# Fish Passage - Culvert Inspections
# where
# Yellowhead Highway 16 and Singlehurst Road
# cross
# Singlehurst (Swede) Creek

Yellowhead Highway 16 Culvert and broken down fish ladder

Singlehurst Road Culvert

**March 2006**

**Fish Passage - Culvert Inspections where**
**Yellowhead Highway 16 and Singlehurst Road cross Singlehurst Creek**
**(Watershed Code 400-232100)**

**Contract 356CS0561**

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## Executive Summary

Culvert crossings at Singlehurst Creek (watershed code 400-232100) on the Yellowhead Highway 16 and the Singlehurst Road were assessed on August 23rd, 2005. Fish passage culvert inspections were conducted at the both crossings following methods outlined in the Fish Passage – Culvert Inspection Procedures (Watershed Restoration Technical Circular No. 11). In addition, Fisheries Priority Scores were calculated to allow a comparison of the findings, from a fisheries perspective, to other culvert obstructions that have been identified along Highway 16 from Terrace to New Hazelton.

In Singlehurst Creek, Dolly Varden, cutthroat trout, and rainbow trout/steelhead have been documented upstream of the Highway 16 crossing (0.8 km upstream of the Skeena River) and the Singlehurst Road crossing (1.5 km upstream of Highway 16), and pink salmon were observed 200 meters upstream of Singlehurst Road on August 23rd, 2005. Stream gradient of the mainstem and southern tributaries quickly increase to greater than 20% at the foot of Bornite Mountain, which limits fish distribution to the lower 3 km of Singlehurst Creek and a few short sections of its lower tributaries below 200 metre elevation. Good salmonid spawning and rearing habitat was identified in this system, and Singlehurst Creek has previously been identified as an important system for coho and Dolly Varden.

The Highway 16 culvert was identified as a partial obstruction to fish passage, while the extent of fish passage issues at the Singlehurst Road culvert were not conclusively determined. Neither of the two culverts were embedded or baffled. The 2000 mm diameter culvert at the Highway 16 crossing of Singlehurst Creek appears to be undersized, has a gradient of 2.5%, and exhibits water velocities in excess of burst or prolonged swimming abilities of juvenile salmonids in the system. A log structure, constructed in 1978 on the downstream end of the Highway 16 culvert has reduced the drop from the culvert from more than one metre to less than 15 cm, but the structure was in need of repair, and was impeding fish passage at the time of survey. The 3000 mm diameter culvert at the Singlehurst Road crossing was adequately sized for estimated FPCI $Q_{100}$ flow levels, the average water velocity was within the range reported for juvenile salmonids, but a 1.5 meter section with high water velocity at the inlet of the culvert exceeds burst and prolonged swimming abilities for juvenile fish and may make the culvert impassable for some life stages at some flows. Some of the water at the Singlehurst Road crossing appears to be draining under, rather than through the culvert, and the upstream end of the half-pipe is lifting, causing increased water velocity.

Recommendations for the Highway 16 crossing and the Singlehurst Road crossing of Singlehurst Creek include short-term and long-term options. Because the Highway 16 structure is undersized, short-term recommendations are limited to restoring or replacing the log weirs and the temporary fish ladder downstream of the culvert to ensure that the crossing continues to be passable for adult salmon and trout. Installation of baffles or backwatering of the culvert are not considered viable options because of the relatively low discharge capacity of the existing structure. The eventual replacement of the structure with an adequately sized open bottom structure is recommended. Since the Singlehurst Road crossing is adequately sized to accommodate estimated FPCI $Q_{100}$ flow levels, several mitigation options have been identified. Proposed options to ensure fish passage for all life stages that may be considered at the Singlehurst Road crossing include installation of weirs to backwater the culvert, potential embedding of the culvert, and installation of baffles, in conjunction with repairs at the culvert inlet that will ensure water flow does not continue to undermine the structure. A greater range of restoration options were identified at the Singlehurst Road crossing than at the Highway 16 crossing because the Highway 16 crossing appears to be undersized, which limits potential retrofit designs at this site to those that do not decrease the capacity of the culvert.

FPCI rankings and Fisheries Priority Scores determined for both structures indicate that the Highway 16 crossing is a higher priority for fish passage restoration than the Singlehurst Road crossing. Highway 16 received an FPCI ranking of a "High Priority", while the Singlehurst Road crossing received an FPCI ranking of "Low Priority", reflecting the more significant fish passage problems at Highway 16, and the greater amount of fish habitat upstream of Highway 16. The fisheries priority score for the Highway 16 crossing was third highest of 13 culverts along Highway 16 where fish passage issues have been identified. This is largely due to the high quality and quantity of fish habitat upstream of Highway 16. The fisheries priority score for the culvert where Singlehurst Road crosses of Singlehurst Creek was considerably lower, and was equivalent to the 7$^{th}$ highest score of the Highway 16 crossings between Terrace and New Hazelton, largely due to the lower quantity of available fish habitat upstream of the crossing. Maintenance concerns at the Singlehurst Road crossing, where some water appears to drain underneath the culvert, may provide opportunities to improve fish passage at this site in conjunction with culvert maintenance activities.

**Acknowledgements**

We wish to acknowledge the thorough review and helpful comments provided on draft versions of this report by Daryl Nolan (Ministry of Transportation) and Lana Miller (Fisheries and Oceans Canada). We also thank Don Hjorth (Fisheries and Oceans Canada) for meeting with us on site, and providing insight into conceptual plans for restoration of fish access at the highway crossing. This project was jointly funded by the BC Ministry of Transportation, and Fisheries and Oceans Canada.

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## 1.0 INTRODUCTION

Ministry of Transportation (Northern Region) and Fisheries and Oceans Canada (Smithers) contracted SKR Consultants Ltd. to conduct fish passage inspection where the Yellowhead Highway 16 crosses Singlehurst Creek. This stream crossing was chosen for assessment, in conjunction with the crossings at Station Creek and Flint Creek (SKR 2006a, b) since the Gitksan Watershed Authority identified these crossings as high priority sites for additional assessments during a preliminary study conducted in 2004 (Rabnett and Williams 2004). An additional culvert crossing on Singlehurst Road was also assessed to determine the potential for upstream barriers to fish migration in Singlehurst Creek.

The study area is located in north central British Columbia. Singlehurst Creek (watershed code: 400-232100) is a 4$^{th}$ order (1:20,000 scale) tributary to the Skeena River, and is located approximately 19 km north of Terrace (Figure 1). Singlehurst Creek drains the west slope of Bornite Mountain and enters into the Skeena River between Kleanza Creek and Chimdemash Creek. This system falls within the Skeena Region of the Ministry of Environment (MoE), the Prince Rupert Region (Region 6) of Fisheries and Oceans Canada, and the Skeena District (No. 10) of the Ministry of Transportation. The system drains an area of approximately 13 km$^2$ (Rabnett and Williams 2004) with a range in elevation from 100 metres to approximately 1300 metres. The Highway 16 crossing of Singlehurst Creek is located approximately 800 metres upstream of the Skeena River, and crosses Highway 16 between the Kleanza Bridge and Gooden Road. Singlehurst Road also crosses Singlehurst Creek approximately 1.5 km upstream of Highway 16. The Ministry of Transportation location from the Landmark Kilometer Inventory system (LKI) is 15.61 km on Highway 16 in Segment 1510 (Terrace-Kitwanga) (Cypher Consulting 2005).

The main objective of this project was to give Ministry of Transportation (MoT) and Fisheries and Oceans Canada (FOC) a more a detailed description of the types and relative values, from a fisheries perspective, of future efforts toward restoring fish passage at Singlehurst Creek. The focus of this study was to assess the Singlehurst Creek crossings for fish passage, review existing information on fish distribution to determine fish species for which fish passage is required, and determine the amount and quality of habitat upstream of the crossings. The Singlehurst Creek crossings at Yellowhead Highway 16 and Singlehurst Road were assigned Fish Passage-Culvert Inspection (FPCI) priority rankings (Parker 2000) and more detailed fisheries priority scores (Johnson and Saimoto 2003) for a relative comparison of the benefits to restoring fish passage at different culvert crossings along the portion of the Yellowhead Highway 16 from Terrace to Hazelton.

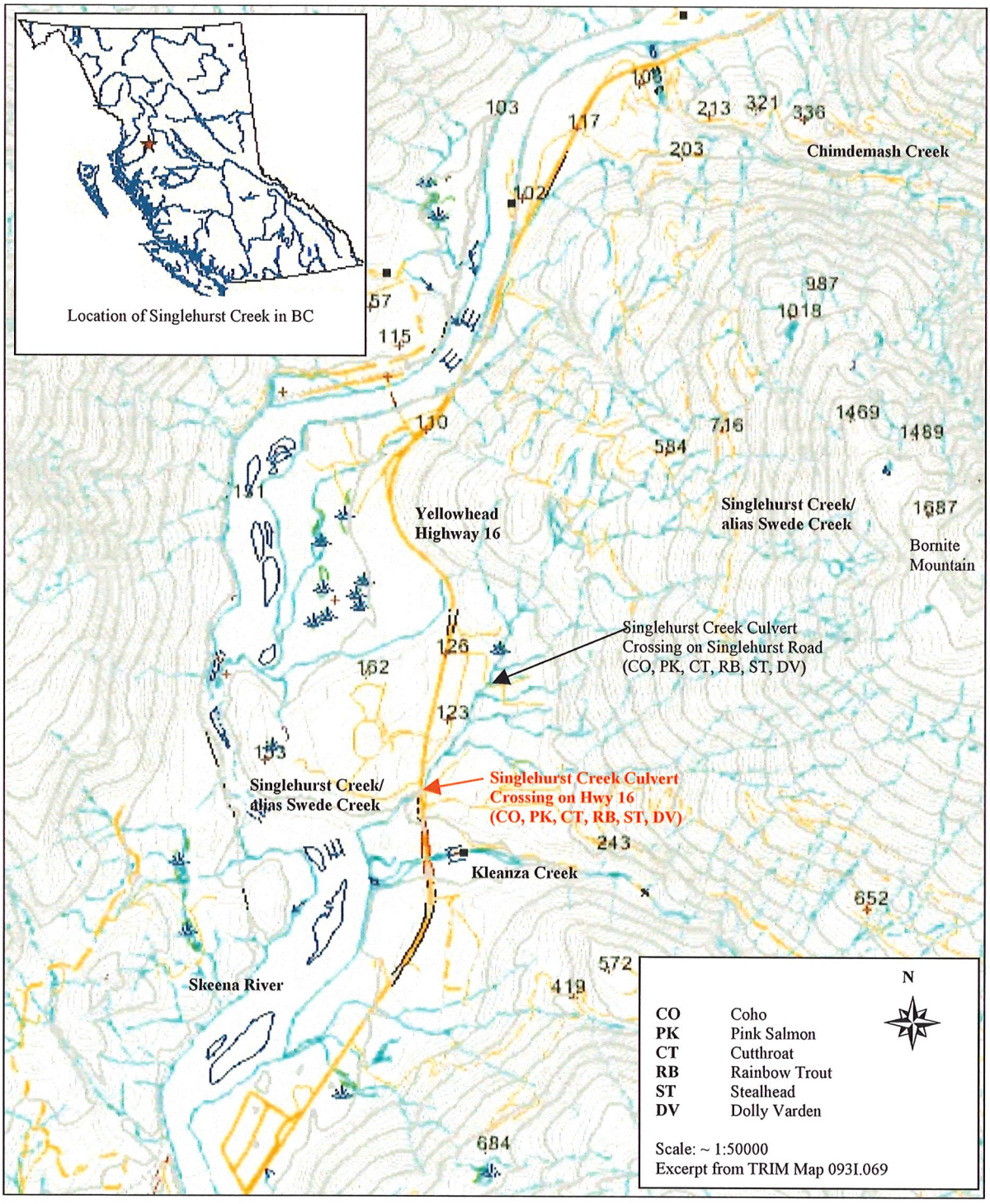


**Figure 1.** Locations where Yellowhead Highway 16 and Singlehurst Road cross Singlehurst Creek in the Skeena River Watershed.

## 2.0 METHODS

The following sections include a summary of the pre-field planning, the field component and criteria used to provide a rank (i.e. FPCI Score and Ranking), and a relative priority from a fisheries perspective (i.e. Fisheries Priority Score) for future work on Singlehurst Creek.

### 2.1 PRE FIELD PLANNING

Available fisheries information for Singlehurst Creek was compiled and reviewed prior to the initial field visit. The Fisheries Information Summary System (FISS 2005), as well as the Smithers MoE, MoT, and FOC offices were consulted for related information. Ministry of Transportation kindly provided an excerpt of a report summarizing a previous preliminary assessment of the Singlehurst Creek crossing (Rabnett and Williams 2004). The watershed code for Singlehurst Creek was determined from the watershed atlas (BC Ministry of Sustainable Resource Management 2005 at http://msrm.gov.bc.ca/gis).

### 2.2 FIELD COMPONENT

A preliminary visit to the Singlehurst Creek crossing was conducted on August 5th, and follow-up visit was conducted on August 23rd, 2005 with Lana Miller and Don Hjorth (Fisheries and Oceans Canada) as well as Daryl Nolan (Ministry of Transportation). Data were collected as per *Watershed Restoration Technical Circular #11: Fish Passage – Culvert Inspection Procedure* (FPCI) (Parker, 2000), and the data forms in the FPCI were used during the field assessment of the culvert (Appendix 1). Field investigation included field confirmation of natural limits to fish distribution to provide more accurate estimates of the suitability of sites for improvements of fish passage. The following procedures were used for collecting the required data:

- FPCI field forms (Parker 2000)
- A hip chain was used to measure culvert length, and to measure stream lengths sampled.
- A meter stick and tape measure were used to measure: culvert diameter (rise/span, width/height); culvert wetted width; culvert water depth; culvert out-fall drop; pool depth at outfall; channel width and wetted width; stream bankfull depth and stream water depth;
- Water velocities (stream and culvert) were measured using a *Global Water FP201* velocity meter. This meter is a propeller type that can be fitted with a low-flow adapter kit if required.
- Stream gradient was measured using an Abney Level or a Suunto clinometer.
- Culvert slope was measured at the upstream and downstream end using an Abney level; measurements were averaged to obtain the culvert slope.
- The UTM locations at road crossings and natural barriers to fish migration were determined using a Garmin E-trex Legend GPS. Locational reference information recorded also included the Landmark Kilometer Inventory (Cypher Consulting 2005).
- Site photographs were taken using a high-resolution digital camera (Sony Cyber-shot, 4.1 megapixel camera).
- Conductivity and temperature were recorded using an Oaktron TDStestr3 handheld conductivity meter and an alcohol thermometer, respectively.

## 2.3 OBSTRUCTIONS TO FISH PASSAGE

Defining the severity of obstructions to fish migration considers how culvert gradient, water velocity, outfall drop and culvert length may exceed the abilities of different species at specific life stages to migrate upstream. The interpretation of the severity of obstructions to fish passage related to culvert crossings includes consideration of fish species distribution, the jumping and swimming abilities for relevant life stages of the fish species present at each location surveyed (Tables 1 and 2), and barrier classes defined by Johnston and Saimoto (2003). Specific criteria used for full and partial barrier classes for culvert gradient, water velocity, and drop are described in Appendix 2b and 2c.

**Table 1.** Maximum jumping height for adult and juvenile salmonids known or suspected present in Singlehurst Creek.

| Species | Maximum Jumping Height *[1] | |
|---|---|---|
| | Adults | Juveniles |
| Coho | 2.4 m | 0.5 m (120 mm length) |
| Chinook | 2.4 m | 0.5 m (120 mm length) |
| Chum | 1.5 m | |
| Pink | 1.5 m | |
| Cutthroat | 1.5 m | 0.6 m (125 mm length) |
| Rainbow | 1.5 m | 0.6 m (125 mm length) |
| Steelhead | 3.4 m | 0.6 m (125 mm length) |
| Dolly Varden | | |

*[1] Jumping heights are obtained from Whyte et al. (1997).

**Table 2.** Burst and prolonged swimming abilities*[1] for salmonids present in Singlehurst Creek.

| Species | Juvenile*[2] | | Adult | |
|---|---|---|---|---|
| | Burst Speed | Prolonged Speed | Burst Speed | Prolonged Speed |
| Coho | | 0.4-0.6 m/s | 3.2 - 6.6 m/s | 2.7 - 3.2 m/s |
| Chinook | | 0.4-0.6 m/s | 3.2 - 6.6 m/s | 2.7 - 3.2 m/s |
| Chum | | | 2.3 - 4.6 m/s | 1.0 - 2.3 m/s |
| Pink | | | 2.3 - 4.6 m/s | 1.0 - 2.3 m/s |
| Cutthroat | 0.4-1.1 m/s | 0.3-0.7 m/s | 1.8 - 4.3 m/s | 0.9 - 1.8 m/s |
| Rainbow | 0.4-1.1 m/s | 0.3-0.7 m/s | 1.8 - 4.3 m/s | 0.9 - 1.8 m/s |
| Steelhead | | | 4.2 - 8.1 m/s | 1.4 - 4.2 m/s |
| Dolly Varden | | 0.6-1.0 m/s | | |

*[1] Data were obtained from Whyte et al. (1997) except for Dolly Varden. Swimming ability for Dolly Varden was obtained from Hunter and Mayor (1986) as in Anonymous (2001).

*[2] Swimming abilities depend on the size of the fish. Lower range refers to juveniles 50 mm in length, upper range refers to juveniles 120-130 mm in length

The most significant obstruction to fish passage at culvert stream crossings is due to perched outlets. In conjunction with fish sampling, the drop from culvert outlets minus the plunge pool depth at the outlet is used to evaluate the severity of obstructions to fish passage at culvert outlets (Appendix 2b and 2c). The maximum jumping heights for various species present in Singlehurst Creek are provided in table 1, but it has been reported that different configurations of obstacle and plunge pool can significantly influence the jumping ability of fish (Eiserman et al. 1975 as in Bjorn and Reiser 1991) and that fish also need plunge pools to be 1.25 times as deep as the height of the fall to achieve the maximum jumping height (Whyte et al 1997). With these complications, the severity of obstructions to fish passage based on the maximum jumping abilities of relevant species (Table 1) is not very accurate for many perched culverts due to the large variability in physical configurations of the barriers at different locations. For Fisheries Priority Scores (Johnston and Saimoto 2003) 0.6 metres for drop regardless of the pool depth is considered to be a severe enough obstruction to be called a full barrier (Appendix 2b), and a 0.15 – 0.6 metre drop is considered to be a partial barrier to fish migration (Appendix 2c).

The severity of obstructions to fish migration due to culvert slope is based on the expected water velocities through a culvert versus burst and prolonged swimming abilities of the fish species present (Table 2). Since measurements taken at the inlet and outlet of the culvert do not account for sags or settling of the culvert that may increase velocities at the outlets and inlets or create pools or holding areas in the middle sections of a culvert, more detailed inspection of water velocity barriers are done where culvert slope and average water velocity data were not complimentary. Water depths in the culvert were also considered when evaluating the severity of obstructions to fish passage due to culvert slope. With these considerations, field data were examined to ensure that average water velocity and swimming abilities of fish species present (Table 2) are in agreement with the severity of the obstruction to fish passage based on the culvert slope criteria (Appendix 2b and 2c).

For an evaluation of the suitability of the existing structures at stream crossings for improvement of fish passage (e.g. baffles) versus replacement of the structure, a 100-year flood event (FPCI $Q_{100}$) was estimated and compared to FPCI recommended crossing structures (Appendix 3). The FPCI $Q_{100}$ was calculated using the following equations described in the FPCI Procedures (Parker 2000):

Equation 1: $A = ((W_w+W_{bf})*D_{bf})/2$

Where: $A$ = bankful area at average annual peak
$W_w$ = mean wetted width (m)
$W_{bf}$ = mean bankful width (m)
$D_{bf}$ = mean bankful depth (m)

Equation 2: $Q_{100} = 3(A)$

The FPCI procedures also recommend that the FPCI $Q_{100}$ be corrected by a factor of 1.16 for round culverts and 1.25 for elliptical culverts to allow for the culvert to be embedded 20% with a less than 0.5% gradient stream bed to facilitate fish passage. The $Q_{100}$ estimate completed for the culvert assessment in this study may not be acceptable for design standards used by hydrologists or engineers. Prior to final stream crossing designs, more detailed calculations of 100-year flood events (e.g. Manning's formula, BCSI and Beaumont methods) should be compared to the FPCI $Q_{100}$ and adjusted to ensure the integrity of any replaced or modified structures.

## 2.4 FISH PASSAGE CULVERT INSPECTION RANKING

The Fish Passage - Culvert Inspection (FPCI) methodology (Parker 2000) was used to calculate a score for ranking the severity of the obstruction to fish passage at the sites assessed. FPCI points are given for fish species present, habitat value, severity of the barrier, the amount of mainstem habitat to be gained, the percent of the stream barred, and whether or not the habitat to be gained is limited by other anthropogenic barriers upstream. The FPCI scoring matrix is presented in table 3, and methodologies for designating different scores are as follows:

**Table 3.** FPCI Scoring Matrix used for designating FPCI rankings for prioritization

| *Fish Species Value* | | *Habitat Value* | | *Severity of Barrier* | | *Amount of new Habitat* | | *% stream barred* | | *Limiting to Upstream barrier* | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Multiple or Significant | 10 | H | 10 | Full | 10 | ≥1 km | 10 | >70% | 10 | Yes | 5 |
| Single | 6 | M | 6 | Partial | 6 | <1km ≥500m | 6 | ≤70% ≥50% | 6 | No | 0 |
| Other | 3 | L | 3 | Undeter-mined | 3 | <500m | 3 | <50% | 3 | | |

*Species Value*: Based on the number of target or other species present. The scoring matrix distinguishes between sites with multiple target or significant species, single target species, and other species. Target species generally include sport fish, while other species include non-listed coarse fish.

*Habitat Value*: Site assessor's subjective rating (high, moderate, low) of the value of habitat to be gained based in part on habitat complexity, stream characteristics, and limiting habitats in the system.

*Severity of Barrier*: Site assessor's subjective evaluation of the severity of the obstruction (full, partial, undetermined), substantiated by culvert characteristics, ecology of fish species present, and fish distribution information.

*Amount of Habitat gained*: The length of mainstem habitat (≥1 km, ≥500m to 1km, <500m) upstream of the culvert to the natural limit of fish distribution. The natural extent of fish distribution may be determined from map and airphoto interpretation, historical information, and/or field investigations.

*Percent stream barred:* The proportion (>70%, 51-70%, <50%) of the mainstem stream length upstream of the culvert that is obstructing fish passage.

*Limiting to upstream barrier*: Provides additional scores for systems where one or more additional culverts upstream are obstructing fish passage, or where fish passage remains undetermined. Where no upstream culverts are present, or where the upstream culverts are not obstructing fish passage, this category is scored as "No". For sites where upstream culverts are known or undetermined to obstruct fish passage, this category is scored as "Yes".

Based on the FPCI matrix scores, a total score is calculated using the following equation:

**FPCI Score** = *Species Value* + *Habitat Value* + *Severity of Barrier* + *Amount of new Habitat* + *% stream barred* + *Barrier Upstream*

A ranking for different ranges of FPCI scores is given to help categorize sites with similar needs and priorities for future attention and potentially more detailed assessments and planning. FPCI Priority Rankings for future attention to fish passage issues are as follows:

| | | |
|---|---|---|
| **High** | FPCI scores | 55-39 |
| **Moderate** | FPCI scores | 38-26 |
| **Low** | FPCI scores | 25-15 |

## 2.5 FISHERIES PRIORITY SCORE FOR RESTORATION OF FISH PASSAGE

In addition to methods outlined in the Fish-Passage Culvert Inspection guidebook (Parker 2000), priority scoring from a fisheries perspective (Fisheries Priority Score) is included in this culvert assessment. The Fisheries Priority Score (Johnston and Saimoto 2003) is used to help prioritize sites based on benefits that restoring fish passage may provide. This methodology incorporates the certainty of fisheries information (*Fish Presence Factor*), the importance of species with special concern (*Species Status Factor*), the severity of the barrier to fish passage (*Barrier Factor*), and the habitat value based on the types of habitat present (*Habitat Type*), the quantity of each habitat type (*Amount of Habitat*), and the value to the species expected to use the habitat type (*Habitat Factor*).

The equation used to calculate the Fisheries Priority Score for future work on restoring fish passage is:

**Fisheries Priority Score** = [*Fish Presence Factor*] x [*Species Status Factor*] x [*Barrier Factor*] x [Habitat Value]

where:

Habitat Value = [Habitat Type]Σ[*Amount of Habitat* (km)] x [*Habitat Factor*]

The default values used for the Fisheries Priority Scoring for future attention to fish passage issues are presented in Appendix 2. General descriptions of the different factors in the equations are as follows:

*Fish Presence Factor*: Factor used to give higher priority for sites where fish are known present and lower priority where fish are not likely present (*for details see* Appendix 2f).

*Species Status Factor*: Factor used to give higher priority for sites with species of special concern (i.e. Provincial or Regional) (*for details see* Appendix 2g).

*Barrier Factor*: Factor used to give higher priority for sites with more severe obstructions to fish based on outfall drop, water velocity through a culvert, culvert gradient, or culvert length (*for details see* Appendix 2a).

Habitat Value: Factor used to estimate the habitat value specific to species present or suspected to use the habitat upstream of the barrier based on *habitat type*, *amount of habitat*, and *habitat factor*

- *Habitat Type:* Categories used to differentiate the value of fish habitat based on stream size (1st, 2nd and 3rd order or greater) and stream gradient (High (0-5%), Moderate (5-10%), and Low (>10%)) using 1:20,000 TRIM map interpretation and historical information.
- *Amount of Habitat*: The amount of habitat (km) upstream of each culvert from site analysis that used gradient classes and stream order to differentiate habitat types (*for details see* Appendix 2e).
- *Habitat Factor*: Factor used to give different habitat value for different habitat types based on species preference and species distribution (*for details see* Appendix 2f).

## 3.0 RESULTS AND DISCUSSION

The Highway 16 crossing of Singlehurst Creek was visited on August 23rd, 2005. Singlehurst Creek was walked from approximately 200 meters below the Highway 16 crossing to 250 meter above the Singlehurst Road crossing. The culvert at Singlehurst Road, located approximately 1.5 km upstream of the Highway 16 crossing, was also assessed for fish passage from approximately 100 metres downstream to approximately 250 metres upstream of Singlehurst Road. The following sections summarize culvert characteristics and stream characteristics at the Highway 16 and Singlehurst Road crossing locations, as well as fish distribution, obstructions to fish passage and fish habitat values in Singlehurst Creek. Summaries of Fish Passage - Culvert Inspection Rankings (Parker 2000) and Fisheries Priority Scores (Johnson and Saimoto 2003) are included in this section for future cost benefit comparisons to other sites in the Skeena Watershed that require more detailed assessments, improvements or restoration of fish passage.

### 3.1 FISHERIES INFORMATION

Based on historical information, Dolly Varden (*Salvelinus malma*), coho (*Oncorhynchus kisutch*), chinook (*O. tsawytscha*), chum (*O. keta*), rainbow trout/steelhead (*O. mykiss*), and cutthroat (*O. clarki*) have been documented to be present in the lower reach of Singlehurst Creek (FISS 2005, Rabnett and Williams 2004). In addition, a significant number of pink salmon (*O. gorbusha*) were observed spawning both downstream and upstream of Highway 16 during our field investigation. Due to the amount of spawning habitat and uncertainty of species identification from past studies, bull trout are also suspected to be present in Singlehurst Creek. Fish species documented or suspected in Singlehurst Creek, and their conservation status are summarized in table 4.

**Table 4.** BC Conservation status, Global and Provincial Ranking (B.C. Species and Ecosystem Explorer 2005) for fish species in Singlehurst Creek.

| Species | Global | Provincial | BC Status |
|---|---|---|---|
| Dolly Varden *(Salvelinus malma)* | Secure (G5) | Vulnerable/Apparently Secure (S3S4) | Blue |
| Cutthroat trout *(Oncorhynchus clarki clarki)* | Apparently Secure (G4T4) | Vulnerable/Apparently Secure (S3S4) | Blue |
| Bull trout[1] *(Salvelinus confluentus)* | Vulnerable (G3) | Vulnerable (S3) | Blue |
| Rainbow trout/steelhead *(O. mykiss)* | Secure (G5) | Secure (S5) | Yellow |
| Pink salmon *(O. gorbusha)* | Secure (G5) | Secure (S5) | Yellow |
| Coho salmon *(O. kisutch)* | Apparently Secure (G4) | Apparently Secure (S4) | Yellow |
| Chinook salmon *(O. tsawytscha)* | Secure (G5) | Apparently Secure (S4) | Yellow |
| Chum salmon *(O. keta)* | Secure (G5) | Secure (S5) | Yellow |

[1] bull trout have not been documented, but may be present

Fish habitat in Singlehurst Creek is restricted to elevations below 200 metres by steep gradients at the foot of Bornite Mountain. Fish habitat upstream of Highway 16 includes the upper 2200 metre section of available mainstem habitat and the lower elevation sections of two 3rd order, two 2nd order and five 1st order tributaries that flow into Singlehurst Creek upstream of Highway 16. Coho, cutthroat trout, rainbow trout, steelhead, and Dolly Varden have been reported present in Singlehurst Creek upstream of Highway 16 and Singlehurst Road (FISS 2005). In addition, pink salmon were observed spawning upstream of Singlehurst Road, approximately 2.4 kilometres upstream of the Skeena River during this site assessment, and cutthroat trout and Dolly Varden have been documented present in one of the first order tributaries that flows into Singlehurst Creek just downstream from the Singlehurst Road crossing (FISS 2005).

Singlehurst Creek has been reported to be an important coho stream (Culp 2000 as in Rabnett and Williams 2004) and coho synoptic surveys that have been conducted throughout the Skeena Watershed have included sampling of Singlehurst Creek at up to three road accessible sites upstream of Highway 16 (Taylor 1995, 1996, 1997, 1998, 2000, Bustard 1997). Results from the coho synoptic surveys support high coho use as the density estimates for age 0 coho at Singlehurst Creek were among the highest of the various streams examined throughout the Skeena watershed. For example, density estimates for age 0 coho in Singlehurst Creek approximately 600 metres upstream of Highway 16 was 0.36 coho/$m^2$ and was the 5th highest density estimate of the 27 sites sampled in the Skeena watershed for 1996 (Bustard 1997). High densities of age 0 coho upstream of the Highway 16 culvert implies that Singlehurst Creek provides very productive coho spawning habitat and that the culvert was not a significant obstruction to adult coho prior to 1999.

Synoptic surveys also included density estimates for juvenile cutthroat trout, rainbow trout/steelhead and Dolly Varden up to 2.4 km upstream of the Skeena River. Habitat assessments conducted in conjunction with synoptic surveys included lineal estimates of habitat types (riffles, pools), channel and wetted width, and LWD size and distribution that support the ranking of very good habitat quality throughout the mainstem of Singlehurst Creek. Density estimates for age 0 and age 1 cutthroat trout, rainbow trout and Dolly Varden indicate that the section of Singlehurst Creek upstream of Highway 16 is very productive for a diversity of fish species. For example, the Dolly Varden density in 1994 was estimated at 5.7 Dolly Varden per lineal meter (Petersen Estimate upstream of Highway 16) and was the highest density estimate for Dolly Varden at the 43 stream sites sampled in the Skeena watershed (Taylor 1995).

## 3.2 CULVERT ASSESSMENT

Two road crossings on Singlehurst Creek were assessed for fish passage issues during the fish passage culvert inspection project in 2005. The following sections summarize the characteristics and present conditions of the culverts located where Highway 16 and Singlehurst Road cross Singlehurst Creek.

### 3.2.1 Culvert at Yellowhead Highway 16

A detailed culvert assessment, including the completion of the Fish Passage - Culvert Inspection form (FPCI form), as outlined by Parker (2000) was conducted on August 23rd, 2005 where Highway 16 crosses Singlehurst Creek. The Highway 16 crossing of Singlehurst Creek consists of a 2000 mm diametre culvert that has a gradient of 2.5%, is not baffled or embedded, and had an outfall drop of 12.5 cm (Figure 2). The physical characteristics and the conditions at this location during the site assessment are summarized in table 5. Similar to previous assessments (Rabnett and Williams 2004), the Singlehurst Creek culvert at Highway 16 was noted to be a partial barrier to fish passage. Based on culvert area/diameter relationships in the FPCI procedures, the existing culvert is significantly undersized and is not suitable for considering installation of baffles or backwatering. The recommended size of culvert based on estimated volumes for 100 year flood events for the culvert at Highway 16 would be either 3050 mm round or 3890 x 2690 elliptical if embedded 20%.

**Figure 2.** Downstream view of culvert inlet (left) and upstream view of culvert outlet (right) where Highway 16 crosses Singlehurst Creek.

**Table 5.** Summary of FPCI assessment of culvert where Highway 16 crosses Singlehurst Creek. For details see attached culvert assessment form in Appendix 1.

| Criteria | Description |
|---|---|
| Culvert Shape: | Round |
| Culvert Material: | Multi-plate |
| Culvert Size: | 2010 by 2000 mm |
| Culvert Length: | ~ 34 meters |
| Culvert embedded: | No |
| Culvert slope: | 2.5% |
| Culvert wetted width: | 111 cm |
| Culvert water depth: | 32 cm |
| High water mark: | 65 cm |
| Outfall drop: | 12.5 cm |
| Culvert water velocity: | 2.15 m/s |
| Fill Slope Depth: | ~ 5 meters |
| Culvert Maintenance Required: | Moderate |
| Pool depth at outfall: | 120 cm |
| Sediment source: | No |
| FPCI Q100 | 6.15 $m^2$ |

### 3.2.2 Culvert at Singlehurst Road

In addition to the culvert assessment at Highway 16, a detailed culvert assessment, including the completion of the Fish Passage - Culvert Inspection form (FPCI form) was conducted on August 23rd, 2005 at the Singlehurst Road crossing of Singlehurst Creek. The Singlehurst Road structure was not included in culvert inspections of road crossings along Highway 16 conducted in 2004 (Rabnett and Williams 2004), but was assessed in 2005 to provide a more complete assessment of potential culvert obstructions on Singlehurst Creek. The Singlehurst Road crossing of Singlehurst Creek consists of 3000 mm diametre culvert that has an average gradient of 0.75%, and is not baffled or embedded (Figure 3). The physical characteristics and the conditions at this location during the site assessment are summarized in table 6. Some of the flow at the Singlehurst Road culvert on Singlehurst Creek appears to drain under rather than through the culvert. The existing culvert appears suitable for modifications to facilitate juvenile fish passage because the recommended size of culvert based on estimated volumes for 100 year flood events would be either 3050 mm round or 3890 x 2690 elliptical if embedded 20%.

**Figure 3.** Upstream view of culvert outlet (left) and downstream view of culvert inlet (right) where Singlehurst Road crosses Singlehurst Creek.

**Table 6.** Culvert Assessment where Singlehurst Road crosses Singlehurst Creek. For details see attached culvert assessment form in Appendix 1.

| Criteria | Description |
|---|---|
| Culvert Shape: | Round |
| Culvert Material: | Multi-plate |
| Culvert Size: | 3000 mm |
| Culvert Length: | 26 meters |
| Culvert embedded: | No |
| Culvert slope: | 0.75% |
| Culvert wetted width: | 161 cm |
| Culvert water depth: | 26 cm |
| High water mark: | 38 cm |
| Outfall drop: | 0 m |
| Culvert water velocity: | 0.85 m/s |
| Fill Slope Depth: | 1.0 meters |
| Culvert Maintenance Required: | Low |
| Pool depth at outfall: | 5 cm |
| Sediment source: | No |
| FPCI Q100 | 5.42 $m^2$ |

## 3.3 FISH HABITAT ASSESSMENT

Assessments of fish habitat in Singlehurst Creek were conducted outside of areas influenced by road crossings both upstream and downstream of culverts where Highway 16 and Singlehurst Road cross Singlehurst Creek. Some additional information on fish habitat in Singlehurst Creek was obtained from a previous culvert assessment (Rabnett and Williams 2004), a number of synoptic surveys (Taylor 1995, 1996, 1997, 1998, 2000, Bustard 1997), and from stream classification of the mid-upper portion of the mainstem and tributaries (Sheridan 1998). The stream data for Singlehurst Creek at Highway 16 from a previous culvert assessment (Rabnett and Williams 2004) were not comparable due to their use of point sampling at exactly 25 metres and 50 metres upstream and downstream of culverts where stream characteristics were representative of anthropogenic disturbances, and not habitat quality or reach characteristics. The following sections summarize the findings related to fish habitat quality in stream reaches associated with the Highway 16 and Singlehurst Road crossings.

### 3.3.1 Fish Habitat at Yellowhead Highway 16

Fish habitat in Singlehurst Creek was assessed on August 23rd, 2005 for 200 metres immediately upstream and downstream of the culvert at Highway 16. Channel measurements were not taken in sections of stream significantly influenced by the culvert crossing in an attempt to best represent the undisturbed stream habitat upstream and downstream of the highway. At Highway 16, Singlehurst Creek is a moderate sized stream with an average channel width of 6.8 metres. The channel was 78% wetted at the time of survey (Figure 4). Gradients ranged from 1 to 2 % and the riffle/pool morphology of the channel appeared stable both upstream and downstream of the highway. Stream characteristics upstream and downstream of the Highway 16 crossing of Singlehurst Creek are summarized in table 7.

**Figure 4.** Downstream view from culvert outlet where pink salmon are congregated and spawning (left) and upstream view approximately 80 metres upstream of culvert (right) where Highway 16 crosses Singlehurst Creek.

**Table 7.** Stream characteristics of Singlehurst Creek approximately 100 m upstream and 100 m downstream of the culvert at the Highway 16.[1]

| Criteria | Below culvert | Above culvert |
|---|---|---|
| Wetted Width: | 516 cm | 540 cm |
| Water Depth: | 59.7 cm | 25.7 cm |
| Water Velocity: | 0.7 m/s | 0.73 m/s |
| Bankfull Width: | 690 cm | 710 cm |
| Bankfull Depth: | 36.3 cm | 35 cm |
| Stream Gradient: | 1.5 % | 1% |
| Substrate: | Gravel (Size = 1-20 cm) | Gravel, Cobble (Size = 1-25 cm) |
| Fish Habitat Quality: | High | High |
| Beaver Activity: | None | None |
| Species caught: | Pink Salmon observed | Pink Salmon observed |

[1] For details see attached culvert assessment form (Appendix 1).

For FPCI scoring and ranking, the habitat value for Singlehurst Creek was assessed upstream and downstream of Highway 16. Fish habitat downstream of the culvert appeared to be excellent, with pink salmon holding and spawning throughout the entire section surveyed. The substrate and gradient appeared to provide ideal salmonid spawning habitat, and this was supported by the presence of approximately 200 adult pink salmon and several redds in the 200 metre section surveyed downstream of the highway. Suitable spawning habitat was less abundant in the section surveyed upstream of Highway 16 as upstream disturbances appear to have degraded the habitat where gradient is slightly lower and fine sediment deposits were noted. No side or back channel habitat was observed in the sections surveyed, but the mature forest surrounding Singlehurst Creek, with its stable stream banks, good volume of discharge, the presence of some deep pools (0.6 m deep) and sections with cobble substrate suggest that this reach provides good rearing and overwintering habitat. Overall, habitat quality appears to be excellent upstream of the highway based on the high quality and quantity of good rearing habitat that was more abundant than in the section surveyed downstream of the highway. In agreement with a previous culvert assessment in 2004 (Rabnett and Williams 2004), the above findings identified the habitat value for Singlehurst Creek at Highway 16 to score high for the FPCI scoring matrix. More detailed breakdowns of habitat value for the Fisheries Priority Score are provided in Section 3.6.

### 3.3.2 Fish Habitat at Singlehurst Road

Fish habitat in Singlehurst Creek was assessed on August 23rd, 2005 for 300 metres immediately upstream and 150 metres downstream of the culvert at Singlehurst Road. Channel measurements were not taken in sections of stream significantly influenced by the culvert crossing in an attempt to best represent the types of stream habitat upstream and downstream of Singlehurst Road. At Singlehurst Road, Singlehurst Creek is a moderate sized stream with an average channel width of 6.2 metres and the channel was 76% wetted at the time of survey (Figure 5). Gradients ranged from 0.5 to 2 % with riffle/pool morphology, but the channel was heavily braided and banks were heavily scoured approximately 200 metres upstream of the road crossing. Stream characteristics upstream and downstream of the Highway 16 crossing of Singlehurst Creek are summarized in table 8.

**Figure 5.** Downstream view (left) and upstream view (right) of Singlehurst Creek from Singlehurst Road.

**Table 8.** Stream characteristics of Singlehurst Creek approximately 40 m upstream and 40 m downstream of the culvert at the Singlehurst Road crossing. For details see attached culvert assessment form (Appendix 1).

| Criteria | Below culvert | Above culvert |
|---|---|---|
| Wetted Width: | 490 cm | 450 cm |
| Water Depth: | 23 cm | 18 cm |
| Water Velocity: | 0.9 m/s | 0.5 m/s |
| Bankfull Width: | 640 cm | 596 cm |
| Bankfull Depth: | 35 cm | 31.3 cm |
| Stream Gradient: | 1% | 1% |
| Substrate: | Sand, Gravel | Sand, Gravel |
| Fish Habitat Quality: | High | High |
| Beaver Activity: | None | None |
| Species caught: | Pink Salmon observed | Pink Salmon observed |

For FPCI scoring and ranking, the habitat value for Singlehurst Creek was assessed upstream and downstream of Singlehurst Road. Fish habitat downstream of the culvert appears to provide excellent rearing and overwintering habitat due to the presence of good flow, deep glides and pools with overhanging vegetation, undercut banks, and some functioning large woody debris. A few small pockets of gravel substrate suitable for spawning were observed, but fine sediments dominated the substrate. The stream was braided in several sections upstream from the culvert for approximately 250 metres but one pair of pink salmon was observed approximately 200 metres upstream of Singlehurst Road. Some excellent potential spawning habitat was identified upstream of the braided section, but sediment wedges appeared to limit fish migration during lower flows. Upstream disturbances appear to have degraded the habitat where gradient is slightly lower and fine sediment deposits were noted. Overall, habitat quality appears to have been more productive prior to upstream disturbances, but high densities of juvenile fish in previous synoptic surveys suggest that this habitat provides very good rearing and spawning habitat. Despite the presence of some channel instability upstream of Singlehurst Road, the habitat value for the FPCI matrix scoring for Singlehurst Creek is rated high (10 points) where it is crossed by Singlehurst Road. More detailed breakdowns of habitat value for the Fisheries Priority Score are provided in Section 3.6.

## 3.4 OBSTRUCTIONS TO FISH MIGRATION

Two culvert stream crossings, located where Highway 16 and Singlehurst Road cross Singlehurst Creek, were assessed to identify the severity of their obstructions to fish passage and to designate the barrier types for their FPCI Ranking and Fisheries Priority Scores.

### 3.4.1 Obstruction to Fish Passage at Yellowhead Highway 16

Prior to 1978, the drop from the culvert outlet located where Highway 16 crosses Singlehurst Creek was approximately 1.7 metres and was a full barrier to fish passage (Rabnett and Williams 2004). In 1978, Fisheries and Oceans Canada (FOC) installed two log weirs downstream of the culvert (Figures 6 and 7) in order to restore fish passage (Southgate 1978 as in Rabnett and Williams 2003, Hancock *et al* 1983 as in Rabnett and Williams 2004). An approximately 2 metre wide, 10 metre long side channel was added on river left, with boulder step pool morphology in conjunction with a wood fish ladder parallel to the log weir to aid in fish passage past the weir (Figure 7). Since the placement of this weir, the culvert has been reported to be a partial barrier to fish passage, and a significant obstruction to fish passage for some life stages (Rabnett and Williams 2004). This site was visited on August 23rd 2005, to re-assess the conditions and severity of obstruction to fish migration of the culvert and weir located where Highway 16 crosses Singlehurst Creek.

At the time of survey, the length and size, shallow water depth, and moderate water velocity in this culvert appeared to significantly impede fish migration. The outfall drop at the Highway 16 culvert (12.5 cm) did not form an obstruction to fish migration due to an approximately 1.4 metre deep pool at the outlet that was created by the backwatering effect of the log weir that was installed by FOC in 1978. Culvert slope (2.5%) exceeds the maximum recommended culvert slope of un-baffled culverts greater than 24 m in length (0.5%) (Parker 2000) and water velocity at the Highway 16 culvert (2.15 m/s) exceeds the burst and prolonged swimming abilities reported for all juvenile salmonids that utilize Singlehurst Creek for rearing habitat. In addition, water velocity in this culvert is in the upper range of the prolonged swimming abilities reported for adult chum and pink salmon in the literature (table 2). Water depth in the culvert (32 cm) was also near the minimum recommended water level in culverts requiring adult salmonid passage (30 cm, Parker 2000) at the time of survey. Pink salmon were observed struggling to swim the entire length of this culvert at the time of survey, and the few that were accidentally chased downstream into the culvert inlet were washed all the way downstream to the outlet.

**Figure 6.** Upstream view of approximately 12.5 cm drop from culvert outlet (left) and downstream view of deep pool and top of first weir downstream of the culvert outlet where Highway 16 crosses Singlehurst Creek.

**Figure 7.** Upstream view of log weir structure with broken wood fish ladder (left) and 12% gradient, boulder side channel beside the log weir (right) in Singlehurst Creek at outlet from the Highway 16 culvert.

The log weir structures located immediately downstream of the culvert are in need of restoration efforts if replacement of this culvert is not planned for in the immediate future. The effective culvert drop is expected to increase and may form an additional obstruction if the deteriorating log structure at the culvert outlet is not upgraded or replaced. The lower weir was embedded in the stream bed and was hardly visible at the time of survey. The upper weir was located approximately 8 metres downstream from the culvert outlet and creates an approximately 1.4 metre drop into a very shallow pool that is filled with gravel and cobble. Pink salmon were observed attempting to jump this barrier without success. Remnants of the wooden fish ladder that was originally placed parallel to the log weir was not functional at the time of survey (Figure 7). The side channel on river left of the upper weir that was constructed with boulder step pools was also degraded and appeared to be significantly impeding fish passage at the time of survey (Figure 7). The presence of approximately 80 fish immediately downstream of the weir and only a few fish in the pool above the upper weir at the time survey suggests that the weirs below this culvert were a significant obstruction to pink salmon migration with the flow conditions at the time of survey.

The culvert located where Highway 16 crosses Singlehurst Creek was obstructing juvenile fish passage due to velocity barriers, and a combination of the culvert and failing weir structures appeared to obstruct adult fish migration at some flows. This crossing was confirmed not to be a full barrier to fish passage, as indicated by the presence of pink salmon spawning upstream of the crossing. Since adult pink salmon are known to have relatively poor jumping and swimming abilities (Tables 1 and 2), adults of all salmonid species documented to use Singlehurst Creek are likely able to migrate upstream through the existing structure. However, fish passage at the Highway 16 crossing may be further jeopardized if the failing log weir structure is not repaired or replaced.

### 3.4.2 Obstructions to Fish Passage at Singlehurst Road

The culvert located where Singlehurst Road crosses Singlehurst Creek had not been previously assessed, but was visited on August 23rd 2005 during a field investigation of the limits of fish distribution in Singlehurst Creek upstream of Highway 16. At the time of survey, flow from the outlet of this culvert had only a short but gradual drop over a shallow riffle and did not appear to impede fish passage. Although the average water velocity from measurements taken at the inlet and outlet of the culvert (0.85

m/s) exceeded the prolonged swimming ability for the juvenile life stages of most species in the system, flow was deemed passable along the shallower edges of wetted area through this culvert (Section 3.2, Figure 3). Overall, this culvert is likely passable for most species and life stages, but the higher velocity flow at the inlet to this culvert (1.2 m/s), where the half-pipe portion appeared to be lifting, likely impedes juvenile fish passage at some flows (Section 3.2, Figure 3). Notably, the culvert water depth (26 cm) was below the recommended minimum depth for adult anadromous fish (30 cm), but was above the minimum recommended depth for resident trout (15 cm) (Votapka 1991 as in Parker 2000) and did not appear to effect either adult or juvenile fish migration during the low summer flows at the time of survey. One pair of pink salmon was observed approximately 200 metres upstream of this crossing and this implies that the adults of all species documented in the system are also able to migrate through the culvert since pink salmon are reported to have the weakest swimming abilities (Table 2). This culvert stream crossing was considered to be a partial barrier to fish passage due to it not being embedded or baffled, and because the lifting half-pipe portion of the culvert at the inlet appears to impede juvenile migration at some flows.

## 3.5 FPCI Ranking for Obstructions to Fish Passage

In order to rank culverts with respect to their priority for further restoration efforts, the data collected for Singlehurst Creek were used to calculate the FPCI matrix score for FPCI Rankings for the stream crossings at Highway 16 and Singlehurst Road. Data were assessed using the FPCI scoring matrix (Parker 2000, see Appendix 1). The matrix totals the subscore values for fish species present, habitat value, barrier type (full, partial, undetermined), length of habitat upstream, proportion of stream habitat barred, and the presence of further upstream barriers to determine if the culvert is within the range of low, moderate or high priority for further efforts toward restoring fish passage.

The Singlehurst Creek crossing at Highway 16 received a prioritization score of 46 (of a maximum possible score of 55), and the crossing at Singlehurst Road received a score of 23 (Appendix 1). Scoring information for the Singlehurst crossings are summarized in the FPCI summary table (Table 9) below. The FPCI score obtained during our assessment of the Singlehurst Creek culvert structure at Highway 16 is similar to that obtained by Rabnett and Williams (2004), who calculated a score of 50. Rabnett and Williams (2004) scored the Singlehurst structure as a full barrier since the log work below the culvert was deteriorating, and they felt that the culvert would be a full barrier in the absence or continued decay of the log works. Based on the FPCI scoring matrix results (Table 9), the culvert at Singlehurst Road is given a low priority ranking, while the culvert at Highway 16 is given a high priority for further efforts toward improving or restoring fish passage.

**Table 9.** Fish passage - culvert inspection (FPCI) summary table for the Highway 16 and the Singlehurst Road crossings of Singlehurst Creek. The scores of individual parameters are identified in parenthesis.

| Location | Species* | Habitat Value | Barrier | Length to be Gained | % stream barred | Barrier Upstream | FPCI Ranking |
|---|---|---|---|---|---|---|---|
| Yellowhead Highway 16 | DV, CT CO, PK RB/ST (10) | High (10) | Partial (6) | > 1 km (10) | 73% (10) | No (0) | **High Priority (46)** |
| Singlehurst Road | DV, CT CO, PK RB/ST (10) | High (10) | Undetermined (3) | N/A (0) | N/A (0) | No (0) | **Low Priority (23)** |

* see Appendix 2 for species codes

## 3.6 FISHERIES PRIORITY SCORES FOR RESTORATION OF FISH PASSAGE

In addition to the FPCI scoring matrix and priority ranking, Fisheries Priority Scores for the culvert crossing of Singlehurst Creek at Highway 16 and at Singlehurst Road were also calculated. The Fisheries Priority Score describes the fisheries values in more detail than the FPCI Rankings by incorporating species preferences for different habitat types (stream order and gradient) and the quantity of different habitat types in the portion of the mainstem and its tributaries that are upstream of culverts that are obstructing fish passage. The fish habitat value for Singlehurst Creek and its tributaries upstream of the culvert at Highway 16 (Table 10) are inclusive of the habitat values upstream of Singlehurst Road (Table 11), which is limited by its close proximity to the high gradient portion of Bornite Mountain.

**Table 10.** Habitat Value for fish upstream of Highway 16 used for calculating prioritization scores for future work, from a fisheries perspective.

| Stream Order | Habitat Quality Class (% Gradient) | Species * | Species Factor* | Amount of habitat (km) | Habitat Value |
|---|---|---|---|---|---|
| ≥ 3rd | Good (0-5) | CO,PK, RB/ST,CT, DV | 3 | 1.6 | 4.8 |
| ≥ 3rd | Moderate (5-10) | CO, RB/ST, CT, DV | 2 | 1.9 | 3.8 |
| ≥ 3rd | Limited (10-20) | RB/ST, DV, CT | 1 | 0.4 | 0.4 |
| 2nd | Good (0-5) | CO, RB/ST, CT, DV | 3 | 0 | 0 |
| 2nd | Moderate (5-10) | CT, DV, RB/ST | 2 | 0.45 | 0.9 |
| 2nd | Limited (10-20) | CT, DV | 1 | 0 | 0 |
| 1st | Good (0-5) | CO, ST, CT, DV | 1 | 0 | 0 |
| 1st | Moderate (5-10) | CT, DV, RB/ST | 0.5 | 2.4 | 1.2 |
| 1st | Limited (10-20) | CT, DV | 0.25 | 0 | 0 |
| **Total Habitat Value upstream of Highway 16** | | | | | **11.2** |

* Highest species factor for species present or suspected present (see Appendix 2 for species codes)

**Table 11.** Habitat Value for fish upstream of Singlehurst Road used for calculating prioritization scores for future work, from a fisheries perspective.

| Stream Order | Habitat Quality Class (% Gradient) | Species * | Species Factor* | Amount of habitat (km) | Habitat Value |
|---|---|---|---|---|---|
| ≥ 3rd | Good (0-5) | CO,PK, RB/ST,CT, DV | 3 | 0.5 | 1.5 |
| ≥ 3rd | Moderate (5-10) | CO, RB/ST, CT, DV | 2 | 0.2 | 0.4 |
| ≥ 3rd | Limited (10-20) | RB/ST, DV, CT | 1 | 0 | 0 |
| 2nd | Good (0-5) | CO, RB/ST, CT, DV | 3 | 0 | 0 |
| 2nd | Moderate (5-10) | CT, DV, RB/ST | 2 | 0.45 | 0.9 |
| 2nd | Limited (10-20) | CT, DV | 1 | 0 | 0 |
| 1st | Good (0-5) | CO, ST, CT, DV | 1 | 0 | 0 |
| 1st | Moderate (5-10) | CT, DV, RB/ST | 0.5 | 0.7 | 0.35 |
| 1st | Limited (10-20) | CT, DV | 0.25 | 0 | 0 |
| **Total Habitat Value upstream of Singlehurst Road** | | | | | **3.15** |

* Highest species factor for species present or suspected present (see Appendix 2 for species codes)

The Fisheries Priority Score was determined for each crossing by multiplying the habitat value scores (Tables 10 and 11), by factors for species characteristics (Fish Presence and Species Status) and the severity of the obstruction (barrier) as summarized in table 12. The fisheries priority score for the Singlehurst Road crossing is 12.6 reflecting the relatively low impact of the structure on fish passage, from a fisheries perspective. Although the culvert at Highway 16 is presently only a partial obstruction to fish passage, the quantity and quality of habitat upstream and the presence of blue listed species resulted in a relatively high fisheries priority score of 46.3, suggesting that future efforts toward improving fish passage at this location could be beneficial from a fisheries perspective.

**Table 12.** Fisheries Priority Scores for future work at culvert crossings at Highway 16 and Singlehurst Road, from a fisheries perspective.

| Location | Fish Presence (Factor) | Species Status (Factor) | Barrier (Factor) | Upstream Habitat Value | Fisheries Priority Score |
|---|---|---|---|---|---|
| Yellowhead Highway 16 | Known (3) | Blue listed (1.33) | Partial (1) | 11.2 | **44.3** |
| Singlehurst Road | Known (3) | Blue listed (1.33) | Partial (1) | 3.15 | **12.6** |

## 3.7 PRIORITIZATION FOR IMPROVING FISH PASSAGE

The culvert located where Highway 16 crosses Singlehurst Creek was given a high priority ranking and the culvert located where Singlehurst Road crosses Singlehurst Creek was given a low priority ranking for restoration of fish habitat based on the FPCI scoring matrix. However, the FPCI rankings do not provide prioritization of this crossing in relation to other culverts on Highway 16 where fish passage issues have been identified. Fisheries Priority Scores for these stream crossings are presented in table 13 for comparison to other culvert crossing along Highway 16 between Terrace and Hazelton that were assessed in previous and concurrent studies. In total, fish passage issues related to culvert stream crossings have been identified at 13 locations along Highway 16 between Terrace and New Hazelton (Table 13). The culvert located where Singlehurst Road crosses Singlehurst Creek was added to table 13 for comparison, and fisheries priority scores were determined for each of these crossings (Table 13). With a low FPCI ranking and a fisheries priority score of 12.6, the culvert located where Singlehurst Road crosses Singlehurst Creek was outscored by six other sites along Highway 16 from Terrace to New Hazelton. Only the culvert crossings at Andimaul and Mission creeks received a higher fisheries priority score than the culvert located where Highway 16 crosses Singlehurst Creek.

**Table 13.** List of culvert crossings along Yellowhead Highway 16 from Terrace to New Hazelton that are impeding fish passage.

| Stream (Hwy Section) | LKI*[1] (km) | Barrier | FPCI Ranking | Fisheries Score*[2] | Comments |
|---|---|---|---|---|---|
| Station Creek [1] (Kitwanga-Hazelton) | 40.18 | Full | High | **478.8** | |
| Andimaul Creek [2] (Kitwanga-Hazelton) | 10.84 | Full | High | **103.2** | The priority rating for this site requires consideration of the anthropogenic disturbance causing significant instabilities of the mainstem upstream of Highway 16. |
| **Singlehurst Creek [3] (Terrace-Kitwanga)** | 15.64 | **Partial** | **High** | **44.3** | **Priority for work at this site may be higher because the weirs, previously constructed to provide fish passage at this location, are presently breaking down.** |
| Unnamed Creek [4] (Terrace-Kitwanga) | 39.42 | Full | High | **24.6** | This culvert appears to impede fish passage to excellent juvenile fish rearing habitat. |
| Comeau Creek [4] (Kitwanga-Hazelton) | 30.40 | Partial | High | **30.3** | Channel width is only 2.6 metres upstream of culvert. Recommend more detailed field assessment of habitat upstream of this partial barrier. An apparent obstruction to anadromous fish downstream of this culvert may reduce the impact of this partial obstruction. Rabnett and Williams (2004) indicated that there are not fish passage issues at this site. |
| Waterfall Creek [4] (Kitwanga-Hazelton) | 43.18 | Partial | | **14.7** | The Fisheries Priority Score was based on it being a full barrier due to length of culvert, but the culvert appears passable by fish at most flows. |
| Chicago Creek [4] (Kitwanga-Hazelton) | 35.88 | Partial | | **12.6** | Rabnett and Williams (2004) did not identify any fish passage issues at this site. There is a resident population of cutthroat trout in Seeley Lake, upstream of Highway 16. |
| **Singlehurst Creek (Singlehurst Road)** | | **Partial** | **Low** | **12.6** | **The needs for culvert repairs at this location may make improvements of fish passage a higher priority.** |
| Gershwin Creek [4] (Kitwanga-Hazelton) | 30.65 | Partial | NA | **11.2** | Rabnett and Williams (2004) identified no fish passage issues but recommend that old beaver guard be replaced, and fish sampling be conducted. |
| Shandilla Creek [5] (Kitwanga-Hazelton) | 3.71 | Full | High | **11.0** | FPCI Priority Ranking was high due to the close proximity of this culvert to its confluence with the Skeena. Only 460 metres of moderate gradient habitat is available upstream of this culvert. |
| Gossen Creek [4] (Terrace-Kitwanga) | 13.09 | Full | High | **9.0** | Estimate of available habitat is likely an underestimate as Valhalla Creek appears to have been redirected into this drainage. A more detailed field assessment of this location is recommended to confirm fisheries value. |
| Noble Five Creek [4] (Terrace-Kitwanga) | 13.52 | Full | Low | **6.8** | |
| Flint Creek [6] (Terrace-Kitwanga) | 63.22 | Partial | Moderate | **4.6** | Only 580 metres of moderate gradient habitat is available upstream of this culvert. |
| Skovens Creek [4] (Terrace-Kitwanga) | 19.81 | Partial | Low | **2.7** | |

*[1] LKI Landmark Kilometre Inventory – distance from starting point of highway section
*[2] Fisheries Scores are from MoT Stream Crossing Database representing priority based on the relative benefit to fish production in the Skeena River watershed.
Site specific data for Fisheries Priority Scoring and FPCI scores obtained from [1] SKR 2006b, [2] SKR 2003a, [3] current study, [4] Rabnett and Williams 2004, [5] SKR 2003b, [6] SKR 2006a

# 4.0 RECOMMENDATIONS FOR RESTORING FISH PASSAGE

Of the two culverts assessed on Singlehurst Creek, the culvert at Highway 16 has a significantly higher priority than the Singlehurst Road culvert. This is primarily due to the severity of the obstruction, the continuing decay of the lumber and side channel portions of log weir structure at the outlet that facilitates fish passage, and the greater quantity of fish habitat upstream of Highway 16 than upstream of Singlehurst Road. The low FPCI score and the relatively low Fisheries Priority Score of the culvert at Singlehurst Road indicates that efforts would be better focused on the Highway 16 crossing of this system or other higher priority structures within the area that may be eligible for available funds. However, the lifting portion of the culvert and evidence of flow under the culvert at Singlehurst Road should be monitored and may increase the priority for work at Singlehurst Road in the near future. The following sections recommend long-term plans and some potential short-term options for improving fish migration at both Highway 16 and Singlehurst Road with consideration to the cost benefits from a fisheries perspective.

## 4.1 IMPROVEMENTS OF FISH PASSAGE WHERE HIGHWAY 16 CROSSES SINGLEHURST CREEK

The long-term objective toward completely restoring fish passage for all species and life stages where Highway 16 crosses Singlehurst Creek will require the eventual replacement of the existing, undersized culvert with an open bottom or well embedded structure that will not restrict natural stream dynamics. The relatively high fish habitat value and fisheries priority score upstream of this culvert make planning and budgeting for the eventual replacement of this structure worth considering. In the interim, some short-term options have been considered to maintain the present level of fish passage since the culvert has withstood past flood events and coho synoptic surveys have indicated that habitat upstream of the culvert has remained productive while the weir downstream of the crossing has been functional.

Although the existing culvert has withstood past flood events, a 3000 mm diameter culvert is recommended based on the FPCI $Q_{100}$ for Singlehurst Creek even without accounting for fish passage (Parker 2000). Due to the apparently undersized structure at this location, the existing 2000 mm diameter culvert is suspected to be vulnerable to washing out during unusually high flood events, which could have drastic impacts on fish and valuable spawning habitat downstream of this crossing. The installation of baffles at the culvert may assist in reducing water velocity through the existing culvert, but will also reduce the discharge capacity of this structure. Due to the concerns related to engineering restrictions at the existing crossing, no short-term options for restoring juvenile fish passage have been proposed.

The primary objective in the short term should be to restore, maintain, and possibly improve adult fish migration through the existing culvert and to prepare to mitigate any potentially disastrous flood events. Presently, the log weir downstream of Highway 16 has significantly deteriorated, and this crossing will soon return to being a full barrier to fish passage. The existing, but failing log structure that was constructed to reduce the effective height of the culvert outfall, still provides some backwatering up to the culvert outlet, but is in need of repair. The lumber portions of the weir appeared unstable, the wooden fish ladder up to the culvert pool has collapsed, and boulders used to construct the step pool morphology in the side channel have been displaced. In conjunction with increasing the height of the upper weir by about 20 cm, a new fish ladder should be constructed parallel to the log weir, and the step pools in the side channel around the weir should be restored. Consideration should also be given to the construction of a short series of smaller weirs upstream of the culvert in order to lower the presently elevated channel and reduce water velocity at the culvert inlet.

In summary, it is recommended that planning and budgeting occur for the eventual replacement of the somewhat undersized culvert located where Highway 16 crosses Singlehurst Creek, and immediate attention be given toward restoring and maintaining the deteriorating fish weir to ensure that fish passage

is maintained. If replacement of this structure is not scheduled for the near future, cost breakdowns for materials and services for the short-term options should be developed soon to ensure that fish passage to the high valued habitat in the upper Singlehurst Creek watershed is not lost. Emergency plans should also be prepared and monitoring methodologies for potential flooding disasters should be implemented to protect the fish and fish habitat downstream from a significant failure of the existing culvert. Comparisons of the design, installation and maintenance costs between the long-term plan and short-term options should also be made to help determine the most cost effective solutions for this site.

## 4.2 IMPROVEMENTS OF FISH PASSAGE WHERE SINGLEHURST ROAD CROSSES SINGLEHURST CREEK

The long-term objective toward completely restoring fish passage for all species and life stages where Singlehurst Road crosses Singlehurst Creek will require the eventual replacement of the existing culvert with an open bottom or well embedded structure or the use of baffles and weirs that will prevent flow from scouring under the culvert and improve fish passage for juvenile life stages. The presence of some good fish habitat and the assignment of a moderate fisheries priority score upstream of this culvert make planning and budgeting for the eventual improvement of fish passage at this structure worth considering.

The immediate replacement of the existing culvert with an open bottomed structure is not recommended since the structure appears to be large enough to handle significant flood events based on the FPCI $Q_{100}$ taken at this location. However, in order to restore juvenile fish migration at all flows and to prevent the creek from scouring under the existing culvert, it is recommended that some restoration of fish passage be conducted in conjunction with future culvert repairs. Plans for culvert repairs or significant maintenance projects at this location should include designs for bank stabilization upstream of the road to confine flow more directly into the culvert opening, in conjunction with sufficient backwatering and weir construction downstream of the culvert to allow the culvert to be 20% embedded with a relatively low gradient. A series of natural rock weirs constructed downstream of this culvert should be designed to ensure minimal maintenance and to make water depths through the culvert greater than 30 cm during low summer flows. In the interim, it is suggested that the culvert at Singlehurst Road should be regularly monitored due to the evidence of flow under a lifting portion of the culvert inlet that could increase the priority for work at Singlehurst Road or may result in a significant impact on fish and fish habitat downstream.

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**Appendix 1.** Fish Passage Culvert Inspection Forms

**Culvert where Yellowhead Highway 16 crosses Singlehurst Creek, 2005**

and

**Culvert where Singlehurst Road crosses Singlehurst Creek, 2005**

## Fish Passage – Culvert Inspection — Yellowhead Highway 16 - Singlehurst Creek

| | | | |
|---|---|---|---|
| **Date (mm/dd/yy)** | 2005/08/23 | **Stream Name** | Singlehurst (Swede) Creek |
| **Road Name/ID#** | Yellowhead Highway 16 | **Road Location** | MoT LKI: 15.64 km from Terrace |
| **UTM/GPS Location** | 9.538539.6050848 | **Watershed Code** | 400-316300 |
| **1:20 000 Map Sheet** | 093E.069 | **Recorders Name** | Ron Saimoto |
| **Site Number** | 1 | **MoT District** | Skeena District (No. 11) |

### Culvert Characteristics:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Culvert Diameter (mm)** | 2010 mm x 2000 mm | | | **Culvert Slope (%)** | Us 3.0 | Ds 2.0 | 2.5 % |
| **Culvert Length (m)** | ~34 m | | | **High Water Mark (cm)** | 65 cm | | |
| **Culvert Material** | Multi-plate | | | **Culvert Water Depth (cm)** | 32 cm | | |
| **Culvert Water Velocity (m•sec-1)** | 2.2 | 2.1 | 2.15 | **Culvert Outfall Drop (cm)** | 12.5 cm | | |
| **Culvert Shape** | Round | | | **Culvert Maintenance** | Mod | | |
| **Culvert Wetted Width (cm)** | 111 cm | | | **Fill Slope Depth (m)** | about 5.0 m | | |

### Stream Characteristics:

| | | | |
|---|---|---|---|
| **Stream Reach** | 2 | **Stream Classification** | S2 |
| **Pool Depth at Outfall (cm)** | 12 cm | **Blue Listed/Significant** | Cutthroat, Dolly Varden |
| **Sediment Source/Degree** | No | | |

| **Measure** | **Measurement(s) Below Culvert** | | | **Measurement(s) Above Culvert** | | | **Average Measurement** |
|---|---|---|---|---|---|---|---|
| **Wetted Width (m)** | 5.1 | 6.4 | 4.0 | 6.0 | 5.5 | 4.7 | 5.28 m |
| **Bankfull Width (m)** | 6.1 | 8.4 | 4.8 | 7.1 | 6.2 | 8.1 | 6.78 m |
| **Water Depth (cm)** | 105 | 32 | 42 | 20 | 32 | 25 | 42.7 cm |
| **Bankfull Depth (cm)** | 35 | 32 | 42 | 35 | 32 | 28 | 34.0 cm |
| **Stream Water Velocity (m•sec-1)** | 0.1 | 0.8 | 1.2 | 1.0 | 0.5 | 0.7 | 0.71 m•s-1 |
| **Stream Gradient (%)** | 2 | 1 | | 1 | 1 | | 1.25 % |
| **Fish Presence** | Yes | | | Yes | | | NA |
| **Fish Sampling Method** | Visual observation, historical info. | | | Visual observation, historic info. | | | NA |
| **Sampling Effort (time)** | | | | | | | NA |
| **Species Present** | Pink Salmon observed spawning<br>Coho, Dolly Varden, Cutthroat, Rainbow trout, Steelhead previously reported | | | A few PK Pink Salmon observed<br>Coho, Dolly Varden, Cutthroat, Rainbow trout, Steelhead previously reported | | | NA |
| **Beaver Activity/Type** | None Observed | | | None Observed | | | NA |

### Barrier Evaluation:

| **Barrier** | **Comments** |
|---|---|
| **Barrier Type : Partial** | Previously a full barrier to fish migration due to ~1.7 metre drop from culvert which was improved by a log weir structure that was breaking down at time of survey.<br>Difficult passage even for adult salmonids due to confinement in small culvert; velocity barrier to juvenile fish.<br>Five Pink salmon were accidently spooked downstream into the culvert and none could hold in the culvert and eventually dropped back below the culvert.<br>No pinks were observed making it past the culvert inlet at the time of survey<br>The fish ladder previously constructed parallel to the log weir was broken down and impassable by pink salmon at the time of survey with only a 45 cm plunge pool at the base of a 1.4 m high log weir<br>An ~10 metre long side channel on river left of the weir had a gradient of ~12%, but the boulders assembled for step pools were displaced and the side channel provided very difficult fish passage for several pinks attempting to migrate past the weir. |

**Site Photos**:

| Photo Number | Description | Photo Number | Description |
|---|---|---|---|
| **DSC00020.jpg** | **Inlet upstream photo** | **DSC00021.jpg** | **Outlet downstream photo** |
| **DSC00019.jpg** | **Inlet downstream photo** | **DSC00022.jpg** | **Outlet upstream photo** |
| DSC00015.jpg | Pink salmon downstream of culvert | DSC00016.jpg | Pink salmon downstream of culvert |
| DSC00017.jpg | U/S view 80 m upstream of culvert | DSC00018.jpg | D/S view 80 m upstream of culvert |
| DSC00023.jpg | U/S view of side channel | DSC00024.jpg | D/S view of side channel |
| DSC00025.jpg | U/S view of side channel | DSC00026.jpg | U/S view of broken down fish ladder |
| DSC00027.jpg | Pink salmon downstream of culvert | | |

**Comments:**

Approximately 200 pink salmon were observed in the 200 metre section of stream surveyed immediately downstream of the culvert. The stream channel was significantly influenced by the log weir structures for approximately 50 metres downstream of the culvert so channel measurements started ~80 metres downstream of the culvert. Excellent spawning and good potential rearing habitat was observed throughout the entire section surveyed.

Approximately 20 pink salmon were observed in the 200 metre section of Singlehurst Creek that was surveyed upstream of the culvert. The channel was slightly lower gradient and some fine sediment deposits from upstream disturbances were observed to reduce the quality of spawning habitat in the section surveyed, but rearing habitat was excellent due to deep pools and glides with excellent cover from cutbanks, overhanging vegetation and functioning large woody debris.

## Office Calculations: (*to be completed for full and partial barriers only)

| | | | |
|---|---|---|---|
| **Q100 Diameter Estimate (mm)** | Q100 = 6.15<br>20% Embedded Q100= 7.13<br>3050mm round culvert<br>3890x2690 elliptical | **Stream Length Above Barrier** | 2200 m |
| **Road Responsibility** | Ministry of Transportation | **% Stream Barred** | 73 % |

## Prioritization Calculations – FPCI Scoring Matrix:

| **Fish species** | | **Habitat value** | | **Barrier** | | **Length of new habitat** | | **Stream barred (%)** | | **Limiting to upstream barrier** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Multiple or significant | 10 | H | 10 | Full | | ≥1 km | 10 | >70% | 10 | Yes | |
| Single | | M | | Partial | 6 | <1 km<br>≥500 m | | 51–70% | | No | 0 |
| Other | | L | | Undeter | | <500 m | | <50% | | | |

**Total Score: 46** **FPCI Ranking: HIGH PRIORITY**

## Fish Passage – Culvert Inspection — Singlehurst Road - Singlehurst Creek

| | | | |
|---|---|---|---|
| **Date (mm/dd/yy)** | 2005/08/23 | **Stream Name** | Singlehurst (Swede) Creek |
| **Road Name/ID#** | Singlehurst Road | **Road Location** | |
| **UTM/GPS Location** | 9.539084.6051836 | **Watershed Code** | 400-316300 |
| **1:20 000 Map Sheet** | 093E.069 | **Recorders Name** | Ron Saimoto |
| **Site Number** | 1 | **MoT District** | Skeena (No. 11) |

### Culvert Characteristics:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Culvert Diameter (mm)** | 3000 mm | | | **Culvert Slope (%)** | Us 0.5 | Ds 1.0 | 0.75 % |
| **Culvert Length (m)** | ~ 26 m | | | **High Water Mark (cm)** | 38 cm | | |
| **Culvert Material** | Multi-plate | | | **Culvert Water Depth (cm)** | 26 cm | | |
| **Culvert Water Velocity (m•sec-1)** | 0.5 | 1.2 | 0.85 | **Culvert Outfall Drop (cm)** | 0 cm | | |
| **Culvert Shape** | Round | | | **Culvert Maintenance** | Moderate | | |
| **Culvert Wetted Width (cm)** | 161 cm | | | **Fill Slope Depth (m)** | 1.0 m | | |

### Stream Characteristics:

| | | | |
|---|---|---|---|
| **Stream Reach** | 2 | **Stream Classification** | S2 |
| **Pool Depth at Outfall (cm)** | 5 cm | **Blue Listed/Significant** | Cutthroat, Dolly Varden |
| **Sediment Source/Degree** | No | | |

| **Measure** | **Measurement(s) Below Culvert** | | | **Measurement(s) Above Culvert** | | | **Average Measurement** |
|---|---|---|---|---|---|---|---|
| **Wetted Width (m)** | 5.7 | 5.2 | 3.9 | 4.8 | 5.0 | 3.6 | 4.70 m |
| **Bankfull Width (m)** | 6.1 | 7.3 | 5.9 | 5.7 | 6.5 | 5.8 | 6.20 m |
| **Water Depth (cm)** | 35 | 15 | 20 | | | | 23 cm |
| **Bankfull Depth (cm)** | 35 | 37 | 33 | 36 | 30 | 28 | 33.2 cm |
| **Stream Water Velocity (m•sec-1)** | 0.9 | 1.2 | 0.6 | 0.74 | 0.5 | 0.35 | 0.71 m•s-1 |
| **Stream Gradient (%)** | 1 | 1 | | 1.5 | 0.5 | | 1 % |
| **Fish Presence** | Yes | | | Yes | | | NA |
| **Fish Sampling Method** | Visual observation, historical info. | | | Visual observation | | | NA |
| **Sampling Effort (time)** | | | | | | | NA |
| **Species Present** | Pink Salmon Observed<br>Coho, Dolly Varden, Cutthroat, Rainbow trout, Steelhead previously reported | | | Pink Salmon Observed<br>Coho, Dolly Varden, Cutthroat, Rainbow trout, Steelhead previously reported | | | NA |
| **Beaver Activity/Type** | | | | | | | NA |

### Barrier Evaluation:

| **Barrier** | **Comments** |
|---|---|
| **Barrier Type : Undetermined** | The half culvert portion of this culvert at this inlet appeared to have been partially lifted and created an approximately 1.5 metre section with 1.2 m/sec flow. There was some evidence of flow backing up under and around the culvert inlet. The lifting portion of the culvert inlet appeared to be a potential velocity barrier to juvenile fish at some flows. |

**Site Photos:**

| Photo Number | Description | Photo Number | Description |
|---|---|---|---|
| **DSC00030.jpg** | **Inlet upstream photo** | **DSC00028.jpg** | **Outlet downstream photo** |
| **DSC00031.jpg** | **Inlet downstream photo** | **DSC00029.jpg** | **Outlet upstream photo** |
| DSC00032.jpg | U/S view ~250 metres upstream of Singlehurst Road upstream of braided section that appears to impede fish passage | DSC00033.jpg | D/S View ~250 metres upstream of Singlehurst Road upstream of braided section that appears to impede fish passage |

**Comments:**

A very old deactivated road through private property approximately 200 metres upstream of Singlehurst Road appears to have significantly disturbed this stream channel where it is heavily braided and sediment wedges have created several 0.5 to 1.0 metre drops. One pair of pink salmon was observed in one of the larger braids ~200 metres upstream of Singlehurst Road. Some excellent potential spawning habitat was observed upstream of the heavily braided section but gradient and confinement appeared to increase further upstream.

Heavy deposits of fine sediments were observed downstream of the culvert, but numerous deep pools and glides with cutbanks, overhanging vegetation and functioning large woody debris appeared to provide excellent rearing habitat. Very limited potential spawning habitat was observed for 200 metres downstream of the culvert and only five pink salmon were observed holding in the 200 metre section surveyed.

## Office Calculations: (*to be completed for full and partial barriers only)

| | | | |
|---|---|---|---|
| **Q100 Diameter Estimate (mm)** | Q100 = 5.42<br>20% embedded Q100= 6.28<br>(3050mm round culvert)<br>(3890x2690 elliptical) | **Stream Length Above Barrier** | 800 m |
| **Road Responsibility** | | **% Stream Barred** | 26 % |

## Prioritization Calculations – FPCI Scoring Matrix:

| Fish species | | Habitat value | | Barrier | | Length of new habitat | | Stream barred (%) | | Limiting to upstream barrier | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Multiple or significant | 10 | H | 10 | Full | | ≥1 km | | >70% | | Yes | |
| Single | | M | | Partial | | <1 km ≥500 m | | 51–70% | | No | 0 |
| Other | | L | | Undeter-mined | 3 | <500 m | | <50% | | | |

**Total Score: 23** **FPCI Ranking: LOW PRIORITY**

**Appendix 2.** Summary of default settings for criteria and priority scoring factors used to ranking sites for their potentially impact on fish and fish habitat.

Note: The following list of codes for fish species are used in tables throughout this report

| Species Code | Common Name | Scientific Name |
|---|---|---|
| **BT** | Bull trout | *(Salvelinus confluentus)* |
| **CH** | Chinook salmon | *(Oncorhynchus tsawytscha)* |
| **CM** | Chum salmon | *(Oncorhynchus keta)* |
| **CO** | Coho salmon | *(O. kisutch)* |
| **CT** | Cutthroat trout | *(O. clarki clarki)* |
| **DV** | Dolly Varden | *(S. malma)* |
| **PK** | Pink salmon | *(O. gorbusha)* |
| **RB/ST** | Rainbow trout/steelhead | *(O. mykiss)* |

**Appendix 2a.** Scoring Factors based on the Severity of Barriers

**Appendix 2b.** Barrier Criteria used for identifying significant obstructions to fish passage (i.e. "B1" Severity)

**Appendix 2c.** Barrier criteria used for identifying partial obstructions to fish passage (i.e. "B2" Severity)

**Appendix 2d.** Scoring Factors for the potentially for fish use upstream of culverts impeding fish passage

**Appendix 2e.** Habitat Units used to evaluate the quality of fish habitat upstream of culverts based on map interpretation

**Appendix 2f.** Scoring Factors used to calculate the value of habitat upstream of the culvert dependent on specific species that are either present or suspected present.

**Appendix 2g.** Scoring Correction Factors based on Species status

## Appendix 2a. Scoring Factors based on the Severity of Barriers

| [Severity of Barrier] | [Code Description] | [Barrier Factor] | [Barrier Factor Description] |
|---|---|---|---|
| B1 | A significant obstruction/barrier to upstream fish migration of all age classes and species present or suspected upstream of the culvert (*for details see* Barrier Criteria) | **3** | The default barrier factor for "B1" is 3 to raise immediate attention toward sites that are known to be limiting fish production. This factor is used to differentiate the priority scores for sites where culvert replacements or repairs may be appropriate without further assessment and sites where immediate work will be the most beneficial for fish without additional assessments of fish distribution. |
| B2 | Partial obstruction to fish migration at any time and for any age class of fish present or suspected present upstream of the culvert [*for details see* Barrier Criteria] | **1** | The default barrier factor for "B2" is 1 to help differentiate the high priorities for immediate repair or replacement of culverts at sites from the priorities for more detailed assessments of fish presence, the severity of the obstruction, and the quantity and quality of habitat upstream of the obstruction. Because the severity of partial obstructions is so variable and dependent on a multitude of factors, culverts of this status are grouped together and the habitat value upstream of the culvert becomes the predominant value used to determine priorities for future work (i.e. Fish Presence Factor, Habitat Units, and Species Factors). |
| B3 | No Obstruction to fish migration could be identified if none of the above criteria are met | **0** | This value is 0 and should not be modified. To reduce the number of sites that receive this value, adjustments should be made to [Barrier Criteria] |

**Appendix 2b.** Barrier Criteria used for identifying significant obstructions to fish passage (i.e. "B1" Severity)

| [Barrier Type] | [Code Description] | [Barrier Criteria] | [Barrier Criteria Description] |
|---|---|---|---|
| B1_GR | Culvert Gradient is a significant Obstruction/Barrier to fish migration [Severity of Barrier] = "B1" | **3%** | The default value is 3% and tries to account for inconsistent gradients through the culvert that may provide some holding areas for fish or if where the water velocity was measured was not representative of the total length of the culvert. Although it is possible that some large adult fish may be able to pass through this gradient if the culvert is not too long, this default value for culvert gradient is considered to obstruct fish passage enough to qualify a site to be "B1" for severity. |
| B1_VEL | Velocity in culvert is a significant Obstruction/Barrier to fish migration [Severity of Barrier] = "B1" | **2.5 m/sec** | The default value is 2.5 m/s based on average prolonged swimming abilities for adults of the species that were identified during this study (range: 1.8 to 4.2 m/sec, Whyte *et al.* 1997). Water velocity through most of the culverts were measured during only moderate discharge, thus this criteria value intends to recognize that flows may be higher during higher flow conditions. Although the prolonged swimming ability of some species is less than 2.5 m/sec, this value considers the variability of velocity within the entire length of each culvert that often allows burst-swimming capabilities to play a significant role. Although some species may be able to migrate through this velocity (prolonged swimming abilities up to 4.2 m/sec), this default value for velocity is considered to obstruct even stronger swimming fish enough to qualify a site to be "B1" for severity. |
| B1_DR | Vertical drop from outlet is a barrier if width or diameter of the culvert is < 2 metres [Severity of Barrier] = "B1" | **0.6 m** | The default value is a 0.6 metre drop at the outfall from any culvert less than 2 metres in diameter is a significant obstruction/barrier to juvenile and adult fish migration. Although the maximum jump height for various species is greater than 0.6 metres, this default value is considered to obstruct fish passage enough to qualify a site to be "B1" for severity regardless of the pool depth. Detailed reviews of the severity of these drops should be conducted on all sites with culvert size greater than or equal to 2 metres. |
| B1_D-P | Drop – pool depth at the outlet of a culvert is a significant Obstruction/ Barrier to fish migration if width or diameter of culvert is <1.5 metres [Severity of Barrier] = "B1" | **0.3 m** | The default value is >0.3 since a drop of less height than the criteria for "B_DR" from a relatively small culvert will obstruct fish passage enough to qualify a site to be "B1" (i.e a significant obstruction). Detailed reviews of the severity of drops should be conducted on all sites with culvert size greater than or equal to 1.5 metres. |
| B1_Lgth | Length of culvert | **45** | The default value is 45 metres to ensure that attention is given to all long culverts regardless of drop from the outlet or gradient. |

**Appendix 2c.** Barrier criteria used for identifying partial obstructions to fish passage (i.e. "B2" Severity)

| [Barrier Type] | [Code Description] | [Barrier Criteria] | [Barrier Criteria Description] |
|---|---|---|---|
| B2_GR | Culvert Gradient is suspected to be a partial obstruction to juvenile and/or adult fish migration if width or diameter of culvert is < 2 metres [Severity of Barrier] = "B2" | **2%** | The default value is 2% to identify where migration by juvenile and some adult species is being significantly obstructed. This criteria value is set to ensure that even minor obstructions are considered for future attention. The priority for attention at these sites will be based mostly on the quality and quantity of habitat upstream of the culvert. |
| B2_VEL | Culvert Velocity Gradient is suspected to be a partial obstruction to juvenile and/or adult fish migration if width or diameter of culvert is < 2 metres [Severity of Barrier] = "B2" | **1 m/sec** | The default value is 1 m/sec based on estimated prolonged swimming abilities for juvenile adults of the species that were identified during this study. Water velocity through most of the culverts were measured during only moderate discharge, thus this value intends to recognize that flows may be higher during higher flow conditions. Although the prolonged swimming ability by juveniles of some species is less than 1 m/sec, the criteria value considers the variability of velocity within the entire length of each culvert that often allows burst-swimming capabilities to play a significant role in fish passage. This criteria value is set to ensure that even minor obstructions are considered for future attention based on the quality and quantity of habitat upstream of the culvert. |
| B2_D-P | Drop – pool depth at the outlet of a culvert is considered to be a Partial Obstruction/ Barrier to fish migration if width or diameter of culvert is <1.5 metres [Severity of Barrier] = "B2" | **>0.15** | The default value is 0.15 metres to allow this scoring matrix to identify minor obstructions to fish passage. This criteria value is set to ensure that even minor obstructions are considered for future attention based on the quality and quantity of habitat upstream of the culvert. |
| B2_LGTH | Length of culvert if width or diameter is <2 metres [Severity of Barrier] = "B2" | **35** | The default value is for culverts >35 metres long to ensure that sites with very long lengths of culvert are considered when priorities for culvert replacement or maintenance are being reviewed. This criteria value is set to ensure that no potentially obstructions to fish passage are ignored. |

**Appendix 2d.** Scoring Factors for the potentially for fish use upstream of culverts impeding fish passage

| [Fish Presence Type] | [Code Description] | [Fish Presence Factor] |
|---|---|---|
| FP | Fish Present based on Historical Records | **3** |
| SFP1 | Fish Suspected based on reach gradient < 10%) | **2** |
| SFP2 | Fish Suspected based on Gradient 10-20%, or potentially barrier downstream | **0.5** |
| FA | Fish Absent based on Historical Records, or reach gradient > 20%) | **0** |

**Appendix 2e.** Habitat Units used to evaluate quality of habitat upstream of culverts based on map interpretation

| [Habitat Unit] | [Code Description] | [Map Gradient Criteria] | [Description of Map Gradient Criteria] |
|---|---|---|---|
| *≥ 3rd order streams* | | | |
| 3_G | Good Quality, Suitable Habitat | <5 | Good: 5% units are used due to their easy identification based on 20m contours on TRIM |
| 3_M | Moderate Quality, Suitable Habitat | 5-10 | Moderate: Considered moderate due to the significantly lower quantity and quality of rearing habitat present as stream gradient increases. |
| 3_L | Limited Quality due to Gradient | 10-20 | Low: designated to sections of stream with 10-20% gradient sections or sections upstream of a likely obstruction to fish passage based on airphoto and TRIM map interpretation |
| *2nd order streams* | | | |
| 2_G | Good Quality, Suitable Habitat | <5 | Good: 5% units are used due to their easy identification based on 20m contours on TRIM |
| 2_M | Moderate Quality, Suitable Habitat | 5-10 | Moderate: Considered moderate due to the significantly lower quantity and quality of rearing habitat present as stream gradient increases. |
| 2_L | Limited Quality due to Gradient | 10-20 | Low: designated to sections of stream with 10-20% gradient sections or sections upstream of a likely obstruction to fish passage based on airphoto and TRIM map interpretation |
| *1st order streams* | | | |
| 1_G | Good Quality, Suitable Habitat | <5 | Good: 5% units are used due to their easy identification based on 20m contours on TRIM |
| 1_M | Moderate Quality, Suitable Habitat | 5-10 | Moderate: Considered moderate due to the significantly lower quantity and quality of rearing habitat present as stream gradient increases. |
| 1_L | Limited Quality due to Gradient | 10-20 | Low: designated to sections of stream with 10-20% gradient sections or sections upstream of a likely obstruction to fish passage based on airphoto and TRIM map interpretation |

**Appendix 2f.** Scoring Factors used to calculate the value of habitat upstream of the culvert dependent on specific species that are either present or suspected present.

| [Species Code] | [Habitat_Species Factor] *(default settings)* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *≥3rd order streams* | | | *2nd order streams* | | | *1st order streams* | | |
| | 3_G | 3_M | 3_L | 2_G | 2_M | 2_L | 1_G | 1_M | 1_L |
| BT | **3** | **2** | **1** | **1** | **0.5** | **0.25** | **0** | **0** | **0** |
| CH | **3** | **1** | **0** | **.05** | **0** | **0** | **0** | **0** | **0** |
| CM | **3** | **1** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| CO | **3** | **2** | **0** | **3** | **1** | **0.5** | **1** | **0.5** | **0.25** |
| CT_C | **3** | **2** | **1** | **3** | **2** | **1** | **1** | **0.5** | **0.25** |
| CT | **3** | **2** | **1** | **3** | **2** | **1** | **1** | **0.5** | **0.25** |
| DV | **3** | **2** | **1** | **3** | **2** | **1** | **1** | **0.5** | **0.25** |
| GR | **3** | **1** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| MW | **3** | **1** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| PK | **3** | **1** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| RB | **3** | **2** | **1** | **3** | **2** | **0.5** | **1** | **0.5** | **0.1** |
| SK | **3** | **1** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| ST | **3** | **2** | **1** | **3** | **2** | **0.5** | **1** | **0.5** | **0.1** |
| ST_NS | **3** | **2** | **1** | **3** | **2** | **0.5** | **1** | **0.5** | **0.1** |
| RB/CT | **3** | **2** | **1** | **3** | **2** | **1** | **1** | **0.5** | **0.25** |
| RB/ST | **3** | **2** | **1** | **3** | **2** | **0.5** | **1** | **0.5** | **0.1** |

Note: The Scoring Query will be designed to select only the highest scoring species for each category

**Appendix 3.** Effective culvert area/diameter relationship for round and elliptical culverts (adapted from Parker 2000). [a]

| Round Culverts | | Elliptical arch culverts | |
|---|---|---|---|
| **Diameter of culvert (mm)** | **Total culvert area required ($m^2$)** | **Diameter of culvert (mm)** | **Total culvert area required ($m^2$)** |
| 500 | 0.19 | 560 x 420 | 0.19 |
| 600 | 0.27 | 680 x 500 | 0.27 |
| 700 | 0.37 | 800 x 580 | 0.37 |
| 800 | 0.48 | 910 x 660 | 0.48 |
| 900 | 0.61 | 1030 x 740 | 0.61 |
| 1000 | 0.74 | 1150 x 820 | 0.74 |
| 1200 | 1.06 | 1350 x 870 | 1.06 |
| 1400 | 1.44 | 1630 x 1120 | 1.44 |
| 1600 | 1.87 | 1880 x 1260 | 1.87 |
| 1800 | 2.36 | 2130 x 1400 | 2.36 |
| 1810 | 2.58 | 2060 x 1520 | 2.49 |
| 1970 | 3.04 | 2249 x 1630 | 2.90 |
| 2120 | 3.54 | 2440 x 1750 | 3.36 |
| 2280 | 4.07 | 2590 x 1880 | 3.87 |
| 2430 | 4.65 | 2690 x 2080 | 4.49 |
| 2590 | 5.26 | 3100 x 1980 | 4.83 |
| 2740 | 5.91 | 3400 x 2010 | 5.28 |
| 3050 | 7.32 | 3730 x 2290 | 6.61 |
| 3360 | 8.89 | 3890 x 2690 | 8.29 |
| 2000 | 3.14 | | |
| 2200 | 3.80 | | |
| 2400 | 4.52 | | |
| 2700 | 5.73 | | |

[a] Shading indicates multi-plate culvert.