands-on restoration and riparian planting work, as well as provide an opportunity for contractors to educate these volunteers on the importance in conserving WCT habitat.

HAMOR01

Site Habitat Evaluation and Restoration Assessment

Tributary:	Morrissey Creek	Site code:	HAMOR01
Lat:	49.36212	Date:	2019-03-10
Long:	-114.98454	Surveyors:	Brett E, Emily T, Kaleigh M

1) Identified Concerns **(Watershed Restoration Implementation Sequence - Johnston and Moore 1995)**

Hillslope (Y/N):	N	Riparian (Y/N):	Y
Gully (Y/N):	N	Channel/habitat (Y/N):	Y
Proceed with Habitat Assessment and Evaluation (Y/N):		Y	

Comments: Actively eroding bank is increasing sediment load. Could be impeding fish downstream/reducing habitat connectivity. Trees have fallen and/or activly falling into stream off bank. High Priority site for restoration given use of Morrissey Creek by WCT, adjacent land uses (gas line/ active logging in catchment). Easily acessable from road via right of way. Site visit #2: Heavy rain. Witnessed active erosion, water downstream significantly more turbid. Appears like more trees may fall. High water could further undercut/widen stream.

2) Habitat Assessment **(Streamkeepers handbook, module 2)**	Result	Score	Comments
1. % boulder & cobble	88%	16	
2. % Embededness	10%	16	
3. Instream Cover	0.67	1	
4. % Pool Habitat	11%	1	
5. Off-channel habitat	minimal	6	
6. Bank stability	unstable	2	
7. Bank Vegetation (%)	81%	5	
8. Overhead Canopy (%)	29%	6	
9. Riparian Zone	>2	8	
Habitat Assessment Score		61	

Description of degratative factors and Rehabilitation requirements:

Actively eroding bank is increasing sediment load. Could be impeding fish downstream/reducing habitat connectivity. Trees have fallen and/or activly falling into stream off bank. High Priority site for restoration given use of Morrissey Creek by WCT, adjacent land uses (gas line/ active logging in catchment). Easily acessable from road via right of way. Rehabilitation requirements: Bank realignment and stabilization (likely require revegetation). Addition of LWD at tow slope to prevent furhter erosion and improve habitat.

HAMOR01

3) Prioritization Criteria (subjective assesment)	Score **1 to 4**
1. One or more life stages?	3
WCT are known to use Morrissey Creek in all life stages. It is likely that Bull Trout use this stream as well, however minimal research has beendone to assess the importance of Morrissey Creek for Bull Trout. System also may be imprtant for Mountain Whitefish spawning, based on visual observations in the Fall (Mountain Whitefish are a yellow listed species in BC).	
2. Spawning or overwintering Habitat?	3
High potential for spawning habitat post restoration, given surrounding habitat. Active spawing up and downstream of site.	
3. Technical difficulty?	1
Similar bank stabilization projects have been conducted by ERA in the past. However the existance of a TP gas line creates a level of technical difficulty with regard to utilizing heavy machinery.	
4. Complementary Restoration?	3
Another site (HAMOR2) approximately 500m downstream from this site has been identifed as a degraded habitat. Although sites are not close enough to directly benefit each other, restoration of either site would contribute to improving the health of the tributary.	
5. Accessibility?	3
The site is relatively accessable due to the TP gas right of way, the site is approximatly 25 minutes from Fernie with a minimal componant of well maintained forrestry road.	
6. Opportunities for Partnership?	3
Yes. As the site is located on a Fortis BC TP gas line there is potential for assistance here. Additionally the land is privatly owned by Canwel, with the potential for assistance with log and LWD replacemnt.	
7. Cost	1
Cost for similar projects is around $55,000.	
8. Project longevity potential	3
This bank stabilization is projected to last between 10-20 years depending on the succes of planted vegetation and stream dynamics in that time.	
9. Contribution to species awareness?	2
The site itself is off main forestry roads and therefore unlikely to be seen by members of the public, however volunteer and public outreach events will allow a high degree of public awareness on the project and Westslope Cutthroat trout.	
Prioritization score	22
Habitat Assessment Score	61
Habitat Evaluation Score	36.07

HAMOR01

Comments and recommendations:
Morrissey Creek is an important tributary for spawning and rearing WCT, therefore increasing the priority of restoring this site. The site in an area that has the potential to provide significant habitat to WCT. Given the location of the site on private land and the presence of Fortis gas line, cooperation and additional permits would be necessary. However, Canwel may be willing to donate some logs for LWD implementation and Fortis may be interested in partnering on the project. This site could be rehabilitated through the use of bioengineering techniques. A combination of adding/repositioning LWD, re-shaping the stream bank and planting native riparian vegetation on the bank could be used. This would help to stabilize the bank, limit sedimentation and turdity, promote restoration of the riparian zone and create new in-stream habitat for WCT. Project design and costs would be similar to restoration work in the past (Alexander Creek Restoration). This previous work would also provide evidence in longevity. Since redds have been observed both downstream and upstream of this site (ERA redd surveys 2019), increasing the habitat value here could increase connectivity and productivity in the stream. The site is not near any main roads to showcase in the public eye, however if restoration efforts took place a complementary public outreach initiative could be implemented. This could involve community in hands-on restoration and riparian planting work, as well as provide an opportunity for contractors to educate these volunteers on the importance in conserving WCT habitat.

HAMOR02

Site Habitat Evaluation and Restoration Assessment

Tributary:	Morrissey Creek	Site code:	HAMOR02
Lat:	49.3592	Date:	2019-07-11
Long:	-114.9893	Surveyors:	Brett E, Chad H

1) Identified Concerns **(Watershed Restoration Implementation Sequence - Johnston and Moore 1995)**

Hillslope (Y/N):	N	Riparian (Y/N):	Y
Gully (Y/N):	Y	Channel/habitat (Y/N):	Y
Proceed with Habitat Assessment and Evaluation (Y/N):		Y	

Comments: Entire bank/gully failing into 100m section of stream. Multiple springs destabilizing soil coupled with stream erosion. Active sedimentation.

2) Habitat Assessment **(Streamkeepers handbook, module 2)**	Result	Score	Comments
1. % boulder & cobble	56%	16	
2. % Embededness	22%	16	
3. Instream Cover	1.86	10	
4. % Pool Habitat	14%	1	
5. Off-channel habitat	seasonal	11	
6. Bank stability	unstable	0	
7. Bank Vegetation (%)	23%	1	
8. Overhead Canopy (%)	3%	1	
9. Riparian Zone	1 to 2	6	
Habitat Assessment Score		62	

Description of degratative factors and Rehabilitation requirements:

Rehabilitation efforts would require significant work to stabilize the bank as well as either armour the eroding bank or redirect the current stream through the old stream channel to bypass the eroding sections. Rehabilitation requirements: Bank realignment and stabilization (likely require revegetation). Addition of LWD at tow slope to prevent furhter erosion and improve habitat.

HAMOR02

3) Prioritization Criteria (subjective assesment)	Score **1 to 4**
1. One or more life stages?	3
WCT are known to use Morrissey Creek in all life stages. It is likely that Bull Trout use this stream as well, however minimal research has beendone to assess the importance of Morrissey Creek for Bull Trout. System also may be imprtant for Mountain Whitefish spawning, based on visual observations in the Fall (Mountain Whitefish are a yellow-listed species in BC).	
2. Spawning or overwintering Habitat?	3
High potential for spawning habitat post restoration, given surrounding habitat. Active spawing up and downstream of site.	
3. Technical difficulty?	1
Restoration at this location would be very difficult due to the large scale of disturbance and erosion coupled with multiple springs washing sediment into the stream from above.	
4. Complementary Restoration?	3
Another site (HAMOR1) approximately 500m upstream from this site has been identifed as a degraded habitat. Although sites are not close enough to directly benefit each other, restoration of either site would contribute to improving the health of the tributary.	
5. Accessibility?	1
While area site is approximatly 25 minutes from Fernie with a minimal componant of well maintained forestry road, the site itself is approximatly 100m from existing forestry roads. Given the scale of site (100m and approx. 7m high banks) heavy machinery access would not be feasible without some disturbance. May be ab ideal location to use a spyder hoe or work may be restricted to hand tools to limit disturbance to the surrounding habitat.	
6. Opportunities for Partnership?	2
The land is privately owned by Canwel, with the potential for assistance with log and LWD replacement.	
7. Cost	1 to 3
The cost of any significant earthmoving and restoration activites would be well over $80,000. Alternativly, realignment of the creek via hand labour may be feasible, at around $10-20,000 total project cost.	
8. Project longevity potential	1 to 3
Extensive earthmoving and rehabilitation would likely have potential for long term longevity. Realignment of the creek would likely have a shorter lifespan depending on high water events.	
9. Contribution to species awareness?	2
The site itself is off main forestry roads and therefore unlikely to be seen by members of the public, however volunteer and public outreach events will allow a high degree of public awareness on the project and Western Cutthroat trout.	
Prioritization score	14 to 16
Habitat Assessment Score	62
Habitat Evaluation Score	23-26

HAMOR02

Comments and recommendations:
Morrissey Creek is an important tributary for spawning and rearing WCT, therefore increasing the priority of restoring this site. The site in an area that has the potential to provide significant habitat to WCT. Given the location of the site on private land, cooperation and additional permits would be necessary. However, Canwel may be willing to donate some logs for LWD implementation and may be interested in partnering on the project. This site is a more complicated restoration project given its difficulty in access, size and the costs that would incur. Rehabilitation efforts would require significant work to stabilize the bank as well as either armour the eroding bank or redirect the current stream through the old stream channel to bypass the eroding sections. However, that being said, this site appears to be severely altered due to this eroded bank and may continue to worsen. This could be a potential restoration project that brings in a collaboration with multiple partners, including: ERA, MFLNROD, Canwel, Lotic and KNC. Restoration may be most feasible by either conducting restoration with work by hand or through the use of a spyder hoe. A project at this site could also include a research and monitoring component to assess benthic invertebrates and fish densities before and after restoration work. However again, this would increase costs significantly. The site is not near any main roads to showcase in the public eye, however if restoration efforts took place a complementary public outreach initiative could be implemented. This could involve community in hands-on restoration and riparian planting work, as well as provide an opportunity for contractors to educate these volunteers on the importance in conserving WCT habitat.

Appendix F: Restoration plans

Elk River Alliance

Coal Creek HACOL01 Streamside Restoration Plan

March 2020

Prepared for the Habitat Trust Conservation Foundation

Coal Creek (HACOL01) Streamside Restoration Plan

"The aim of ecological restoration is to fully restore the components and processes of a damaged site or ecosystem to a previous historical state, to a contemporary standard, or towards a desired future condition."
~Gayton, 2001

Prepared by: Chad Hughes and Beth Millions

Date: March 2020

Introduction

In 2019 the Elk River Alliance (ERA) identified a degraded section streambank of Coal Creek with reduced habitat potential based on the watershed restoration implementation sequence (Johnston and Moore 1995). The area was found to have an eroded bank, large debris left from historical use, and invasive plants colonizing the exposed soil. ERA proposes to restore the site by stabilizing the eroding/unstable slopes and improve the area's habitat potential. Proposed restoration activities include: (1) removal of large metal debris from the site and surrounding area; (2) removal of invasive species from site and surrounding area, and; (3) use of bioengineering techniques to stabilize the eroded bank and create overhead canopy cover. This project should also include a community awareness component to improve public understanding of habitat conservation and the importance of protecting natural areas and water quality. The success of this project will be measured by several metrics including: area of habitat restored, amount of debris and invasive species removed, and number of collaborators/volunteers attending restoration and community events.

Project Rational

Due to human activity resulting in fragmentation and habitat destruction, riparian cottonwood ecosystems have been significantly reduced from their historical range and are considered an endangered ecosystem in the southern interior of British Columbia (Egan, Cadrin, and Cannings 1997). Cottonwood ecosystems are incredibly important in this region for providing landscape level connectivity for a number of different animals, several of which are at risk or endangered either provincially or federally. These include a number of birds such as the yellow-breasted chat (Red listed in BC; Environment and Climate Change Canada 2016) and Lewis' Woodpeckers and Western Screech-owls (Blue listed in BC; Environment and Climate Change Canada 2017; Ministry of Environment 2008) that use mature cottonwoods for nesting habitat, reptiles such as the Rubber Boa (Blue listed in BC; B.C. Ministry of Environment 2015), and several blue listed bats including the Fringed Myotis and Western Small-footed Myotis (British Columbia Ministry of Environment 2016). Fish species also benefit from cottonwood ecosystems, as these forests provide necessary stream shade that maintains cool stream temperatures, supply leaves and other organic matter into the stream that becomes part of the aquatic food chain, and provide cover and habitat for fish in the form of snags and large woody debris.

In the Elk Valley, Westslope Cutthroat Trout (WCT; *O. clarkii lewisii*) benefits from cottonwood riparian ecosystems. WCT are blue listed in British Columbia and are listed as being of Special Concern under Schedule 1 of the federal Species at Risk Act (SARA; Fisheries and Oceans Canada 2017). As of 2006, the species is provincially blue-listed as Special Concern according to the Committee on the Status of Endangered Wildlife in Canada (Fisheries and Oceans Canada 2017). The species faces many threats in the Elk Valley, including habitat loss, degraded water quality from coal mining, logging, riparian clearing due to industrial and urban development, and an increase in angling pressure (Fisheries and Oceans Canada 2017; Tepper 2008). The species has experienced dramatic population declines throughout their historic range due to habitat loss and degradation, overexploitation, competition, predation by non-native salmonids, and introgressive hybridization with other trout species (Fisheries and Oceans Canada 2017; Shepard et al. 1997).

Coal Creek provides habitat to adult and rearing WCT as well as a number of other wildlife. Restoration to Coal Creek's riparian cottonwood ecosystems will improve not only its capacity to support healthy wildlife populations, but also improve landscape connectivity. The site in question would benefit from restoration efforts to mitigate the damaging effects of human impacts on the area. Benefits include stabilizing the slope and a reduction of soil erosion into the stream to improve water quality and provide overstory stream shade for WCT. Long-term benefits would include improved habitat complexity with the eventual introduction of LWD from a mature riparian zone (Hartman, Scrivener, and Miles 1996). The site was determined to be a high priority area due to the positive impact that simple restoration measures will have on the stream and on WCT, and also the ease at which the area can be accessed and likelihood of success.

Site Description

The site (HACOL01) is located at 49.4866416, -114.9774527 on Coal Creek, approximately 7 km east of Fernie and upstream of the Elk River - Coal Creek confluence (

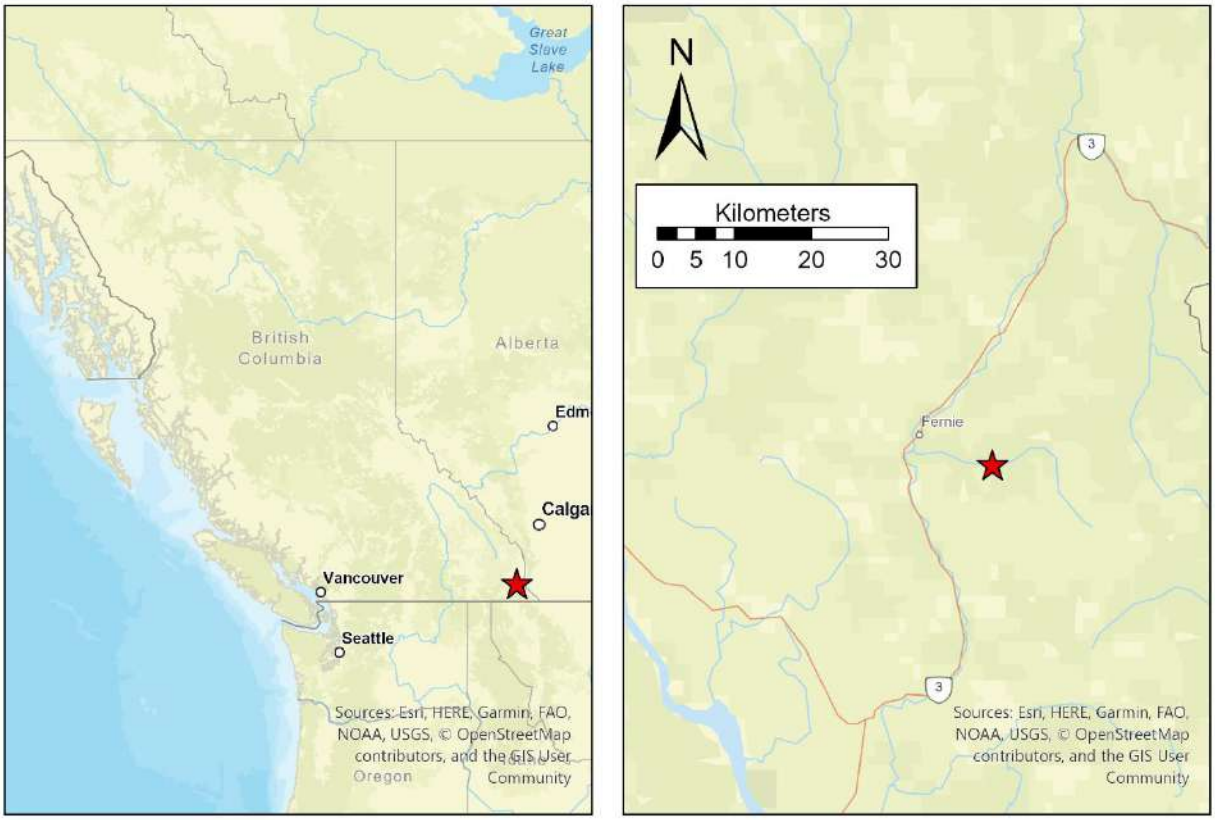


Figure 1). To access the site from Fernie, travel east on Fernie Coal Rd approximately 5 km and then take a left fork off the main road. Travel an additional 1.2 km.

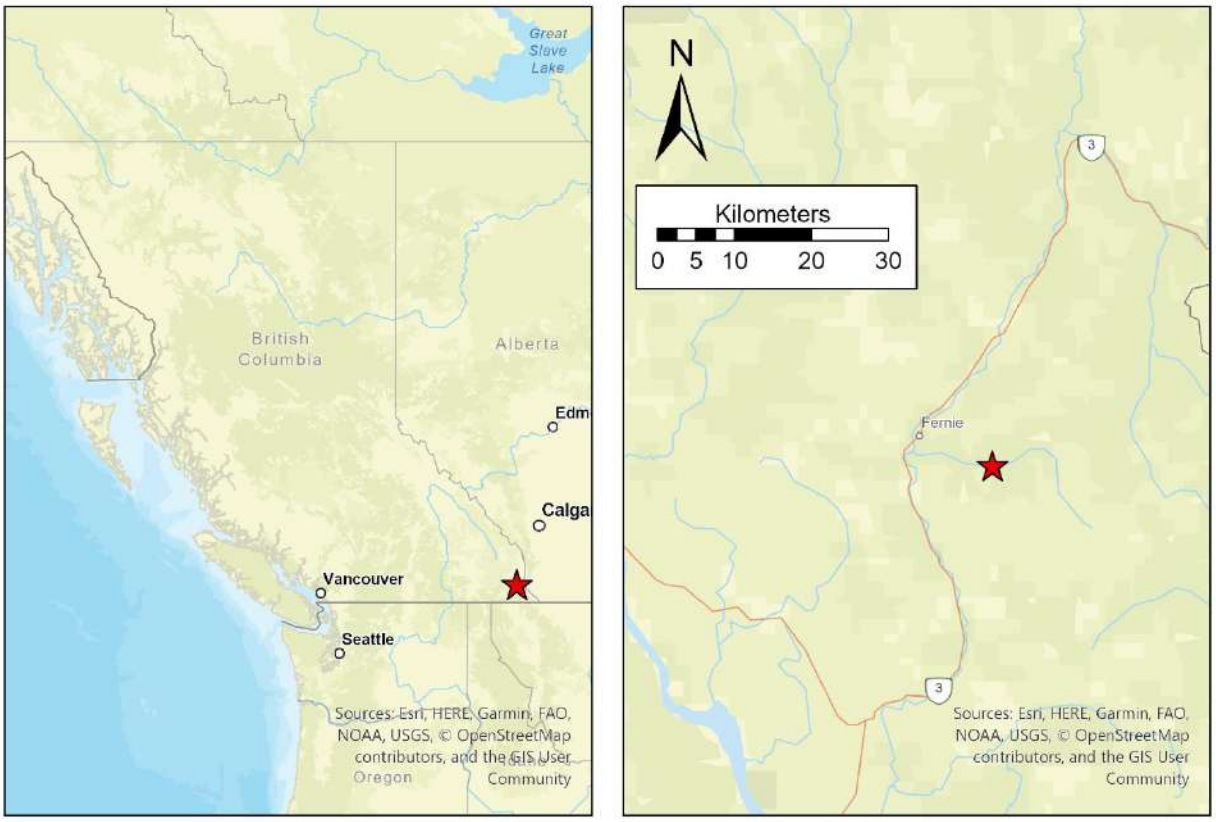


Figure 1: Location of HACOL01, proposed restoration site on Coal Creek near Fernie, BC

HACOL01 situated within the Elk Moist Cool Interior Cedar – Hemlock BEC zone (ICHmk4; MacKillop et al. 2018) and includes the Fm01 Cottonwood Floodplain Ecosystem.

The following vegetation groupings were identified at HACOL01 site during site inspections. These are mapped in Figure 5. Information for these descriptions was taken from LMH 25 (B.C. Ministry of Environment and B.C. Ministry of Forests and Range 2010) and LMH71 (MacKillop et al. 2018)

- **111 (CwSxw – Devil's club):** Spruce (*Picea engelmannii x glauca*) and cedar (*Thuja plicata*) are the dominant overstorey trees, often with Subalpine Fir (*Abies lasiocarpa)*. In the understoreys, devil's club and/or lady fern are typically abundant (> 10%). Black gooseberry (*Ribes lacustre*), thimbleberry (*Rubus parviflorus*), oak fern (*Gymnocarpium dryopteris*), and one-leaved foamflower (*Tiarella unifoliata*) are also common, along with minor cover of false-hellebore (*Veratrum viride*; particularly on colder sites) and stinging nettle (*Urtica dioica*). Leafy mosses and ragged-mosses are usually common and can be abundant.
- **111/At**: Similar to 111 above, on northern side of site. Contains a significant Trembling Aspen (*Populus tremuloides*) component.
- **Fa (Stream Channel)**: Active channel ecosystem, includes gravel bar and islands. Often scoured for prolonged periods. Exposed and are usually immediately adjacent to the river channel at lower

water levels and under water at high water levels. On unstable substrates, such as gravel bars and islands, Fa ecosystems are usually dominated by opportunistic annuals or perennial herb species with extensive root systems that are able to re-sprout after the aboveground structures have been removed by flooding and scouring. This unit also includes a smaller gravel bar and island component dominated by willows.

- **FM02 (Fm02 Cottonwood – Spruce – Dogwood)**: Black cottonwood is dominant in the overstorey, often with minor spruce (*Picea engelmannii x glauca*), and sometimes with cedar (*Thuja plicata*). Red-osier dogwood (*Cornus serica)* is dominant in the shrub layer and frequently occurs with mountain alder (*Alnus incana*), black gooseberry (*Ribes lacustre*), and/or highbush-cranberry (*Viburnum edule*). Willows (*Salix* spp.) and snowberry (*Symphoricarpos)* are also sometimes common. Horsetails (*Equisetum*), sweet-cicely (*Myrrhis odorata*), and pink wintergreen (*Pyrola asarifolia*) are usually present, often with minor cover of bluejoint reedgrass (*Calamagrostis canadensis*), false Solomon's-seal (*Maianthemum racemosum*), oak fern (*Gymnocarpium dryopteris*), and/or blue wildrye (*Elymus glaucus*).
- **Vt (Avalanche Treed)**: A small component of the site includes an avalanche track.
- **Xa (Cleared Area)**: Cleared area makes up a majority of the site. This area is utilised as a laydown/staging area by recreationalists and logging companies, and likely an informal campsite. This would be an ideal area for moderate revegetation and restoration of cottonwood forest. However, should revegetation activities occur in this area it is recommended local users be consulted to determine if ongoing recreational or forestry use of the area is anticipated.
- **XaR (Cleared roads)**: Two access roads pass through the site. The southern road is a well used forestry road utilized by recreationalists and logging trucks. The northern track is a less utilised forestry/historical road used by recreationalists. Both will be required for site access.

While most of Coal Creek is disturbed, a reference site was inspected 100 m upstream to compare the impacts of human activity at the historical bridge and assess the variation in the vegetation community. Black Cottonwood (*Populus trichocarpa*) is the dominant tree species, with a mix of trembling aspen (*Populus tremuloides*) and spruce (*Picea cross*). Shrub composition consists of red osier dogwood (*Cornus serica)*, snowberry (*Symphoricarpos*), paper birch (*Betula papyrifera*), and baldhip rose (*Rosa gymnocarpa*). Grasses and forbs could not be identified due to the timing of the habitat assessments in late fall, but will be assed in the spring to determine appropriate grass seed blends for reseeding.

Significant invasive species presence is notable at HACOL01 and along the adjacent roadways. Species include spotted knapweed (*Centaurea biebersteinii*), burdock (*Arctium spp.*), hound's tongue (*Cynoglossum officinale*), and common tansy (*Tanacetum vulgare*).

During 2019 redd surveys no spawning evidence was observed in the area. Despite redds not being observed in at the site during the surveying period, the lower reaches of Coal Creek have relatively decent spawning and overwintering habitat. The substrate composition was of 4% gravel, 92% Cobble, and 4% boulder, and the gradient of the stream was 2.9%. The stream site is 33% pool, and includes LWD and rooted cutbanks, providing good habitat. WCT have historically been observed both spawning in and

utilizing Coal Creek for habitat, though the creek has many historical and contemporary impacts including coal mining, logging, and public use of forestry roads.

The primary site concern is a 70 m long, 3 m tall eroding slope. This erosion has resulted in a lack of overhead vegetation and a presence of invasive species that are reducing the successful colonization of native plant species. The erosion is likely the result of historical earthworks for either the installation or decommissioning of a bridge over Coal Creek in that location. Concrete remains of the historical bridge existent within the channel are constricting stream morphology (Figure 2). While the stream is typically stable, during high flow events water is forced over and around the concrete resulting in erosion of the north bank (Figure 3).

Figure 2. A historic bridge that collapsed into the stream can be seen altering the surrounding stream morphology. A failing bank can also be seen with invasive plants growing on it.

Figure 3: Same location as Figure 2 (right) during high flow event in June 2020. Note erosion at base of slope by high velocity water..

The stretch of bank eroding into the stream is reducing overhead cover and decreasing the habitat quality for WCT. The erosion, if not controlled, threatens to extend and risk felling mature trees into the stream. This would further reduce the habitat and health of the cottonwood forest. Vegetation further from the stream site has been severely impacted by repeated anthropogenic use, with the majority of vegetation removed for road and recreational access. The site is littered with metal debris both on the shoreline and in-stream (likely from the old mine and township). A map of HACOL01 and the surrounding area can be found in Figure 5.

Currently the land is owned by CanWel Building Materials Group Ltd and operated as a Private Managed Forest (Figure 4). It is unlikely to undergo any logging activities due to the composition of the forest and proximity to a fish-bearing stream. The site is located near to a major logging road and is frequented by recreationalists including fishers, campers, hikers, and bikers.

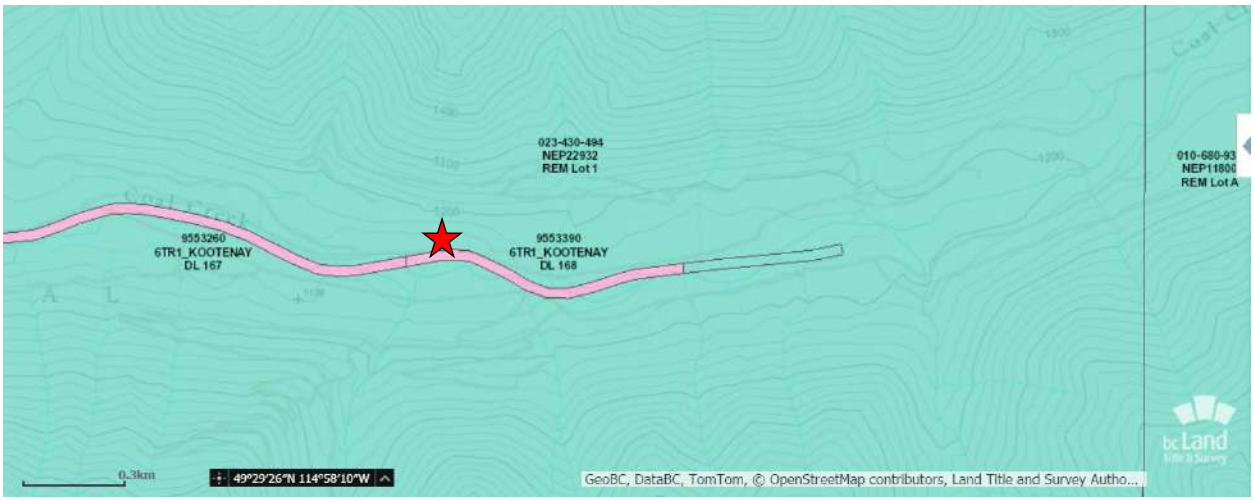


Figure 4: Land ownership of restoration site (Pink: No owner, Green: Private Managed Forest)

Site History

Coal Creek is historically known for providing spawning habitat, though redd survey information is not publicly available (Prince and Morris 2003). WCT are known to inhabit the stream, particularly in the lower reaches such as HACOL01, and many fishermen claim there were (and still are to a degree) abundant opportunities to catch WCT throughout the creek. However, historical impacts have degraded the creeks habitat quality and likely decreased population carrying capacity. Historical impacts to Coal Creek include an abandoned township, defunct coal mine, and logging. Contemporary impacts include ongoing extensive private-land logging and public use of forestry roads. Remnants of historical debris include a concrete embankment failing into Coal Creek and large metal debris in and out of the stream stemming from a historical town and mine site further upstream. The adjacent road to the north side of the creek pinches the slope and does not allow for proper regrading of the slope. Likely the erosion is the result of historical and contemporary bridge construction and road building which destabilized the slope. Further,

approximately 20 m upstream on the left-hand bank the slope has been riprapped to stop erosion and help protect the adjacent logging road.

Project Goals

The proposed restoration site HACOL01 is part of an endangered ecosystem, though it has been heavily disturbed by human activities resulting in a reduction in habitat values, negative impacts to water quality, and decreased connectivity throughout the watershed. Invasive species are common in the area, further reducing the habitat and browsing value and increasing erosion.

The goal of this project is to improve habitat values provided by this site and return it to a more natural pre-disturbance state in accordance to its BEC ecological classification. Specifically, this will be done by meeting the following objectives:

1) Removing invasive species from the riparian and upland zones to make up less than 5% of the understorey canopy;
2) Removing all manmade debris that can be removed by hand, and;
3) Revegetating the eroding slope with native shrubs, forbs, and grasses to reduce sedimentation into the stream, increase slope stability, outcompete invasive plants, and provide overstorey cover to fish utilizing the stream. The goal is to establish a greater than 50% cover in both the shrub and tree canopies with native plant species comparable to the reference site.

In addition to the above objectives, any restoration activities should, given the close proximity to Fernie, also include a community awareness component. This will help improve public understanding of habitat conservation, the importance of protecting natural areas, and improving water quality.

Details of Restoration Activities

Locations of proposed restoration activities are detailed in Figure 5.

Invasive species should be removed throughout the growing season through a series of five weed pulls. Weedpulls should begin in May and June when the rosettes are emerging; these can more easily be removed than adults and will not have gone to seed. Between 10 and 20 people providing between 30 and 50 volunteer hours for each weedpull should be able to effectively remove invasive species on site.

If possible, root systems should be removed along with the main body of the invasive plant and disposed of in garbage bags as general landfill items. In instances where the root system cannot be removed, a greater number of weedpulls may be required.

While not ideal, it is recommended that the large concrete bridge remnants remain in the stream as their removal would likely cause more disruption to stream health than it would improve. It is also recommended to complete plantings by hand and not attempt to reshape the slope. A shallower gradient would reduce erosion, but is not possible with the existing road adjacent to the site. Reshaping the slopes also risks the health of the existing mature trees on the site and significantly increases project costs.

Re-vegetation of the banks with native plants should occur in either the spring after the snow has melted or in the fall before the ground freezes. Planting should not occur during high water events to ensure

safety of personnel working on site. Vegetation should consist of mostly deciduous shrubs and trees with the occasional conifer.

Target deciduous trees and shrubs are those found on site and include the following: willow (*Salix maccalliana*), red osier dogwood (*Cornus stolonifera*), Black Cottonwood (*Populus trichocarpa*), trembling aspen (*Populus tremuloides*), snowberry (Symphoricarpos), saskatoon (*Amelanchier alnifolia*), black hawthorn (*Crataegus douglasii*) and baldhip rose (*Rosa acicularis*).

Some conifers including Engelmann Spruce (*Picea engelmannii*) should also be planted. Conifers, saskatoon, rose, snowberry, and aspen should be restricted to the top half of the bank, and willows, cottonwoods, and red osier dogwood saplings can be planted across the entire slope.

Trees should be spaced 2 m apart; with an area of 210 m^2, this will require 105 trees, although these can be either 1-gallon potted plants or lives stakes depending on nursery availability and available funding. Shrub spacing intervals for streambank stabilization vary depending on the type of installation (live stakes, saplings, etc.) and between 0.2 and 3 m spacing is recommended. Red osier dogwood, aspen, snowberries, and willows should be spaced 1 m apart to ensure high survival and reduce invasive species presence by shading.

If there is greater than 50% mortality (due to grazing, drought, or other factors), additional plantings will need to take place at a later time. Less than 25% mortality will require thinning at a later date to reduce competition. The area should be seeded with a native grass seed mix to discourage invasive species colonization and decrease erosion.

The success of the project will be measured by several metrics including:

- Area of habitat restored (goal: 210 m^2);
- Percent overstory cover (goal: 50% canopy coverage);
- Amount of debris removed (goal: five large garbage bags);
- Presence of invasive species remaining (goal: <5% understory coverage), and;
- Number of collaborators and volunteers attending restoration and community events (goal: 50).

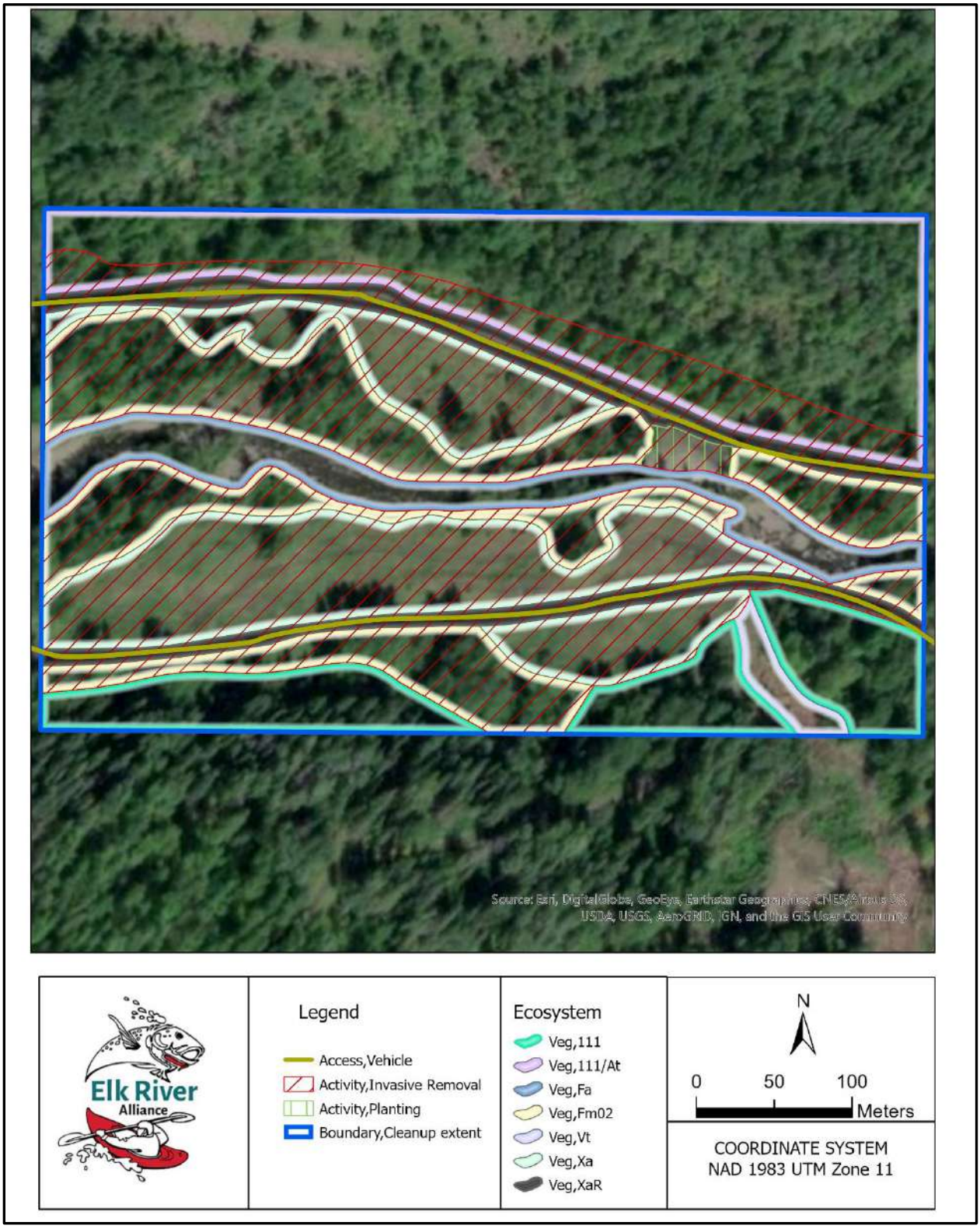


Figure 5: HACOL01 site map detailing vegetation associations present and proposed restoration activities.

Project Costs

The following costs exist for the first year of the project (Table 1). Ongoing monitoring and maintenance will be required (see Long-Term Maintenance and Project Monitoring), with associated costs dependant on monitoring results. Between $2000 and $5000 should be budgeted for 3 to 5 years following project implementation to meet the outlined objectives.

Table 2: Project cost estimate for year one of project activities.

Project Activity	Details	Estimated Cost (Cash)	Estimated Cost (In-kind)
Project Management	Project development and coordination, permit applications, etc.	$1600	$0
Weedpulls	Weeding equipment and supplies, mileage, time, hospitality	$3710	$3750
Site Cleanup	Materials, mileage, supplies, time, hospitality	$680	$600
Planting	Supplies and materials, native plants, grass seed, soil additives, mileage, time, hospitality	$5550	$6500
Monitoring & Maintenance (for first year)	Mileage, watering plants, assessing mortality, water pump rental, time	$2430	$600
Admin (15%)	Associated overhead	$2465	
Total		$16,435	$13,900

Permits

As the site and site access exist on land owned by CanWel Building Materials Group Ltd and is operated as a Private Managed Forest, permission will be required form the landowner. As no earthworks will occur, a Change Approval under the Water Sustainability Act will not be required, but a *Notification For Work In And About A Stream* will be and can be applied for from FrontCounter BC.

Safety

As the restoration site is located on a logging road, it is advisable to travel with a radio set to the appropriate resource road frequency. The onsite project coordinator should be trained in first aid and equipped with a first aid kit and bear spray. As there is no cell service at the site the project coordinator should bring an emergency communication device such as a Spot or inReach, and/or have and have an acceptable safety plan. The project coordinator should be prepared for potential hazards and provide a safety briefing for volunteers prior to their attendance in activities. Potential hazards include risks

associated with moving water, vehicle interaction, slips and trips on uneven ground, wildlife interaction, insect and poisonous plant contact, repetitive stress injuries, etc. Volunteers should be advised of potential risks and asked to wear appropriate clothing and footwear for restoration activities.

Long-Term Maintenance and Project Monitoring

Monitoring of invasive species presence, vegetation survival rates, and overstory canopy will be required to ensure the success of the project and assess next steps required in maintenance.

Ongoing removal of invasive plant species from site will be required for the next 3 to 5 years to ensure the seedbank is depleted. This will involve at minimum annual weedpulls during the growing season. Weedpull intensity will depend on invasive species growth.

The more regularly plants receive water, the more likely they are to survive. Ideally, short-term maintenance for the first year would include watering with a water pump and between once a week and once a month throughout the first growing season. However, monetary constraints can make this degree of maintenance difficult; the above project costs allow for plants to be watered 10 times throughout the growing season.

If there is greater than 50% mortality, either due to grazing, drought, or other factors, additional plantings will need to take place at a later time. If less than 25% mortality shrubs and trees will likely require thinning at a later date to reduce competition.

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Elk River Alliance

Coal Creek HACOL02 Streamside Restoration Plan

March 2020

Prepared for the Habitat Trust Conservation Foundation

Coal Creek HACOL02 Streamside Restoration Plan

"The aim of ecological restoration is to fully restore the components and processes of a damaged site or ecosystem to a previous historical state, to a contemporary standard, or towards a desired future condition."
~Gayton, 2001

Prepared by: Chad Hughes and Beth Millions

Date: March 2020

Introduction

In 2019 the Elk River Alliance (ERA) identified a stretch of Coal Creek in need of restoration efforts. The identified stretch of Coal creek extends 1.4 km upstream from its confluence with the Elk River and includes the HACOL02 site from the fall 2019 habitat assessments. The area has been severely impacted by human activities, including extensive urban development with reduced habitat capacity due to bank armament, invasive species colonization, and minimal instream cover. ERA proposes to improve connectivity and enhance habitat values by planting native vegetation in areas currently devoid of vegetation, using live stakes to help stabilize eroded sections of streams, and removing invasive vegetation. Potential restoration activities are limited as both sides of the stream are heavily urbanized and human safety is the primary focus for management of that section of the river. However, by making small efforts to naturalize the stream there will be an increase in connectivity, and fish will be able to access better rearing habitat further upstream. Vegetation in the riparian zone will provide shade, reducing the impacts of climate change on rising stream temperatures. This project should also include a community awareness component to improve public understanding of habitat conservation and the importance of protecting natural areas and water quality. In particular, focus should be given to the ad hoc creation of weirs, as this stretch of river sees the constructions of small dams by unknowing residents every year. Signage at common areas would greatly benefit fish passage in this area.

The success of this project will be measured by several metrics including:

- Area of riparian zone enhanced,
- Amount invasive species removed,
- Number of live stakes installed,
- Number of woody debris installed,
- Number of collaborators and volunteers attending restoration and community events.

Project Rational

Due to human activity resulting in fragmentation and habitat destruction, riparian cottonwood ecosystems have been significantly reduced from their historical range and are considered an endangered ecosystem in the southern interior of British Columbia (Egan, Cadrin, and Cannings 1997). Cottonwood ecosystems are incredibly important in this region in providing landscape level connectivity for a number of different animals. These ecosystems also provide habitat to a number of flora and fauna, several of which are at risk or endangered either provincially or federally. These include a number of birds such as the yellow-breasted chat (Red listed in BC; Environment and Climate Change Canada 2016), and Lewis' Woodpeckers, Great Blue Herons and Western Screech-owls (Blue listed in BC; Environment and Climate Change Canada 2017; Ministry of Environment 2008) that use mature cottonwoods for nesting habitat, reptiles such as the Rubber Boa (Blue listed in BC; B.C. Ministry of Environment 2015) and several blue listed bats including the Fringed Myotis and Western Small-footed Myotis (British Columbia Ministry of Environment 2016). Many fish species also benefit from cottonwood ecosystems, as these forests provide necessary stream shade that maintains cool stream temperatures, supply leaves and other organic matter into the stream that becomes part of the aquatic food chain, and provide cover and habitat for fish in the form of snags and large woody debris.

In the Elk Valley, Westslope Cutthroat Trout (WCT; *O. clarkii lewisii*) benefits from riparian ecosystems including cottonwood stands. WCT are blue listed in British Columbia and are listed as being of Special Concern under Schedule 1 of the federal Species at Risk Act (SARA; Fisheries and Oceans Canada 2017). As of 2006, the species is provincially blue-listed as Special Concern according to the Committee on the Status of Endangered Wildlife in Canada (Fisheries and Oceans Canada 2017). The species faces many threats, including habitat loss, degraded water quality from coal mining, logging, riparian clearing due to industrial and urban development, and an increase in angling pressure (Fisheries and Oceans Canada 2017; Tepper 2008) and have experienced dramatic population declines throughout their historic range due to habitat loss and degradation, overexploitation, competition, predation by non-native salmonids, and introgressive hybridization with other trout species (Fisheries and Oceans Canada 2017; Shepard et al. 1997).

Coal Creek provides habitat to adult and rearing WCT, as well as a number of other wildlife including benthic invertebrates, birds, aquatic mammals (muskrats and beavers), and small and large terrestrial mammals. Restoration to Coal Creek's riparian cottonwood ecosystems will improve not only its capacity to support healthy wildlife populations, but also improve landscape connectivity, reduce risk of rising stream temperatures (Bowler et al. 2012) and provide a long-term source of Large Woody Debris (LWD) for fish habitat (Hartman, Scrivener, and Miles 1996). The 1.4 km stretch of riparian zone proposed for enhancements would benefit from restoration efforts to mitigate the damaging effects of human impacts in the area. Benefits include stabilizing eroded slopes, vegetating bare and riprapped stream sections, increasing connectivity, reducing the potential for riprap to increase stream temperatures, improving esthetics, and greater overstory stream shade for WCT. The site was determined to be a high priority area due to the positive impact that simple restoration measures will have on the stream and on WCT, the ease at which the area can be accessed, likelihood of success and community engagement and education potential.

Site Description

The area is located between the confluence of Coal Creek with the Elk River at 49.497395, -115.070236 to approximately 1.4 km east of Fernie at 49.496611, -115.054990 (**Error! Reference source not found.**). The 1.4 km stretch of Coal Creek in question has been significantly disturbed by human development. Figures Figure 3 to Figure 8 show habitat and degradation features on Coal Creek.

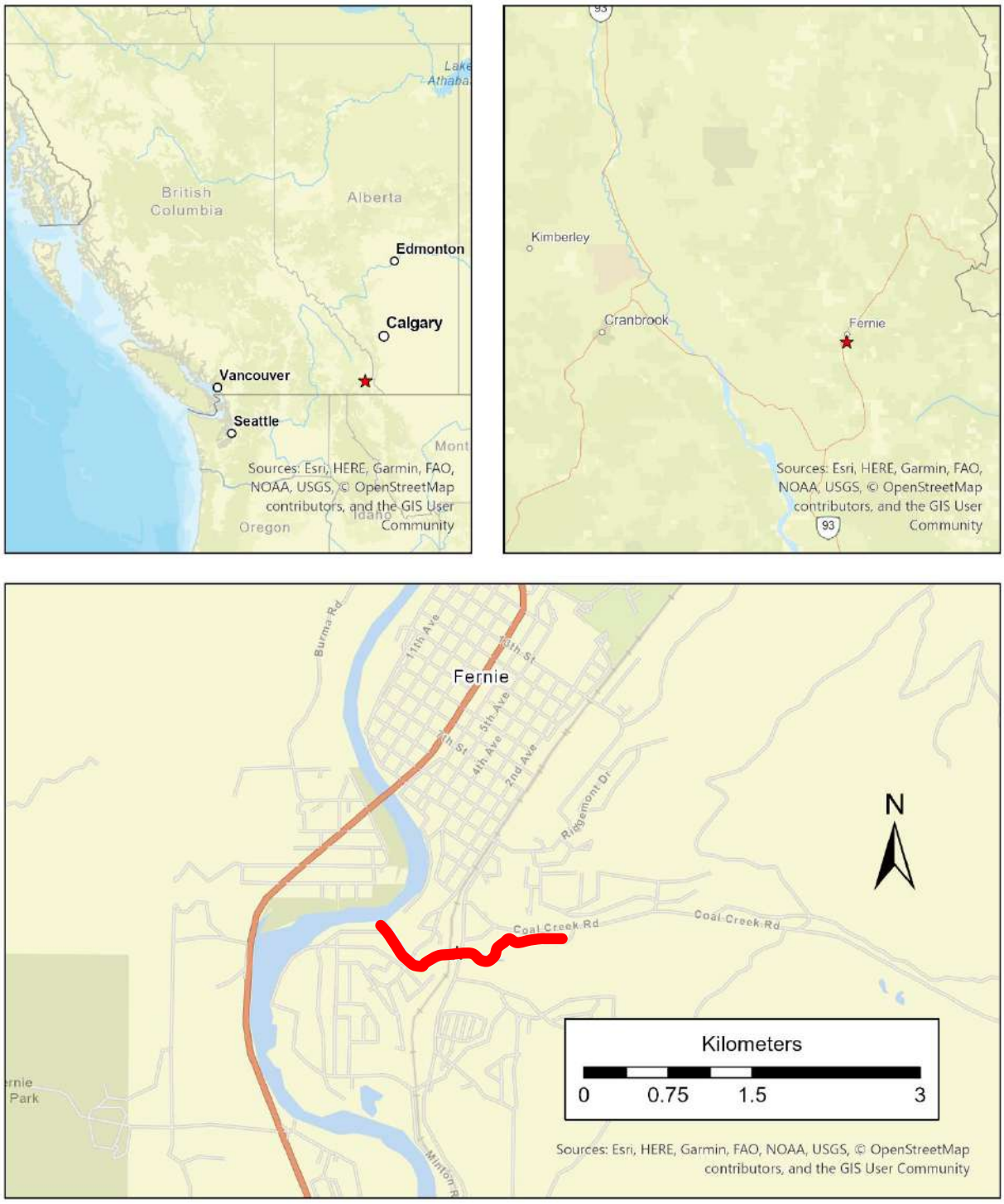

Figure 1: Location of proposed riparian enhancements on Coal Creek near Fernie, BC. Red line shows Coal Creek restoration stretch.

The mouth of Coal Creek situated within the Elk Moist Cool Interior Cedar – Hemlock BEC zone (ICHmk4; (MacKillop et al. 2018) and includes the Fm01 Cottonwood Floodplain Ecosystem. Species within this ecosystem include: Black Cottonwood (*Populus trichocarpa*) is the dominant tree species, with a mix of trembling aspen (*Populus tremuloides*) and spruce (*Picea cross*). Shrub composition consists of red osier dogwood (*Cornus serica)*, snowberry (*Symphoricarpos*), paper birch (*Betula papyrifera*), and baldhip rose (*Rosa gymnocarpa*).

Significant invasive species presence is notable along Coal Creek in the identified stretch and the adjacent pathways. Species include spotted knapweed (*Centaurea biebersteinii*), burdock (*Arctium spp.*), hound's tongue (*Cynoglossum officinale*), common tansy (*Tanacetum vulgare*), blueweed (*Echium vulgare*), and hawkweed (*Hieracium* spp.). Invasive species presence was notable both in areas devoid of an overstory, and gravel bars formed within the past ten years. The latter is of concern due to the potential for seeds at water level to be spread downstream.

Redd surveys were not conducted in this area, though some calm waters, off-channel habitat, and pools with appropriate gradient and substrate material were noted during field surveys. Further, WCT have historically been observed both spawning in and utilizing Coal Creek for habitat. However, in the current state, rearing in the 1.4 km stretch of river is unlikely due to the lack of in-stream cover as a result of the minimal riparian zones

The primary concern for the area is the degradation of the riparian zone and lack of instream cover for WCT. This has occurred as the result of significant human development in the area, constricting the river's ability to meander, and armouring it against erosion in the event of large floods. A lack of riparian buffer and the use of bank armaments can result in a number of negative impacts on stream quality and fish habitat. In particular, a lack of overhanging vegetation, loss of undercut banks, limited potential for LWD, and bank erosion can all negatively impact fish by reducing habitat diversity and availability, which is important for the survival, reproduction, and growth of WCT (Schmetterling, Clancy, and Brandt 2001; Hartman, Scrivener, and Miles 1996). Riparian vegetation is important in helping to regulate water temperature by shading the stream, whereas riprap does not provide this benefit and can increase water temperature (Martin 1995) .This is increasingly important for WCT that require relatively low water temperatures compared to Rainbow Trout (RT) that pose a hybridization threat to WCT (Paul and Post 2001).

Within the 1.4 km section of Coal Creek, approximately 689 m of shoreline (or 26% of shoreline) was found to be armoured with riprap or similar and devoid of either shrub or tree overstory; a further 328 m of shoreline was either bare and eroding, or lacking in suitable stabilizing vegetation and at risk of erosion. 3.6 hectares of riparian area were found to be heavily colonized by invasive species and in need of removal activities. Further, the mouth sees significant recreational use, and often is subjected to illegal weir construction. Education and interpretive signage on the detrimental affects of weirs on fish passage would be beneficial.

Currently the land is owned by the City of Fernie and Parastone Developments Ltd (Figure 2). Coal Creek bisects the City of Fernie, running through urban and recreational areas. As such, the stretch has a high level of public exposure, and is frequented by resident and tourists, including fishers, hikers, and bikers.

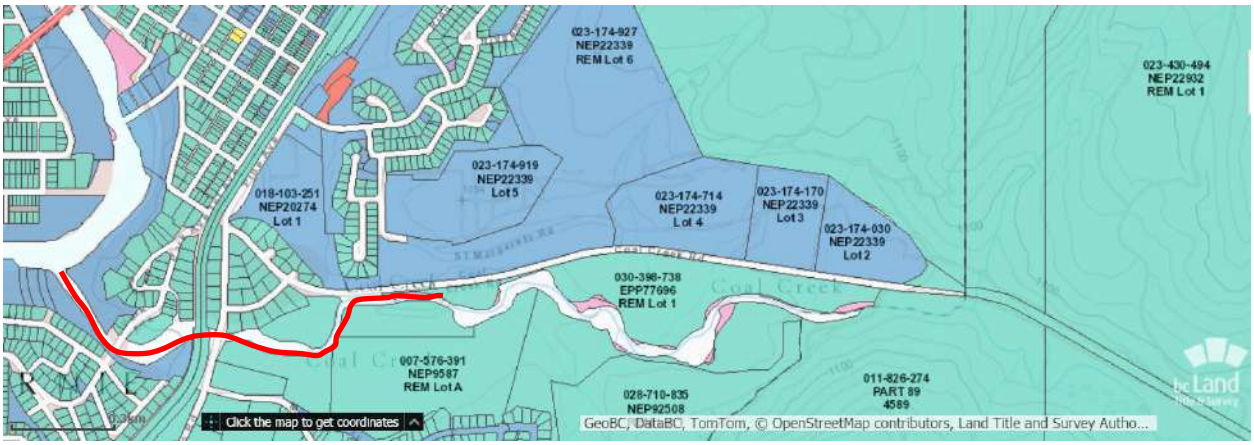

Figure 2: Land ownership of Coal Creek restoration site and surrounds (Red line: Coal Creek restoration reach. Pink: No owner, Blue: Municipal, Green: Private Managed Forest)

Figure 3: Riparian zone at mouth of Coal Creek. Note lack of understory vegetation and low density of cottonwood trees. Low native vegetation density encourages establishment of invasive species.

Figure 4: Large metal debris along Coal Creek.

Figure 5: Bare riparian zone resulting from human access. Areas like this will likely wash out during high flow events, widening the watercourse.

Figure 6: Rooted cut bank in adjacent to area shown in Figure 5. This bank is much more resilient to erosion, provides fish habitat, shades the water and slows water velocity during high water events.

Figure 7: Metal siding (left) clads coal creek. While siding prevents erosion, it provides minimal habitat value or shading. On the right riprap can be seen, this also has minimal habitat value compared to the vegetated riparian zone seen downstream.

Figure 8: Weedy banks, riprap and low under/overstory vegetation on Coal Creek.

Site History

Coal Creek is historically known for providing spawning habitat, though redd survey information is not publicly available (Prince and Morris 2003). WCT are known to inhabit the stream, particularly in the lower reaches, and many fishermen claim there were (and still are to a degree) abundant opportunities to catch WCT throughout the creek. Historical and contemporary impacts have degraded the creeks habitat quality

and likely decreased population carrying capacity. Historical impacts to Coal Creek include an abandoned township, defunct coal mine, and logging. Contemporary impacts include ongoing extensive private-land logging and urban development. The site has been armoured with riprap and corrugated metal siding to protect nearby homes from flood events. The mouth of the creek in particular is riprapped and pinched between housing developments, restricting opportunities to meander and impeding the development of a riparian vegetation zone.

Project Goals

The proposed enhancements for this 1.4 km stretch of Coal Creek are focused improving the riparian zone and increasing cover for WCT to improve connectivity. The project seeks to restore degraded riparian zone while accommodating the existing human presence. The area includes an endangered Cottonwood ecosystem type, though it has been heavily disturbed by human activities resulting in a reduction in habitat values and decreased connectivity throughout the watershed. Invasive species are common in the area, further hindering native plant recolonization of the riparian zone.

Improved habitat values and enhancing a natural and functional riparian zone will be accomplished by meeting the following objectives:

1) Removing invasive species from the riparian and upland zones to make up less than 5% of the understorey canopy of largely impacted locations;
2) Revegetating open areas with native shrubs and tree species to outcompete invasive plants and provide overstorey cover to fish utilizing the stream. The goal is to establish cover in both the shrub canopy with native plant species to a level similar to that of natural cottonwood ecosystems (see details of restoration activities below), and;
3) Improving community awareness of fish and fish habitat. Given the close proximity to Fernie, restoration activities should also include a community awareness component. This will help improve public understanding of habitat conservation, the importance of protecting natural areas, and improving water quality.

Details of Restoration Activities

Proposed restoration activities are detailed in Figure 9, Figure 10 andFigure 11

Invasive species will be removed throughout the growing season through a series of five weed pulls. Weedpulls should begin in May and June when the rosettes are emerging; these can more easily be removed than mature plants and will not have gone to seed. Between 10 and 20 people providing between 30 and 50 volunteer hours at each weedpull should be able to effectively remove invasive species on site.

Where possible, root systems should be removed along with the main body of the invasive plant and disposed of in garbage bags as general landfill items. Should root systems not be removed, additional weedpulls may be required.

The stretch of Coal Creek contains around 278 m of bank that is either exposed or eroding soil, or has suboptimal vegetation cover (i.e. is lacking in either tree or shrub cover). Riparian cottonwood forest in

the Fernie area is generally described as Cottonwood FM01 ecosystem (MacKillop et al. 2018). Typically, this will include over 25% overstory cover (cottonwood), with understory of 10-25% red-osier dogwood and snowberry, with other species having lower variable covers. Successful restoration will replicate these values.

As live staking will primarily be used, species native to local riparian zones have been selected based on their ability to propagate from cuttings. Target deciduous trees and shrubs include the following: willow (*Salix maccalliana*), red osier dogwood (*Cornus stolonifera*), Black Cottonwood (*Populus trichocarpa*), and trembling aspen (*Populus tremuloides*). These species can all be collected during dormancy as live stakes. The Town of Fernie will be consulted before planting to ensure the work conforms with the city's development plans and has resident approval. Live staking will occur in either the spring prior to plants leaving dormancy or in the fall before the ground freezes. For safety reasons planting should not occur during high water events.

The total area that will require live staking is almost 0.8 ha in area; however, as most locations are not experiencing erosion, live staking will be implemented sporadically in clumps throughout the area to help with the development of proper shrub understory cover and will not be planted densely except in instances of erosion.

Discussions with the City of Fernie will need to occur to develop restoration plans for the 200 m section of concrete bank stabilization near the confluence with the Elk River. This section is almost entirely devoid of vegetation and likely contributes to stream warming in August. In some locations such as reinforced metal stream sidings, larger trees may damage infrastructure so discussions will take place with the City as to what vegetation is appropriate to use in order to create stream shading.

Depending on what planting the City will allow in this section, a total of 550 to 800 live stakes will be required for the project.

A 250m stretch of riverway upstream from the road bridge seen in Figure 10 is currently closed to the public due to construction activities and is not included in this restoration plan. This section is largely riprapped and is relatively stable with acceptable streamside vegetation. Future potential restoration activities will be considered when construction plans are released.

The success of the project will be measured by several metrics including:

- Area of habitat restored (goal: 4.06 ha);
- Percent overstory cover (goal: 25% canopy coverage, 20% understory cover);
- Presence of invasive species remaining (goal: <5% understory coverage), and;
- Number of collaborators and volunteers attending restoration and community events (goal: 50).

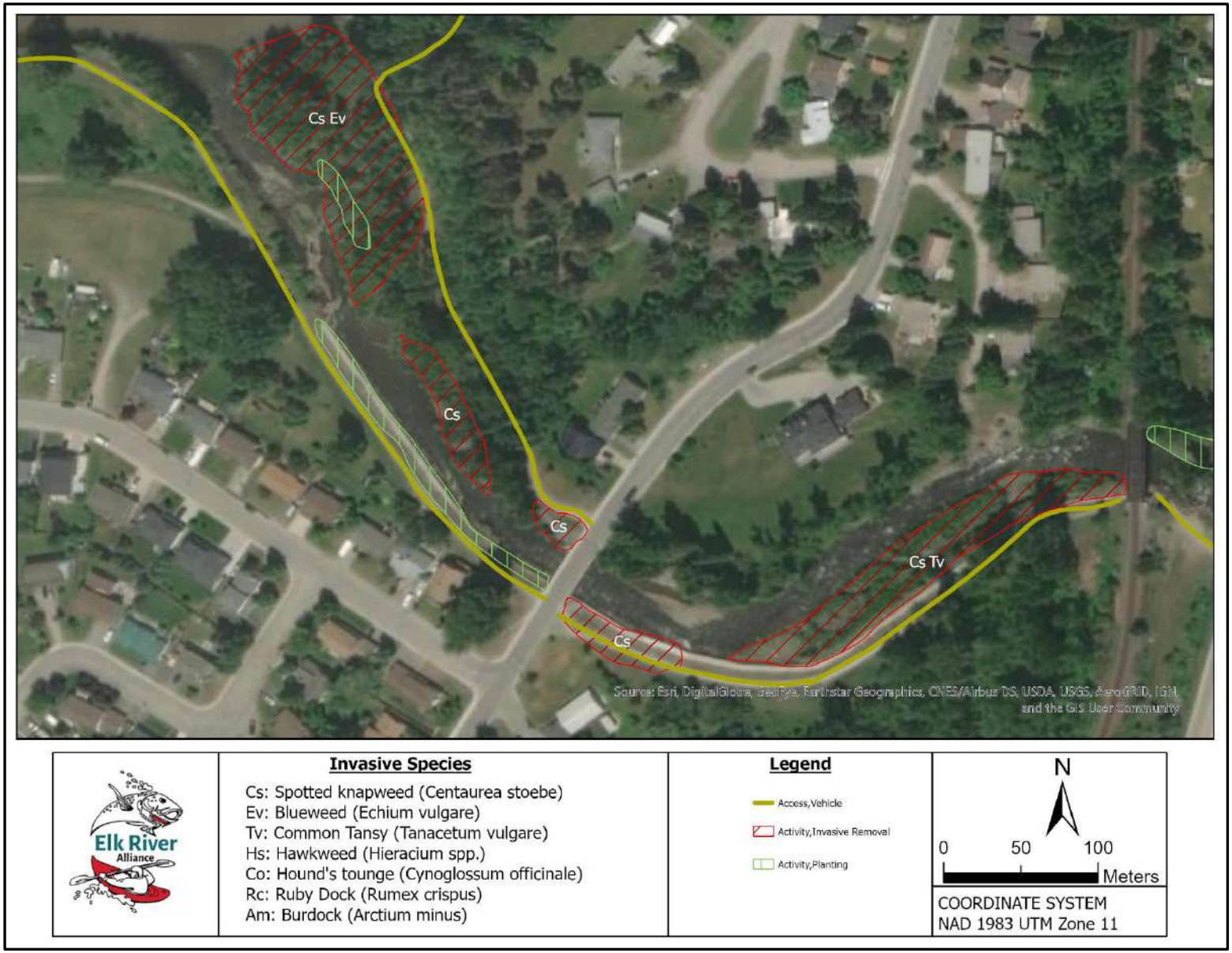

Figure 9: Proposed restoration activities on Coal Creeks 1/3

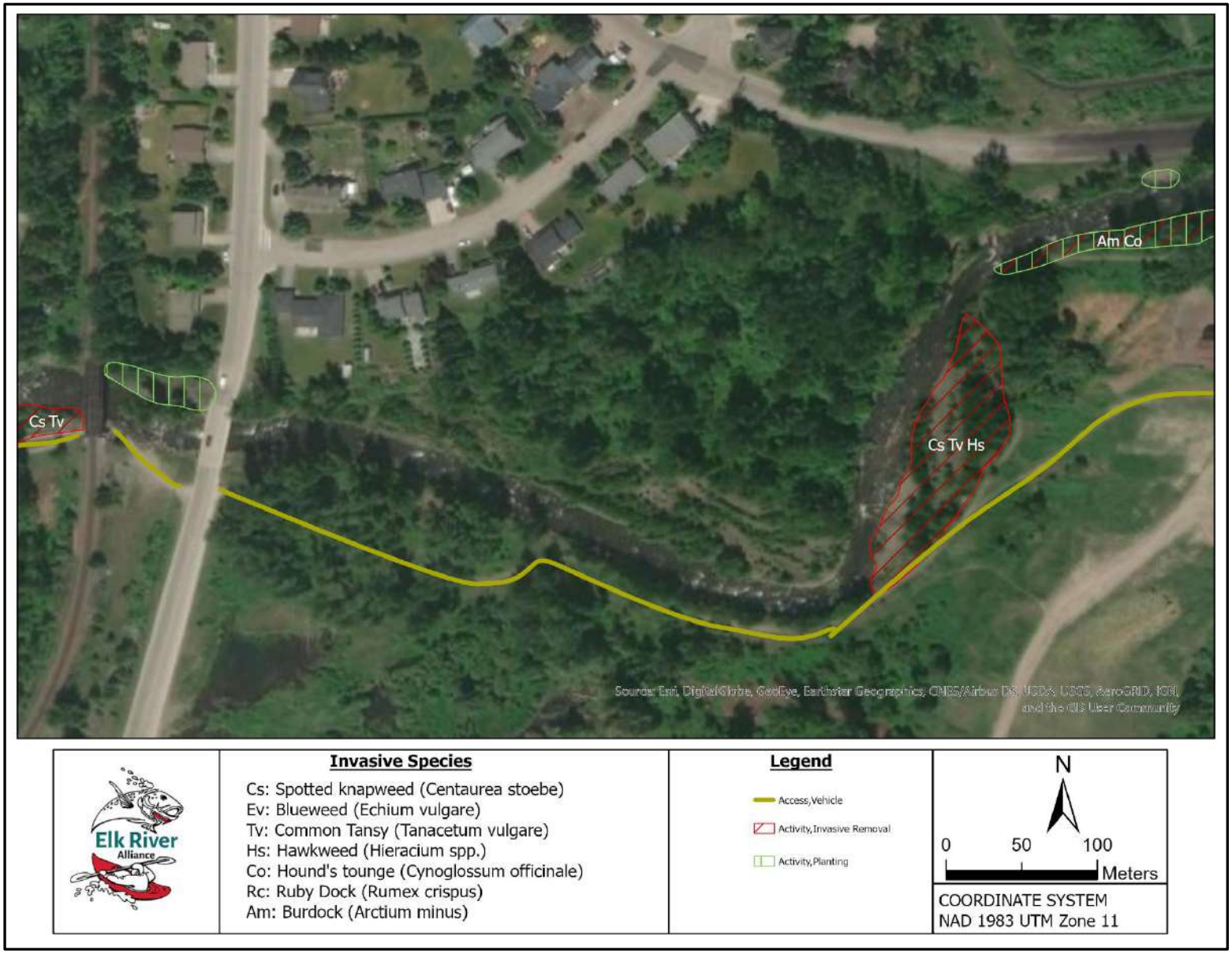

Figure 10: Proposed restoration activities on Coal Creeks 2/3

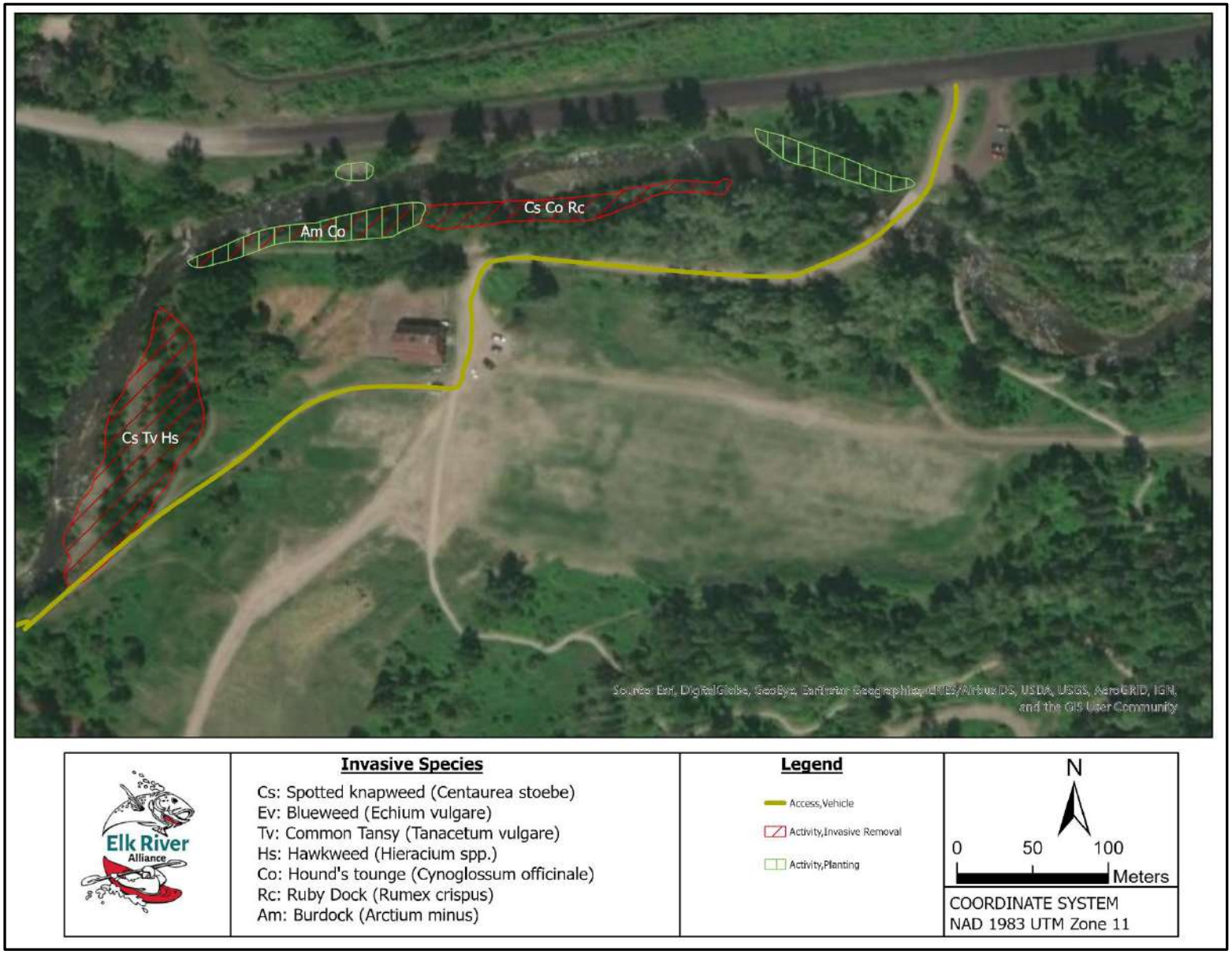

Figure 11: Proposed restoration activities on Coal Creeks 3/3

Project Costs

The following costs exist for the first year of the project (Table 1). Ongoing monitoring and maintenance will be required (see Long-Term Maintenance and Project Monitoring) and associated costs will need to be determined based on monitoring results. Between $2000 and $5000 should be budgeted for 3 to 5 years following project implementation to meet the outlined objectives. Interpretive signage, if desired, would cost an additional $1000-$2000.

Table 2: Project cost estimate for year one of project activities.

Project Activity	Details	Estimated Cost (Cash)	Estimated Cost (In-kind)
Project Management	Project development and coordination, permit applications, etc.	$1600	$0
Weedpulls	Weeding equipment and supplies, mileage, time, hospitality	$1876	$4700
Planting	Supplies and materials, mileage, time, hospitality	$4280	$8200
Monitoring & Maintenance (for first year)	Mileage, assessing mortality, time	$1730	$600
Admin (15%)	Associated overhead	$1674	$0
Total		$11,160	$13,500

Permits

As the site and site access exist on land owned by the City of Fernie and Parastone Developments Ltd. Permission will be required from both City of Fernie and Parastone Developments to conduct weed removal and live staking. As no earthworks will occur, a Change Approval under the Water Sustainability Act will not be required, but a *Notification For Work In And About A Stream* will be applied for from FrontCounter BC.

Safety

The onsite project coordinator should be trained in first aid and equipped with a first aid kit and bear spray. The project coordinator should be prepared for potential hazards and provide a safety briefing for volunteers prior to their attendance in activities. Potential hazards include risks associated with moving water, tripping or falling on uneven ground, wild animal interactions, insect and poisonous plant contact, repetitive stress injuries, etc. Volunteers should be advised of potential risks and asked to wear appropriate clothing and footwear for restoration activities.

Long-Term Maintenance and Project Monitoring

Monitoring of invasive species presence, vegetation survival rates, and overstory canopy will be required to ensure the success of the project and assess next steps required in maintenance.

Ongoing removal of invasive plant species from site will be required for the next 3 to 5 years to ensure the seedbank is depleted. This will involve at minimum annual weedpulls during the growing season. Weedpull intensity will depend on invasive species growth.

The more regularly plants receive water, the more likely they are to survive. Ideally, short-term maintenance for the first year would include watering with a water pump and between once a week and once a month throughout the first growing season. However, monetary constraints can make this degree of maintenance difficult; the above project costs allow for plants to be watered 10 times throughout the growing season.

If there is greater than 50% mortality, either due to grazing, draught, or other, additional plantings will need to take place at a later time. As trees and shrubs will not planted densely, thinning at a later date to reduce competition will not be required.

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Elk River Alliance

Corbin Creek COR01 Streamside Restoration Plan

March 2020

Prepared for the Habitat Trust
Conservation Foundation

Corbin Creek (HACOR01) Streamside Restoration Plan

"The aim of ecological restoration is to fully restore the components and processes of a damaged site or ecosystem to a previous historical state, to a contemporary standard, or towards a desired future condition."
~Gayton, 2001

Prepared by:

Beth Millions and Chad Hughes

Elk River Alliance

Date: March 2020

Introduction

In 2019 the Elk River Alliance (ERA) identified a degraded section streambank of Corbin Creek with reduced habitat potential based on the watershed restoration implementation sequence (Johnston and Moore 1995). The area was found to have an eroding embankment and debris left from historical use, invasive plants colonizing the exposed soil, and an ATV access point through the creek. ERA proposes a two-stage approach to restoring the site and improving the area's habitat potential. The first phase of the proposed restoration includes; (1) removal of historical debris from the site and surrounding area; (2) removal of invasive species from site and surrounding area; (3) plant live willow stakes at the toe of the slope to temporarily improve stability and reduce erosion; (4) work with local residents and ATV groups to develop an appropriate pathway forward in discouraging stream crossings, particularly during the Western Cutthroat Trout spawning and rearing period (typically late April to mid August), and; (5) host engagement sessions to work with local residents, industry (primarily Teck Resources), and local user groups (e.g. ATV clubs, hunting and fishing groups, etc.) to create a plan to reclaim the eroding abutments while accommodating existing recreational use in the area. The project will include a significant community engagement component to work with user groups and improve public understanding of habitat conservation and the need to avoid stream crossings in the fish rearing habitat. The success of this project will be measured by several metrics including: number of consultations, number of live stakes plants at toe of slope, volume of debris and invasive species removed from site, number of signs installed, development of long-term reclamation plan, number of collaborators and volunteers attending restoration and engagement events.

Project Rational

Westslope Cutthroat Trout (WCT; *O. clarkii lewisii*) are a blue listed species in British Columbia under Schedule 1 of the federal Species at Risk Act (SARA; Fisheries and Oceans Canada 2017). As of 2006, the species is provincially blue-listed as Special Concern according to the Committee on the Status of Endangered Wildlife in Canada (Fisheries and Oceans Canada 2017). The species faces many threats, including habitat loss, degraded water quality from coal mining, logging, riparian clearing due to industrial and community development, and an increase in angling pressure (Fisheries and Oceans Canada 2017; Tepper 2008). WCT have experienced dramatic population declines throughout their historic range due to habitat loss and degradation, overexploitation, competition, predation by non-native salmonids, and introgressive hybridization with other trout species (Fisheries and Oceans Canada 2017; Shepard et al. 1997).

Corbin Creek is a tributary of Michel Creek which is known for WCT use and rearing (Prince and Morris 2003). Population abundance estimates for fish with a fork length > 300 mm in Michel Creek were 46 fish/km, compared to 39 fish/km on the main stem of the Elk River (Hagen and Baxter 2009) and fish including WCT, bull trout, eastern brook trout, and mountain whitefish have been observed in Corbin Creek (Golder Associates Ltd. 2014).

Due to the anthropogenic impacts, WCT in the Corbin Creek Watershed face a great deal of pressure from competition with non-native salmonids, habitat loss, and reduced water quality. The site in question faces degraded water quality from upstream activities (e.g. extensive mining impacting 25% of the total

catchment area and private land logging); previous studies have characterized the water quality and benthic invertebrate populations as being poor (Windward Environmental, Minnow Environmental Inc., and CH2M Hill Limited 2014). Increasing trends in selenium, nitrate, and sulphate have been observed (Zajdlik & Associates, Inc. 2013) as have high levels of calcite (Windward Environmental, Minnow Environmental Inc., and CH2M Hill Limited 2014). The site is the source of increased sedimentation and potential contamination from an actively eroding slope comprised of clinker, or coal combustion wastes. Coal combustion wastes often contain elevated concentrations of heavy metals (e.g. lead, mercury, arsenic, cadmium, chromium, etc.) and have been shown to leach and contaminate surface and ground water (Praharaj et al. 2002; Nalawade, Bholay, and Mule 2012). These contaminations can increase elemental concentrations of the receiving waters, as well as change the pH and subsequent mobility of trace elements (Carlson and Adriano 1993). As such, it is important to ensure the proper restoration of the site so that coal combustion wastes are no longer eroding into Corbin Creek and potentially contaminating downstream waterways.

The area also sees ATV traffic and is the site of a stream crossing. The stream crossing is of particular concern as it occurs in desirable spawning and rearing habitat.

HACOR01 would benefit from restoration efforts to mitigate the damaging effects of human impacts on the area. Benefits include stabilizing the slope, a reduction of soil erosion into the stream to improve water quality and provide overstory stream shade for WCT, increased education surrounding ATV impacts on WCT, and a significant reduction in site litter. The site was determined to be a high priority area due to the positive impact that simple restoration measures will have on the stream and on WCT.

Site Description

The site (HACOR01) is located at 49.51334, -114.67554, approximately 50 m upstream of the Corbin-Michel Creeks confluence (Figure 1).

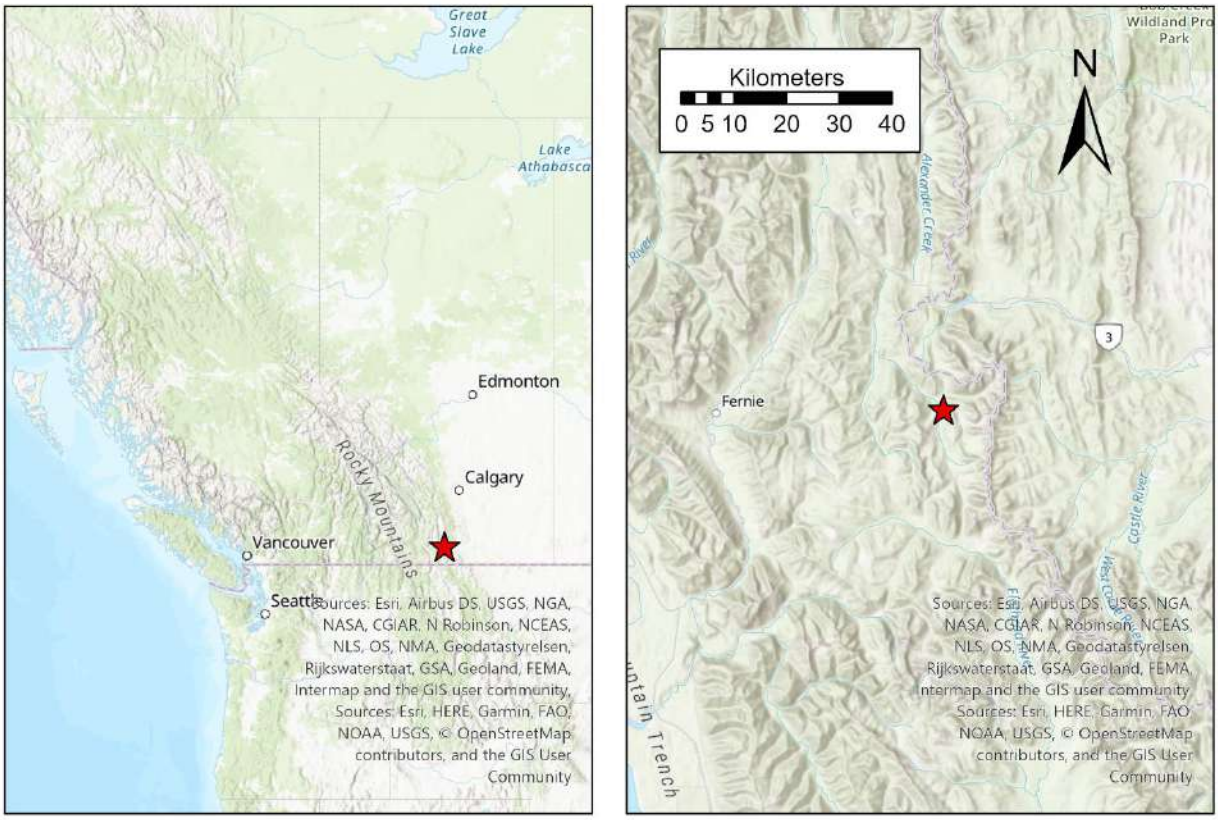

Figure 1: Location of HACOR01, proposed restoration site on Corbin Creek near Corbin, BC

HACOR01 situated within the Montane Spruce BEC zone (MSdw; MacKillop et al. 2018) and can be described as part of the Low Bench Flood Class (Fl) - Willow ecosystem type, with aspects of swamp classes at the margins. However, HACOR01 has been heavily disturbed from over a hundred years of anthropogenic impacts (discussed below) and resists proper classification. A reference site was not selected as attempting to return the site to a proper ecosystem type would have prohibitive costs and minimal ecological benefit. Instead, addressing the specific concerns (discussed below) would have a greater impact. Further, the area is in a state of flux due to significant beaver activity, backing up waters and creating a dynamic system of swamps and ponds.

The vegetation community of HACOR01 consists of predominantly willows (*Salix* spp.), with the occasional black gooseberry (*ribes lacustre*), paper birch (*Betula papyrifera*), and Engelman spruce (*Picea engelmannii*). The surrounding area quickly turns to predominantly Engelman spruce cover as you travel away from the riparian zone. Minimal overstory tree cover exists on the site (<5%) but there is extensive shrub coverage, primarily from the willow community (>60%). The presence of some invasive and non-native species was found on site, including blueweed (*Echium vulvgre*) and great mullein (*Verbascum thapus*).

Figure 2. Photos of HACOR01 on Corbin Creek and the surrounding vegetation and nearby failing embankment.

HACOR01 provides relatively good fish habitat and potential rearing and overwintering habitat, with a gradient of 1.14%, a substrate composition of 44% gravel and 56% cobble, and 30% embeddedness. There are a number of large woody debris in the stretch surveyed, 13% pool presence, and nearby wetland and off channel habitat. The wetland is the result of extensive beaver activity which has resulted in the creation of several large, deep ponds. These ponds likely provide significant overwintering habitat for WCT (Prince and Morris 2003). The riparian zone is in relatively good condition with good coverage of grasses, shrubs, and trees, though there is only 7% overhead canopy coverage, minimal vegetation on the eroded abutment, and no rooted cutbanks.

This site is centered around the remaining abutments from a decommissioned bridge with erosion issues (see Site History). The eroding bank is approximately 10 m long and 5 m tall, and is comprised of sands and coal clinker/coal combustion waste. Few species have been able to colonize the embankments; some grasses have become established on the slopes of the south abutment, but none are established on the north abutment slopes. The only plants that have become established on the slope of the north abutment are blueweed (*Echium vulvgre*) and great mullein (*Verbascum thapus*), and fireweed and one willow shrub at the toe of the slope.

An uncontrolled, unmarked ATV crossing below the embankment is likely causing the stream to widen and encourages irresponsible recreational use. ATV tracks exist in numerous locations around the site. Juvenile trout have been found near this site and in-stream which would be adversely affected by ATV use of the stream. Further, a small man-made weir appears to have been constructed to control waters flowing over the crossing point, which may pose an obstruction to fish passage and serve to increase stream temperatures through solar warming (Figure 3). Further, the ATV crossing itself can result in negative downstream affects (Chin et al. 2004).

Figure 3. Photos of ATV tracks accessing and crossing Corbin Creek.

The site also has numerous large pieces of historical and contemporary debris on site. Some pieces are within the riparian zone and immediately adjacent to Corbin Creek, and significantly more exist within 50 m of the eroding embankment including two large piles of refuse (Figure 4).

Figure 4: Metal debris at and within 50 m of HACOR01 on Corbin Creek.

This site exists on crown land (Figure 5) but access may require partnership with local landowners for some debris removal activity. To access the site from highway 3, turn onto Corbin Rd, approximately 7.5 km west of the Alberta/BC boarder. Take Corbin Rd for approximately 22 km and turn south onto Barnes Rd and travel another 500 m to the site.

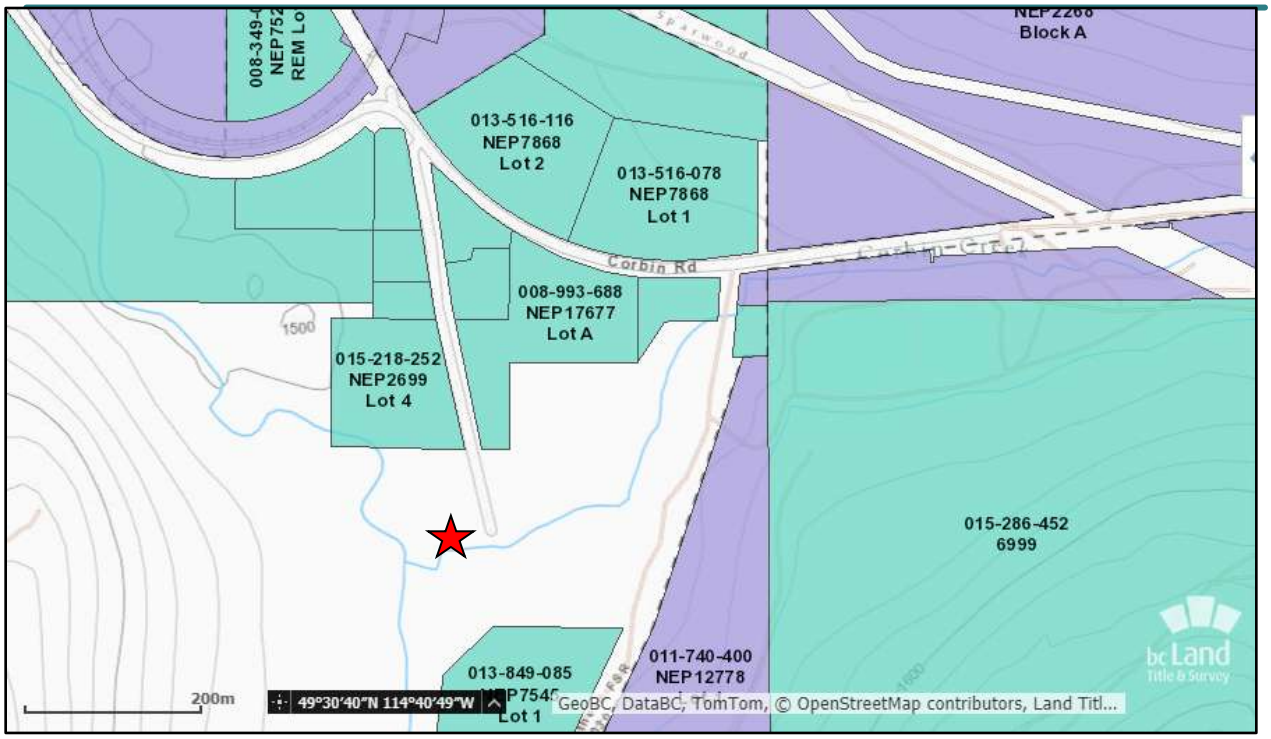

Figure 5: Land ownership of restoration site (Purple: Crown Provincial: Private Land, White: No Owner)

Site History

The Corbin Creek Watershed has been heavily impacted by human activity. The area exists nearby to Coal Mountain, a mining operation that first came into operations in 1908, was shut down in 1935, and reopened under new ownership in 1977 (Hutton, Glen 2019). Coal reserves have since been depleted and in 2018 mining operations ceased while the land owner (Teck Resources) began preparing the mine for reclamation; 25% of the total catchment area of Corbin Creek has been impacted by mining.

The town of Corbin was constructed at the toe of the mine site, but no longer exists today. A few homes remain along Barnes Rd, a few km away from the original townsite (pers. com. Glen Hutton, 2020). The existing residents are approximately 400 m north from HACOR01.

HACOR01 was historically used as a storage location for railway cars full of coal during mining operations from 1908 to 1935. The steel for the railway tracks and the bridge over Corbin Creek were eventually removed during World War II (pers. com. Glen Hutton, 2020) but the site was never restored and the bridge abutments on either side of the stream remain. These abutments were built up primarily out of clinker, or coal combustion waste. The south side abutment has been colonized by grasses and appears to be stable at present, likely because the hydrology of the site results in less force on the left side of the channel, but the north side abutment has not been successfully colonized and is visibly eroding on the north side of the creek. A section of abutment has been removed, possibly by local residents for property fill Figure 6.

Figure 6: Failing abutment (top) and close up of abutment materials (bottom).

Currently, the site is frequently used by outdoor recreationalists who drive through Corbin Creek to access an area south of HACOR01 for camping (pers. com. Glen Hutton, 2020). WCT are known to inhabit Corbin Creek, as well as nearby Michel Creek (Golder Associates Ltd. 2014; Prince and Morris 2003). ATV trails and stream crossings have been linked to increased turbidity and fine sediment (Chin et al. 2004) which can negatively impact downstream fish. A rock weir has been built up to reduce flows at the crossing point.

Project Goals

The proposed restoration for site HACOR01 includes hands-on activities, increasing education for outdoor recreationalists, and consultations for long-term planning. As the issues surrounding the site have a long and complex history, we propose taking a multiphase approach. In the first phase partnerships and plans will be developed to properly mitigate the impacts of the eroding bridge abutments while addressing the

more straight-forward concerns in regards to ATV access and dumping on site. The second phase will address the failing abutments and provide a path forward to properly reclaim the area.

The goals of this project are to improve habitat values for WCT provided by this site and return it to a more natural pre-disturbance state. Specifically, this will be done by meeting the following objectives:

1) Temporarily stabilize the abutment shoreline to reduce erosion by implementing live willow stakes at the toe of the eroding bank;
2) Remove historical debris (pallets, drums, miscellaneous metal debris etc.) from the site (approximately 20 m^3);
3) Work with local residents, ATV clubs, and conservation officers to develop an education and conservation plan to address the ATV use of the area and limit creek crossings during spawning and rearing, and;
4) Engage local residents, Teck, local ATV clubs, and site users in discussions to develop a long-term plan for the area that address health and safety concerns surrounding the eroding embankment.

Details of Restoration Activities

Locations of proposed restoration activities are detailed in Figure 7.

One of the primary recommendations for this site is to address the unsanctioned ATV crossing of the stream; this will involve both an education component for trail users and potentially work to either block the access and make it less desirable for vehicle crossings, provide signage to discourage crossings during the spawning period, or to create an instream “bridge” of rocks and concrete to reduce sedimentation.

Restricting access with a gate or large rocks and providing signage may get long term compliance with minimal effort, though the trail will need to be decommissioned and access restricted to ensure full compliance. Restricting access will likely prove unpopular with site users and may result in forced access. Alternatively, measures can be taken to find a more environmentally friendly manner to cross the creek, which may include constructing a bridge, placing rocks within the stream to drive on as an instream “bridge”, or finding an alternative location. Providing a single crossing point and improving the crossing with large flat rocks will reduce sedimentation, and hopefully discourage crossings in other locations. It is critically important to engage both conservation officers and ATV groups in this effort to ensure that all inputs are considered in order to get compliance and community buy-in. This will involve numerous consultations, developing educational material, and/or implementing educational signage. Consultations with local fishery biologists will be critical in identifying appropriate locations for a designated crossing and potential risks to fish habitat. Constructing a proper crossing structure has significant prohibitive costs, so is unlikely to occur. Adding concrete or large rocks to create a more durable crossing may result in the least impact to environment and local stream users, but conservation officers, regional biologists, and local ATV clubs would need to be consulted to explore this option.

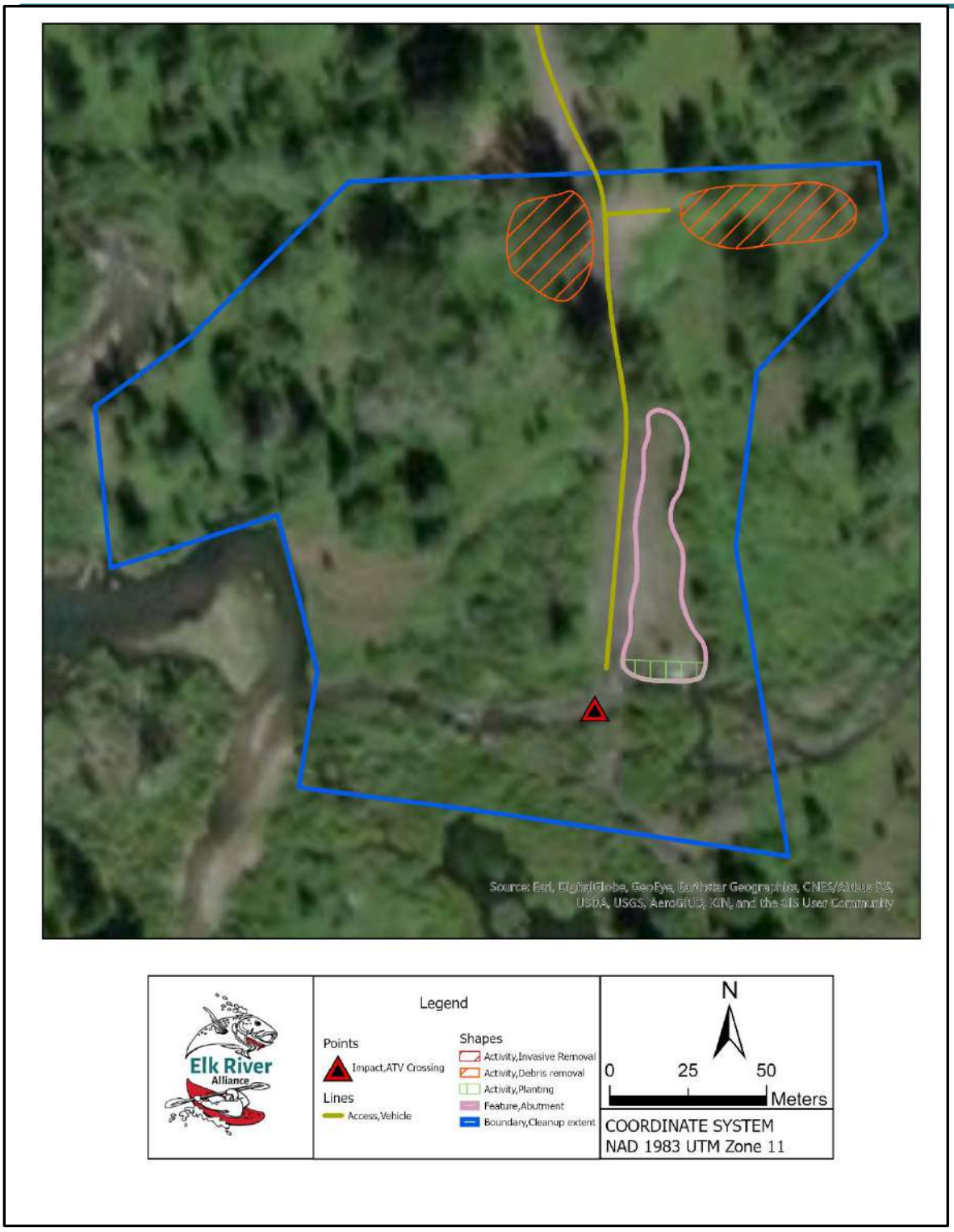

Figure 7: HACOR01 site map detailing access, site features, and proposed restoration activities.

Removal of the historical site debris will require 15-20 community volunteers as removal will first be attempted by hand. Any debris that cannot be removed by hand will be noted and left for the second phase of the project. A roll-off waste bin will need to be used and removed of for proper material disposal.

Re-vegetation of the entire eroded bank is unlikely to be successful given the poor growing conditions created by the slope. However, establishment of live stakes at the base has the potential to help mitigate erosion with minimal effort or cost, given that water availability is not a limiting factor along the stream edge. Should a highwater year occur and remove the live stakes there will be no environmental damage with minimal effort lost. Native willow can be harvested on site and planted at the toe of the slope either in the early spring or fall when the plants are dormant. Willow stakes should be placed in dense clumps to ensure a 50% survival; approximately 5 willow stakes per meter for a total of 50 stakes.

The full and proper reclamation of the abutments will be a long-term task, and the development of a restoration plan will require significant community and industry input. Teck's involvement in developing plans will be important given the historical activities in the area. Teck was not responsible for the creation or improper restoration of the abutments, but as a socially and environmentally responsible company is intent to help mitigate historical issues. Further, as the existing Coal Mountain mine site is currently exploring reclamation options, the surrounding areas are likely to also be considered for restoration. A partnership between industry and community would therefor have the greatest potential to properly restore the area, improve water quality, and provide stewardship initiatives for community members. Consultations will need to be hosted to gain insight into the vision of the site for local residents, site users (i.e. naturalists, ATV users, hunters and fishers, etc.), local fish biologists, and local industry.

The success of the project will be measured by several metrics including:

- Amount of refuse removed (goal: 20 m^3)
- Development of abutment restoration plan (goal: 1)
- Number of consultations held (goal: 10)
- Number of project partners (goal: 5 community groups/industry groups)
- Number of collaborators and volunteers attending restoration and community events (goal: 75).
- Number of signs installed (goal: 1)

Project Costs

The following costs exist for the first year of the project (Table 1). Maintenance and monitoring following activities are minimal during the first phase of the project; monitoring and maintenance costs for the second phase of the project will need to be determined once the second phase is finalized.

Table 2: Project cost estimate for year one of project activities.

Project Activity	Details	Estimated Cost (Cash)	Estimated Cost (In-kind)
Project Management	Project development and coordination, permit applications, etc.	$1600	$0
Site Cleanup	Supplies & materials, weeding equipment, PPE, roll off bin rental, mileage, time, hospitality	$3400	$4700
ATV Education and community consultation	Materials, mileage, signage, consultations, time, hospitality	$6400	$5600
Temporary Bank Stabilization	Supplies and materials, mileage, time, hospitality	$550	$1850
Abutment Consultations and Restoration Planning	Consultations, room rentals, hospitality, mileage, report development, professional and volunteer in-kind	$6150	$6800
Monitoring & Maintenance (for first year)	Mileage, assessing mortality, assessing user compliance, time	$780	$360
Admin (15%)	Associated overhead	$3330	
Total		$22,210	$19,310

Permits

The site exists on crown land but access may require partnership with local landowners for some debris removal activity. If no earthworks will occur, a Change Approval under the Water Sustainability Act will not be required, but a *Notification For Work In And About A Stream* will be and can be applied for from FrontCounter BC to place the live stakes and remove the rock weir. Should rocks be placed in stream to create a more environmentally friendly ATV crossing, a Change Approval will likely be required. Depending on the initiatives taken during the second phase a Change Approval will be required.

Safety

The onsite project coordinator should be trained in first aid and equipped with a first aid kit and bear spray. As there is no cell service at the site the project coordinator should bring an emergency communication device such as a Spot or inReach and have an acceptable safety plan. The project coordinator should be prepared for potential hazards and provide a safety briefing for volunteers prior to

their attendance in activities. Potential hazards include risks associated with moving water, tripping or falling on uneven ground, wild animal interactions, insect and poisonous plant contact, repetitive stress injuries, etc. Volunteers should be advised of potential risks and asked to wear appropriate clothing and footwear for restoration activities.

Long-Term Maintenance and Project Monitoring

The first phase of the project will not require significant long-term maintenance, and monitoring should be incorporated into the second phase of the project. The second phase will likely require significant maintenance and monitoring efforts, and will require assistance from local residents due to the commute required to get to site.

Phase one monitoring will include monthly visits to assess compliance with river crossing mitigation (by indications of river crossings), survival of live stakes at the base of the slope, presence of new waste, and presence of invasive plants. As willow stakes will be planted at stream level, watering will not be required.

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