Subject Matter Expert Report: FISH HANDLING. Evaluation of Cause – Decline in Upper Fording River Westslope Cutthroat Trout Population.

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USE & LIMITATIONS OF THIS REPORT

Acronyms and Abbreviations

DC	Direct Current
DFO	Fisheries and Oceans Canada
EMC	Elk Valley Environmental Monitoring Committee
EVFFHC	Elk Valley Fish and Fish Habitat Committee
FLNRORD	BC Ministry of Forests, Lands, and Natural Resource Operations and Rural Development
FRO	Fording River Operations
KNC	Ktunaxa Nation Council
NMFS	National Marine Fisheries Service
NTU	Nephelometric Turbidity Unit
PIT	Passive Integrated Transponder
SME	Subject Matter Expert
UFR	upper Fording River
WCT	Westslope Cutthroat Trout

Executive Summary

The 2019 Westslope Cutthroat Trout Population Monitoring Project results suggest that between September 2017 and September 2019 some feature or impact unique to the upper Fording River resulted in a population collapse of mature Westslope Cutthroat Trout from 76.3 to 8.6 fish/km for fish greater than 200 mm or from 22.0 to 2.2 fish/km for fish greater than 300 mm. This represented a 93% decline in the population abundance estimate and was unexpected. Annual density estimates for fry and juvenile age classes also demonstrated a significant decrease of approximately 74% in 2019. This decrease in juvenile densities was consistent with the adult enumeration data suggesting the population decline has occurred across all life stages and age classes.

When the 2019 results identifying a precipitous and unexpected fish population decline became available, Teck Coal Limited (Teck Coal) promptly moved to establish a team of Subject Matter Experts (SMEs) and began the Evaluation of Cause investigation into the population decline.

The purpose of this evaluation of fish handling generally, including: sampling (Floy tags, PIT tags, tissue sampling, electro-shocking, angling and trapping), salvage and relocation was to describe the extent to which scientific fish studies and fish salvage activities may affect the upper Fording River Westslope Cutthroat Trout (UFR WCT) population; in terms of the two "Over-arching" Hypotheses:

- Over-arching Hypothesis #1: The significant decline in the UFR WCT population was a result of a single acute stressor or a single chronic stressor.
- Over-arching Hypothesis #2: The significant decline in the UFR WCT population was a result of a combination of acute and/or chronic stressors, which individually may not account for the reduced WCT numbers, but cumulatively caused the decline.

There was concern that the timing of fish salvage events and the timing of snorkel surveys from the 2019 survey and previous years snorkel surveys may have influenced the annual population estimates (*i.e.,* fish salvaged, relocated and present in the surveyed area in 2017 but not in 2019). This concern regarding fish salvage influences on snorkel survey population estimates for mature fish (*i.e.,* fish greater than 200 mm fork length) was not validated by data review. A review of the timing of salvage events in 2017 and 2019 confirmed they were conducted after the snorkel survey was completed.

In addition, neither the scale (*i.e.,* total numbers of salvaged fish in 2017, 2018 or 2019) nor the requisite life stages (*i.e.,* very low numbers of adults) were validated through review of the salvage databases (*i.e.,* Hypothesis #1 – fish salvages and mortality events were the primary causal factor for the population decline). It was also noted that the scale of the fish salvages completed during 2012 to 2019 were not unprecedented. In 2004 and 2005, Clode Pond salvage operations collected and relocated 5,956 Westslope Cutthroat Trout. In 1978, an estimated 10,000 Westslope Cutthroat Trout were relocated from approximately 1,200 m of diverted river channel to accommodate the construction of the South Tailings Pond.

To evaluate the potential cumulative impacts due to fish handling generally, including sampling, monitoring, tagging, salvage, and relocation and their potential to contribute to the population decline as one of a number of stressors (*i.e.,* cumulative effects, Hypothesis #2), the approach was to review the broader database for all Teck Coal Scientific Fish Collection Permits from 2012 through 2019; rather than just fish salvage data submissions.

The causal pathway being investigated under this hypothesis was if the cumulative fish handling through all monitoring, salvages and scientific studies represented a large enough scale of immediate and/or latent mortality that could contribute to reduced population productivity and contribute to the observed population decline through a cumulative effects framework.

The review of the combined salvage and scientific or monitoring captures and handling did identify that a large number of Westslope Cutthroat Trout have been captured and handled, sampled or relocated through electrofishing, angling, seine netting, dip netting, gillnetting and baited traps within the upper Fording River. In total, 13,710 Westslope Cutthroat Trout have been captured and handled in one form or another since 2012. This represents a total cumulative impact of 1,714 Westslope Cutthroat Trout captured and handled every year from 2012 through 2019 (predominantly juveniles). Probably more importantly, from 2012 through 2015 the average annual capture and handling was 715 fish and from 2016 to 2019 this increased 379% to 2,712 fish per year (*i.e.,* almost 4 fold increase).

Given the scale and the recent increase to fish capture and handling there was a high degree of certainty the requisite conditions do exist to contribute to mortalities at the individual level and the scale of total captures has the potential to contribute to reduced population productivity. In order to place these handling numbers in context it was necessary to estimate the total population abundance. This was done in a very coarse manner using a combination of; (1) the total estimated adult abundance for 84% of the available habitat, plus (2) the estimated density of juvenile fish extrapolated over the total available habitat (i.e., wetted width x stream length). There was a high degree of uncertainty in the population level impacts due to the use of subjective habitat suitability indices by life stage, difficulties in estimating total habitat availability, and the potential for low sample size bias and site selection bias to introduce error. These difficulties should prohibit such an extrapolation and the results should be viewed judiciously.

Nevertheless, total habitat availability was estimated and population extrapolations were completed for informative purposes to illustrate a range of mortality scenarios and should not be interpreted as valid population estimates. Scenarios were examined to illustrate uncertainties and provide context for the likelihood that the current (2016-19) scale of captures and handling may contribute to a cumulative impact.

In total, 787,424 m^2 of stream habitat availability was estimated. The highest juvenile densities and the bulk of the fish salvages occur in the following strata; mainstem-upper or headwaters above FRO, the mainstem-mid or onsite FRO and the lower tributary reaches below fish passage barriers. These strata represent 190,702 m^2 or 24% of the total available habitat estimate.

Population extrapolations that included applying a subjective habitat suitability index for the juvenile life stage resulted in a population estimate range of juvenile and adult Westslope Cutthroat Trout within the upper Fording River for a low density year (7,727 in 2019) and a high density year (20,562 in 2017).

Mortality assumptions were used to estimate potential capture and handling mortalities including latent or under-reported mortalities. Based on these estimates, some proportion of the population are captured (*i.e.,* 2,712 fish annually 2016 - 2019) and exposed to potential mortalities of between 7% for a scientific study and 27% for salvage and relocation. A 7% mortality rate was considered a reasonable estimate based on literature values for; (1) 5% mortality (immediate and latent combined) for an experienced fly fisher and handler using barbless, artificial flies, plus (2) a 2% mortality rate (immediate and latent combined) for Floy, PIT, Radio tagging or tissue sampling for an experienced behavioural tagging specialist. The 7% estimated mortality could be higher depending on the capture technique and experience of either the angler or the biologist conducting the sampling. Similarly, the 27% mortality rate was considered a reasonable estimate based on assuming the following; (1) 90% salvage efficiency, (2) 10% latent relocation mortality, (3) 5% latent electrofishing and handling mortality, and (4) 2% immediate handling mortality.

Based on the estimated habitat availability and population scenarios, between 8% and 51% of the total population may be captured and handled in some manner, exposing them to potential mortalities of between 7% and 27% in a given year; depending on capture and handling methods. This results in annual mortality estimates or scenarios (juveniles and adults combined) that range from a low of 130 fish annually (*i.e.,* low handling year = 2016 - 1,861 fish handled at a low 7% mortality estimate for scientific studies) to a high of 1,069 fish annually (*i.e.,* high handling year - 2018 = 3,959 fish handled at high 27% mortality estimate for fish salvages).

Note that the high estimates of population handling (i.e., 51% above) invoke the high fish handling years of the past on the current low population estimate. This provides an example of the potential impact of past levels of handling on the lower current population estimates.

The most likely answer lies somewhere in the middle of this range; perhaps even lower than the median value given that all salvage and scientific collection programs take incidental mortalities seriously and follow both the Teck Coal and permitting guidance on mitigating incidental mortalities. The following are but a few of the measures noted in the data review:

- Angling is employed when targeting adults to mitigate electrofishing impacts in scientific studies;
- Electrofishing crews typically utilize settings designed to mitigate electrofishing injury (*i.e.,* settings that limit injury rather than settings that maximize capture efficiency); and
- Often, before initiating electrofishing, salvage crews employ seine netting, dip netting and trapping as less invasive techniques to minimize electrofishing use.

At higher mortality scenarios (27%) and lower population abundance (7,727 juvenile and adult fish) there are likely to be significant population level effects contributing to cumulative effects. However, neither of these estimates can be validated and there is high uncertainty.

It is likely that the recent scale of salvages, sampling and handling (2,713 Westslope Cutthroat Trout annually 2016-2019) does have some incremental cumulative effect due to incidental and latent mortalities that are under-reported; especially for salvaged fish. Salvage operations dominate both the captures (2,119 Westslope Cutthroat Trout annually 2016-2019) and the higher mortality estimates (27%).

The scale of capture and handling represents an intensively managed population and the concern that the population is, "being studied to death" and that salvage operations are detrimental to the population and that this combination may be unsustainable has merit. This is particularly true under low population densities and a precautionary management strategy. Some quantitative population monitoring data is essential; however, all salvage and scientific studies should be reviewed and prioritized to mitigate potential impacts. At least until the population has recovered.

READER'S NOTE

What is the Evaluation of Cause and what is its purpose?

The Evaluation of Cause is the process used to investigate, evaluate and report on the reasons the Westslope Cutthroat Trout population declined in the upper Fording River between fall 2017 and fall 2019.

Background

The Elk Valley is located in the southeast corner of British Columbia (BC), Canada. It contains the main stem of the Elk River (220 km long) and many tributaries, including the Fording River (70 km long). This report focuses on the upper Fording River, which starts 20 km upstream from its confluence with the Elk River at Josephine Falls. The Ktunaxa First Nation has occupied lands in the region for more than 10,000 years. Rivers and streams of the region provide culturally important sources of fish and plants.

The upper Fording River watershed is at a high elevation and is occupied by only one fish species, a genetically pure population of Westslope Cutthroat Trout *(Oncorhynchus clarkii lewisi)* — an iconic fish species that is highly valued in the area. This population is physically isolated because Josephine Falls is a natural barrier to fish movement. The species is protected under the federal Fisheries Act and the Species at Risk Act. In BC, the Conservation Data Center categorized Westslope Cutthroat Trout as "*imperiled or of special concern, vulnerable to extirpation or extinction."* Finally, it has been identified as a priority sport fish species by the Province of BC.

The upper Fording River watershed is influenced by various human-caused disturbances including roads, a railway, a natural gas pipeline, forest harvesting and coal mining. Teck Coal Limited (Teck Coal) operates the three surface coal mines within the upper Fording River watershed, upstream of Josephine Falls: Fording River Operations, Greenhills Operations and Line Creek Operations.

Evaluation of Cause

Following identification of the decline in the Westslope Cutthroat Trout population, Teck Coal initiated an Evaluation of Cause process. The overall results of this process are reported in a separate document (Evaluation of Cause Team, 2021) and are supported by a series of Subject Matter Expert reports.

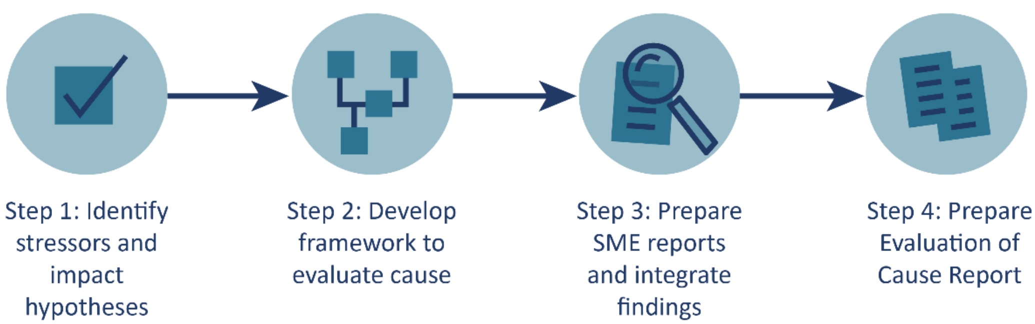
The report that follows this Reader's Note is one of those Subject Matter Expert Reports.

Monitoring conducted for Teck Coal in the fall of 2019 found that the abundance of Westslope Cutthroat Trout adults and sub-adults in the upper Fording River had declined significantly since previous sampling in fall 2017. In addition, there was evidence that juvenile fish density had decreased. Teck Coal initiated an *Evaluation of Cause* process. The overall results of this process are reported separately (Evaluation of Cause Team, 2021) and are supported by a series of Subject Matter Expert reports such as this one. The full list of SME reports follows at the end of this Reader's Note.

Building on and in addition to the Evaluation of Cause, there are ongoing efforts to support fish population recovery and implement environmental improvements in the upper Fording River.

How the Evaluation of Cause was approached

When the fish decline was identified, Teck Coal established an *Evaluation of Cause Team* (the Team), composed of *Subject Matter Experts* and coordinated by an Evaluation of Cause *Team Lead.* Further details about the Team are provided in the Evaluation of Cause report. The Team developed a systematic and objective approach (see figure below) that included developing a Framework for Subject Matter Experts to apply in their specific work. All work was subjected to rigorous peer review.



Conceptual approach to the Evaluation of Cause for the decline in the upper Fording River Westslope Cutthroat Trout population.

With input from representatives of various regulatory agencies and the Ktunaxa Nation Council, the Team initially identified potential stressors and impact hypotheses that might explain the cause(s) of the population decline. Two overarching hypotheses (essentially, questions for the Team to evaluate) were used:

- Overarching Hypothesis #1: The significant decline in the upper Fording River Westslope Cutthroat Trout population was a result of a single acute stressor[1] or a single chronic stressor[2].
- Overarching Hypothesis #2: The significant decline in the upper Fording River Westslope Cutthroat Trout population was a result of a combination of acute and/or chronic stressors, which individually may not account for reduced fish numbers, but cumulatively caused the decline.

The Evaluation of Cause examined numerous stressors in the UFR to determine if and to what extent those stressors and various conditions played a role in the Westslope Cutthroat Trout's decline. Given that the purpose was to evaluate the cause of the decline in abundance from 2017 to 2019[3], it was important to identify stressors or conditions that changed or were different during that period. It was equally important to identify the potential stressors or conditions that did not change during the decline window but may, nevertheless, have been important constraints on the population with respect to their ability to respond to or recover from the stressors. Finally, interactions between stressors and conditions had to be considered in an integrated fashion. Where an *impact hypothesis* depended on or may have been exacerbated by interactions among stressors or conditions, the interaction mechanisms were also considered.

The Evaluation of Cause process produced two types of deliverables:

1. **Individual Subject Matter Expert (SME) reports** (such as the one that follows this Note): These reports mostly focus on impact hypotheses under Overarching Hypothesis #1 (see list, following). A Framework was used to align SME work for all the potential stressors, and, for consistency, most SME reports have the same overall format. The format covers: (1) rationale for impact hypotheses, (2) methods, (3) analysis and (4) findings, particularly whether the requisite

[1] Implies September 2017 to September 2019.
[2] Implies a chronic, slow change in the stressor (using 2012–2019 timeframe, data dependent).
[3] Abundance estimates for adults/sub-adults are based on surveys in September of each year, while estimates for juveniles are based on surveys in August.

conditions[4] were met for the stressor(s) to be the sole cause of the fish population decline, or a contributor to it. In addition to the report, each SME provided a summary table of findings, generated according to the Framework. These summaries were used to integrate information for the Evaluation of Cause report. Note that some SME reports did not investigate specific stressors; instead, they evaluated other information considered potentially useful for supporting SME reports and the overall Evaluation of Cause, or added context (such as in the SME report that describes climate (Wright et al., 2021).

2. **The Evaluation of Cause report** (prepared by a subset of the Team, with input from SMEs): This overall report summarizes the findings of the SME reports and further considers interactions between stressors (Overarching Hypothesis #2). It describes the reasons that most likely account for the decline in the Westslope Cutthroat Trout population in the upper Fording River.

Participation, Engagement & Transparency

To support transparency, the Team engaged frequently throughout the Evaluation of Cause process. Participants in the Evaluation of Cause process, through various committees, included:

Ktunaxa Nation Council

BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development

BC Ministry Environment & Climate Change Strategy

Ministry of Energy, Mines and Low Carbon Innovation

Environmental Assessment Office

[4] These are the conditions that would need to have occurred for the impact hypothesis to have resulted in the observed decline of Westslope Cutthroat Trout population in the upper Fording River.

Citation for the Evaluation of Cause Report

When citing the Evaluation of Cause Report use:

Evaluation of Cause Team, (2021). *Evaluation of Cause — Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited by Evaluation of Cause Team.

Citations for Subject Matter Expert Reports

Focus	Citation for Subject Matter Expert Reports
Climate, temperature, and streamflow	Wright, N., Greenacre, D., & Hatfield, T. (2021). *Subject Matter Expert Report: Climate, Water Temperature, Streamflow and Water Use Trends*. *Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Ecofish Research Ltd.
Ice	Hatfield, T., & Whelan, C. (2021). *Subject Matter Expert Report: Ice. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. Report Prepared by Ecofish Research Ltd.
Habitat availability (instream flow)	Healey, K., Little, P., & Hatfield, T. (2021). *Subject Matter Expert Report: Habitat availability. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited by Ecofish Research Ltd.
Stranding – ramping	Faulkner, S., Carter, J., Sparling, M., Hatfield, T., & Nicholl, S. (2021). *Subject Matter Expert Report: Ramping and stranding. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited by Ecofish Research Ltd.

Focus	Citation for Subject Matter Expert Reports
Stranding – channel dewatering	Hatfield, T., Ammerlaan, J., Regehr, H., Carter, J., & Faulkner, S. (2021). *Subject Matter Expert Report: Channel dewatering. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited by Ecofish Research Ltd.
Stranding – mainstem dewatering	Hocking M., Ammerlaan, J., Healey, K., Akaoka, K., & Hatfield T. (2021). *Subject Matter Expert Report: Mainstem dewatering. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. by Ecofish Research Ltd. and Lotic Environmental Ltd. Zathey, N., & Robinson, M.D. (2021). *Summary of ephemeral conditions in the upper Fording River Watershed. In Hocking et al. (2021). Subject Matter Expert Report: Mainstem dewatering. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. by Ecofish Research Ltd. and Lotic Environmental Ltd.
Calcite	Hocking, M., Tamminga, A., Arnett, T., Robinson M., Larratt, H., & Hatfield, T. (2021). *Subject Matter Expert Report: Calcite. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. by Ecofish Research Ltd., Lotic Environmental Ltd., and Larratt Aquatic Consulting Ltd.
Total suspended solids	Durston, D., Greenacre, D., Ganshorn, K & Hatfield, T. (2021). *Subject Matter Expert Report: Total suspended solids. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Ecofish Research Ltd.
Fish passage (habitat connectivity)	Harwood, A., Suzanne, C., Whelan, C., & Hatfield, T. (2021). *Subject Matter Expert Report: Fish passage. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. by Ecofish Research Ltd. Akaoka, K., & Hatfield, T. (2021). Telemetry Movement Analysis. In Harwood et al. (2021). *Subject Matter Expert Report: Fish passage. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. by Ecofish Research Ltd.

Focus	Citation for Subject Matter Expert Reports
Cyanobacteria	Larratt, H., & Self, J. (2021). *Subject Matter Expert Report: Cyanobacteria, periphyton and aquatic macrophytes. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Larratt Aquatic Consulting Ltd.
Algae / macrophytes	
Water quality (all parameters except water temperature and TSS [Ecofish])	Costa, EJ., & de Bruyn, A. (2021). *Subject Matter Expert Report: Water quality. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Golder Associates Ltd. Healey, K., & Hatfield, T. (2021). *Calculator to assess Potential for cryoconcentration in upper Fording River.* In Costa, EJ., & de Bruyn, A. (2021). *Subject Matter Expert Report: Water quality. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Golder Associates Ltd.
Industrial chemicals, spills and unauthorized releases	Van Geest, J., Hart, V., Costa, EJ., & de Bruyn, A. (2021). *Subject Matter Expert Report: Industrial chemicals, spills and unauthorized releases. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Golder Associates Ltd. Branton, M., & Power, B. (2021). *Stressor Evaluation – Sewage.* In Van Geest et al. (2021). *Industrial chemicals, spills and unauthorized releases. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Golder Associates Ltd.
Wildlife predators	Dean, D. (2021). *Subject Matter Expert Report: Wildlife predation. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by VAST Resource Solutions Inc.
Poaching	Dean, D. (2021). *Subject Matter Expert Report: Poaching. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by VAST Resource Solutions Inc.

Focus	Citation for Subject Matter Expert Reports
Food availability	Orr, P., & Ings, J. (2021). *Subject Matter Expert Report: Food availability. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Minnow Environmental Inc.
Fish handling	Cope, S. (2020). *Subject Matter Expert Report: Fish handling. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Westslope Fisheries Ltd.
	Korman, J., & Branton, M. (2021). *Effects of capture and handling on Westslope Cutthroat Trout in the upper Fording River: A brief review of Cope (2020) and additional calculations.* Report prepared for Teck Coal Limited. Prepared by Ecometric Research and Azimuth Consulting Group.
Infectious disease	Bollinger, T. (2021). *Subject Matter Expert Report: Infectious disease. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by TKB Ecosystem Health Services Ltd.
Pathophysiology	Bollinger, T. (2021). *Subject Matter Expert Report: Pathophysiology of stressors on fish. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by TKB Ecosystem Health Services Ltd.
Coal dust and sediment quality	DiMauro, M., Branton, M., & Franz, E. (2021). *Subject Matter Expert Report: Coal dust and sediment quality. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Azimuth Consulting Group Inc.
Groundwater quality and quantity	Henry, C., & Humphries, S. (2021). *Subject Matter Expert Report: Hydrogeological stressors. Evaluation of Cause - Decline in upper Fording River Westslope Cutthroat Trout population.* Report Prepared for Teck Coal Limited. Prepared by SNC-Lavalin Inc.

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1 Introduction

1.1 Background

1.1.1 Overall Background

This document is one of a series of Subject Matter Expert (SME) reports that support the overall Evaluation of Cause into the upper Fording River Westslope Cutthroat Trout population decline (citation for EoC report). For general information, see the preceding Reader's Note.

In 2010, the Province of British Columbia closed the upper Fording River to angling due to uncertainty around the Westslope Cutthroat Trout (WCT) population status. The Upper Fording River Westslope Cutthroat Trout Population Assessment and Telemetry Study was completed by Westslope Fisheries Ltd. under the guidance and direction of a Steering Committee that consisted of representatives from Teck Coal Limited (Teck Coal), the BC Ministry of Forests, Lands, and Natural Resource Operations and Rural Development (FLNRORD), and the Ktunaxa Nation Council (KNC); with statistical guidance provided by Dr. Carl Schwarz (Simon Fraser University, retired). Fisheries and Oceans Canada (DFO) participated as a Steering Committee member in the study design and implementation phase. These agencies now participate through the Elk Valley Fish and Fish Habitat Committee (EVFFHC); where membership overlaps to some extent with the Elk Valley Environmental Monitoring Committee (EMC).

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

The overall goal of the population study was to determine whether the upper Fording River Westslope Cutthroat Trout population was viable and sustainable. The results of the 2012-2015 study indicated:

- The population metrics for sub-adult and adult abundance ranged between 2,552 – 3,874 fish greater than 200 mm fork length;
- Habitat availability included 57.5 km main stem river plus approximately 59 km tributary habitat;
- Genetic integrity of the Westslope Cutthroat Trout (pure strain with no hybridization with other trout species); and
- Condition factor, growth rates, population age structure and growth model estimates.

Considering uncertainty in population resilience and sustainability, further population monitoring was recommended every two years. The study recommended continued population trend monitoring in 2017, 2019 and 2021 to achieve six years of data over a 10-year period to reduce the uncertainty of the population estimates. The population estimates include; (1) snorkel counts for sub-adult and adult population estimates (fish greater than 200 mm), and (2) three pass removal-depletion counts for fry and juvenile density estimates. The monitoring program had established statistical triggers (+/- 25%) that if exceeded would indicate that the change is not within the statistical error and should be investigated.

The 2019 monitoring was completed from August 19-28 for fry /juveniles (three pass removal-depletion) and September 4-12 for sub-adults and adults (snorkel counts). Results were 74% lower for juveniles and 93% lower for adults compared to the 2017 monitoring results. Adult population estimates and juvenile densities were stable or increasing up until 2017. The 2019 results indicate a significant and unexpected decline in Westslope Cutthroat Trout. There is confidence in the estimates and the decline given the time series (2012 to 2019) and the power to detect a change (+/- 25%) in relation to the magnitude of the decline (74% and 93%). Confirmatory sampling through an additional snorkel survey was initiated in late October 2019 after fish migration into key overwintering areas; that survey confirmed the reduction in population.

1.1.2 Report-specific Background

This report provides an evaluation of potential stressors related to fish handling generally, including both scientific sampling and salvage-relocation. This evaluation also includes a review of the timing of fish salvage events and timing of snorkel surveys from this years and previous years snorkel surveys; and how those salvage events may or may not have influenced the annual population estimates (*i.e.,* present in the surveyed area).

Depletion sampling in combination with multiple-pass electrofishing is an important fisheries management tool for wadeable streams (Hilborn and Walters 1992, Van De-venter and Platts 1983). This combination of techniques has been used routinely for several decades as a reliable means to obtain quantitative data on trout populations and as a fish salvage technique. Fish salvages are completed as part of a drainage maintenance plan to avoid injuring or killing fish that occupy areas that will become dewatered, or for water quality concerns. Under section 32 of the Federal Fisheries Act, no person may destroy fish by any means other than fishing except as authorized by the minister; fish salvages that collect and relocate fish are a common mitigation strategy under these circumstances. Electrofishing is often considered the most effective and benign technique for capturing fish, but when adverse effects are problematic and cannot be sufficiently reduced, its use should be severely restricted (Snyder 2003). Less invasive capture techniques (i.e., trapping, beach seining, drain-and dip-net) are either not effective or much less efficient and fish not salvaged through these techniques are at higher mortality risk and may result in higher mortalities as capture efficiencies decline.

Electrofishing can be highly stressful to fish and mortality can be extremely high in warm water conditions. It is well known that the capture method (electrofishing), and experience of the crew in regards to electrofishing, as well as fish handling and tagging or sampling can influence fish behavior and survival (Mamer and Meyer 2016, Cook *et al.* 2014, Panek and Densmore 2011). Because of these known impacts to fish, electrofishing, especially multiple pass methods, is the capture method of last resort in the implantation of electronic transmitting devices in fish for behavioral studies.

Our qualifications in regards to the above concerns, stem from our experience as life history and population assessment specialists with over 25 years of experience within East Kootenay watersheds. We are uniquely qualified to comment on stressors related to fish handling given our fish capture and handling expertise; especially as it relates to bio-telemetry methods where the fate (*i.e.,* behavior and survival) of fish are followed; typically for at least one year but can be up to five years. This experience includes a variety of species including 350 radio tagged Westslope Cutthroat Trout (Cope and Cope 2020, Cope *et al.* 2016, Cope and Prince 2012, Morris and Prince 2004, Prince and Morris 2003), as well as Mountain Whitefish (*Prosopium williamsoni*) (Cope and Prince 2012), Bull Trout (*Salvelinus confluentus*) (Prince 2010), Rainbow Trout (*Oncorhynchus mykiss*) (Prince *et al.* 2000), Pacific salmon (Sockeye (*Oncorhynchus nerka*), Hinch *et al.* 1996; Coho (*Oncorhynchus kisutch*), Healey and Prince 1998), White Sturgeon (*Acipenser transmontanus*) (Prince 2004, R.L.&L. Environmental Services Ltd. 1996) and Burbot (*Lota lota*) (Kang *et al.* 2015, Cope 2011).

Similarly, electrofishing methods have been employed for a variety of species including Westslope Cutthroat Trout and are supported by over 27 years of implementation and interpretation by the principle biologists (Cope and Cope 2020, Cope *et al.* 2016, Cope 2008, 2007, 2001, Cope and Morris 2006, Bisset and Cope 2002, Morris *et al.* 1997). The Westslope Fisheries Ltd. study team has captured, Floy, PIT and radio tagged over 3,400 Westslope Cutthroat Trout over a 12 year period since 2000.

Finally, fish handling techniques are also supported by the capture and handling of approximately 20 million salmonid fry and smolts between 1998 and 2014 (Cope 2015).

1.2 Objectives

The purpose of this evaluation of fish handling generally, including: sampling (Floy tags, PIT tags, radio tags, tissue sampling, electro-shocking, angling and trapping), salvage, and relocation was to describe the extent to which scientific fish studies and fish salvage may affect the upper Fording River Westslope Cutthroat Trout population; in terms of the two "Over-arching" Hypotheses (see Reader’s Note) and whether they could either; (1) represent the primary causal factor for the population decline (Hypothesis #1), or (2) contribute to the population decline as one of a number of stressors (*i.e.,* cumulative effects, Hypothesis #2). This evaluation also includes a review of the timing of fish salvage events and timing of snorkel surveys from this years and previous years snorkel surveys; and how those salvage events may or may not have influenced the annual population estimates.

The applicable and appropriate temporal and spatial scales to support the Evaluation of Cause will extend to 2012 and will consider the upper Fording River watershed (*i.e.,* upstream of Josephine Falls).

1.3 Approach

1.3.1 Overall Approach

When the 2019 Westslope Cutthroat Trout population monitoring project results identifying a precipitous and unexpected fish population decline became available, Teck promptly moved to establish a team of subject matter experts (SMEs) and began the Evaluation of Cause for the population decline. Desirable attributes for SMEs included relevant technical experience, experience in the Elk Valley system, and being a qualified professional. A balance was struck between individuals that are familiar with the Valley and the data and those that are new to this watershed and industry.

While the SMEs are retained by Teck, the Evaluation of Cause process necessarily must be "thorough, transparent and objective." The SME team will undertake the evaluation in accordance with the scope of work as defined in Power (2020) and will provide opportunities for input during the process.

1.3.2 SME Specific Approach

The 2019 population monitoring results suggest that between September 2017 and September 2019 some feature or impact unique to the upper Fording River resulted in a population decline for mature Westslope Cutthroat Trout from 76.3 to 8.6 fish/km for fish greater than 200 mm or from 22.0 to 2.2 fish/km for fish greater than 300 mm. Annual density estimates for fry and juvenile age classes also demonstrated a significant decrease of approximately 74% in 2019. This decrease in juvenile densities was consistent with the adult enumeration data suggesting the population decline has occurred across all life stages and age classes.

This report provides an evaluation of potential stressors related to fish handling generally, including: sampling (electro-shocking, angling, trapping and Floy tags, PIT tags, radio tags and tissue sampling), and salvage and relocation. This evaluation also includes a review of the timing of fish salvage events and timing of snorkel surveys from this years and previous years snorkel surveys; and how those salvage events may or may not have influenced the annual population estimates (*i.e.,* present in the surveyed area).

Prior to evaluating the two Over-arching Hypotheses, the author reviewed the Teck Coal salvage database for events in 2017 and 2019. The purpose of this was to determine if fish salvage efforts over this time period had the potential to impact population estimates. Fish salvage data from the Decline Window were reviewed in relation to the dates of the snorkel survey and juvenile removal - depletion surveys. Identification of any temporal overlap would then be investigated further for any potential spatial overlap with population estimates. The causal pathway for fish salvage events to influence annual population estimates would be for a salvage event to precede the population survey (snorkel count or juvenile removal - depletion) and to have relocated salvaged fish into the population survey area.

The approach to evaluate Over-arching Hypothesis #1 was to review the Teck Coal fish salvage database for all events and life stages (fry, juvenile, adult) salvaged by year and location to evaluate the potential for fish salvages to represent a single acute/stochastic stressor or a single chronic stressor that could result in the observed population decline. This review will also be considered under the broader context of all fish handling within the upper Fording River (*i.e.,* salvages plus scientific studies and population monitoring). Electrofishing settings, timing and environmental conditions will be included in the assessment of potential mortality factors. The causal pathway for salvage events to represent a single acute or chronic stressor resulting in the observed population decline (*i.e.* 93% decline in mature fish) would be mortality (both immediate and latent) from capture methods, salvage efficiency (mortality of fish not salvaged), handling, transport, and relocation.

The approach to evaluate Over-arching Hypothesis #2 was to review the scale of fish handling within the upper Fording River generally, including; scientific and monitoring sampling, salvage, and relocation. The numbers of fish handled annually will be framed in terms of potential immediate and latent mortality by year (2012 - 2019). This evaluation would be placed in context with current population estimates during the same time period to evaluate the potential for fish handling within the upper Fording River as a chronic stressor, which individually may not account for reduced Westslope Cutthroat Trout numbers, but cumulatively may be contributing to the population decline.

2 OVER-ARCHING HYPOTHESES 1

2.1 Description of and Rationale for Impact Hypothesis

Prior to evaluating the two Over-arching Hypotheses, the author reviewed the Teck Coal salvage database for events in 2017 and 2019. The purpose of this was to determine if fish salvage efforts over this time period had the potential to impact population estimates. Fish salvage data from the Decline Window were reviewed in relation to the dates of the snorkel survey and juvenile removal - depletion surveys. Identification of any temporal overlap would then be investigated further for any potential spatial overlap with population estimates.

The causal pathway being investigated was for salvage events to precede the population survey (snorkel count or juvenile removal - depletion) and to have relocated salvaged fish into the population survey area. For example, were the high numbers of juveniles and adults enumerated within FRO river Segments S7, S8, S9, and S10 in 2017 a result of salvage relocations; resulting in inflated estimates in 2017 but not in 2019 (Cope 2017, 2019).

The approach to evaluate Over-arching Hypothesis #1 was to review the Teck Coal fish salvage database for events in 2017 and 2019 for life history stages, spatial extent, duration, location, timing and intensity that cumulatively could provide the requisite conditions and/or causal pathway to explain the observed decline in population estimates.

The causal pathway being investigated under this hypothesis was for salvage events (and associated mortality events) to represent a single acute or chronic stressor that could result in mortality across all life stages at a scale necessary to result in the observed population decline between 2017 and 2019 (*i.e.,* 93% decline in adults, 74% decline in juveniles).

2.2 Evaluation Methods

Teck Coal databases for 2017 and 2019 were reviewed for fish mortality events and fish salvage events including project timing, numbers of fish salvaged, and number of fish relocated; by life stage (fry, juveniles, adults) and release location. Where overlap was identified the potential to influence population estimates was investigated further.

2.3 Analysis

The following databases and reports provided by Teck Coal were reviewed:

- 2012 - 2019 Fish Salvage Summaries (Teck Coal 2019);
- 2017 Fish Salvage Summary Table (Teck Coal 2019);
- 2019 Fish Salvage Summary Table (Teck Coal 2019);
- 2017 Fish Relocation at Lake Mountain Creek Reaches 4 and 5 FRO (Vast 2017);
- Fish Relocation at Greenhills Primary Pond, Greenhills Creek Sediment Pond Spillway and Thompson Creek Primary Pond, Greenhills Creek Operations (Vast 2017);

- Fish Relocation at Greenhills Creek Sediment Pond Spillway Stilling Basin Greenhills Operations (Vast 2019); and
- FRO Fish Salvage and Relocation Report 2019 (Nupqu 2020).

2.4 Findings

There was concern that the timing of fish salvage events and the timing of snorkel surveys from this years and previous years snorkel surveys may have influenced the annual population estimates (*i.e.,* fish salvaged, relocated and present in the surveyed area). This concern regarding fish salvage influences on snorkel survey population estimates for mature fish (*i.e.,* fish greater than 200 mm fork length) was not validated by data review. A review of the timing of salvage events in 2017 and 2019 confirmed they were conducted after the snorkel survey was completed.

Secondly, neither the scale (*i.e.,* total numbers of salvaged fish in 2017, 2018 or 2019) nor the requisite life stages (*i.e.,* very low numbers of adults) were validated through review of the salvage databases (*i.e.,* Hypothesis #1). The review of the fish salvage database (Teck Coal 2019) did identify that a large number of Westslope Cutthroat Trout juveniles were being captured and relocated through electrofishing, seine netting, dip netting and baited traps for salvage and relocation.

In total, 9,585 Westslope Cutthroat Trout have been captured and relocated within the upper Fording River since 2012. (Figure 1). On average, 1,198 Westslope Cutthroat Trout were salvaged and relocated each year (2012 - 2019). Salvage numbers increased substantially in 2016, and 2018 stands out as a very high salvage year. On average, 2,119 Westslope Cutthroat Trout were salvaged and relocated each year since 2016 (2016 - 2019), compared to 277 fish annually prior to 2016 (2012 - 2015).

The scale of the fish salvages completed during the period 2012 to 2019 were not unprecedented. In 2004 and 2005, Clode Pond salvage operations collected and relocated 5,956 Westslope Cutthroat Trout (Interior Reforestation 2006). In 1978, an estimated 10,000 Westslope Cutthroat Trout were relocated from approximately 1,200 m of diverted river channel to accommodate the construction of the South Tailings Pond (Wood 1978).

Salvage operations almost exclusively recover juveniles less than 200 mm fork length and even if there was timing overlap would not influence the estimation of the mature population and it would not be possible to influence estimates to the degree noted in 2019 (*i.e.,* decrease of 93% for mature fish greater than 200 mm). For example, in 2019 salvage summaries (Nupqu 2020) there were 700 Westslope Cutthroat Trout salvaged from Smith Creek and 156 fish were measured. Only four fish (0.57%) were within the mature category (greater than 200 mm). There were 995 Westslope Cutthroat Trout salvaged from Swift Creek and 110 fish were measured. Zero fish (0.00%) were within the mature category (greater than 200 mm).

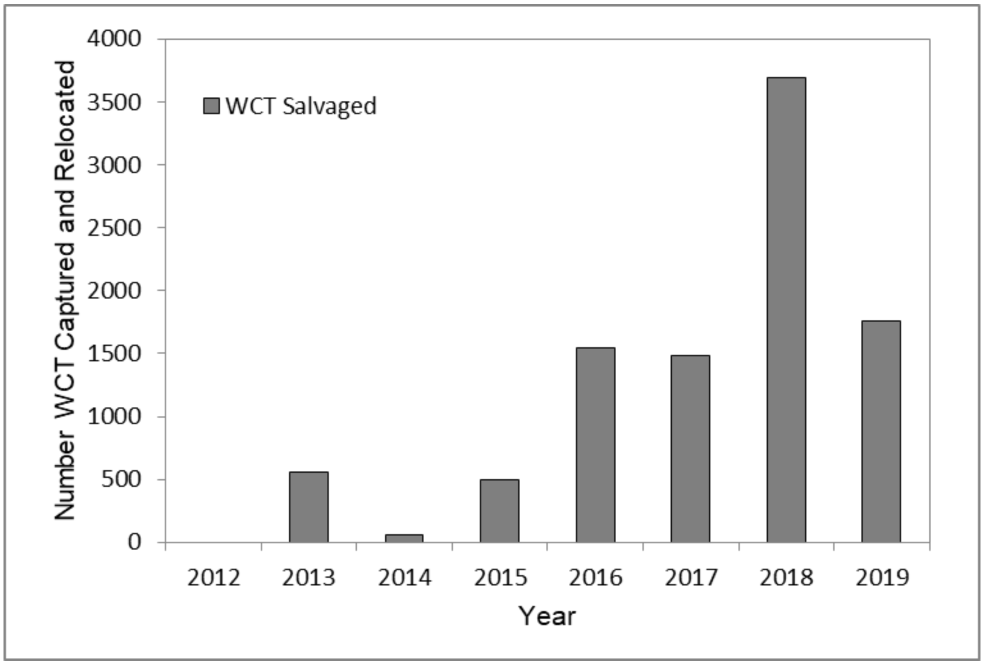

Figure 1. Numbers of Westslope Cutthroat Trout salvaged and relocated within upper Fording River (FRO), Greenhills Creek (GHO), and Dry Creek (LCO) Teck Coal Operations. Source data 2012 - 2019 Fish Salvage Summaries (Teck Coal 2019).

Fish salvage and relocation can induce mortality at various stages of the operation and are by no means a benign mitigation measure. Although the reported mortalities are very low; typically in the 0% to 3% range (Nupqu 2020, Hemmera 2019, Vast 2019, 2018, 2017a, 2017b, Lotic 2017, 2015), these mortalities represent immediate trauma due to capture or handling and do not account for:

- Mortality (acute and latent) due to environmental conditions, stress, and predation susceptibility that precipitated the salvage necessity;
- Salvage inefficiency (*i.e.,* less than 100% fish recovered);
- Relocation mortality; and
- Latent mortalities due to stress/trauma due to capture and handling (including PIT tagging).

Fish salvage operations typically involve dewatered habitats either naturally, due to operational impacts, or intentionally to improve capture success. The immediate mortalities of fish left stranded during dewatering of habitats remains largely unreported. Salvage efficiency depends on fish size and substrate composition; with mortality rates increasing with decreasing fish size and increasing substrate size. These effects are well documented within the hydro-electric ramping rate literature (Bradford *et al.* 1995). Fluvial fry and juvenile salmonids prefer gravel-cobble-boulder interstices and may move 15-30 cm below the substrate surface. These fish are not typically accessible to salvage technicians; especially in the turbid water reported during salvage operations (*i.e.,* NTU's reported typically increase to 50 - 75 NTU temporarily). As a result, mortalities due to the initial dewatering event and predation if unintentional or the mortalities due to salvage efficiencies of less than 100% remain largely unreported.

The vast majority of fish salvages collect mostly fry and juveniles from shallow, small tributary habitat with water quality challenges and relocate them into adjacent mainstem Fording River habitats (Nupqu 2020, Hemmera 2019). While this limits handling and holding stress and is recognized as the preferred approach for these reasons; there is a trade-off. Additional mortality can be induced during relocation if site selection does not account for life- stage habitat requirements, differences in water temperature, predation and handling stress. The species literature and habitat utilization within the upper Fording River watershed document fry and juveniles prefer tributary habitats. These habitats are limited and ongoing efforts to exclude them from these habitats have failed over many years (*i.e.,* at least 15 years in Clode Ponds). Presumably these fry and juveniles are selecting these habitats for fitness advantages and relocating them into disparate habitats likely has some negative consequence that is not being documented. These mortalities are not immediately evident at the time of release and remain unreported.

A key assumption to employing electrofishing and handling protocols is that the capture method is relatively benign and captured fish have similar fates and behavior relative to conspecifics. It is well documented that electrofishing is not entirely benign and can result in physiological stress (elevated stress hormone levels, cardiac arrest and erratic heart function), injuries (hemorrhagic trauma, spinal compressions, misalignments and fractures) and sampled or tagged fish are more likely to suffer short and long term adverse effects to their behavior, health, growth, or reproduction (Panek and Densmore 2011, Schreer *et al.* 2004, Snyder 2003, Nielsen 1998, Dalbey *et al.* 1996, Hollender and Carline 1994).

Many concerned biologists believe they have learned to use electrofishing techniques for efficient sampling with good recovery and negligible injury or mortality. However, sub-lethal effects are not always externally evident in electrofished populations, and biologists appear to greatly under-estimate spinal injuries from external examinations alone (Nielsen 1998). For example, Dalbey *et al.* (1996) reported only 2% of the captive wild rainbow trout they surveyed had externally visible deformities, but X-ray analysis after nearly one year in captivity indicated 37% of the population had actually been injured. This reflects an extreme example using boat electrofishing of adult fish at high voltages to test configurations and external evidence of injury.

Injury rates can be reduced through electrofishing configuration and targeting smaller fish. Hollender and Carline (1994) examined the effects of Direct Current (DC) backpack electrofishing in small streams. They electrofished and examined (X-rays and autopsies) 579 Brook Trout ranging in length from 95 to 237 mm total length. On average, 22% of fish had hemorrhages and spinal injuries. Schreer *et al.* (2004) provide results more in line with current day practices and expectations (this author`s opinion). They examined various pulsed DC voltage, frequency, pulse width and shock duration settings on Rainbow Trout and monitored behavioral recovery times and internal hemorrhaging. Internal injury ranged from 0 to 7 cm^2 of hemorrhaging along the spine and surrounding musculature, although only 4% of the fish had corresponding damage to the vertebrae. They also documented cardiac arrest, erratic heart function and increased cardiac output and stroke volume and although behavioral recovery typically took only a few minutes (*i.e.,* regain equilibrium and begin swimming normally), cardiac function took 2 to 3 hours to return to resting levels. Regardless of electroshocker settings, electrofishing has considerable negative physiological and behavioral impact on trout that is not apparent externally. These latent effects remain unreported.

In total, 498 salvaged fish representing 5.9% of the catch were implanted with PIT tags between 2016 and 2019 (note there was no PIT tagging of salvaged fish prior to 2016). Since it is well known that the capture method, tagging methods, tag placement and the experience of the technician or biologist applying tags influence both tag retention and fish survival (Mamer and Meyer 2016, Cook *et al.* 2014, Panek and Densmore 2011), it is critical to employ experienced personnel employing best practices. This is especially critical for smaller fish (*i.e.,* less than 250 mm) where PIT tagging requires a laparotomy to insert tags intraperitoneally (*i.e.,* in the body cavity). The experience of the technician or biologist applying tags is not reported in the databases provided and these effects remain unreported.

Various baited trapping techniques of one form or another (*i.e.,* fyke or minnow traps) are ineffective for this species representing 2% of captures, despite extensive effort. Given the demonstrated failure of baited trapping methods for the species in question they are not a valid alternative sampling method and are not discussed further. Gillnetting (1%) was a single unique sample in the Greenhills Settling Pond and is not discussed further. The vast majority of salvaged fish are captured through electrofishing.

2.4.1 Requisite Conditions and Uncertainties

The requisite conditions do not exist temporally, spatially, or for all life stages to the extent documented in the 2019 monitoring report (Cope 2019), and the hypothesis that the timing of fish salvage events and the timing of snorkel surveys from this years and previous years snorkel surveys may have influenced the annual population estimates is rejected.

In addition, based on the salvage databases provided there was a high degree of certainty in the data that it was not possible for salvage operations during the Decline Window to represent the primary or acute influence on annual population estimates to the degree observed.

2.4.2 Concluding Summary and Strength of Evidence

There was strong evidence that the requisite conditions (*i.e.,* timing, spatial extent, mature life history stages) were not present or not at a scale that is explanatory for the Westslope Cutthroat Trout population decline. Uncertainty is low and this conclusion is unlikely to change; unless there is data that was unaccounted for in regards to salvage events or mortality events on a large scale specific to the adult life stages.

2.6 Other Relevant Observations & Findings

There was some very minor overlap between Greenhills Creek juvenile population monitoring and salvage events in 2019. On June 16 and July 20 2019 a total of 20 Westslope Cutthroat Trout were relocated from water treatment infrastructure downstream into the population enumeration reach. This overlap was not at a scale that is explanatory for the Westslope Cutthroat Trout population decline in 2019.

The causal factor investigation has also been tasked with a review of electrofishing impacts including fish salvage, fish relocation, fish handling and tagging and their potential impact as a stressor and cumulative impact to population productivity (*i.e.,* Over-arching Hypothesis #2 cumulative impacts). The following Section 3 provides the evaluation for the cumulative impacts hypothesis and the larger dataset for all Scientific Fish Collection Permit data submissions for the period 2012 - 2019. Ongoing salvage and scientific fish sampling that employ electrofishing at the scale documented for fish salvage may have the potential to represent a stressor within a cumulative impact framework.

The effectiveness of electrofishing is affected by several factors including water temperature, conductivity and electrofisher settings (voltage, pulse width, pulse rate). There are discrepancies within the Teck Coal (2018) fish salvage guidance document and with salmonid guidelines for electrofishing mitigation regarding water temperature. In the Teck Coal guidance document in Appendix 2 the values for optimal water temperatures for fish salvage operations is listed as 5 - 15 degrees Celsius. The accompanying text on best practices applicable specifically to fish salvage operations identifies optimal water temperatures as between 5 - 18 degrees Celsius. Specific to salmonid guidelines for mitigation of electrofishing impacts, the National Marine Fisheries Service (NMFS) uses 14 degrees Celsius as the upper water temperature limit (NMFS 2000). Westslope Cutthroat Trout are a cold water species and the lower maximum temperature specific to salmonids and electrofishing effects should be incorporated into the salvage guidance document as a precautionary mitigative measure.

This review of electrofishing impacts does not include a review of conductivity and electrofishing settings as these parameters were not included in the salvage database provided. In addition, not all contractors fill in electrofisher settings. These fields are optional in the mandatory British Columbia Scientific Fish Collection Permit Fish Data Submission. A scan of electrofishing settings within the individual Scientific Fish Collection Permit Fish Data Submissions identified consistency in settings among sampling crews. It was also noted that sampling crews typically utilize settings designed to mitigate electrofishing injury (*i.e.,* settings that limit injury rather than settings that maximize capture efficiency).

Nevertheless, reporting of water temperature, conductivity, electrofishing settings and operator experience should be mandatory for all Teck Coal salvage and scientific collection activities. Similarly, any invasive sampling (tissue sampling) or tagging (PIT, Floy, Radio) should include identification of field crew handling experience specific to working with threatened or endangered populations and minimizing handling stress and the sample or tagging method employed. The electrofisher settings and the skill of the electrofishing team and the skill of the fish handling personnel influence fish injury rates.

3 OVER-ARCHING HYPOTHESIS 2

3.1 Description of and Rationale for Impact Hypothesis

To evaluate the potential cumulative impacts due to fish handling generally, including scientific sampling (Floy Tags, PIT tags, tissue sampling, electrofishing, angling) in addition to salvage, and relocation and their potential to contribute to the population decline as one of a number of stressors (*i.e.,* cumulative effects, Over-arching Hypothesis #2), the approach was to review the broader database for all Teck Coal Scientific Fish Collection Permits from 2012 through 2019; rather than just fish salvage data submissions.

The causal pathway being investigated under this hypothesis was if the cumulative fish handling through all monitoring, scientific studies and salvages represented a large enough scale of immediate and/or latent mortality that could contribute to reduced population productivity and contribute to the observed population decline through a cumulative effects framework.

Depletion sampling in combination with multiple-pass electrofishing is an important fisheries management tool for wadeable streams. This combination of techniques has been used routinely for several decades as a reliable means to obtain quantitative data on trout populations as well as a fish salvage technique. But electrofishing can be highly stressful to fish and injury and mortality can be high under certain conditions. Electrofisher settings, water temperature and conductivity as well as the experience of the crew in regards to electrofishing, fish handling and tagging-sampling can influence fish behavior and survival.

The scientific community is in agreement regarding the effects of electrofishing on individuals but remains divided regarding population level effects of incidental mortalities on individuals sampled within a small proportion of the total available habitat.

3.2 Evaluation Methods

All Teck Coal Scientific Fish Collection Permit and Fish Salvage data submissions from 2012 through 2019 were compiled and reviewed by sample method (*i.e.,* Electrofishing, Angling, Seine Netting, Baited Traps) and fish handling protocols (none, length and weight only, Floy tags, PIT tags, radio tags, tissue sampling, salvage and relocation). Review included project timing, water temperatures, conductivity, numbers of fish salvaged and relocated, and reported mortalities (*i.e.,* immediate); by life stage (juveniles, adults) and location.

3.3 Analysis

The following databases and reports provided by Teck Coal were reviewed and summarized as noted above:

- 2012 - 2019 Fish Salvage Summaries (Teck Coal 2019);
- 2012 - 2019 Scientific Fish Collection Permit Data submission summaries (Teck Coal 2020);
- 2017 Fish Salvage Summary Table (Teck Coal 2019);
- 2019 Fish Salvage Summary Table (Teck Coal 2019);

- 2017 Fish Relocation at Lake Mountain Creek Reaches 4 and 5 FRO (Vast 2017);
- Fish Relocation at Greenhills Primary Pond, Greenhills Creek Sediment Pond Spillway and Thompson Creek Primary Pond, Greenhills Creek Operations (Vast 2017);
- Fish Relocation at Greenhills Creek Sediment Pond Spillway Stilling Basin Greenhills Operations (Vast 2019); and
- FRO Fish Salvage and Relocation Report 2019 (Nupqu 2020).

In addition, an evaluation of stressors was completed (and their potential mortality rates) related to fish handling generally including; salvage and relocation, scientific fish collection, associated sampling and handling (Electrofishing, Angling, PIT Tagging, Floy Tagging, Radio Tagging and tissue sampling). The application of potential mortality rates to fish collection totals can be used to provide unvalidated estimates of mortalities. A Qualitative Scenario Analysis (*i.e.,* a simple, coarse scale, unvalidated model) was used to estimate the total number of Westslope Cutthroat Trout juveniles and adults within the upper Fording River. The Qualitative Scenario Analysis relies on very coarse and subjective habitat availability estimates and suspect population extrapolations to place the estimated handling mortalities in context of possible population level effects. These results should be viewed judiciously.

3.4 Findings

The review of the fish salvage database identified a substantial number of Westslope Cutthroat Trout juveniles are being captured, handled and relocated annually within the upper Fording River. Salvages accounted for 9,585 Westslope Cutthroat Trout that were captured and relocated (Figure 1). As outlined in the previous section, reported mortalities (immediate mortalities evident during capture and handling) were very low; in the range of 0% to 3%. There are however, additional mortalities related to salvage methods that remain unreported. These include; salvage inefficiency (less than 100% of fish recovered and removed), latent mortalities due to capture and handling stress or trauma, latent mortalities due to additional PIT tagging stress and or trauma, and removing juveniles from habitats selected for fitness advantages and relocating them into disparate habitats in a stressed condition. Salvage numbers increased substantially in 2016. On average, 2,119 fish were salvaged each year from 2016 to 2019 compared to 277 fish on average each year from 2012 to 2015; however, the 2016 - 2019 levels of salvage effort are not unprecedented within the history of mining operations within the upper Fording River (Interior Reforestation 2006, Wood 1978).

In order to fully quantify the potential cumulative effect of all fish captures, handling and tagging, all Scientific Fish Collection Permits related to Westslope Cutthroat Trout studies and monitoring were compiled; in addition to the salvage captures. Figure 2 illustrates these scientific captures totaling 4,125 Westslope Cutthroat Trout. Scientific fish capture and handling averaged 515 fish per year since 2012. This represents less than 50% of the annual salvage impact (1,198 fish per year on average). Figure 3 illustrates the 4,125 captures by sample method. Capture methods were dominated by electrofishing (77%) that most often targeted juveniles and/or small body form tributary fish. Angling (20%) targeted larger adults and all Radio tags, Floy Tags, and most tissue samples were collected from angled fish. Angling was specifically selected to eliminate electrofishing impacts either physiologically or behaviorally for these fish undergoing more invasive sampling. Baited traps of one form or another are ineffective for this species (2%) and Gillnetting (1%) was a single unique sample in the Greenhills Settling Pond.

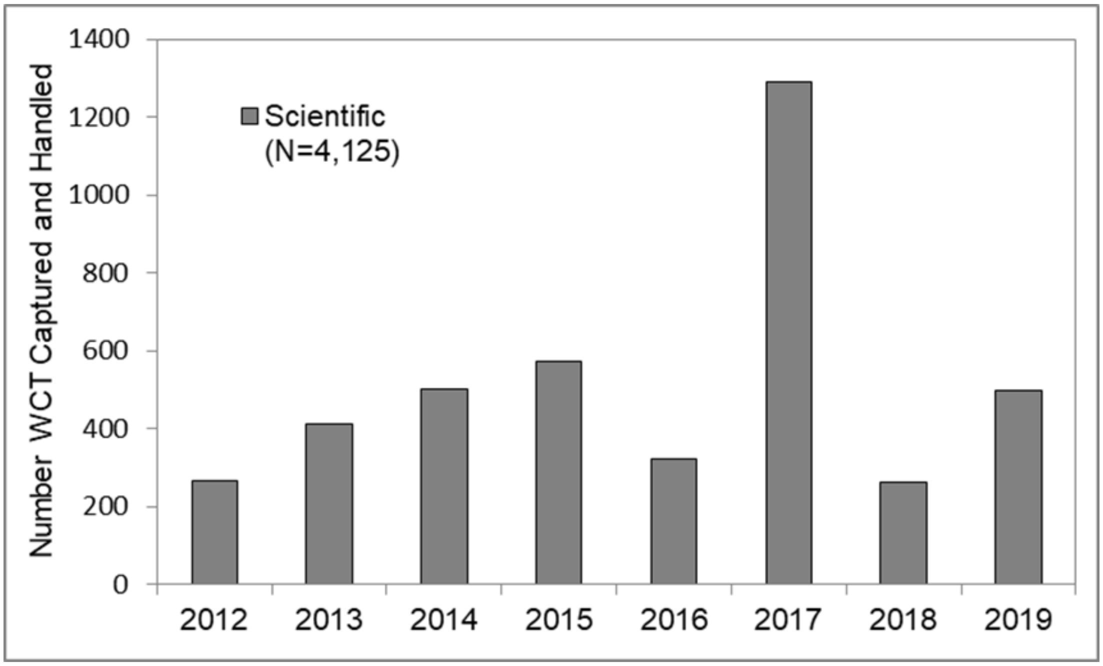

Figure 2. Numbers of Westslope Cutthroat Trout captured and handled for scientific and/or monitoring purposes within the upper Fording River 2012 - 2019. Source data 2012 - 2019 Scientific Fish Collection Permit Mandatory Fish Data Submissions.

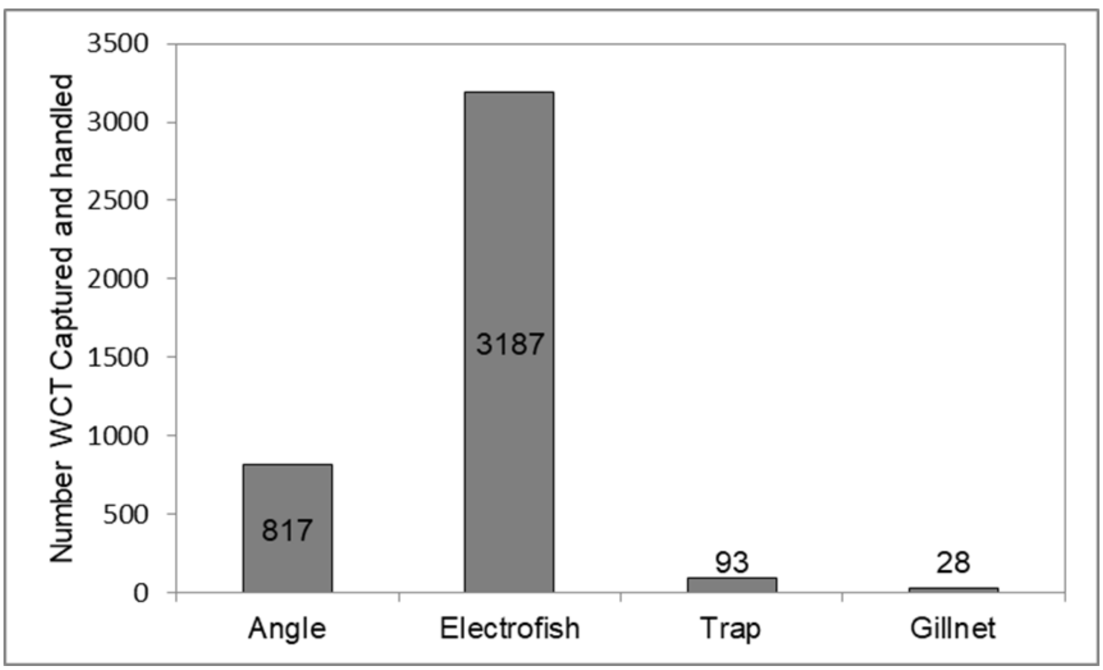

Figure 3. Numbers of Westslope Cutthroat Trout by capture method within the upper Fording River 2012 - 2019. Source data 2012 - 2019 Scientific Fish Collection Permit Mandatory Fish Data Submissions.

Since 2012, in terms of the more invasive scientific handling methods, a total of 1,892 Westslope Cutthroat Trout or 46% of fish captured for scientific reasons were either; PIT tagged (N=917 or 22%), Floy tagged (N=495 or 12%), sampled for DNA (N=218 or 5%), radio tagged (N=181 or 4%), or tissue sampled (N=81 or 2%).

In total, 13,710 Westslope Cutthroat Trout have been captured and handled in one form or another since 2012. (Figure 4). This represents a total cumulative impact of 1,714 Westslope Cutthroat Trout captured and handled every year from 2012 through 2019 (predominantly juveniles). Probably more importantly, from 2012 through 2015 the average annual capture and handling was 715 fish and from 2016 to 2019 this increased 379% to 2,712 fish per year (*i.e.,* almost 4 fold increase).

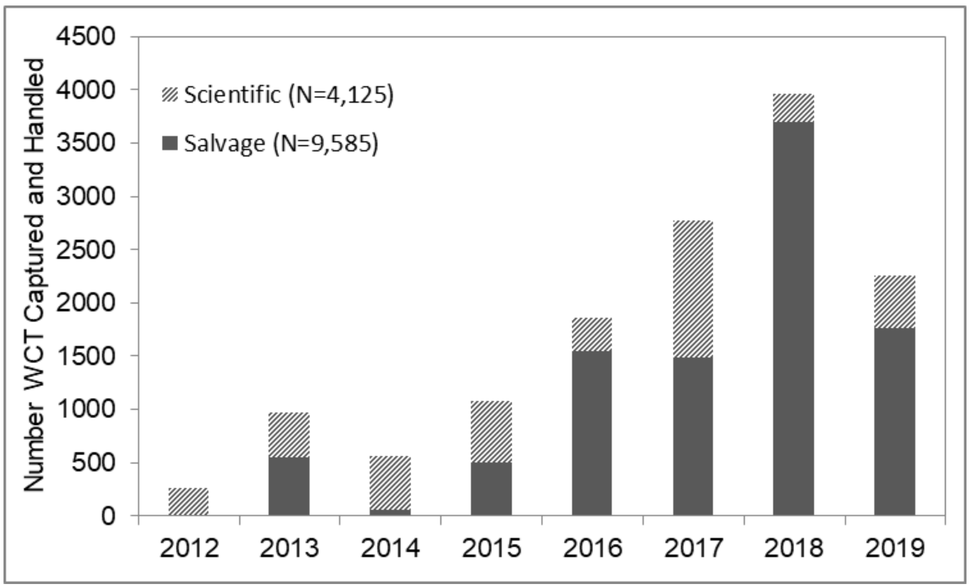

Figure 4. Total numbers of Westslope Cutthroat Trout captured and handled within the upper Fording River watershed through both salvage and scientific collection purposes.

Angling is employed when targeting adults to mitigate electrofishing impacts in scientific studies but the predominant capture method for both salvage operations and scientific study employ backpack electrofishing. Backpack electrofishing for salmonids has been a principal sampling technique for decades, however, numerous publications on injury, mortality, stress and growth effects have brought into question the use of this technology for scientific study of threatened or endangered populations (Nielsen 1998). As noted in the previous section, many concerned biologists believe they have learned to use electrofishing techniques for efficient sampling with good recovery and negligible injury or mortality. However, sub-lethal effects are not always externally evident in electrofished populations, and biologists appear to greatly under-estimate spinal injuries from external examinations alone (Nielsen 1998). The National Marine Fisheries Service (NMFS) in the United States believes there is ample evidence that electrofishing can cause serious harm to fish and the general agency position is to not necessarily preclude the method but to encourage researchers to seek out less invasive ways to sample fish listed under the Endangered Species Act; or if necessary to ensure that adequate safeguards are in place to protect threatened or endangered salmonids (NMFS 2000).

On the other hand, there is a lack of long-term mortality studies demonstrating differences in survival between electrofished and control samples and when the small fraction of the entire population sampled, and the even smaller fraction harmed, are considered in the context of the entire stream population, the influence of electrofishing induced injury in a few habitats becomes insignificant when compared to natural mortality (Schill and Beland 1995). Some biologists have noted most minor or moderately injured fish usually survive and appear to behave normally (Snyder 1995). As such there still remains a need for studies of the effects of long-term electrofishing injury at the population level.

While there is no doubt that electrofishing and capture (mark) - recapture methods have served many positive purposes in the fisheries community over the last 80 years, it presents the research and conservation communities with a difficult dilemma. Some accurate and consistent quantitative measure of population abundance is needed but the most effective tool in common use on fishes may reduce the fitness and reproductive success of a small number of individuals and could impact rare or endangered populations at low abundance levels (Nielson 1998). To date, no consensus has been reached within the scientific community on a methodology that will provide the relatively accurate abundance estimates often required with negligible risk to increased injury, predation or mortality.

In order to place these handling numbers in context it is necessary to estimate the total population abundance. This can be done in a qualitative way using a combination of; (1) the total estimated adult abundance for 84% of the available habitat, plus (2) the estimated density of juvenile fish extrapolated over the available habitat.

The adult abundance estimate is a fairly robust representation of the total adult population given that it enumerates such a large proportion of the available adult habitat (84%); and is based on quantitative assessment of observer efficiency through mark-recapture and radio telemetry (Schwarz *et al.* 2013). The extrapolation of the juvenile densities from a small fraction of habitat is more problematic, and essential given this life stage represents the majority of the salvage and relocation fish and as such, also has the highest potential for latent or under-reported mortality effects.

The author has resisted such a Qualitative Scenario Analysis or simple modelling exercise to estimate juvenile population abundance due to the uncertainties and biases associated with such a model. First, only 0.75% of the estimated available habitat was used to estimate juvenile densities. The potential for low sample size bias to introduce error is very likely and should prohibit such an extrapolation. Secondly, the juvenile densities are dominated by sites selected to accommodate the methods (less than 1.5 m deep) and to represent juvenile rearing habitat. This would no doubt inflate watershed extrapolations and should prohibit such an extrapolation except for informative purposes to illustrate a range of scenarios; not population estimates.

A modelling exercise could be employed calculating the available habitat for representative watershed strata (*i.e.,* lower, mid-, upper mainstem, lower and upper tributary) and expanding the mean density for a given strata over the estimated area (wetted width x stream length). However, this also requires professional judgment in assigning a correction for weighted usable area for the life stages in question (*i.e.,* subjective habitat value opinion). Such "guestimates" must be viewed with caution given their propensity for observer variation.

Nevertheless, there was a high degree of certainty the requisite conditions do exist to contribute to mortalities at the individual level and the scale of total captures has the potential to contribute to reduced population productivity. There was a high degree of uncertainty in the population level impacts due to difficulties in estimating total habitat availability by life stage, high variation in juvenile population abundance, and uncertainties in latent mortality rates. The following scenario analysis illustrate these uncertainties and the likelihood that the current (2016-19) scale of captures and handling may contribute to a cumulative impact.

Table 1 summarizes the habitat availability calculated using low level aerial photography (Cope *et al.* 2016). These same watershed strata are used for population monitoring comparisons (Cope *et al.* 2016, Cope 2017, 2019). Table 1 also summarizes the creek habitat availability calculated for illustrative purposes noting the uncertainty these contain having used surrogate information. In total, 787,424 m^2 of stream habitat availability was estimated from September 2012 wetted widths and surrogate data for creeks. Note that the highest juvenile densities and the bulk of the fish salvages occur in the following strata; mainstem-upper or headwaters above FRO, the mainstem-mid or onsite FRO and the lower tributary reaches below fish passage barriers. These strata represent 190,702 m^2 or 24% of the total available habitat estimate.

Table 1. Westslope Cutthroat Trout habitat availability estimate including the creek summary for illustrative purposes. Habitat estimates derived from Table 3.26 and Table 3.29 Cope *et al.* 2016. For null values (canopy cover) electrofishing site wetted widths were considered representative and used with stream length to an upstream limit of approximately 20% gradient.

Watershed Strata	Area m^2
Main-Lower	462,082
Main=Mid	122,511
Main-upper	41,272
Trib-lower	26,919
Trib-upper	134,639
Totals	787,424

Creek	Sample Strata	Area m^2
Henretta	lower	6,350
	upper	52,394
Fish pond	lower	12,715
Clode		150
Lake Mtn	Lower	0
Kilmarnock		0
Swift		125
Cataract		0
Chauncey	lower	3,055
	upper	18,444
Ewin	lower	0
	upper	24,262
Dry	lower	3,349
	upper	15,589
Greenhills	lower	1,175
	upper	23,950

Note - null values (canopy cover) used EF site wetted widths and estimated stream length to calculate area estimate.
Note - mainstem upper distribution used was river kilometer 72 (of 78 total to headwaters).
Note - tributaries include mainstem only. Except Fish Pond unnamed tributary.
Note - most upper tributary habitat represents isolated or fragmented populations.
Note - lower Ewin densities were zero. This reach was included in the upper tributary low density area.

Table 2 illustrates a range of fry and juvenile density estimates and their respective population abundance extrapolations for a low density year (12,335 in 2019) and a high density year (94,901 in 2017). A range of nearly 800% of the lower estimate is not very informative or helpful. This is primarily due to fry densities, which are known to be highly variable within the species literature and the upper Fording River is no exception.

Table 2. Extrapolation of fry and juvenile fish density estimates combined across coarse scale watershed strata and estimation of total upper Fording River Westslope Cutthroat Trout abundance.

Watershed Strata	Area m^2	Fry/Juv low density 2019	Fry/Juv High density 2017	Low juv Popn Est(2019)	High Juv Popn Est(2017)	Low Adult Popn Est (2019)	High Adult Popn Est (2017)
Main-Lowe	462,082	1.05	12.35	4,852	57,067		
Main=Mid	122,511	2.21	12.96	2,708	15,877		
Main-uppe	41,272	2.67	16.47	1,102	6,797		
Trib-lower	26,919	9.85	31.80	2,652	8,560		
Trib-upper	134,639	0.45	2.16	606	2,908		
Totals	787,424			11,919	91,211	416	3690
		Fry, Juvenile and Adult Life Stages combined				**12,335**	**94,901**

Juvenile population extrapolations were recalculated without the fry densities to provide a more precise estimate. Table 3 illustrates the range of juvenile density estimates and their respective population estimates for a low density year (12,335 in 2019) and a high density year (26,924 in 2017).

Table 3. Extrapolation of juvenile fish density estimates across coarse scale watershed strata and estimation of total upper Fording River Westslope Cutthroat Trout abundance (excluding fry or young-of-year).

Watershed Strata	Area m^2	Juv low density 2019	Juv High density 2017	Low juv Popn Est(2019)	High Juv Popn Est(2017)	Low Adult Popn Est (2019)	High Adult Popn Est (2017)
Main-Lower	462,082	1.05	0.52	4,852	2,403		
Main=Mid	122,511	2.21	4.32	2,708	5,292		
Main-upper	41,272	2.67	16.47	1,102	6,797		
Trib-lower	26,919	9.85	23.12	2,652	6,224		
Trib-upper	134,639	0.45	1.87	606	2,518		
Totals	787,424			11,919	23,234	416	3690
		Juvenile and Adult Life Stages combined				**12,335**	**26,924**

While we have calculated a population estimate, it assumes 100% of the wetted habitat is juvenile habitat and this is not true. A subjective correction was applied using the mean habitat suitability index for each strata. A habitat suitability rating (*i.e.,* % available habitat) is assigned for each life stage noted on the habitat survey forms by the survey biologist at the time of survey. Table 4 updates the population extrapolations in the previous table by applying this subjective habitat suitability index for the juvenile life stage. This provides a population estimate range of juvenile and adult Westslope Cutthroat Trout within the upper Fording River for a low density year (7,727 in 2019) and a high density year (20,562 in 2017).

Table 4. Extrapolation of juvenile fish density estimates including application of a subjective habitat suitability index (*i.e.,* % available habitat) across coarse scale watershed strata and estimation of total upper Fording River Westslope Cutthroat Trout abundance (excluding fry or young-of-year).

Watershed Strata	Area m^2	Juv low density 2019	Juv High density 2017	Low Juv Popn Est(2019)	High Juv Popn Est(2017)	S.I.= Juvenile Habitat Suitability	S.I.* Low Juv Popn Est(2019)	S.I.* High Juv Popn Est(2017)	Low Adult Popn Est (2019)	High Adult Popn Est (2017)
Main-Lower	462,082	1.05	0.52	4,852	2,403	0.41	1,989	985		
Main=Mid	122,511	2.21	4.32	2,708	5,292	0.70	1,895	3,705		
Main-upper	41,272	2.67	16.47	1,102	6,797	0.78	860	5,302		
Trib-lower	26,919	9.85	23.12	2,652	6,224	0.79	2,095	4,917		
Trib-upper	134,639	0.45	1.87	606	2,518	0.78	473	1,964		
Totals	787,424			11,919	23,234		7,311	16,872	416	3690
								Juvenile and Adult Life Stages combined	**12,335**	**26,924**
								This assumes 100% habitat is juvenile habitat		
								Juvenile and Adult Life Stages combined	**7,727**	**20,562**
								This applied the mean habitat suitability index for juv in each strata*		

Table 5 illustrates the mortality assumptions used to estimate potential capture and handling mortalities including latent or under-reported mortalities. Based on these estimates, some proportion of the population are captured (*i.e.,* 2,712 fish annually 2016 - 2019) and exposed to potential mortalities of between 7% and 27%. A 7% mortality rate is a reasonable estimate based on literature values for; (1) 5% mortality (immediate and latent combined) for an experienced fly fisher and handler using barbless, artificial flies, plus (2) a 2% mortality rate (immediate and latent combined) for Floy, PIT, Radio tagging or tissue sampling for an experienced behavioural tagging specialist. The 7% estimated mortality could be higher depending on the capture technique and experience of either the angler or the biologist conducting the sampling. Similarly, the 27% mortality rate was considered a reasonable estimate based on assuming the following; (1) 90% salvage efficiency, (2) 10% latent relocation mortality, (3) 5% latent electrofishing and handling mortality, and (4) 2% immediate handling mortality.

Table 5. Mortality estimates used to estimate potential capture and handling mortality including latent or under-reported mortality factors.

Mortality Factors	%
Immediate handling	2
Latent EF and Handling	5
Salvage inefficiency	10
Latent tissue, PIT, Floy radio tag	5
Latent relocation	10
Salvage combined	27
Scientific combined	12
Scientific Angle (incl. tag)	7

The potential population effect of these assumed mortalities is illustrated in Table 6. Estimated losses from scientific sampling are much lower than those from salvage operations. This was due to the higher numbers salvaged versus scientific sampling and the much higher mortality estimates for salvages. Based on habitat availability and population abundance scenarios provided above, between 8% and 51% of the total population may be captured and handled in some manner, exposing them to potential mortalities of between 7% and 27% in a given year; depending on capture and handling methods. This results in annual mortality estimates or scenarios (juveniles and adults combined) that range from a low of 130 fish annually (*i.e.,* low handling year = 2016 - 1,861 fish handled at a 7% mortality estimate) to a high of 1,069 fish annually (*i.e.,* high handling year - 2018 = 3,959 fish handled at 27% mortality estimate. These mortality estimates would represent between 0.6% of the population (low mortality and high population abundance estimates) and 13.8% of the population (high mortality and low population abundance estimates). Note that the high estimates of population handling (i.e., 51% above) invoke the high fish handling years of the past on the current low population estimate. This provides an example of the potential impact of past levels of handling on the lower current population estimates.

Table 6. Population abundance scenarios illustrating a range of captures and the proportion of the population sampled to illustrate the potential for a population level effect.

Year	Juv and Adult Popn Est.	Salvage apture 2018 (Max)	Salvage Captures 2016-2019 (Avg)	Salvage Captures 2016 (low)	Scientific Captures 2017 (Max)	Scientific Captures 2016-2019 (Avg)	Scientific Captures 2016 (low)	Combined Captures 2018 (Max)	Combined Captures 2016-2019 (Avg)	Combined Captures 2016 (low)
2019	12,335	3,696	2,119	1,861	1,291	594	263	3,959	2,713	1,861
% Popn		30	17	15	10	5	2	**32**	22	**15**
2019*S.I.	7,727	3,696	2,119	1,861	1,291	594	263	3,959	2,713	1,861
% Popn		48	27	24	17	8	3	**51**	35	**24**
2017	26,924	3,696	2,119	1,861	1,291	594	263	3,959	2,713	1,861
% Popn		14	8	7	5	2	1	**15**	10	**7**
2017*S.I.	20,562	3,696	2,119	1,861	1,291	594	263	3,959	2,713	1,861
% Popn		18	10	9	6	3	1	**19**	13	**9**

While it is possible to pursue refinements to the coarse estimates of habitat availability, and to some degree habitat suitability and mortality, the scenario modelling does not inform well because:

- The low juvenile sample proportion (0.75% available habitat) and inherent electrofishing sample biases;
- Subjective habitat assessments (habitat suitability);
- High variation/range in population estimates or densities; and
- Wide range in mortality consequences depending on salvage or scientific collection methods that are problematic to estimate due to latent mortalities that are difficult to determine and report.

Figure 5 illustrates the long-term effect of current capture and handling levels on one large mature Westslope Cutthroat Trout within the upper Fording River; and this does not include potential salvage and relocation captures that could not be detected before 2016. The cumulative lifetime mortality risk should be considered in evaluating possible capture and handling impacts. This Westslope Cutthroat Trout has a 7 year capture - recapture history confirming it is at least 10 or 11 years old. This fish was captured and tagged or tissue sampled three times over a 7 year period. Assuming a conservative 5 - 7% mortality rate per capture and handling event results in a 15 - 21% lifetime mortality risk. A 5% mortality rate is a reasonable estimate based on literature values for an experienced fly fisher and handler using barbless, artificial flies and could be much higher depending on the capture technique and experience of the angler-handler.

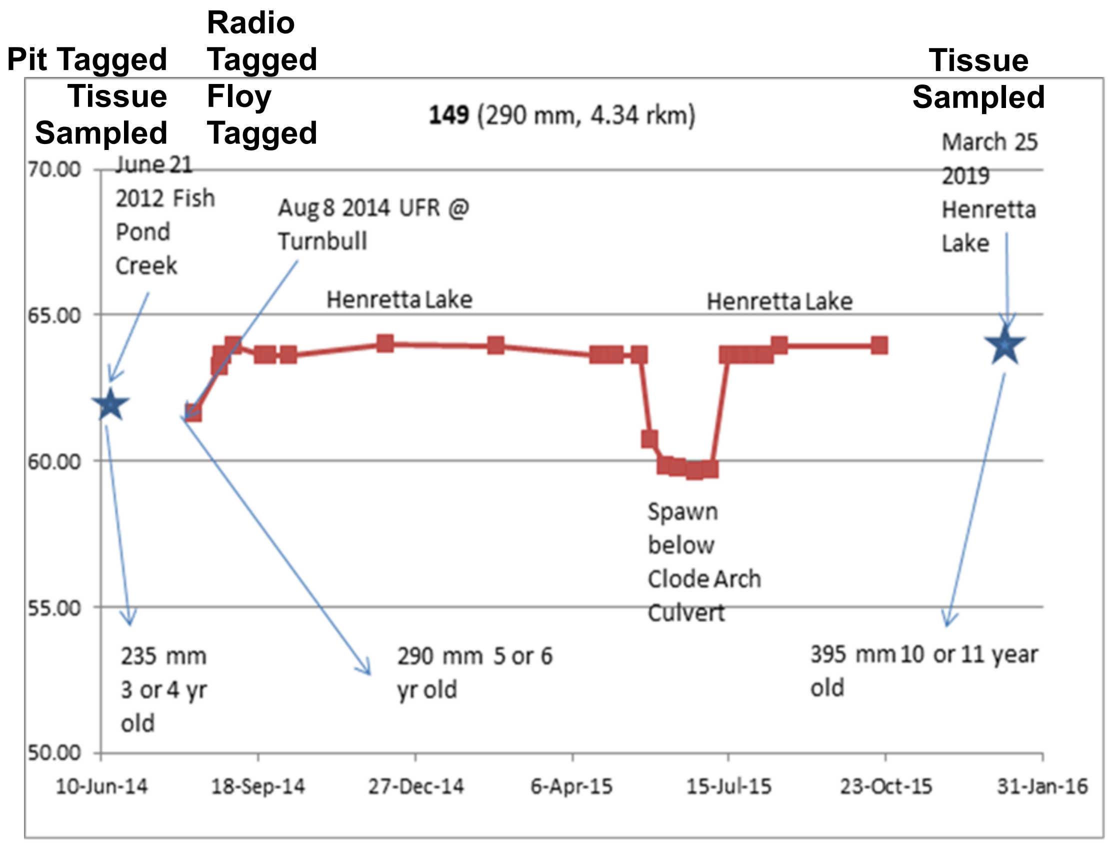

Figure 5. Westslope Cutthroat Trout illustrating 7 year capture-recapture history confirming at least 10 or 11 years old including three capture and tagging or tissue sampling events. Lifetime mortality risk should be considered in evaluating capture and handling effects on population.

3.4.1 Requisite Conditions and Uncertainties

There was a high degree of certainty that it was not possible for fish capture and handling in general to represent the primary or acute influence on annual population estimates to the degree observed within the Decline Window (Cope 2019).

There was a high degree of certainty the requisite conditions do exist to contribute to mortalities at the individual level and the scale likely contributes to reduced population productivity.

There was a high degree of uncertainty in the population level impacts due to difficulties in estimating total habitat availability by life stages, juvenile population abundance, and uncertainties in latent mortality rates.

3.4.2 Concluding Summary and Strength of Evidence

There is evidence that the requisite conditions (*i.e.,* timing, spatial extent, mature life history stages) were not present or not at a scale that is explanatory for the Westslope Cutthroat Trout population decline; due to capture and handling alone. However, it is likely that the scale of sampling and handling exerted on the upper Fording River population of Westslope Cutthroat Trout does have some negative component (*i.e.,* mortality) that is limiting population productivity and may have contributed to the observed population decline. The scale of capture and handling represents an intensively managed population and the concern that the population is, "being studied to death", has merit. Some quantitative population monitoring data is essential; however, all salvage and scientific studies should be reviewed and prioritized to mitigate potential impacts. At least until the population has recovered to previous levels.

The recent scale of captures (2,713 Westslope Cutthroat Trout annually 2016-2019) are likely to have some incremental cumulative effect due to incidental and latent mortalities that are under-reported; especially salvaged fish. Salvage operations dominate both the captures (2,119 Westslope Cutthroat Trout annually 2016-2019) and the higher mortality estimates (27%).

At the higher sample years (*i.e.,* 2018 – 3,959 captures), assuming higher mortality scenarios (*i.e.,* 27%) and lower population abundance (7,727 juvenile and adult fish) there are likely to be significant population level effects contributing to cumulative effects. At the opposite extreme, (*i.e.,* low handling year = 2016 - 1,861 fish handled at the lower 7% mortality estimate and a high population abundance of 20,562), the potential mortality effect is negligible (*i.e.,* 0.6% population mortality).

Reliance on salvage operations has increased significantly in recent years (2016 – 2019) and needs to be curtailed. This includes permanent fish exclusions constructed or source issues addressed (water quality or quantity).

3.5 Preliminary Evaluation of Cause

Given the scale (*i.e.,* thousands of fish captured and handled annually), the potential for fish handling generally as a stressor and cumulative impact to population productivity is plausible. Ongoing salvage and scientific fish sampling at the scale documented has the potential to represent a stressor within a cumulative impact framework. This would be particularly true at the currently very low population abundance estimates.

3.6 Other Relevant Observations & Findings

Recapture data suggest the same fish may be handled a number of times throughout their lifespan within the upper Fording River. Growth rates from recaptured fish (n= 92) have been used to validate age class estimates and longevity estimates (*i.e.,* 20 years old for a 485 mm WCT) (Cope *et al.* 2016, Cope 2019). Individual Westslope Cutthroat Trout with a capture history interval of 7 years confirms at least a 10 or 11 year life span; and this fish was 395 mm in a population with maximum lengths of 485 mm (Cope 2019). Recently emerging otolith data suggests Westslope Cutthroat Trout can reach ages of at least 16 years (Janowicz *et al.* 2018, Minnow Environmental Inc. 2011, Wilkinson 2009). Until recently, it was generally accepted that, maximum life span was typically less than eight years (McPhail 2007, Behnke 2002).

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