Barriers and Fish Passage: Aquatic Connectivity along Highway 3

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# TABLE OF CONTENTS

1. Introduction ................................................................................................................................. 1  
   1.1. Objectives ................................................................................................................................. 3  
   1.2. Partnership ................................................................................................................................. 4  
2. Background ..................................................................................................................................... 5  
   2.1. Ecological Context ....................................................................................................................... 5  
   2.2. Terrestrial Study ............................................................................................................................ 5  
   2.3. Literature Review of Fish Passage Studies .................................................................................... 6  
3. Methods .......................................................................................................................................... 8  
   3.1. Field Data Collection .................................................................................................................. 8  
   3.2. Preliminary Passage Assessment and Prioritization ................................................................. 8  
4. Results ........................................................................................................................................... 11  
   4.1. Physical and Hydraulic Field Data of Crossing Sites ............................................................... 11  
   4.2. Preliminary Passage Assessment and Prioritization ............................................................... 13  
5. Recommendations ........................................................................................................................... 16  
   5.1. Recommendations for Aquatic Crossings ............................................................................... 16  
   5.2. Making Connections with the Terrestrial Study ........................................................................ 19  
6. Appendix  
7. References
LIST OF TABLES

Table 1: Summary of crossing names and type.................................................11

Table 2: Summary of basic culvert properties.................................................12

Table 3: Summary of hydraulic data at each crossing.....................................13

Table 4: Site rankings for barriery and ecological value.................................14

Table 5: Summary of all categories for all crossings.....................................15

Table 6: Summary of mitigation recommendations and priority.....................17
LIST OF FIGURES

Figure 1: Highway 3 study area in the Crown of the Continent Ecosystem……………………2

Figure 2: Location of culverts and bridges within the study area………………………………..3

Figure 3: Cumulative frequency and histogram of total culvert widths at each crossing……..10

Figure 4: Location of high priority crossings in study area…………………………………….18

Figure 5: Terrestrial mitigation sites and bridges and culverts crossing Highway 3…………….19

LIST OF APPENDICES

Appendix A: Field Data Sheets

Appendix B: Photographs of Crossings
1. INTRODUCTION

Aquatic ecosystems are often severely fragmented due to improperly designed, constructed or maintained culverts and other structures that allow water to flow under the road. Culverts and bridges when properly designed and maintained can provide unimpeded passage for fish and other aquatic organisms as well as stream and river function. In special cases, aquatic barriers may be advisable to keep populations separate; for example, to protect imperiled native trout species from introgressive hybridization with non-native species. Highway 3, a major east-west transportation corridor through the southern Canadian Rocky Mountains, currently supports 6,000 to 9,000 vehicles a day and runs parallel to, and often crosses, the Crowsnest River and many of its tributaries. This transportation corridor bisects the Crown of the Continent Ecosystem and has been identified as a major challenge to maintaining wildlife and aquatic connectivity through this region (see Figure 1).

The Crowsnest River and its tributaries support a world-class fishery, with naturalized rainbow trout (*Oncorhynchus mykiss*) being a targeted species. This fishery also includes native bull trout (*Salvelinus confluentus*) in the lower reaches, downstream of Lundbreck Falls and westslope cutthroat trout (*O. clarkii lewisi*) throughout. Historically, there were bull trout in the Crowsnest River, particularly Crowsnest Lake. It is believed that over fishing and/or destruction of spawning grounds contributed to the loss of this species in this area (Warnack, 2012). Bull trout are recognized throughout most of their range as vulnerable and are ranked as *Sensitive* in the Province of Alberta (Alberta Sustainable Resource Development, 2001). Due to competition and hybridization with rainbow trout, westslope cutthroat trout populations are typically isolated to tributary habitat. In 2006, COSEWIC designated all genetically pure populations of westslope cutthroat trout (i.e., <1% hybridized) living within their native range in Alberta as *Threatened* (Department of Fisheries and Oceans, 2012). The Albertan population of westslope cutthroat trout is also recognized under the federal *Species at Risk Act*.

The level or degree that existing Highway 3 infrastructure prevents, limits, or provides aquatic passage to native trouts and other fish species is largely unknown at this time. Therefore, the purpose of this study was to perform a baseline assessment and preliminary review of existing Highway 3 infrastructure from Lundbreck upstream to the British Columbia/Alberta provincial border (see Figure 2) to determine the impacts of the highway to aquatic connectivity, species movements and conservation. The Highway 3: Transportation Mitigation for Wildlife and Connectivity report recommended this study as an important complement to the terrestrial focus taken in the completed study (Clevenger et al. 2010).
Figure 1: Highway 3 study area in the Crown of the Continent Ecosystem (courtesy of Miistakis Institute).
In a broad context, aquatic connectivity refers to the movement of all aquatic organisms as well as ecological flows and processes. Ecological flows include the movement of water, nutrients, woody debris, sediment and other quantities. This study focused on the fish passage component only.

It should be pointed out that this project involved an initial assessment of the crossings in the project corridor. This report provides a baseline and initial ranking of crossings with preliminary mitigation recommendations from which additional and more detailed studies of aquatic connectivity through this corridor should be completed. At the time this report was written, we have outstanding proposals to Devon Energy and Alberta Transportation for completion of a more thorough assessment of fish passage through the study corridor.

1.1. Objectives

This project had several objectives:

- perform an initial passage assessment of all culverts and bridges along this corridor to identify the level of connectivity through each structure,
• identify conservation support opportunities and mitigation strategies for enhancement of passage and restoring habitat near the structures, and
• Identify conservation opportunities to support protection and enhancement of pure populations of native trout species from introgression with non-native species, and develop a prioritization list of short- and long-term projects.

1.2. Partnership

This project was performed by a partnership between the Western Transportation Institute, Miistakis Institute, Anatum Ecological and Lotic Environmental.
2. BACKGROUND

2.1. Ecological Context

The Crowsnest River watershed, located in southwestern Alberta, contains valuable fisheries resources with both recreational fishery and ecological significance. The Crowsnest River system contains two sport fish of particular conservation concern: bull trout and westslope cutthroat trout. Both of these native species have documented declines in SW Alberta largely due to increased cumulative impacts on the landscape including industrial activity, recreational activities as well as competition from introduction of non-native fish (ASRD 2012). These species are considered key indicators of the health of aquatic ecosystems throughout their native range; therefore, conservation efforts focused on restoring healthy populations of them will improve the general health of the ecosystem and natural biodiversity.

Bull trout, Alberta’s provincial fish, are now limited to the lower Crowsnest River below Lundbreck Falls, which is located downstream of this project’s study area (Blackburn 2011). Bull trout are recognized throughout most of their range as vulnerable and are ranked as Sensitive in the province of Alberta (ASRD, 2001). This listing is due largely to significant range reductions and reported population declines where they do persist. Restoration of bull trout to their historic range is a key goal of conservation efforts for both local and regional organizations (ASRD 2012).

The Albertan population of westslope cutthroat trout has a COSEWIC listing of Threatened. Similarly, the listing of westslope cutthroat trout comes from range reductions, but also the adverse effects of species introductions (e.g., rainbow trout). Improving movement throughout the remnant ranges of these species may be critical to their persistence in this watershed. The role that anthropogenic fish movement barriers currently play in isolating specific populations must also be considered. By assessing the function of stream crossing structures in terms of their current ability to facilitate fish movement, streams can be assessed on an individual basis to determine whether fish passage improvements are (1) required and (2) of benefit to these species of concern that may be isolated upstream of a migratory barrier.

In addition to bull trout and westslope cutthroat trout, the Crowsnest River drainage supports a fairly diverse fishery with a long-standing reputation for large rainbow trout and mountain whitefish (Prosopium williamsoni) (Blackburn, 2011). Rainbow trout and mountain whitefish dominate the species upstream of Lundbreck Falls, with relatively intact populations of westslope cutthroat trout in the tributaries of Island, Giardi, Star, upper Blairmore, upper Gold and upper Rock Creeks. Other species present in the watershed include brown trout (Salmo trutta), brook trout (Salvelinus fontinalis), lake trout (Salvelinus namaycush), burbot (Lota lota), longnose sucker (Catostomus catostomus) and white sucker (Catostomus commersonii) (Blackburn, 2011). Lundbreck falls is acting as an upstream migration barrier to large schools of sucker species which appear to thrive in the Oldman Reservoir.

2.2. Terrestrial Study

Ecological connectivity is a central principle to the conservation of wildlife, ecosystems, and the native biodiversity that they encompass (Crooks and Sanjayan 2006, Clevenger et al. 2010).
Developing an understanding of how wildlife are distributed across the landscape, their characteristics of habitat use and the quality of available habitat along the Highway 3 corridor has been used to develop potential mitigation strategies to conserve ecological connectivity (Clevenger et al. 2010). The terrestrial assessment was the first step to facilitate the reduction of wildlife motor vehicle conflicts and maintain habitat connectivity. The focus of the aquatic project is to initiate an assessment of aquatic resources impacted by Highway 3, following a similar process as the terrestrial study.

Examining the terrestrial and aquatic components in parallel enables the development of mitigation strategies to improve ecosystem function to the benefit of both the aquatic and terrestrial systems. It is likely that there are culverts preventing or reducing hybridization between westslope cutthroat trout and other trout species; therefore, recommendations for terrestrial connectivity may be to the detriment of the aquatic system. This report attempts to identify areas where aquatic connectivity can be improved or barriers need to be maintained.

2.3. Literature Review of Fish Passage Studies

Culverts are a common and often cost-effective means of providing transportation intersections with naturally occurring streams or rivers, but have been identified as potential barriers to fish mobility. Fish passage presents a complex challenge to engineers, hydrologists and biologists due in part to the dynamic nature of the system, both physically and biologically. The interactions between the physical and biological elements further complicate the problem. There are many physical factors that determine whether a fish can or cannot pass through a culvert; insufficient water depth, large outlet drop height and excessive water velocity comprise the most common physical factors limiting passage (Baker and Votapka, 1990; Votapka, 1991; Fitch, 1995). Biological factors such as a fish’s swimming ability, its motivation and behavior play an equally important role in passage.

Although no comprehensive inventory of the number of culverts on fish-bearing streams in North America is available, there is an estimated 1.4 million stream-road crossings in the United States (USFWS). Examples of the number of culvert barriers from various parts of North America further highlight the problem. Sixty-one percent of culvert crossings in the Notikewin watershed and 74% of culvert crossings in the Swan River watershed, both in Alberta, likely impede fish movement (Tchir et. al., 2004). In Whatcom County, Washington, researchers assessed the passage status of culvert crossings on 1,673 crossings, they believe 837 (50%) are barriers to fish passage (Whatcom County Public Works, 2006). A recently completed inventory and analysis of fish passage across road-stream crossings identified 2,900 culverts on 50,000 miles of forest roads in Montana, northern Idaho, and western North and South Dakota. The analysis showed that about 80% of the culverts are barriers to westslope or Yellowstone cutthroat trout at some life stage. Of the total surveyed, 576 (about 20%) were classified as total barriers that completely isolate upstream fish populations (USDA, 2008). An evaluation of four bridges and 47 culverts along a 210 kilometer (km) segment of the Trans Labrador Highway identified that 53% of the culverts posed fish passage problems due to poor design or construction (Gibson et. al., 2005). In Alberta’s Kakwa River watershed, 57% of culvert crossings are perched, thus blocking fish access to an estimated 98 km of upstream habitats (Johns and Ernst, 2007).
Common Approaches to Assessing the Barrier Status of Culverts

There are many different methods to analyze the barrier status of culverts, each with distinct advantages and disadvantages. For this discussion, these methods are split into direct and indirect assessments. Direct assessments measure the amount of movement by fish in the field with an experiment such as a mark-recapture study (Cahoon et al., 2005; Belford and Gould, 1989; Warren and Pardew, 1998). Another method that can directly measure passage and also allow for the ability to analyze fish movement through a range of flow conditions is the use of PIT (passive integrated transponders) tags and antennae placed at the upstream and downstream ends of a culvert (Cahoon et al., 2005). These approaches can provide detailed information concerning both the passage status of a culvert and the hydraulic environment within and adjacent to the culvert that allowed or prevented passage; however, they can be labor-intensive and are only practical for assessing a smaller number of culverts.

Indirect methods generally approximate fish movement potential by comparing the culvert physical conditions to those that the fish are known to be able to overcome. FishXing is a software program that combines culvert characteristics (slope, length, roughness, etc.) and stream hydrology to model the hydraulic conditions in and near the culvert (FishXing, 2012). These hydraulic conditions are then compared to the swimming ability of the fish species of interest to determine a passage status. Although this method of analysis may be useful for assessing a large number of culverts with a relatively small amount of field data collection, caution must be used when interpreting the results, as research shows that this method can provide a conservative (i.e. more barriers to movement are predicted when compared to direct assessment results) estimate of the barrier status of culverts (Cahoon et al., 2005; Karle, 2005).

Species abundance, size structure, and genetic differentiation can also be used as an indirect approach to evaluate fish passage. Typically, these studies compare the results of fish samples taken from locations both upstream and downstream of the culvert. For example, population surveys performed upstream and downstream of a perched culvert indicated that cutthroat trout (O. clarki) density was 64% lower upstream than downstream and the size structure was skewed to a higher proportion of large fish downstream of the culvert, suggesting that the culvert was functioning as at least a partial barrier to upstream movement (USFWS, 2002). This upstream and downstream approach can provide valuable information about how culverts affect the abundance, size structure, and distribution of fish populations; however, results from these studies can be inconclusive as to the barrier status of the culvert, because there may not be significant differences between the upstream and downstream samples even though the culvert may be a barrier. Inconclusive results may indicate either recent genetic isolation or that the culvert allows partial movement of the species of interest (Knaepkens et al., 2004).
3. METHODS

Study methods involved gathering basic physical data at road-stream crossings. The baseline data was used to develop mitigation recommendations and site prioritizations.

3.1. Field Data Collection

Baseline field data was collected during November 2012 and included basic culvert characteristics and measurement of hydraulic data. The baseline culvert characteristics included:

- shape of culvert,
- culvert width,
- culvert material,
- entrance configuration (such as mitered or projecting),
- presence of internal structures such as baffles,
- amount of substrate within the culvert barrels, and
- degree of blockage by debris.

In addition to measuring and recording culvert characteristics, field personnel made qualitative observations about the degree of fish passage, descriptions about the quality of fish habitat upstream and downstream of the crossing, and other observations. All of this information was recorded on field data sheets (Appendix A). In addition, photographs of road-stream crossings were taken and are included in Appendix B.

Hydraulic measurements including water depths, inlet and outlet drop height, and velocities were collected at the inlet and outlet of the culverts. Discharge estimates were obtained following the mid-point method. This method involves using a flow metre (in this case Swoffer 2100) to measure the depth and velocity at the mid-point of evenly spaced intervals (10 or 20 based on stream width > or <1.5 m, respectively) and at 60% depth when the stream is <0.75 m deep, at 20% and 80% when the depth is 0.75 - 1 m or at 20%, 60% and 80% when depth is >1 m. Water depths in culvert inlets and / or outlets were measured using a graduated rod to the nearest tenth of a foot.

3.2. Preliminary Passage Assessment and Prioritization

Prioritizing crossings is a good way to identify the crossings that represent the greatest risk to fish passage and would benefit the ecosystem most from improvements. A draft site prioritization matrix was developed to aid in identifying crossings that are of greater risk to fish passage and could, through retrofitting or replacement, provide the greatest improvement to ecological conditions and fish mobility through the Highway 3 corridor. The draft matrix considered four parts or factors: (1) passability or “barrierity” of each crossing, (2) ecological value, (3) constructability and (4) native species conservation value.

The matrix and the different factors are considered draft for a couple reasons: (1) this study is only preliminary and uses a limited amount of data for evaluating passage, and (2) other stakeholders should be involved in development or approval of the final factors for the prioritization to be viewed as credible and implementable. Additional data collection, as proposed in pending proposals, to further refine passage conditions at each crossing is
recommended in order to understand the dynamic nature of the various factors involved with passage. For example, water velocity is a very important physical condition that can control passage through a structure. However, water velocity is related to the flow rate in a structure and flow is constantly changing over the course of a season. The data we have collected to date represents only a “snapshot” of flow conditions at each crossing. Quantifying flow through at least one runoff season is a good method that captures a range of flows that a crossing may experience in a relatively short period of time. In addition, using hydraulic models to estimate flow conditions (water depth and velocity) for larger flow events can provide useful information; especially when combined with flood frequency information and runoff measurements for a stream crossing.

Barrierity of a crossing refers to the severity or degree to which a crossing acts as a barrier to fish passage. The most common physical features in road-stream crossings that create barriers to upstream fish passage include outlet drop height, shallow water depth, and high velocity (Baker and Votapka, 1990; Votapka, 1991; Fitch, 1995). For this study, we evaluated the barrierity using field measurements collected in November 2012 including: outlet drop height, water depth, and water velocity. In addition, field personnel also made qualitative observations regarding fish passage conditions at the time of the survey. By combining this information, each crossing was assigned a “risk” level, indicating the likelihood that a crossing is acting as an upstream passage barrier, that ranged between low (likely not a barrier), medium (possibly a barrier at some flows), and high (likely a passage barrier at a large range of flows). Numeric values were than assigned as follows: 2 for low, 4 for medium and 6 for high risk.

The second part of the prioritization matrix or framework evaluated the ecological value of replacing or retrofitting a crossing. The ecological value framework was developed using a combination of methods and information gathered from numerous sources along with knowledge of local issues and species needs, physical site data, and professional judgement. The framework broke ecological conditions of a crossing into two broad categories: habitat value and connectivity value.

- Habitat value includes a qualitative assessment of the upstream and downstream habitat conditions at each crossing. Habitat value was scored as 1 for “low quality”, 2 for “medium quality” and 3 for “high quality”.
- Connectivity value includes the proximity of the crossing to potential barriers both upstream and downstream. If no other crossings were located upstream or downstream of the crossing, the connectivity score was 3, if another crossing was located either upstream or downstream of the crossing, the connectivity score was 2, and if a natural barrier existed upstream and close, the connectivity score was 0.

Some methods for prioritizing culverts use species value as another factor for evaluating ecological value; however, this factor was not included in the analysis.

Constructability is a term used to define the complexity and cost for replacement of a structure. The constructability framework used a combination of individual culvert width, cumulative culvert width at a crossing and a discretionary component that involved knowledge of each crossing’s characteristics and professional judgment. The method assumes that larger crossings are more costly to reconstruct than smaller crossings. Figure 3 shows the cumulative frequency distribution for total culvert width for all crossings sites evaluated during this project. The
distribution was used to group the crossings into three categories; greater than 3.5 meters, greater than 2 meters but less than 3.5 meters, and less than 2 meters. These categories were then assigned a value of 1 to 3 as follows: (1) cumulative width < 2 meters, (2) cumulative width between 2 and 3.5 meters, and (3) cumulative width > 3.5 meters.

Figure 3: Cumulative frequency and histogram of total culvert widths at each crossing.

The discretionary ranking included factors such as road width (similar to culvert length) at crossings, anticipated traffic volumes, steepness of road embankments, road type and potential utility conflicts. The factors were used to represent the complexity of reconstructing a crossing. A value of 1 (least complex), 2 (moderately complex) and 3 (most complex) was assigned based on the anticipated complexity and thus increased cost for replacement construction. A combined constructability ranking for each crossing was then determined by summing the cumulative culvert width ranking and the discretionary ranking. The combined rankings were then broken down into three general constructability categories that yielded the final constructability ranking including lower cost (1-2), moderate cost (3-4) and higher cost (5-6).

The last factor includes conservation value of the crossing or the “need for replacement” when considering native fish populations. In some cases, passage through a crossing is not desirable in order to preserve native species that are present upstream of a crossing from competition and possible hybridization with non-native species. If a crossing has a known population of pure or relatively pure westslope cutthroat trout, a provincially listed threatened species, improving passage at this time is not recommended. This approach is consistent with local and regional
fisheries management strategy. In these cases the need for replacement trumps any other site ranking criteria and strategies should focus on maintaining the barrier to fish passage.

4. RESULTS

A total of ten culvert crossings and two bridge crossings were evaluated during the study. Table 1 summarizes the crossing by location (stream name) and type. The preliminary passage assessment and prioritization only included culvert crossings as the bridge crossings were determined by field personnel to adequately span the stream channel and thus not restrict fish passage.

Table 1: Summary of culvert location and type.

<table>
<thead>
<tr>
<th>Culvert Location</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girardi Cr.</td>
<td>culvert</td>
</tr>
<tr>
<td>Allison Cr.</td>
<td>culvert</td>
</tr>
<tr>
<td>Bohomolec Cr.</td>
<td>culvert</td>
</tr>
<tr>
<td>McGillvray Cr.</td>
<td>culvert</td>
</tr>
<tr>
<td>Nez Perce Cr.</td>
<td>culvert</td>
</tr>
<tr>
<td>First Cr.</td>
<td>culvert</td>
</tr>
<tr>
<td>Peltiere Cr.</td>
<td>culvert</td>
</tr>
<tr>
<td>Leitch Cr.</td>
<td>culvert</td>
</tr>
<tr>
<td>Rock Cr.</td>
<td>culvert</td>
</tr>
<tr>
<td>Burmis Cr.</td>
<td>culvert</td>
</tr>
<tr>
<td>Gold Cr.</td>
<td>bridge</td>
</tr>
<tr>
<td>Blairmore Cr.</td>
<td>bridge</td>
</tr>
</tbody>
</table>

4.1. Physical and Hydraulic Field Data of Crossing Sites

Table 2 summarizes the physical data collected at each crossing. Most culverts in the study where either spiral or annular corrugated metal pipes (CMP), with the exception of the culvert at McGillvray Cr., which was a closed-bottom concrete arch pipe. In all but two cases, culvert entrances were mitered to the road embankment. There were no internal structures within the culverts except for Bohomolec Cr. which has internal baffles. The crossing at Allison Cr. has two barrels, with the main barrel embedded with substrate and an overflow culvert placed higher to capture flood flows.
Table 2: Summary of basic culvert properties.

<table>
<thead>
<tr>
<th>Culvert Location</th>
<th>Total Culvert Width¹ m</th>
<th>Shape of Culvert</th>
<th>Material</th>
<th>Inlet Type</th>
<th>Internal Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girardi Cr.</td>
<td>1.5</td>
<td>Oval</td>
<td>Spiral CMP</td>
<td>Mitered</td>
<td>None</td>
</tr>
<tr>
<td>Allison Cr.</td>
<td>5.5</td>
<td>Circular</td>
<td>Annular CMP</td>
<td>Mitered</td>
<td>Substrate is continuous through structure.</td>
</tr>
<tr>
<td>Bohomolec Cr.</td>
<td>2</td>
<td>Circular</td>
<td>Annular CMP</td>
<td>Mitered</td>
<td>Baffles</td>
</tr>
<tr>
<td>McGillvray Cr.</td>
<td>3</td>
<td>Closed Bottom Arch</td>
<td>Concrete</td>
<td>Wingwall 30 to 70 degrees</td>
<td>None</td>
</tr>
<tr>
<td>Nez Perce Cr.</td>
<td>1.6</td>
<td>Circular</td>
<td>Spiral CMP</td>
<td>Headwall</td>
<td>None</td>
</tr>
<tr>
<td>First Cr.</td>
<td>0.65</td>
<td>Circular</td>
<td>Spiral CMP</td>
<td>Projecting</td>
<td>None</td>
</tr>
<tr>
<td>Peltiere Cr.</td>
<td>1.56</td>
<td>Circular</td>
<td>Spiral CMP</td>
<td>Mitered</td>
<td>None</td>
</tr>
<tr>
<td>Leitch Cr.</td>
<td>0.6</td>
<td>Circular</td>
<td>Spiral CMP</td>
<td>Mitered</td>
<td>None</td>
</tr>
<tr>
<td>Rock Cr.</td>
<td>1.7</td>
<td>Circular</td>
<td>Annular CMP</td>
<td>Mitered</td>
<td>None</td>
</tr>
<tr>
<td>Burmis Cr.</td>
<td>2.04</td>
<td>Circular</td>
<td>Annular CMP</td>
<td>Mitered</td>
<td>None</td>
</tr>
</tbody>
</table>

Table Note: (1) culvert width is the cumulative width of all culverts in a battery.

Hydraulic data collected at each crossing was used to supplement passage observations made at the time of the field effort. A reminder these measurements only represent a “snapshot” in time of the water depth, velocity and outlet drop in each culvert. As flows increase during spring runoff, these values will change and potentially change the degree of passage through a structure. Table 3 summarizes the hydraulic data.

Inlet velocity ranged from 0.01 m/s to 0.68 m/s and outlet velocity ranged between 0.01 m/s to 0.73 m/s. When compared with the swimming capabilities of bull trout and westslope cutthroat trout, these velocities alone are within what would be considered the prolonged swimming range for both species and do not present a barrier to passage. Inlet water depths ranged from 0.07 m to 0.38 m and outlet depths ranged between 0.07 m and 0.38 m. In some cases, these water depths may create a passage barrier to upstream migrating trout. Only three crossings had outlet drops, with First Cr. having an outlet drop of 1.13 m likely making it a barrier to upstream fish passage (possibly a complete barrier).
Table 3: Summary of hydraulic data at each culvert location.

<table>
<thead>
<tr>
<th>Culvert Location</th>
<th>Inlet Velocity</th>
<th>Outlet Velocity</th>
<th>Inlet Water Depth</th>
<th>Outlet Water Depth</th>
<th>Outlet Drop Height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m/s</td>
<td>m/s</td>
<td>m</td>
<td>m</td>
<td>m</td>
</tr>
<tr>
<td>Girardi Cr.</td>
<td>0.02</td>
<td>0.69</td>
<td>0.38</td>
<td>0.09</td>
<td>ND</td>
</tr>
<tr>
<td>Allison Cr.</td>
<td>0.36</td>
<td>0.41</td>
<td>0.22</td>
<td>0.27</td>
<td>ND</td>
</tr>
<tr>
<td>Bohomolec Cr.</td>
<td>0.68</td>
<td>0.37</td>
<td>0.1</td>
<td>0.32</td>
<td>0.1</td>
</tr>
<tr>
<td>McGillvray Cr.</td>
<td>0.54</td>
<td>0.54</td>
<td>0.13</td>
<td>0.11</td>
<td>ND</td>
</tr>
<tr>
<td>Nez Perce Cr.</td>
<td>0.17</td>
<td>0.01</td>
<td>0.1</td>
<td>0.38</td>
<td>ND</td>
</tr>
<tr>
<td>First Cr.</td>
<td>0.1</td>
<td>0.22</td>
<td>0.07</td>
<td>0.02</td>
<td>1.13</td>
</tr>
<tr>
<td>Peltiere Cr.</td>
<td>0.27</td>
<td>0.01</td>
<td>0.07</td>
<td>0.15</td>
<td>ND</td>
</tr>
<tr>
<td>Leitch Cr.</td>
<td>0.01</td>
<td>0.13</td>
<td>0.15</td>
<td>0.07</td>
<td>ND</td>
</tr>
<tr>
<td>Rock Cr.</td>
<td>dry</td>
<td>dry</td>
<td>dry</td>
<td>dry</td>
<td>dry</td>
</tr>
<tr>
<td>Burmis Cr.</td>
<td>0.32</td>
<td>0.73</td>
<td>0.14</td>
<td>0.2</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Table Note: ND = no drop.

4.2. Preliminary Passage Assessment and Prioritization

Initially, the prioritization ranking analysis combined all four parts of the framework: barrierity, ecological value, constructability, and conservation value. However, upon further consideration, it was decided that an initial ranking that combined barrierity and ecological value only is more useful for identifying fish passage concerns. The combined ranking highlights specific crossings that present both a high risk of limiting passage and provide the highest amount of ecological benefits through replacement or retrofitting. Rankings for ecological value were color coded as follows: green represents crossings on streams with lower ecological value and thus less benefit to the ecosystem from replacement; yellow represents crossings on streams with medium ecological value and moderate benefit from replacement, and red highlights crossings with the highest ecological value and most benefit to the ecosystem from replacement. Passage or barrierity were color coded as follows: red highlights crossings that have a high risk of acting as a passage barrier, yellow highlights crossings that have a medium risk of acting as a passage barrier, and green indicates crossings that have low risk of acting as a barrier or are thought to be passable for most flows for the key species. The combined ranking is also color coded as follows and provides the author’s best assessment of replacement value: red indicates crossings that ranked high for replacement, yellow indicates crossings that ranked medium for replacement, and green indicates crossings that would benefit very little from replacement.

Table 4 includes site rankings based on barrierity and ecological value only. As previously mentioned, using only these two criteria highlights crossings that present both a high risk of limiting passage and provide the highest amount of ecological benefits through replacement or retrofit.
Table 4: Site rankings for barriery and ecological value.

<table>
<thead>
<tr>
<th>Crossing Name</th>
<th>Ecological Value Score&lt;sup&gt;A&lt;/sup&gt;</th>
<th>Passage or Barriery Score&lt;sup&gt;B&lt;/sup&gt;</th>
<th>Cumulative Score&lt;sup&gt;C&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girardi Cr.</td>
<td>6</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Allison Cr.</td>
<td>6</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Bohomolec Cr.</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>McGillvray Cr.</td>
<td>6</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Nez Perce Cr.</td>
<td>4</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>First Cr.</td>
<td>2</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Peltiere Cr.</td>
<td>5</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Leitch Cr.</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Rock Cr.</td>
<td>6</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Burmis Cr.</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
</tbody>
</table>

Notes: (A) Ecological value score: red - highest ecological value and greatest benefit from replacement, yellow - medium ecological value and moderate benefit from replacement, green - lowest ecological value and smallest benefit from replacement; (B) Passage score: red - high risk that structure may be limiting passage, yellow - medium risk that structure may be limiting passage, green - low risk that structure may be limiting passage; (C) Cumulative score incorporates consideration of ecological value and passage; red - high ranking for replacement or retrofit, yellow - medium ranking for replacement or retrofit, green - low ranking for replacement or retrofit.
Table 5 incorporates the cumulative score for barrierity and ecological value with constructability and the need for connectivity regarding native cutthroat presence upstream of the crossing.

Table 5: Summary of all categories for all crossings.

<table>
<thead>
<tr>
<th>Crossing Name</th>
<th>Cumulative Score\textsuperscript{A}</th>
<th>Constructability\textsuperscript{B}</th>
<th>Need for Connectivity\textsuperscript{C}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girardi Cr.</td>
<td>10</td>
<td>2</td>
<td>Westslope cutthroat upstream.</td>
</tr>
<tr>
<td>Allison Cr.</td>
<td>8</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Bohomelec Cr.</td>
<td>6</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>McGillvray Cr.</td>
<td>12</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Nez Perce Cr.</td>
<td>10</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>First Cr.</td>
<td>8</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Peltiere Cr.</td>
<td>9</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Leitch Cr.</td>
<td>7</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Rock Cr.</td>
<td>12</td>
<td>5</td>
<td>Westslope cutthroat upstream.</td>
</tr>
<tr>
<td>Burmis Cr.</td>
<td>9</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Notes: (A) cumulative score is from Table 4 and incorporates both ecological value and passage ranking; (B) constructability: red highlights crossings that are more expensive to replace; yellow highlights crossings that are of medium cost to replace; and green highlights crossings that are least expensive; (C) need for connectivity highlights crossings with known pure cutthroat populations upstream.

As an example, Nez Perce Cr. may be a good candidate for mitigation by culvert replacement because it has a high cumulative score indicating that it may be a barrier while providing medium to high ecological value, and it is relatively cost effective to replace. In addition, existing data does not indicate a need to isolate or protect an upstream population of pure cutthroat trout.
5. RECOMMENDATIONS

This section summarizes preliminary mitigation recommendations for road-stream crossings evaluated in this study. In addition, key information regarding mitigation recommendations from the terrestrial study is integrated with recommendations from this study.

5.1. Recommendations for Aquatic Crossings

The following recommendations presented in Table 6 are based upon field information, site prioritization and professional judgment of local biologists and the authors of this report. Figure 4, following the table, highlights with green arrows those crossings that have higher priority for mitigation.
**Table 6: Summary of mitigation recommendations and priority.**

<table>
<thead>
<tr>
<th>Crossing Name</th>
<th>Mitigation Recommendation</th>
<th>Priority Level</th>
<th>Basis For Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girardi Cr.</td>
<td>Do not replace. Confirm that crossing is acting as a total fish passage barrier.</td>
<td>High</td>
<td>There is a pure or relatively pure population of westslope cutthroat upstream of this crossing.</td>
</tr>
<tr>
<td>Allison Cr.</td>
<td>none</td>
<td>Low</td>
<td>This crossing appears to provide adequate passage for upstream movement of resident fish species.</td>
</tr>
<tr>
<td>Bohomolec Cr.</td>
<td>Further study to confirm passage.</td>
<td>Medium</td>
<td>Based on the baseline data this crossing does not appear to be limiting fish passage.</td>
</tr>
<tr>
<td>McGillvray Cr.</td>
<td>Replace structure with a bridge or a fish-friendly culvert.</td>
<td>High</td>
<td>This crossing is on a known fish bearing stream and based on the baseline study it appears to be limiting fish passage.</td>
</tr>
<tr>
<td>Nez Perce Cr.</td>
<td>Replace structure with a bridge or a fish-friendly culvert. Consider further study to refine passage through this crossing.</td>
<td>High</td>
<td>The crossing appears to be limiting passage, but not completely preventing passage. Fish habitat near the crossing is not high quality.</td>
</tr>
<tr>
<td>First Cr.</td>
<td>Confirm presence or absence of fish in stream. If fish bearing, replace structure with a bridge or a fish-friendly structure. Also, if fish bearing consider further study to refine passage through this crossing.</td>
<td>Medium</td>
<td>The crossing appears to be limiting passage, but not completely preventing passage. Fish habitat near the crossing is low quality.</td>
</tr>
<tr>
<td>Peltiere Cr.</td>
<td>Further study to evaluate passage through this crossing.</td>
<td>Medium</td>
<td>This crossing appears to be limiting passage, but not completely preventing passage. Fish habitat near the crossing is medium quality.</td>
</tr>
<tr>
<td>Leitch Cr.</td>
<td>Further study to evaluate passage through this crossing.</td>
<td>Low</td>
<td>This crossing appears to be limiting passage, but not completely preventing passage. Fish habitat near the crossing is low quality.</td>
</tr>
<tr>
<td>Rock Cr.</td>
<td>Do not replace. Confirm that crossing is acting as a total fish passage barrier.</td>
<td>High</td>
<td>There is a pure or relatively pure population of westslope cutthroat upstream of this crossing.</td>
</tr>
<tr>
<td>Burnis Cr.</td>
<td>Confirm presence or absence of fish in stream. If fish bearing, replace structure with a bridge or a fish-friendly structure. Also, if fish bearing consider further study to refine passage through this crossing.</td>
<td>Medium</td>
<td>The crossing appears to be limiting passage, but not completely preventing passage. Fish habitat near the crossing is low quality.</td>
</tr>
<tr>
<td>Gold Cr.</td>
<td>none</td>
<td>Low</td>
<td>Crossing is a bridge and does not appear to limit fish passage.</td>
</tr>
<tr>
<td>Blairmore Cr.</td>
<td>none</td>
<td>Low</td>
<td>Crossing is a bridge and does not appear to limit fish passage.</td>
</tr>
</tbody>
</table>

Notes: (A) Priority refers to the combined barrierity and ecological value ranking; (B) There is some research that indicates this crossing may not be a true barrier. We recommend confirming the accuracy of the barrier assessment data and basing future assessment (if needed) from there.
Figure 4: High priority culvert sites along Highway 3.
5.2. Making Connections with the Terrestrial Study

The culvert locations in this aquatic study and terrestrial mitigation sites from the Highway 3: Transportation Mitigation for Wildlife Connectivity report (Clevenger et al. 2010) are displayed in Figure 5.

Figure 5: Terrestrial mitigation sites and bridges and culverts crossing Highway 3.

There are two sites, Rock Creek and McGillvray Creek, where terrestrial mitigation site recommendations should be assessed in relation to a review of culverts and fish passage. Rock Creek is also a priority terrestrial mitigation site and strategies to improve connectivity for large mammal species, including both carnivore and ungulate species, are important for improving human and wildlife safety. However, given the possible importance of the current culvert acting as a barrier between introduced trout species and westslope cutthroat trout mitigation for large mammal connectivity is best served away from the aquatic system. The current recommendation for improving connectivity for large mammals at Rock Creek mitigation site is to build an underpass under the highway away from the aquatic system.
McGillvrary mitigation site was identified as an area with a high number of wildlife vehicle collisions involving deer, elk and moose. The recommendations for this culvert site are to improve connectivity for fish passage. At this site it would be beneficial to improve both aquatic and terrestrial species connectivity by replacing the existing culvert with an open span bridge that allows adequate space for wildlife movement (3 m wide and 2 m high). Because this site scored as a high priority culvert for replacement and the Highway 3 terrestrial report indicated it is cost effective to mitigate for a single span bridge, it is recommended that the priority placed on this site is increased.
6. APPENDIX

Appendix A: Field Data Sheets
CULVERT MONITORING FIELD DATA SHEET
HIGHWAY 3 AQUATICS

STREAM NAME: Flumerfelt creek
ROAD NAME: Hwy 3
NEAREST MILE POST: 49.6366/57.1145/503187
LOCATION (LAT./LONG.): 49.6366/57.1145/503187
NEAREST MILE POST: 49.6366/57.1145/503187
FIELD DATE: Nov 23, 2012

CROSSING STRUCTURE

Shape: Circular
Dimensions (m): width: 1.6, height: 1.6

Structure material:
- Spiral CMP
- Annular CMP
- Structural plate (SP)
- Concrete
- PVC
- Smooth steel
- Other:

Structure shape comments:

Structure material comments:

Corrugations:
- 2 2/3 x 1/2 inch
- 3 x 1 inch
- 3 x 2 inch (SP only)
- None

Skew from road:
- 50

Outlet configuration:
- Yes

Inlet type:
- yes

Outlet configuration:
- at stream grade

Baffles, weirs or other internal structures:
- YES

Wingwall:
- Mitered
- Cascade over riprap
- Material: 
- Describe:

Headwall:
- Outlet apron
- Other:

Apron:
- Other:

Trashrack:
- Other:

Pipe conditions:
- Breaks inside culvert (Location)
- Fill eroding
- Debris plugging inlet (% blockage 25)
- Bent inlet
- Bottom worn through
- Poor alignment with stream
- Debris in culvert (i.e. rock, snow, wood)
- Water flowing under culvert
- Other:

Describe overall conditions:

STREAMBED SUBSTRATE RETENTION IN STRUCTURE

- No substrate in structure
- Discontinuous layer of substrate in structure begins at outlet; ends at outlet ft (measured from inlet)
- Substrate is continuous throughout structure

If present, substrate depth at inlet ft; substrate depth at outlet ft

Comments:

Desert habitat potential u/s of crossing in Flumerfelt park.

Culvert appears to have a slight bend under the highway, but this was not confirmed.

Approx. 50 m of stream d/s from outlet to 19th ave, where another culvert exists.

Photographs: (identify and provide captions)

<table>
<thead>
<tr>
<th>Photo caption</th>
<th>Photo #</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Inlet from upstream</td>
<td>1229</td>
<td></td>
</tr>
<tr>
<td>2. Outlet from downstream</td>
<td>1231</td>
<td></td>
</tr>
<tr>
<td>3. Inlet from road</td>
<td>1232</td>
<td></td>
</tr>
<tr>
<td>4. Outlet from road</td>
<td>1233</td>
<td></td>
</tr>
</tbody>
</table>
**CULVERT MONITORING FIELD DATA SHEET**

**HIGHWAY 3 AQUATICS**

**STREAM NAME:** Allison

**ROAD NAME:** Hwy 3

**NEAREST MILE POST:**

**INSPECTOR NAME(S):** MR, DP

**LOCATION (LAT./LONG.):** 49.632509/-114.586501

**FIELD DATE:** Nov / 23 / 2012

---

### CROSSING STRUCTURE

<table>
<thead>
<tr>
<th>Shape</th>
<th>Dimensions (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>width: 2.75</td>
</tr>
<tr>
<td></td>
<td>height: 2.75</td>
</tr>
</tbody>
</table>

**Structure shape comments:**

- Multiple structures at site: 2, if of total openings at the crossing site.

---

### Structure material

- Corrugations:
  - See Attached Figures for Clarification

- Corrugations:
  - 2 2/3 x 1/2 inch
  - 3 x 1 inch
  - 5 x 1 inch
  - 6 x 2 inch (SP only)

**Skew from road:**

- 90 degrees

---

### Structure conditions:

- Breaks inside culvert (Location______________)

- Fill eroding
- Bent inlet
- Bottom worn through
- Poor alignment with stream
- Debris in culvert (i.e. rock, snow, wood)
- Water flowing under culvert

**Describes overall conditions:**

- Good

---

### STREAMBED SUBSTRATE RETENTION IN STRUCTURE

- No substrate in structure

- Discontinuous layer of substrate in structure begins at _______ ft; ends at _______ ft (measured from inlet)

- Substrate is continuous throughout structure

**If present, substrate depth:**

- Inlet depth: 1 / 2.5 ft
- Outlet depth: 1 / 2.5 ft (Wetted/Dry)

---

### Comments:

- Fully passible. Two culverts: #1 = wetted, #2 = dry. Site is an excellent example of how to use two structures
  - To have a small low flow crossing, but maintain flood capacity. The strength has naturally blocked
  - Of #2 to an elevation equal to the flood plain. Site is an excellent example of a property
  - Sneaking crossing. Excellent fish habitat u/s and d/s.

---

### Required Photos:

1. Inlet from upstream
2. Outlet from downstream
3. Inlet from road
4. Outlet from road

---

### Photographs:

<table>
<thead>
<tr>
<th>Photo caption</th>
<th>Photo #</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet from upstream</td>
<td>1247</td>
<td></td>
</tr>
<tr>
<td>Outlet from downstream</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inlet from road</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outlet from road</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
STREAM NAME: Bohomolec
ROAD NAME: Hwy 3
NEAREST MILE POST: 

INSPECTOR NAME(S): MR, DP
LOCATION (LAT./LONG.): 49.635697/-114.556592
FIELD DATE: Nov_23_2012

CROSSING STRUCTURE

Shape
- Circular
- Box
- Open-bottom arch
- Pipe-arch
- Ford
- Other:

Dimensions (m)
- width: 2.0
- height: 2.0

Structure material
- Corrugations: Spiral CMP 2 2/3 x 1/2 inch, 90 degrees
- Annular CMP 3 x 1 inch
- Structural plate (SP): 5 x 1 inch
- Concrete 6 x 2 inch (SP only)
- PVC None
- Smooth steel Paved or smooth invert
- Other: ____________________________

Inlet type
- Projecting
- Mitred
- Wingwall 10-30 o
- Wingwall 30-70 o
- Headwall
- Apron
- Traprack
- Other:

Outlet configuration
- See Attached Figures for Clarification
- No substrate in structure
- Discontinuous layer of substrate in structure begins at __________ ft; ends at __________ ft (measured from inlet)
- Substrate is continuous throughout structure
- If present, substrate depth at inlet __________ ft; substrate depth at outlet __________ ft

Inlet conditions:
- Breaks inside culvert (Location)
- Fill eroding
- Debris plugging inlet (% blockage)
- Poor alignment with stream
- Debris in culvert (i.e. rock, snow, wood)
- Water flowing under culvert
- Other: Describe overall conditions: __good__

Outlet conditions:
- Mitered
- Cascade over riprap
- Headwall into pool
- Outlet into riprap
- Outfall apron
- Other:

Structure comments:

Structures are numbered 1-1239 (left to right looking downstream)

Photographs:
1. Inlet from upstream
2. Outlet from downstream
3. Inlet from road
4. Outlet from road

1. Inlet from upstream
2. Outlet from downstream
3. Inlet from road
4. Outlet from road

Photos:
- Required Photos: 
- Photos: (identify and provide captions)

Comments:
- Upstream habitat has sufficient flows, but quality is poor.
- Highly degraded from horse grazing. Metal culverts for 1st 15 m from inlet and outlet, then turns into concrete box culvert (1239+1243). Potential exists for gradient barrier between crossing and Crowsnest River. Overall good quality habitat at site.
- Concrete box culvert had steps approx. 15 cm high, spread every 10 m. Fish passage is highly probable.
**CULVERT MONITORING FIELD DATA SHEET**

**HIGHWAY 3 AQUATICS**

**STREAM NAME**: McGillvary  
**ROAD NAME**: Hwy 3  
**NEAREST MILE POST**:  
**INSPERATOR NAME(S)**: MR, DP  
**LOCATION (LAT./LONG.)**: 49.635166 /-114.520859  
**FIELD DATE**: Nov / 23 / 2012  

---

**CROSSING STRUCTURE**

**Shape**
- **Circular**
- **Box**
- **Open-bottom arch**
- **Pipe-arch**
- **Ford**
- **Other: concrete arch, closed bottom**

**Dimensions (m)**

<table>
<thead>
<tr>
<th>Shape</th>
<th>Width</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circular</td>
<td>3.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Box</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open-bottom arch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe-arch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ford</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: concrete arch, closed bottom</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Structure shape comments**: 3.5 m from bottom to top of arch.

**Structure material**
- **Circular CMP**
- **Annular CMP**
- **Structural plate (SP)**
- **Concrete**
- **PVC**
- **Smooth steel**
- **Other:**

- **Corrugations**
  - 2.0 x 1/2 inch
  - 3 x 1 inch
  - 6 x 2 inch (SP only)
  - None

- **Skew from road**
  - 90 degrees

**Structure comments**: See Attached Figures for Clarification

---

**Outlet configuration**

<table>
<thead>
<tr>
<th>Inlet type</th>
<th>Outlet configuration</th>
<th>Baffles, weirs or other internal structures:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projecting</td>
<td>Gated grade</td>
<td>YES</td>
</tr>
<tr>
<td>Mitered</td>
<td>Cascades over riprap</td>
<td>NO</td>
</tr>
<tr>
<td>Wingwall 10-30'</td>
<td>Inlet into pool</td>
<td></td>
</tr>
<tr>
<td>Wingwall 30-70'</td>
<td>Inlet onto riprap</td>
<td></td>
</tr>
<tr>
<td>Headwall</td>
<td>Apron</td>
<td></td>
</tr>
<tr>
<td>Apron</td>
<td>Apron</td>
<td></td>
</tr>
<tr>
<td>Trashrack</td>
<td>Apron</td>
<td></td>
</tr>
</tbody>
</table>

**Other**: There is a drop from the concrete invert to the bottom of pool (around 0.75m)

---

**Pipe conditions**:  
- **Breaks inside culvert (Location):**
- **Fill eroding**
- **Debris plugging inlet (% blockage):**
- **Poor alignment with stream**
- **Debris in culvert (i.e. rock, snow, wood)**
- **Water flowing under culvert**

**Describe overall conditions**: Good

---

**STREAMBED SUBSTRATE RETENTION IN STRUCTURE**

- **No substrate in structure**
- **Discontinuous layer of substrate begins at:**
- **Substrate is continuous throughout structure**
- **Substrate depth at inlet:**
- **Substrate depth at outlet:**

---

**Comments**:  
- Very good potential. Structure appears to be a low flow barrier with less than 5 cm of water depth.
- Stream is a very good size for substantial habitat gains (5m wetted width d/s of crossing).
- Habitat u/s is also high value, Creek is highly defined.
- Fish passage could be greatly improved with baffling or better yet by masonry work with cobble to redefine a meandering hi-flow channel within the crossing.

---

**Photographs** (identify and provide captions):  
1. Inlet from upstream  
2. Outlet from downstream  
3. Inlet from road  
4. Outlet from road

<table>
<thead>
<tr>
<th>Photo caption</th>
<th>Photo #</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Inlet from upstream</td>
<td>1236</td>
<td></td>
</tr>
<tr>
<td>2. Outlet from downstream</td>
<td>1234</td>
<td></td>
</tr>
<tr>
<td>3. Inlet from road</td>
<td>1237</td>
<td></td>
</tr>
<tr>
<td>4. Outlet from road</td>
<td>1235</td>
<td></td>
</tr>
</tbody>
</table>
STREAM NAME: Tourist Info Creek
ROAD NAME: Hwy 3
NEAREST MILE POST: 
LOCATION (LAT./LONG.): 49.631527/-114.607362 
FIELD DATE: Nov 23, 2012

CROSSING STRUCTURE

Shape: 
- Circular
- Box
- Open-bottom arch
- Pipe-arch
- Ford
- Other: oval

Dimensions (m): 
- width: 1.5
- height: 0.8
- 88 to TOC

Multiple structures at site: 
1 # of total openings at the crossing site.

Structure shape comments:

Structure material: 
- Annular CMP
- Structural plate (SP)
- Concrete
- PVC
- Smooth steel
- Other:

See Attached Figures for Clarification

Corrugations: 
- 2 2/3 x 1/2 inch
- 5 x 1 inch
- 8 x 2 inch (SP only)
- None
- Paved or smooth invert
- Other:

Skew from road:
- 60

Outlet configuration: 
- at stream grade
- cascade over riprap
- in let into pool
- out of let onto riprap
- out of d apron
- Other:

Baffles, weirs or other internal structures: 
- YES
- NO

Inlet type: 
- Projecting
- Mitered
- Wingwall 10.30°
- Wingwall 30.70°
- Headwall
- Apron
- Trashrack
- Other:

See Attached Figures

Pipe conditions: 
- Breaks inside culvert (Location:)
- Fill eroding
- Debris plugging inlet (% blockage:)
- Poor alignment with stream
- Debris in culvert (i.e. rock, snow, wood)
- Water flowing under culvert
- Other:

Describe overall conditions: good

Crossing name/number: Tourist Info
Structure: of:

STREAMBED SUBSTRATE RETENTION IN STRUCTURE

- No substrate in structure
- Discontinuous layer of substrate in structure begins at ft; ends at ft (measured from inlet)
- Substrate is continuous throughout structure

If present, substrate depth at inlet ft; substrate depth at outlet ft

Comments:
Known pure cutthroat population upstream. Habitat is poor at crossing, but improves upstream.

Required Photos:
1. Inlet from upstream
2. Outlet from downstream
3. Inlet from road
4. Outlet from road

Photographs: (identify and provide captions)

<table>
<thead>
<tr>
<th>Photo caption</th>
<th>Photo #</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Inlet from upstream</td>
<td>1249</td>
</tr>
<tr>
<td>2. Outlet from downstream</td>
<td>1251</td>
</tr>
<tr>
<td>3. Inlet from road</td>
<td>1250</td>
</tr>
<tr>
<td>4. Outlet from road</td>
<td>1252</td>
</tr>
</tbody>
</table>
**CULVERT MONITORING FIELD DATA SHEET**  
**HIGHWAY 3 AQUATICS**

**STREAM NAME:** First Creek  
**ROAD NAME:** Hwy 3  
**NEAREST MILE POST:**  
**INSPECTOR NAME(S):** MR, DP  
**LOCATION (LAT./LONG.):** 49.634313/-114.486838  
**FIELD DATE:** Nov./23/2012

---

**CROSSING STRUCTURE**

<table>
<thead>
<tr>
<th>Shape</th>
<th>Dimensions (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>width: 0.65</td>
</tr>
<tr>
<td></td>
<td>height: 0.75</td>
</tr>
</tbody>
</table>

**Structure shape comments:**

---

**Structure material**

- **Spiral CMP**
- **Annular CMP**
- **Structural plate (SP)**
- **Concrete**
- **PVC**
- **Smooth steel**
- **Other:**

**Corrugations**

- **2 2/3 x 1/2 inch**
- **3 x 1 inch**
- **6 x 2 inch (SP only)**

**Skew from road**

- **90 degrees**

**Outlet configuration**

- **at stream grade**
- **cascade over riprap**
- **Refall into pool**
- **outlet apron**
- **Other:**

**Pipe conditions:**

- **Breaks inside culvert**
- **Fill eroding**
- **Debris plugging inlet** (% blockage: 50)
- **Bent inlet**
- **Bottom worn through**
- **Poor alignment with stream**
- **Debris in culvert** (i.e. rock, snow, wood)
- **Water flowing under culvert**
- **Other:**

**Inlet type**

- **Projecting**
- **Mitered**
- **Wingwall 10-30**
- **Wingwall 30-70**
- **Headwall**
- **Apron**
- **Trashrack**
- **Other:**

**Outlet type**

- **Projecting slightly**

---

**Required Photos:**

1. Inlet from upstream  
2. Outlet from downstream  
3. Inlet from road  
4. Outlet from road

---

**STREAMBED SUBSTRATE RETENTION IN STRUCTURE**

- **No substrate in structure**
- **Discontinuous layer of substrate in structure begins at ft; ends at ft (measured from inlet)**
- **Substrate is continuous throughout structure**

**If present, substrate depth at inlet ft; substrate depth at outlet ft**

---

**Comments:**

Poor habitat u/s of crossing. Organic grass channel. Some flows present.

Rock blocking inlet at around 50%. Only around 100m of stream u/s of crossing. Outlet drop 1.16m and 30% gradient from outlet prevent fish passage.

---

### Photographs: (identify and provide captions)

<table>
<thead>
<tr>
<th>Photo caption</th>
<th>Photo #</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Inlet from upstream</td>
<td>1224</td>
<td></td>
</tr>
<tr>
<td>2. Outlet from downstream</td>
<td>1228</td>
<td></td>
</tr>
<tr>
<td>3. Inlet from road</td>
<td>1225-26</td>
<td></td>
</tr>
<tr>
<td>4. Outlet from road</td>
<td>1227</td>
<td></td>
</tr>
</tbody>
</table>
CULVERT MONITORING FIELD DATA SHEET
HIGHWAY 3 AQUATICS

STREAM NAME: ___Peltiere creek___
ROAD NAME: ___Hwy 3___
NEAREST MILE POST: __________
INSPECTOR NAME(S): __________ MR, DP ________________________________
LOCATION (LAT./LONG.): __________ FIELD DATE: __Nov/23/2012__

CROSSING STRUCTURE

Shape
- Circular
- Box
- Open-bottom arch
- Pipe-arch
- Ford
- Other: __________

Dimensions (inches)
- Width: __0.78__
- Height: __0.92__

Structure shape comments: ___________

Structure material
- Spiral CMP
- Annular CMP
- Structural plate (SP)
- Concrete
- Smooth steel
- Other: __________

Corrugations
- 0.2 x 1.0 inch
- 0.5 x 1.0 inch
- 0.6 x 2.0 inch (SP only)
- None

Skew from road
- __130__ degrees

Outlet configuration
- Yes
- No

Baffles, weirs or other internal structures:
- __________

Inlet type
- Projecting
- Mixed
- Wingwall 10.30°
- Wingwall 30.70°
- Headwall
- Apron
- Trash rack
- Other: __________

Pipe conditions:
- Breaks inside culvert (Location __________)
- Fill eroding
- Debris plugging inlet (% blockage __________)
- Bent inlet
- Bottom worn through
- Poor alignment with stream
- Debris in culvert (i.e. rock, snow, wood)
- Water flowing under culvert
- Other: __________

Describe overall conditions: __________

STREAMBED SUBSTRATE RETENTION IN STRUCTURE

- No substrate in structure
- Discontinuous layer of substrate in structure begins at __________ ft; ends at __________ ft (measured from inlet)
- Substrate is continuous throughout structure

If present, substrate depth at inlet __________ ft; substrate depth at outlet __________ ft

Crossing name/number: __________ Structure: __________ of: __________

Comments:

Double culvert with flow in both. Moderate habitat u/s of road. Could be improved with some structures to diversity from homogenous riffle.

Photographs: (identify and provide captions)

<table>
<thead>
<tr>
<th>Photo caption</th>
<th>Photo #</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Inlet from upstream</td>
<td>1220</td>
<td></td>
</tr>
<tr>
<td>2. Outlet from downstream</td>
<td>1223</td>
<td></td>
</tr>
<tr>
<td>3. Inlet from road</td>
<td>1221</td>
<td></td>
</tr>
<tr>
<td>4. Outlet from road</td>
<td>1222</td>
<td></td>
</tr>
</tbody>
</table>
STREAM NAME: Leitch creek
ROAD NAME: Hwy 3
NEAREST MILE POST: 0
LOCATION (LAT./LONG.): 49.657416/-114.325841
FIELD DATE: Nov. 23, 2012

CROSSING STRUCTURE

Shape
- Circular
- Box
- Open-bottom arch
- Pipe-arch
- Ford
- Other:

Dimensions (m)
- Circular width: 0.60
- Height: 0.75

Structure shape comments:
- Multiple structures at site:
  1. If of total openings at the crossing site.

Structure material
- Corrugations:
  - Spiral: CMP
  - Annular: CMP
  - Structural plate (SP): 2 2/3 x 1/2 inch
  - Concrete: 3 x 1 inch
  - Steel: 5 x 1 inch
  - Smooth: 6 x 2 inch (SP only)
  - Smooth steel: None
  - PVC: None
  - Smooth steel: Paved or smooth invert
  - Other:

Outlet configuration
- Baffles, weirs or other internal structures:
  - YES
  - NO

Outlet type
- Projecting
- Mitered
- Wingwall 10-30°
- Wingwall 30-70°
- Headwall
- Apron
- Trashrack
- Other:

Inlet type
- Projecting
- Mitered
- Wingwall 10-30°
- Wingwall 30-70°
- Headwall
- Apron
- Trashrack
- Other:

Outlet configuration comments:
- At stream grade
- Cascade over riprap
- Reversal into pool
- Reversal onto riprap
- Outlet apron
- Other:

Shape comments:
- Inlet grade but onto:
- Other:

Structure comments:
- Fill slope of road so not natural grade.
- Material:
- Description:
- Describe overall conditions:

Crossing name/number:
- Structure of:

STREAMBED SUBSTRATE RETENTION IN STRUCTURE
- No substrate in structure
- Discontinuous layer of substrate in structure begins at ______ ft; ends at ______ ft (measured from inlet)
- Substrate is continuous throughout structure
If present, substrate depth at inlet ______ ft; substrate depth at outlet ______ ft

Comments:
- Very low flows draining wetland upstream. Culvert generally in good shape. No real potential for u/s fish habitat.
- Outlet spills onto road fill with no real defined channel. Unlikely to have any fish bearing habitat between Hwy3 and CP rail line.

Photographs: (identify and provide captions)

<table>
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<tr>
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<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet from upstream</td>
<td>1208</td>
<td></td>
</tr>
<tr>
<td>Outlet from downstream</td>
<td>1210</td>
<td></td>
</tr>
<tr>
<td>Inlet from road</td>
<td>1207</td>
<td></td>
</tr>
<tr>
<td>Outlet from road</td>
<td>1209</td>
<td></td>
</tr>
</tbody>
</table>
STREAM NAME: Rock
ROAD NAME: Hwy 3
NEAREST MILE POST: 

LOCATION (LAT./LONG.): 49.581709/-114.230124
FIELD DATE: Nov. 23, 2012

CROSSING STRUCTURE

Shape
- Circular
- Box
- Open-bottom arch
- Pipe-arch
- Ford
- Other:

Dimensions (m)
- width: 2.04
- height: 3.10

Structure shape comments: oval - taller than wide

Structure material
- Spiral CMP
- Annular CMP
- Structural plate (SP)
- Concrete
- Smooth steel
- PVC
- Other:

Corrugations
- See Attached Figures for Clarification
- 2 3/9 x 1/2 inch
- 3 x 1 inch
- 5 x 1 inch
- 6 x 2 inch (SP only)
- None

Skew from road
- 45
- Other:

Inlet type
- Projecting
- Mitered
- Wingwall 10-30°
- Wingwall 30-70°
- Headwall
- Apron
- Trasstrap
- Other:

Outlet configuration
- at stream grade
- cascade over riprap
- freefall over pool
- outlet apron
- Other:

Baffles, weirs or other internal structures:
- YES
- NO
- Potentially

Material:
- Describe:
- Describe overall conditions:

Pipe conditions:
- Off inside culvert
- Known
- Debris plugging inlet (% blockage)
- Bent inlet
- Bottom worn through
- Poor alignment with stream
- Debris in culvert (i.e. rock, snow, wood)
- Water flowing under culvert
- Other:

Crossing name/number: __________

STREAMBED SUBSTRATE RETENTION IN STRUCTURE
- No substrate in structure
- Discontinuous layer of substrate in structure begins at __________ ft; ends at __________ ft (measured from inlet)
- Substrate is continuous throughout structure
- If present, substrate depth at inlet __________ ft; substrate depth at outlet __________ ft

Comments:

A very long culvert under 30m fill. Could not observe much inside the culvert due to ice. The culvert bends at 30 degrees at 40m from inlet. From what was observed it appears that the culvert was installed on a 2 gradient.

Fish passage is likely difficult due to overall culvert length.

Culvert plunge is minimal but could be removed with backwatering.

Installation of baffles would likely be required.

Overall fish habitat is excellent. Consideration of hybridization must be given.

Photographs: (identify and provide captions)

<table>
<thead>
<tr>
<th>Photo caption</th>
<th>Photo #</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Inlet from upstream</td>
<td>1199/1200</td>
<td></td>
</tr>
<tr>
<td>2. Outlet from downstream</td>
<td>1195/1196</td>
<td></td>
</tr>
<tr>
<td>3. Inlet from road</td>
<td>1199/1200</td>
<td></td>
</tr>
<tr>
<td>4. Outlet from road</td>
<td>1197/1198</td>
<td></td>
</tr>
<tr>
<td>5. U/s culvert</td>
<td>1193-1194</td>
<td></td>
</tr>
</tbody>
</table>
CULVERT MONITORING FIELD DATA SHEET
HIGHWAY 3 AQUATICS

STREAM NAME: Burmis creek
ROAD NAME: Hwy 3
NEAREST MILE POST: 

INSPECTOR NAME(S): MR, DP
LOCATION (LAT./LONG.): 49.556081/-114.303779
FIELD DATE: Nov/23/2012

CROSSING STRUCTURE

Shape | Dimensions (m)
--- | ---
Circular | width: 1.7, height: 1.8
Open-bottom arch
Pipe-arch
Ford
Other: 

Structure shape comments:

Multiple structures at site: 1 of total openings at the crossing site.

Structure material
- Corrugations: See Attached Figures for Clarification
- Skew from road: 40°

Inlet type
- Projecting
- Mitered
- Wingwall 10.30°
- Wingwall 30.70°
- Headwall
- Apron
- Trash Rack

Outlet configuration
- At stream grade
- Cascade over rip rap
- Reentry into pool
- Reentry into rip rap
- Outlet apron
- Other: 

Baffles, weirs or other internal structures:
- YES
- NO
- Material: 
- Describe (see sketch): 

Pipe conditions:
- Breaks inside culvert (Location: )
- Fill eroding
- Debris plugging inlet (% blockage: )
- Bent inlet
- Bottom worn through
- Poor alignment with stream
- Debris in culvert (i.e. rock, snow, wood)
- Water flowing under culvert

Describe overall conditions:

Crossing name/number: Structure: 

STREAMBED SUBSTRATE RETENTION IN STRUCTURE
- No substrate in structure
- Discontinuous layer of substrate in structure begins at ________ ft; ends at ________ ft (measured from inlet)
- Substrate is continuous throughout structure

If present, substrate depth at inlet ________ ft; substrate depth at outlet ________ ft

Comments:
Dry at time of survey. 0.5 m channel leading into culvert.

Photographs: (identify and provide captions)

<table>
<thead>
<tr>
<th>Photo caption</th>
<th>Photo #</th>
<th>Comments</th>
</tr>
</thead>
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<td>1201-02</td>
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</tr>
<tr>
<td>2. Outlet from downstream</td>
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<td>3. Inlet from road</td>
<td>1203</td>
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</tr>
<tr>
<td>4. Outlet from road</td>
<td>1204</td>
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</tbody>
</table>
Appendix B: Crossing Photographs
View from upstream at Girardi Cr. culvert inlet.

View from downstream at Girardi Cr. culvert outlet.
View from downstream at Allison Cr. culvert outlets.

View from inlet at Allison Cr. channel upstream of crossing.
View from downstream at Bohomolec Cr. culvert outlet.

View from upstream at Bohomolec Cr. culvert inlet.
View from downstream at McGillvray Cr. culvert outlet.

View from inlet of McGillvray Cr. at upstream channel.
View from downstream at Nez Perce Cr. culvert outlet.

View from upstream at Nez Perce Cr. culvert inlet.
View from downstream at First Cr. culvert outlet.

View from upstream bank at First Cr. culvert inlet.
View from upstream at Peltiere Cr. culvert inlet.

View from upstream at Peltiere Cr. culvert outlet.
Barriers and Fish Passage

Appendix

View from downstream at Leitch Cr. culvert outlet.

View from downstream at Leitch Cr. culvert inlet.

Western Transportation Institute
View from downstream at Rock Cr. culvert outlet.

View of Rock Cr. culvert inlet.
View from downstream at Burmis Cr. culvert outlet.

View of Burmis Cr. culvert inlet.
View from downstream at Gold Cr. Bridge.
View from downstream at Blairmore Cr. bridge.
7. REFERENCES


Department of Fisheries and Oceans. 2012. URL: http://www.cosewic.gc.ca/eng/sct0/index_e.cfm#sar, accessed November 26, 2012.


