Columbia River Project Water Use Plan

Lower Columbia River Fish Management Plan

Lower Columbia River Fish Stranding Assessment and Ramping Protocol

Implementation Year 9

Reference: CLBMON-42A

Lower Columbia River Assessments (CLBMON-42A) and Kootenay River Fish Stranding Assessments

Study Period: April 1, 2015 to April 1, 2016

Golder Associates Ltd. 201 Columbia Ave. Castlegar, BC. V1N 1A8

July, 7, 2016

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ANNUAL SUMMARY REPORT

Lower Columbia River (CLBMON#42[A]) and Kootenay River Fish Stranding Assessments: Annual Summary (April 2015 to April 2016)

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REPORT

Golder Associates

Cover Photo: Large pool formed at the Kootenay River (RUB) site during a flow reduction (see Appendix A; Figure A1 for location).

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Executive Summary

Discharge reductions and flow ramping from Hugh L. Keenleyside Dam/Arrow Lakes Generating Station (HLK/ALH) and Brilliant Dam/Expansion (BRD/X) can result in stranding of native fish species of the lower Columbia and Kootenay rivers. The program assessed fish stranding at pre-determined sites (Appendix A) between HLK and the Canada/USA border. The primary objective of the revised fish stranding protocol, "Canadian Lower Columbia River: Fish Stranding Risk Assessment and Response Strategy" (Golder 2011), was to mitigate the effects of flow reductions from HLK/ALH and BRD/X on native fish species through flow reduction planning. A consequence of this objective was an expected reduction in the number of stranding assessments conducted annually. The number of occurrences when stranding crews were deployed due to flow reductions from HLK/ALH has fluctuated over the past seven years of data collection. During that time, the annual number ranged from 8 to 15 deployments with crews going out on an average of 82% of the reductions. The present study saw the highest number of stranding assessments (n=15) for reduction events (REs) at HLK/ALH over the past seven years of data collection. The higher number of stranding assessments was due to lower than average discharge from HLK/ALH during the winter and the need to assess reconnaissance sites at these less common water levels. The number of reductions from BRD/X and combined reductions from both facilities has decreased over the past seven years, from nine REs in 2009/2010 to zero REs in 2015/2016. Over time the number of flow reductions requiring assessments may decrease as the continued collection of data will eliminate data gaps in less common discharge levels and will further focus stranding assessment efforts.

This report summarizes the information collected following flow reductions at HLK/ALH on the Columbia River. Stranding assessments were conducted for 15 of 18 REs that occurred between 1 April 2015 and 1 April 2016. All 15 assessments were conducted in response to flow reductions from HLK/ALH. An estimated 5686 isolated or stranded fishes were observed during the 15 REs. This number represents an increase from the decreasing trend of total fish numbers observed in the previous three annual summary reports. Fish numbers reported by ascending year (starting with the 2012-2013 report period) were; n=6700, n=4845 and n=4521 fish. The majority (68.5%) of stranded fishes in 2015/2016 were observed during two REs; RE2015-10 on 26 September 2015 and RE2016-03 on 5 and 6 February 2016. The most commonly stranded species were Sucker spp. (44%), Northern Pikeminnow (23%) and Umatilla Dace (8%). None of the stranding assessments conducted during the sample period were classified as a 'Significant Fish Stranding' event (>5000 fishes observed at a site).

Fish stranding in the study area from HLK/ALH to the Canada/USA border, including the Kootenay River below BRD/X, is influenced by operational factors from both dams. The operational factors that have been implicated for their influence on fish stranding include time of day, wetted history, and flow reduction (ramping) rate (Golder 2011). Since each system has unique operation management strategies and operation drivers, distinct information for each system has been identified. (i.e., the Water Use Planning Objectives, Management Questions and Hypotheses specific to CLBMON #42A [Table ES1]).

Table ES1: CLBMON#42A Status of Hugh L. Keenleyside Dam Program Objectives, Management Questions and Hypotheses

Primary Objective	Secondary Objectives	Management Questions	Management Hypotheses	Year 9 (2015/2016) Status
To assess the impact of flow reductions and flow ramping rates from HLK on the native species of the lower Columbia River.	To determine ramping rates for flow reductions which reduce the stranding rate of fish at different times of the year.	Is there a ramping rate (fast vs. slow, day vs. night) for flow reductions from HLK that reduces the number of fish stranded (interstitially and pool) per flow reduction event in the summer and winter?	The number of stranded fish is independent of either the ramping rate or time of day of flow reductions in the summer and winter.	Previous studies suggested that ramping rates were not a statistically significant predictor of fish stranding (Golder/Poisson 2010). Data (2000 to 2016) supports this finding. No ramping studies were conducted during this study period.
	To determine whether the wetted history influences the stranding rate of fish for flow reductions.	Does wetted history (length of time the habitat has been wetted prior to the flow reduction) influence the number of fish stranded (interstitially and pool) per flow reduction event for flow reductions from HLK?	Wetted history does not influence the stranding rate of fish (both interstitially and pool stranding) for flow reductions from HLK.	Wetted history influences the stranding rate of fish. A significant increase in the number of stranded fish was observed after a 10-day wetted history, although the effect size (rate of stranding as a function of days of wetted history) has not been accurately quantified. Golder/Poisson 2010). No additional analysis of wetted history data collected during this study period was undertaken because of lack of significant variation from previous analysis.
	To determine whether a conditioning flow reduction from HLK reduces the stranding rate of fish.	Can a conditioning flow (temporary, one step, flow reduction of approximately 2 hours to the final target dam discharge that occurs prior to the final flow change) from HLK reduce the stranding rate of fish?	A conditioning flow from HLK does not reduce the stranding rate of fish in the lower Columbia River.	Hypothesis cannot be rejected at this time due to the limited data and the preliminary stages of analysis (Golder/Poisson 2010). A conditioning flow would require an experimental manipulation of flowsfor a definitive answer. Replicates with significant time between tests would be desirable. No additional data were collected during this study period.
	To determine whether physical habitat manipulation will reduce the incidence of fish stranding.	Can physical habitat works (i.e., re-contouring) reduce the incidence of fish stranding in high risk areas?	Physical habitat manipulation does not reduce the stranding rate of fish in the lower Columbia River.	Previous studies demonstrated that physical habitat manipulation reduces incidences of fish stranding. The effect size (rate of stranding per reduction event) has not been adequately quantified.
	Reduce the number of occurrences when a stranding crew would be deployed for a flow reduction.	Does the continued collection of stranding data, and upgrading of the lower Columbia River stranding protocol, limit the number of occurrences when stranding crews need to be deployed due to flow reductions from HLK?	The number of fish salvage events can be reduced through adaptive adjustments made as a result of ongoing data collection.	Data collected over the previous 7 years does not support this hypothesis. Continued collection of stranding data and upgrading the Columbia River stranding protocol has not decreased the number of stranding events where crews were deployed. The number of occurrences when stranding crews were deployed ranged from 8 to 15 deployments with crews going out on an average of 82% of the reductions. During the winter of 2015/2016 discharge from HLK was lower than average. As a result more REs were responded to. Crews responded to 15 of the 18 flow reductions during this study period.

Key Words

lower Columbia River

Kootenay River

Water Use Planning

Fish Stranding

Flow Reduction

Discharge Regulation

Re-contouring

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1.0 INTRODUCTION

1.1 Scope and Objectives

The main objective of the monitoring program was to collect fish stranding data to assess the impact of flow reductions and flow ramping rates from Hugh L. Keenleyside Dam/Arrow Lakes Generating Station (HLK/ALH) and Brilliant Dam/Expansion (BRD/X) on native fish species of the lower Columbia and Kootenay rivers. The program assessed fish stranding at pre-determined sites (Appendix A) between HLK and the Canada/USA border. Secondary objectives included: 1) determining ramping rates for flow reductions that reduced incidences of fish stranding at different times of the year; 2) determining whether wetted history influenced the stranding rate of fish during flow reductions; 3) determining whether a conditioning flow reduction from HLK reduced the stranding rate of fish; 4) determining whether physical habitat manipulation (e.g., re-contouring the shoreline) reduced incidences of fish stranding in the lower Columbia River; and 5) reducing (through risk management strategies) the number of occurrences when stranding crews needed to be deployed during flow reductions (BC Hydro 2007).

This report describes the results of fish stranding assessments conducted in the lower Kootenay and Columbia rivers from 1 April 2015 to 1 April 2016. Results are compared with data from previous years of monitoring and are discussed in relation to the objectives, management questions, and hypotheses outlined above and below.

1.2 Management Questions

The key management questions identified under the Columbia Water Use Plan and addressed under the current monitoring program are (BC Hydro 2007):

1) Is there a ramping rate (fast vs. slow, day vs. night) for flow reductions from HLK that reduces the number of fish stranded (interstitially and pool) per flow reduction event in the summer and winter?

2) Does wetted history (the length of time the habitat has been wetted prior to the flow reduction) influence the number of fish stranded (interstitially and pool) per flow reduction event for flow reductions from HLK?

3) Can a conditioning flow (a temporary, one step, flow reduction of approximately 2 hours to the final target dam discharge that occurs prior to the final flow change) from HLK reduce the stranding rate of fish?

4) Can physical habitat works (i.e., re-contouring) reduce the incidence of fish stranding in high risk areas?

5) Does the continued collection of stranding data, and upgrading of the lower Columbia River stranding protocol, limit the number of occurrences when stranding crews need to be deployed due to flow reductions from HLK?

1.3 Management Hypotheses

For fish stranding in the lower Columbia River, the following hypotheses (BC Hydro 2007) will be tested:

Ho_1: The number of stranded fish is independent of either the ramping rate or time of day of flow reductions in the summer and winter.

Ho_2: Wetted history does not influence the stranding rate of fish (both interstitially and pool stranding) for flow reductions from HLK.

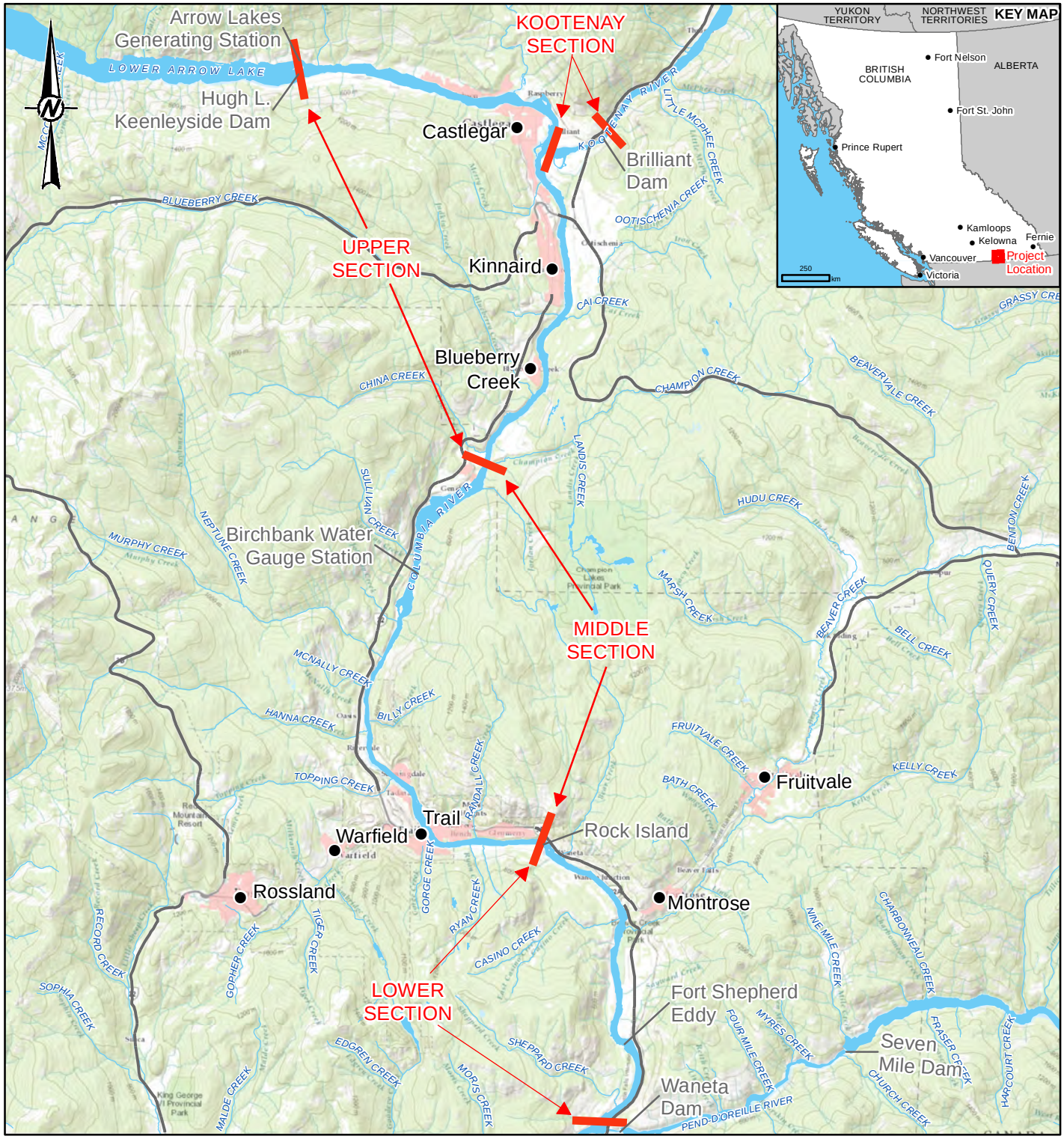
Ho_3: A conditioning flow from HLK does not reduce the stranding rate of fish in the lower Columbia River.

Ho_4: Physical habitat manipulation does not reduce the stranding rate of fish in the lower Columbia River.

Ho_5: The number of fish salvage events can be reduced through adaptive adjustments made as a result of ongoing data collection.

1.4 Study Area

The study area encompasses the approximately 56 km long section of the lower Columbia River from HLK to the Canada/USA border and the lower Kootenay River (approximately 2.8 km) from below BRD/X to the Columbia River confluence (Figure 1).



LEGEND

- TOWN
- HIGHWAY
- WATERCOURSE
- RESIDENTIAL AREA
- WATERBODY

0 5 10

1:200000 KILOMETERS

REFERENCES

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DATUM: NAD 1983 UTM ZONE 11N

CLIENT
BC HYDRO

PROJECT
LOWER COLUMBIA RIVER AND KOOTENAY RIVER FISH STRANDING

TITLE
STUDY AREA OVERVIEW

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-02
DESIGNED	DB
PREPARED	CD
REVIEWED	CK
APPROVED	CK

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2.0 METHODS

2.1 Fish Stranding Risk Assessment

The fish stranding protocol *Canadian Lower Columbia River Fish Stranding Risk Assessment and Response Strategy* (Golder 2011) was implemented preceding each reduction event and during all stranding surveys conducted and included in this summary. Fish stranding protocols were previously developed by BC Hydro, Columbia Power Corporation (CPC) and FortisBC, in collaboration with the Columbia Operations Fish Advisory Committee (COFAC). The protocols were developed to manage fish impacts associated with flow reductions from the Columbia (HLK/ALH) and the Kootenay (BRD/X) systems. Fish stranding risk and response was based on current knowledge of factors known to influence fish stranding in regulated systems and the results of previous stranding assessments (Vonk 2003, BC Hydro 2005, Golder and Poisson 2010). Figure 2 summarizes the five phase process for defining fish stranding risk, as well as guiding assessment/salvage response decisions.

Fish stranding risk and assessment/salvage response were determined using the following factors:

- **Timing of Reduction**- Day of Year is a proxy for fish use of near-shore habitats which is similar in timing with the previous protocol. The high stranding risk period occurs from 1 June to 30 September; the Low Risk period occurs from 1 October to 31 May (Golder and Poisson 2010). Stranding risk is greatest in the summer months because newly emerged juvenile fish occupy shallow near-shore habitats where they are more susceptible to stranding (Golder and Poisson 2010).
- **River Stage**- The probability of fish stranding is typically inversely related to water levels. There are certain river stage elevations that have a high risk for stranding because of the formation of pools and the low slope habitat that is uncovered at that elevation. The low angle river bank and presence of shallow depressions at lower water levels result in greater risk of fish stranding than during higher water levels. During the High Risk period (1 June to 30 September), fish stranding risk is less when discharge is greater than 110 kilo cubic feet per second (kcfs) (based on limited data). During the Low Risk period (1 October to 31 May), stranding risk decreases when discharge is greater than 60 kcfs (Golder and Poisson 2010).
- **Info Review**-The Lower Columbia River Fish Stranding Database was developed to archive historic flow reduction assessment data (discharge levels, ramping rates, sites, number of pools isolated, number and species of fish/eggs stranded either interstitially or within pools, etc.) for use in predicting the potential impacts of a proposed flow reduction. Data from each stranding survey were entered into a MS-Access database. A database operating manual assists with the operation and maintenance of the database (Golder 2005a). The database is queried to help define fish stranding risk at a particular site based on historical data collected during similar times of the year under similar flow conditions. Data entered into the query include daily discharge from HLK/ALH and BRD/X (current), proposed resultant daily discharge from HLK/ALH and BRD/X, the Columbia River water temperature from Birchbank Water Station and the date of the proposed reduction. Based on these data, the database provides a prediction of stranding risk at individual sites.

Flow Reduction Fish Stranding Assessment Response

PHASE 1 Timing

HLK /ALH or BRD/BRX Flow Reduction

Day of Year

June 1 – September 30

October 1 – May 31

PHASE 2 Stage

Minimum River Stage during reduction (BB)?

<110 kcfs

>110 kcfs

Minimum River Stage during reduction (BB)?

<60 kcfs

>60 kcfs

Query Stranding Database

PHASE 3 Info Review

> 200 fish (effect) at one site or listed species expected?

No

<5 assessments at Individual sites at Risk (query), non-routine stage or ramping rate, no assessment in past 2 years at this stage?

No

>200 fish (effect) at one site or listed species expected?

No

<5 assessments at Individual sites At Risk (query), non-routine stage or ramping rate, no assessment in past 2 years at this stage?

No

PHASE 4 Management Decision

Yes

Assessment Recommended

Yes

Voluntary Assessment Recommended

No Assessment Required

Yes

Assessment Recommended

Yes

Voluntary Assessment Recommended

No Assessment Required

PHASE 5 Assessment Refinement (Considerations)

1. Review database query results and number of potential sites with effects.

2. Review previous reduction results for significant stranding (> 5000 fish).

3. Estimate wetted history at Birchbank, >10 days wetted history – anticipate more fish stranded.

4. Define daytime air temperature. If air temperature is greater than 25ºC or less than 0ºC, increase crews may be deployed to high risk sites.

5. Consider time of last reduction and ability to assess all potential stranding sites before dark.

If review suggests minimal risk of stranding and limited value in additional information collection an assessment is not necessary.

1. Review database query results and number of potential sites with effects.

2. Review previous reduction results for significant stranding (> 5000 fish).

3. Estimate wetted history at Birchbank, >10 days wetted history – anticipate more fish stranded.

4. Define daytime air temperature. If air temperature is greater than 25ºC or less than 0ºC, increase crews may be deployed to high risk sites.

5. Consider time of last reduction and ability to assess all potential stranding sites before dark.

If review suggests minimal risk of stranding and limited value in additional information collection an assessment is not necessary.

Undertake Assessment Baseline = 1 crew of 2 can assess approximately 7 sites per day. Consider additional crew on standby if you answered YES to questions 1 – 5 above.

Undertake Assessment

Figure 2: Flow reduction fish stranding assessment response procedure

After timing, river stage and results of the stranding database query have been considered a management decision is made to determine whether a stranding assessment is recommended or not. If a stranding assessment is recommended further variables are considered including:

- Number of potential sites from the database query with 'Effects';
- Review of previous reduction results for 'Significant Fish Stranding';
- Wetted history at Birchbank Water Station;
- Daytime air temperature; and
- Time of last reduction.

Based on data collected since 2000, a fish stranding event at a site is defined as:

- A **'Minimal Effect'** site is defined as a site that has a history of stranding less than 200 fish/RE.
- An **'Effect'** site is defined as a site where the maximum number of fish historically stranded at the site is greater than or equal to 200 fish/RE (all species combined), or when species of conservation concern (i.e., species listed under Canada's Species at Risk Act or the British Columbia Conservation Data Centre's red or blue lists) have been recorded as stranded at the site at similar flow levels.
- A **'Reconnaissance'** site is defined as a site that has been visited less than five times at a given river stage since the inception of the program and where there are insufficient data to classify the site under one of the other categories.
- A **'No Pools'** site is defined as a site where pools have never been recorded during assessments conducted under similar conditions (river level and reduction amount).
- A **'Significant Fish Stranding'** site is defined as a site in the lower Columbia and Kootenay rivers that has had greater than 5000 fishes of all species stranded during a single flow reduction event. It is uncertain if this level of stranding would result in a population level effect for a given species; therefore, stranding of this magnitude requires a thorough assessment and, in some cases may warrant additional management attention (e.g., alterations to the flow reduction strategy), particularly where threatened or endangered species are involved.

The fish stranding risk categories (i.e., 'Minimal Effec't, 'Effect', or 'Significant Fish Stranding') are defined based on absolute numbers of fish stranded during previous assessments (Golder 2011) and do not take into account the survey effort in time or area. As it is, the absolute numbers are appropriate guidelines for stranding risk. The assumptions of using the absolute numbers of stranded fishes to define risk are that all the area of isolated pools are searched, and that the relative amount of time spent searching pools (dependent upon size and number of pool in an area) and the resultant efficiency in detecting fish are approximately constant among surveys. These assumptions are likely reasonable, as all the area of pools are typically searched, experienced survey crews attempt to have similar search effort among surveys, and pool habitats are typically simple, which likely results in consistent detection efficiency over time for each site.

During a stranding assessment, sites were selected for fish salvage and surveying in 2015/2016 on a priority basis. The query used projected flow conditions and the stranding history classification in the database to assign designations to each site. Sites where a 'Significant Fish Stranding' or 'Effect' designation was assigned were assessed first. The next priorities were 'Reconnaissance' sites, and, if time permitted, 'Minimal Effect' or 'No Pools' sites to confirm information in the database. Data are summarized and presented in a report "Stranding Risk Assessment Output", of which an example is provided in Appendix B.

2.2 Salvage Methods

Standard methodologies used during the field component for each fish stranding assessment were outlined in the *Canadian Lower Columbia River Fish Stranding Risk Assessment and Response Strategy* (Golder 2011) and are summarized below. The primary objective was to collect information on effects of flow reduction on fish stranding with fish salvage as a secondary objective. Fish stranding and salvage assessments began at the most upstream site identified for assessment by the Lower Columbia River Fish Stranding Database query and continued downstream following the stage recession. The crew was on site no later than one hour after the initiation of a flow reduction from HLK/ALH or BRD/X.

At each site the crew conducted the following activities:

1) Documented the current conditions (date, time, weather, air and water temperature, approximate vertical drawdown of the water level, etc.) on Stranding Field Forms.
2) Observed and recorded the number of new isolated pools that were created as a result of the flow reduction. Pools isolated during previous reductions were not enumerated.
3) Inspected each pool for fish and attempted to salvage any fish present using dipnets, backpack electrofishers (Smith-Root Model LR 24 or 12-B POW), or beach seines.
4) Transferred the captured fish into a bucket of water where each fish was identified to species and life stage and released into the main channel of the river. Where possible, fish were classed into one of the following life stages; egg, young-of-the-year, juvenile, and adult. If stranded fishes were numerous (>200), subsamples of the catch were captured and identified to species. If field identification to species was not possible, a subsample of up to approximately 30 individuals was preserved for positive laboratory identification. Samples were preserved in *Prefer*™ solution or frozen for identification in the laboratory.
5) Visually estimated the number of larvae and alevins present if sample methods were ineffective at capturing these life stages.
6) Inspected interstitial stranding areas and salvaged any fish observed.
7) Photographed representative areas of the site at the time of sampling and photographed representative or unusual fish species where appropriate.
8) Fish length data were collected from up to 20 individuals of each species identified during each reduction event. Total length was measured for sculpin species and fork length was measured for all other species.

The collection of fish length data was proposed in the Columbia River Project Water Use Plan Monitoring Program Terms of Reference - Lower Columbia River Fish Management Plan (CLBMON-42 Lower Columbia River Fish Stranding Assessment and Ramping Protocol, 31 August 2007). These data were collected and were used to investigate whether there is a size at which certain species are more susceptible to stranding.

All length data previously collected were combined, in order to increase the sample size available to assess the frequency of stranding of different size-classes. Combining all length data for each species was considered reasonable based on the assumption that the year did not have a statistical effect on fish length. Length-frequency data are presented for nine non-sportfish species (Longnose Dace [*Rhinichthys cataractae*], Northern Pikeminnow [*Ptychocheilus oregonensis*], Peamouth [*Mylocheilus caurinus],* Prickly Sculpin [*Cottus asper*], Redside Shiner [*Richardsonius balteatus*], sucker species [*Catostomidae*], Columbia Sculpin [*Cottus hubbsi],* Torrent Sculpin [*Cottus rhotheus*] and Umatilla Dace [*Rhinichthys umatilla*] and one sportfish species (Rainbow Trout [*Oncorhynchus mykiss]*).

3.0 RESULTS

3.1 Operations Overview 2015/2016

3.1.1 Columbia River Discharge

During the present study, the mean hourly discharge in the Columbia River at the Birchbank gauging station ranged from 31.3 kcfs recorded on 3 March 2016 to 122.8 kcfs on 7 June 2015 (Figure 3).

3.1.2 Hugh L. Keenleyside and Arrow Lakes Generating Station (HLK/ALH)

During the present study, the mean hourly discharge from HLK/ALH ranged from 9.6 kcfs on 20 March 2016 to 83.2 kcfs on 30 June 2015 (Figure 3).

During the study period, there were 18 operational flow reduction events (REs) from HLK/ALH (Figure 3). Of the 18 REs, six occurred during the High Risk period (1 June to 30 September) and twelve occurred during the Low Risk period (1 October to 31 May). The magnitude of flow reductions ranged from 2.0 to 15.0 kcfs (Table 1). In total, fish stranding assessments were initiated for 15 REs during the study period. After an evaluation of the available data, fish stranding assessments were not initiated by BC Hydro for the remaining 3 REs.

3.1.3 Brilliant Dam and Brilliant Expansion (BRD/X)

During the present study, the Kootenay River mean hourly discharge ranged from a minimum of 6.3 kcfs on 18 October 2015 to a maximum of 65.4 kcfs on 4 June 2015 (Figure 3). Fish stranding surveys were not initiated in response to flow changes at BRD/X during this study. The discharge from BRD/X remained constant during all reduction events in 2015/2016 except for RE2016-03 on 5 February 2016. During this event BRD/X flows dropped from 16.0 kcfs to 15.0 kcfs.

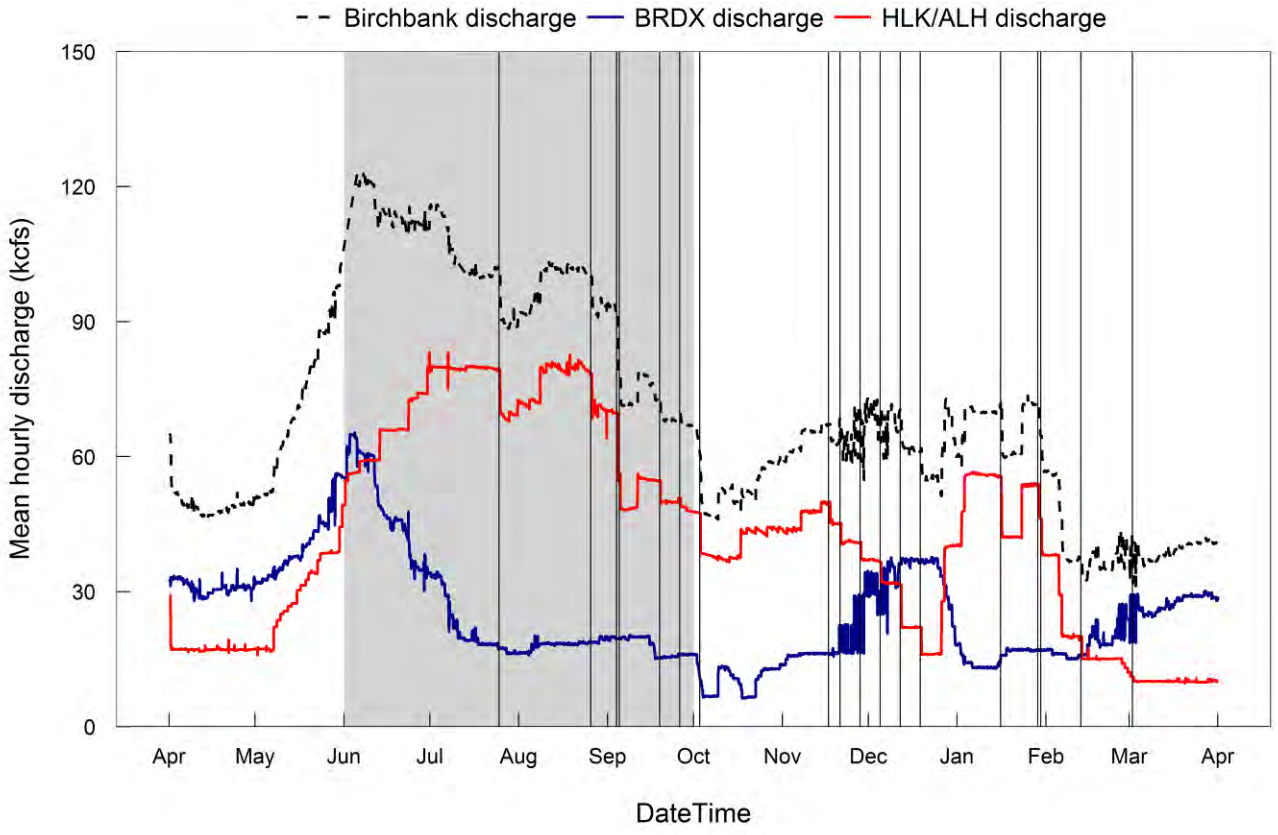

Figure 3: Mean hourly discharge from HLK/ALH (red line), BRD/X (blue line), and at the Water Survey of Canada Gauging Station at Birchbank (dotted black line), 1 April 2015 to 1 April 2016. The solid black vertical lines indicate REs at HLK/ALH. REs were numbered from RE2015-05 to RE2016-05 (left to right on the figure). Grey rectangle represents the period of high risk.

3.2 Fish Stranding Assessments

Fish stranding assessments were conducted for 15 of the 18 REs that occurred between 1 April 2015 and 1 April 2016 (Table 1). The median number of stranding assessments for the previous six reporting periods (2009/2010 to 2014/2015) was 14 (Figure 4). The total number of REs in 2015/2016 (*n*=18) was greater than the number of REs in 2014/2015 (n=16) but slightly below the average number of REs (n=19) from the previous six study years. In Year 2009/2010, 20 REs were recorded. In Year 2010/2011, 21 REs were recorded. In Year 2011/2012, 23 REs were recorded. In Year 2012/2013, 17 REs were recorded. In Year 2013/2014, 14 REs were recorded. In Year 2014/2015, 16 REs were recorded. The numbers of reductions from HLK/ALH have remained fairly consistent, with between 11 and 16 reductions with a median of 14 during the previous six reporting periods (2009/2010 to 2014/2015). The 18 reductions in 2015/2016 represent the greatest number of total reduction events from HLK/ALH during the last seven reporting periods. Reductions from BRD/X and combined reductions from both facilities have generally decreased (from nine reductions in 2009/2010 to zero

reductions in 2015/2016. This is the first year where no fish stranding surveys were initiated due to flow reductions from BRD/X.

During the 2015/2016 study period stranding assessments were conducted for 83% of the REs (Figure 4). This was slightly higher than the previous study period where stranding assessments were conducted for 75% of the reductions. The total number of stranding assessments has generally declined over the previous six years, but in 2015/2016 the total number of stranding assessments was greater than the previous three years (Figure 4).

Table 1: Summary of Reduction Events (RE) from HLK/ALH and BRD/X 1 April 2015 to 1 April 2016.

Reduction Event No.	Reduction Date	Concern Category	Crew Dispatched?	Birchbank				Brilliant Dam/BRX					HLK/ALGS									
				Mean Daily Water Temp (°C)	Max. Q (kcfs)	Min. Q (kcfs)	Magnitude of Reduction (kcfs)	Prev Q (kcfs)	Resulting Q (kcfs)	Magnitude of Reduction (kcfs)	No. Ramped Flow Reductions	Avg. Ramping Rate (kcfs)	Prev Q (kcfs)	Resulting Q (kcfs)	Magnitude of Reduction (kcfs)	No. Ramped Flow Reductions	Avg. Ramping Rate (kcfs/hr)	Pools Formed	Interstitial Stranding	Fish Stranded	Sites Visited	Purpose of flow reduction
HLK/ALH 2015-05	July 25, 2015	High	Yes	16.5	101.0	90.3	10.7	16.0	16.0	0.0	N/A	N/A	80.0	70.0	10.0	2	5.0	Yes	Yes	0	9	Reduction of inflows; Treaty requirements
HLK/ALH 2015-06	August 26, 2015	High	Yes	16.1	100.1	92.4	7.7	19.0	19.0	0.0	N/A	N/A	78.0	70.0	8.0	3	2.7	Yes	Yes	458	11	Reduction of inflows; Treaty requirements
HLK/ALH 2015-07	September 4, 2015	High	Yes	14.5	93.1	77.6	15.5	19.0	19.0	0.0	N/A	N/A	70.0	55.0	15.0	3	5	Yes	Yes	230	13	Reduction of inflows; Treaty requirements
HLK/ALH 2015-08	September 5, 2015	High	Yes	14.8	77.8	71.3	6.5	19.0	19.0	0.0	N/A	N/A	55.0	47.0	8.0	2	4	Yes	Yes	100	13	Reduction of inflows; Treaty requirements
HLK/ALH 2015-09	September 19, 2015	High	Yes	12.7	72.9	67.8	5.1	16.0	16.0	0.0	N/A	N/A	55.0	50.0	5.0	1.0	5	Yes	Yes	28	16	Reduction of inflows; Treaty requirements
HLK/ALH 2015-10	September 26, 2015	High	Yes	13.5	69.5	67.6	1.9	16.0	16.0	0.0	N/A	N/A	50.0	48.0	2.0	1	2	Yes	Yes	1420	8	Reduction of inflows; Treaty requirements
HLK/ALH 2015-11	October 3, 2015	Low	Yes	13.4	61.4	49.2	12.2	16.0	16.0	0.0	N/A	N/A	48.0	38.0	10.0	2	5.0	Yes	Yes	196	7	Reduction of inflows; Treaty requirements
HLK/ALH 2015-12	November 17, 2015	Low	No	8.5	67.3	63.5	3.8	18.0	18.0	0.0	N/A	N/A	50.0	45.0	5.0	2	2.5	N/A	N/A	N/A	0	Reduction of inflows: Treaty requirements
HLK/ALH 2015-13	November 21, 2015	Low	Yes	7.6	66.0	61.8	4.2	20.0	20.0	0.0	N/A	N/A	45.0	41.0	4.0	1	4	Yes	Yes	0	13	Reduction of inflows: Treaty requirements
HLK/ALH 2015-14	November 28, 2015	Low	No	6.5	70.0	58.9	11.1	18.0	18.0	0.0	N/A	N/A	41.0	37.0	4.0	1	4	N/A	N/A	N/A	0	Reduction of inflows; Treaty requirements
HLK/ALH 2015-15	December 5, 2015	Low	Yes	6.4	71.1	63.2	7.9	30.0	30.0	0.0	N/A	N/A	37.0	32.0	5.0	1	5	Yes	Yes	17	10	Reduction of inflows; Treaty requirements
HLK/ALH 2015-16	December 12, 2015	Low	Yes	6.2	70.5	62.5	8.0	30.0	30.0	0.0	N/A*	N/A*	32.0	22.0	10.0	2	10.0	Yes	Yes	5	5	Reduction of inflows; Treaty requirements
HLK/ALH 2015-17	December 19, 2015	Low	Yes	5.4	61.9	55.2	6.7	37.0	37.0	0.0	N/A*	N/A*	22.0	16.0	6.0	2	3	Yes	Yes	47	5	Reduction of inflows; Treaty requirements
HLK/ALH 2016-01	January 16, 2016	Low	Yes	4.0	72.7	60.1	12.6	13.0	13.0	0.0	N/A	N/A	56.0	42.0	14.0	3	4.7	Yes	Yes	12	7	Reduction of inflows; Treaty requirements
HLK/ALH 2016-02	January 29, 2016	Low	No	4.2	71.6	64.7	6.9	17.0	17.0	0.0	N/A	N/A	54.0	46.0	8.0	2	4.0	Yes	Yes	351	2***	Reduction of inflows; Treaty requirements
	January 30, 2016	Low	No	4.2	64.7	56.7	8.0	17.0	17.0	0.0	N/A	N/A	46.0	38.0	8.0	3	2.7					
HLK/ALH 2016-03	February 5, 2016	Low	Yes	3.9	56.0	46.6	9.4	16.0	16.0	0.0	N/A	N/A	38.0	29.0	9.0	2	4.5	Yes	Yes	2115	12	Reduction of inflows; Treaty requirements
	February 6, 2016	Low	Yes	4.0	46.8	38.1	8.7	16.0	15.0	1.0	1	1.0	29.0	20.0	9.0	2	4.5	Yes	Yes	359	11****	
HLK/ALH 2016-04	February 13, 2016	Low	Yes	4.0	38.0	32.6	5.4	15.0	15.0	0.0	N/A	N/A	20.0	15.0	5.0	2	2.5	Yes	Yes	240	5†	Reduction of inflows; Treaty requirements
HLK/ALH 2016-05**	February 27, 2016 to March 2, 2016	Low	Yes	4.5	41.0	31.9	9.1	22.0	22.0	0.0	N/A*	N/A*	15.0	10.0	5.0	5	1.0	Yes	Yes	108	2	Reduction of inflows; Treaty requirements. Drop changed to 5 kcfs in 5 days (1.0 kcfs/day) to accommodate International Forest Products Ltd.

*Brilliant Dam was load factoring at this time.

** Reduction event 2016-05 occurred over 5 days (27 February 2016 to 2 March 2016) The birchbank water temperature, max and min flows were calculated over the entire 5 day period.

*** No crew was mobilized for RE2016-02. One site (Gyro Boat Launch) with a pool remaining from this reduction event was sampled on 5 and 6 February 2016.

**** Three sites (Bear Creek [RUB], Norns Creek Fan [RUB] and Genelle [Mainland] [LUB]) were sampled on 12 and 13 February 2016. These sites had isolated pools remaining from RE2016-03.

† One site (Fort Shepherd [LUB]) was sampled on 2 March 2016. This site had an isolated pool remaining from RE2016-04

N/A = not applicable

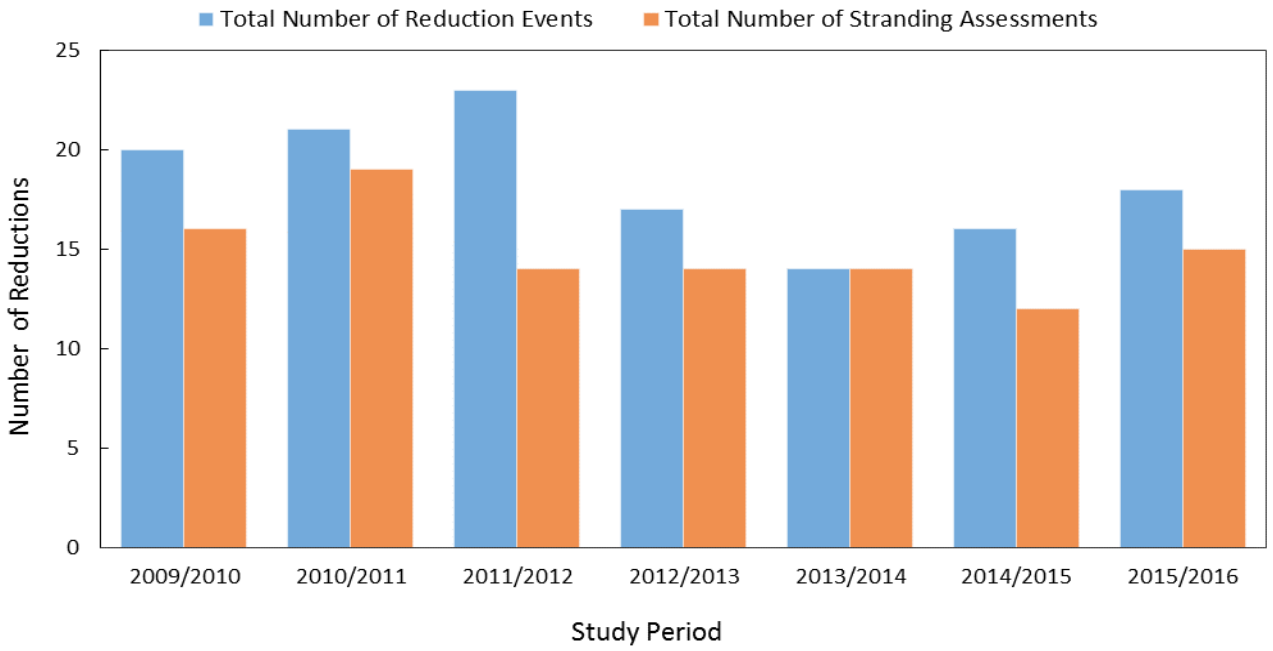

Figure 4: Total number of Reduction Events and Stranding Assessments conducted during each study period from 2009/2010 to 2015/2016.

In total, 21 different sites were assessed at least once during the 2015/2016 stranding assessment period (Table 2). As with previous study years, assessment efforts were concentrated on sites identified as having a high risk of stranding fish defined by a database query and outlined in the *Columbia River Project Water Use Plan Monitoring Program Terms of Reference - Lower Columbia River Fish Management Plan (CLBMON-42 Lower Columbia River Fish Stranding Assessment and Ramping Protocol, 31 August 2007).*

As with previous years, poor site access (e.g., excessive snow) and limited daylight hours during the Low Risk winter season restricted the number of sites that could be assessed, most notably, sites downstream of Gyro Boat Launch site (Beaver Creek RUB, Trail Bridge RUB, Fort Shepherd Launch, Casino Bridge LUB [upstream], Casino Bridge LUB [downstream], and Bear Creek RUB). Additionally, Beaver Creek LUB and Fort Shepherd LUB were infrequently surveyed due to the Fort Shepherd Conservancy access road being closed annually from 1 December until 1 April (Appendix A, Figures A4 to A7).

3.2.1 Fish Captured or Observed During 2015/2016 Stranding Assessments

Isolated pools were observed during all stranding surveys in 2015/2016 and stranded fishes were recorded at all but two events (RE2015-05 and RE2015-13) (Table 1). A stranding assessment was initiated for RE2015-05, but due to the high water (approximately 101 kcfs at Birchbank) only 6 pools were observed and no stranded fish were reported. The fish stranding database query for RE2015-13 resulted in 18 ‘Reconnaissance’ sites, 2 ‘No Pool’ sites, 1 ‘Effect’ site and 1 ‘Minimal Effect’ site. Since little was previously known about stranding risk

at this time of year and river stage a stranding assessment was initiated. Results of this assessment were 38 pools and no stranded fish. During the other 13 REs, 5686 stranded fishes were recorded (Table 2). The majority (68.5%) of these fishes were observed during two RE assessments (RE2015-10 and RE2016-03). The total number of fishes observed or salvaged for each RE ranged from 0 to 2474 (Table 1). None of the stranding assessments conducted during the sample period were classified as a 'Significant Fish Stranding' event (>5000 fishes observed).

The majority (76.3%) of the isolated fishes were recorded in pools located at the Genelle Mainland LUB (40.9%) and Bear Creek (35.4%) sites (Table 2). See Appendix A; Figure A1 through A7 for site locations.

Table 2: Percentage of the Total Number of Fish Stranded during the Reduction Events from 1 April 2015 to 1 April 2016 that were stranded at each Site.

Site[a]	Total Number of Visits	Total Number of Fish Stranded	Median Number of Fish Stranded per Visit	% of Total Stranded Fish at each Site
Genelle (Mainland) (LUB)	15	2325	11	40.9
Bear Creek (RUB)	4	2015	0	35.4
Gyro Boat Launch	8	401	0	7.1
Tin Cup Rapids (RUB)	12	371	1	6.5
Norns Creek Fan (RUB)	15	133	1	2.3
Fort Shepherd Eddy (LUB)	5	113	0	2.0
Kootenay River (LUB)	11	83	0	1.5
Kootenay River (RUB)	12	77	0	1.4
Millennium Park (Tin Cup LUB)	9	68	0	1.2
Beaver Creek (RUB)	5	30	0	0.5
Lions Head (upstream of Norns fan) (RUB)	13	29	0	0.5
CPR Island (MID)	6	16	0	0.3
Blueberry Creek (LUB)	2	11	6	0.2
Fort Shepherd Launch (RUB)	9	6	0	0.1
Trail Bridge (RUB) (Downstream)	3	5	0	0.1
Zuckerberg Island (LUB)	7	3	0	0.1
Casino Road Bridge, Trail (LUB) (Downstream)	2	0	0	0.0
Beaver Creek (LUB)	4	0	0	0.0
Casino Road Bridge, Trail (LUB) (Upstream)	3	0	0	0.0
Genelle Lower Cobble Island (MID)	2	0	0	0.0
Kinnaird Rapids (RUB)	1	0	0	0.0
Total	**148**	**5686**	**19**	**100**

[a]Appendix A; Figures A1 through A7
[b]LUB=left upstream bank; RUB=right upstream bank

3.2.1.1 Fish Species

3.2.1.1.1 Sportfish

Sportfish accounted for 4.6% of total fish stranded in 2015/2016 which is close to the median percentage of sportfish stranded (5.4%) since 2009. Kokanee, Mountain Whitefish or Walleye were not observed during the 2015/2016 stranding events (Table 3).

The majority (98%) of the sportfish stranded were Rainbow Trout. Since 2009 the median percentage of Rainbow Trout was 16.7% of all sportfish stranded. In past years the percentage of Rainbow Trout has been quite low due to the identification of stranded larval Whitefish which are often found in large numbers. In 2015/2016 no Whitefish were identified during stranding assessments. The greatest number of stranded Rainbow Trout were observed at Tin Cup Rapids RUB (n=214), Beaver Creek RUB (n=21) and CPR Island MID (n=15) (Appendix A; Figure A1, A2 and A6). All recorded Rainbow Trout were either young-of-the year or juveniles, except for one adult that was observed in a pool at Genelle Mainland site during RE2015-07. Of the 259 stranded Rainbow Trout, 63% were salvaged.

In 2015/2016 there were the greatest number of Brook Trout (n=4) stranded compared to all previous study years. All stranded Brook Trout were juveniles and were captured at or downstream from Gyro Boat Launch site during RE2016-02 and RE2016-03.

During RE2015-17 one juvenile Yellow Perch was stranded in a small pool at the Millenium Park (Tin Cup LUB) site.

During 2015/2016, fork length measurements were recorded for 71 Rainbow Trout from seven different stranding assessments. Fork length measurements ranged from 50 to 145 mm. All measured Rainbow Trout were classified as juveniles.

Figure 5 shows the length-frequency of measured Rainbow Trout (*n*=221) from all years combined. All measured Rainbow Trout were small and classified as juvenile or Young-of-the-Year fish. The majority (99%) had fork lengths <140 mm and 85% had fork lengths <100 mm. The highest frequency of Rainbow trout (n=59) were those with fork length between 70 and 79 mm.

Table 3: Summary of Fish Species Captured or Observed during Fish Stranding Assessments Subsequent to Reductions in Discharge from Hugh L. Keenleyside Dam/Arrow Lakes Generating Station or from Brilliant Dam/Brilliant Expansion, 1 April 2015 to 1 April 2016.

Species		Total Stranded and/or Captured	Percent of Total Stranded and/or Captured (%)	Number of Mortalities	Number Salvaged	Species Classification		
						SARA[a]	COSEWIC[b]	CDC[c]
Sportfish	Rainbow Trout (*Oncorhynchus mykiss*)	259	4.6	16	163	N/A	N/A	Yellow
	Brook Trout (*Salvelinus fontinalis*)	4	0.1	0	4	N/A	N/A	Exotic
	Yellow Perch *(Perca flavescens)*	1	<0.1	0	0	N/A	N/A	Exotic
Non-Sportfish	Sucker species *(Catostomidae)*	2474	43.5	305	1904	N/A[d]	N/A[d]	N/A[d]
	Northern Pikeminnow (*Ptychocheilus oregonensis*)	1294	22.8	203	967	N/A	N/A	Yellow
	Umatilla Dace (*Rhinichthys umatilla*)	444	7.8	77	361	Schedule 3 Special Concern	Threatened	Red
	Longnose Dace (*Rhinichthys cataractae*)	360	6.3	29	211	N/A	N/A	Yellow
	Torrent Sculpin (*Cottus rhotheus*)	355	6.2	9	344	N/A	N/A	Yellow
	Redside Shiner (*Richardsonius balteatus*)	271	4.8	48	221	N/A	N/A	Yellow
	Sculpin species (*Cottus spp.)*	144	2.5	0	34	N/A[e]	N/A[e]	N/A[e]
	Prickly Sculpin (*Cottus asper*)	37	0.7	4	33	N/A	N/A	Yellow
	Columbia Sculpin (*Cottus hubbsi)*	22	0.4	0	22	Schedule 1 Special Concern	Special Concern	Blue
	Peamouth (*Mylocheilus caurinus*)	11	0.2	0	11	N/A	N/A	Yellow
	Unidentified[f]	10	0.2	0	0	N/A[e]	N/A[e]	N/A[e]
Total		**5686**	**100**	**691**	**4275**			

[a]Species at Risk Act; Species that were designated at risk by COSEWIC (the Committee on the Status of Endangered Wildlife in Canada) before the creation of the *Species at Risk Act* must be reassessed according to the new criteria of the Act before they can be added to Schedule 1. These species are listed on Schedules 2 and 3, and are not yet officially protected under SARA (COSEWIC 2010).
[b]Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2010).
[c]Conservation Data Centre; Red=ecological communities and indigenous species and subspecies that are extirpated, endangered or threatened in British Columbia; Blue= ecological communities and indigenous species and subspecies of special concern in British Columbia; Yellow= ecological communities and indigenous species and subspecies that are not at risk in British Columbia (BCCDC 2011).
[d]No species are listed from this region that are found under any of the classification criteria for species of concern.
[e]Fish identified to family level or other high level taxa may potentially be species of concern under the classification systems listed.

[f]Not identified to species because they were young-of-the-year life stage or observed but not captured.

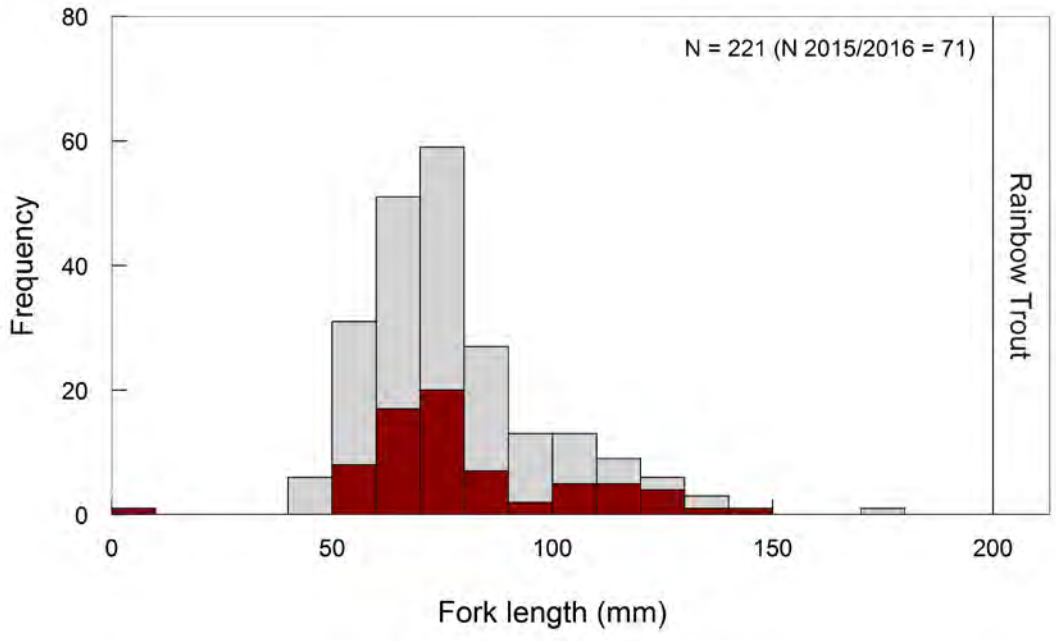

Figure 5: Length-frequency for Rainbow Trout collected during stranding assessments conducted during 2011 to 2016. Length-frequency for Rainbow Trout measured in 2015/2016 represented in red.

3.2.1.1.2 Non-sportfish

The majority of non-sportfish found during the 2015/2016 stranding assessments were young-of-the-year juvenile sucker species (*n*=2474). Of the total sucker species stranded in 2015/2016, 62.4% were found in a large pool at Bear Creek site during RE2016-03. This reduction event occurred on 5 and 6 February 2016, but Bear Creek was not sampled on those dates because the database query did not identify Bear Creek as an 'Effect' site. A member of the public alerted BC Hydro that a number of fish were stranded at the site, and Golder sent a two-person crew to perform a fish salvage at Bear Creek on 12 February 2016. Sucker species were the most abundant (59.3%) of all species observed during this salvage.

Northern Pikeminnow (*n*=1294) were the second most abundant non-sportfish species recorded, followed by Umatilla Dace (*n*=444; Table 3).

A sub-sample of length measurements was recorded for all non-sportfish species collected during the 2015/2016 stranding assessments. Total lengths were collected for Scuplin species and fork lengths were collected for all remaining non-sportfish species. A total of 704 length measurements were collected from non-sport fish (91.6% from fish captured in isolated pools and 8.4% from fishes collected from interstitial stranding areas). The frequencies of stranded fish species by lengths (all years combined) are provided in Figures 6 and 7.

In 2015/2016 all measured Catostomidae species and 89% of Cyprinidae species were classified as juvenile or Young-of-the-Year fish.

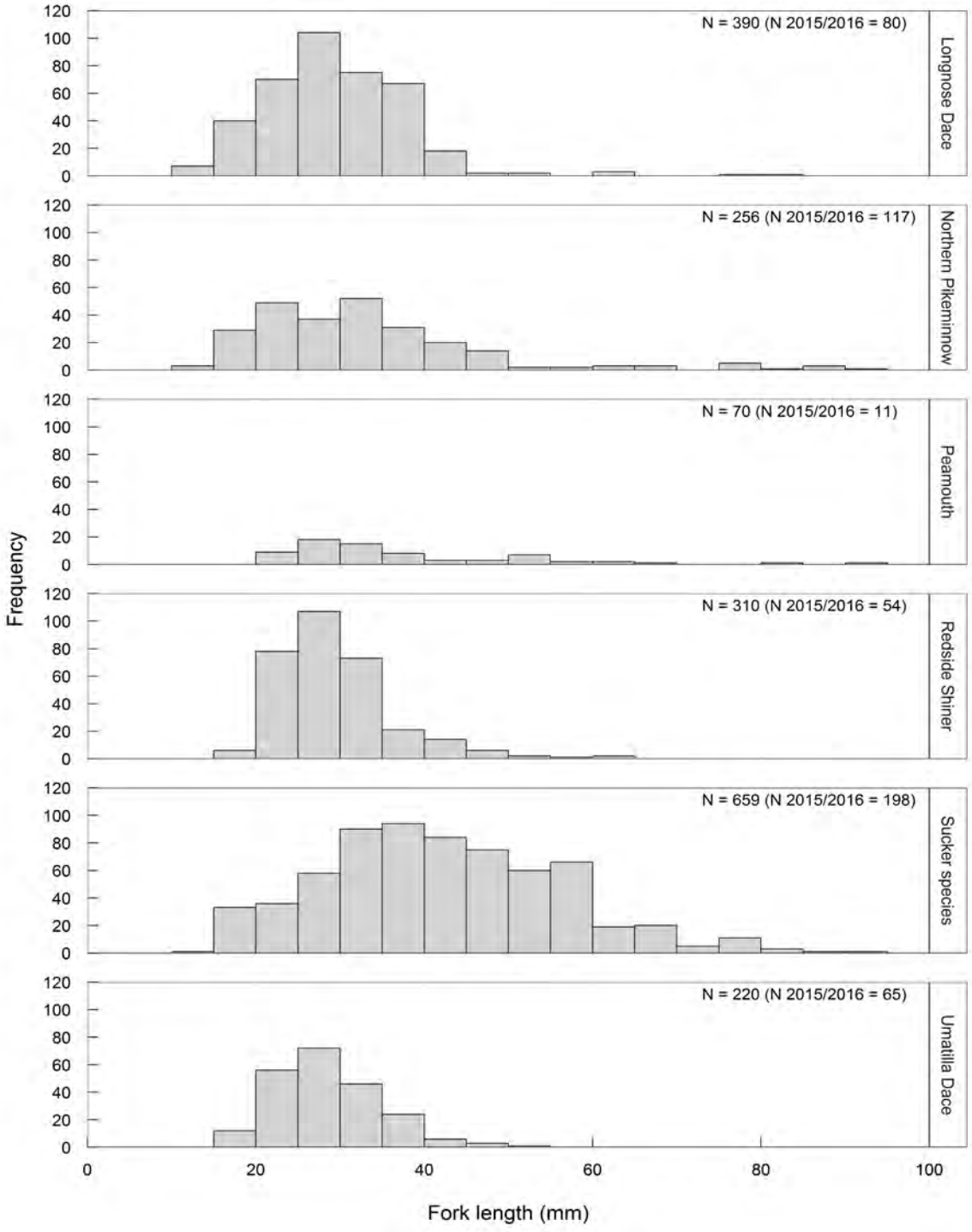

Figure 6: Fork length frequencies for Longnose Dace, Northern Pikeminnow, Peamouth, Redside Shiner, sucker spp. and Umatilla Dace collected during stranding assessments conducted during 2011 to 2016. Number of measured fishes from 2015/2016 represented in brackets. One Northern Pikeminnow and one Largescale Sucker, with fork lengths of 220 and 137 mm, respectively, were also captured, but not shown, to improve figure legibility.

Both adult and juvenile sculpin were recorded during the stranding events. Of the measured Columbia, Prickly and Torrent Sculpin from 2015/2016, 38% were considered adults, based on total lengths >45 mm (AMEC 2014).

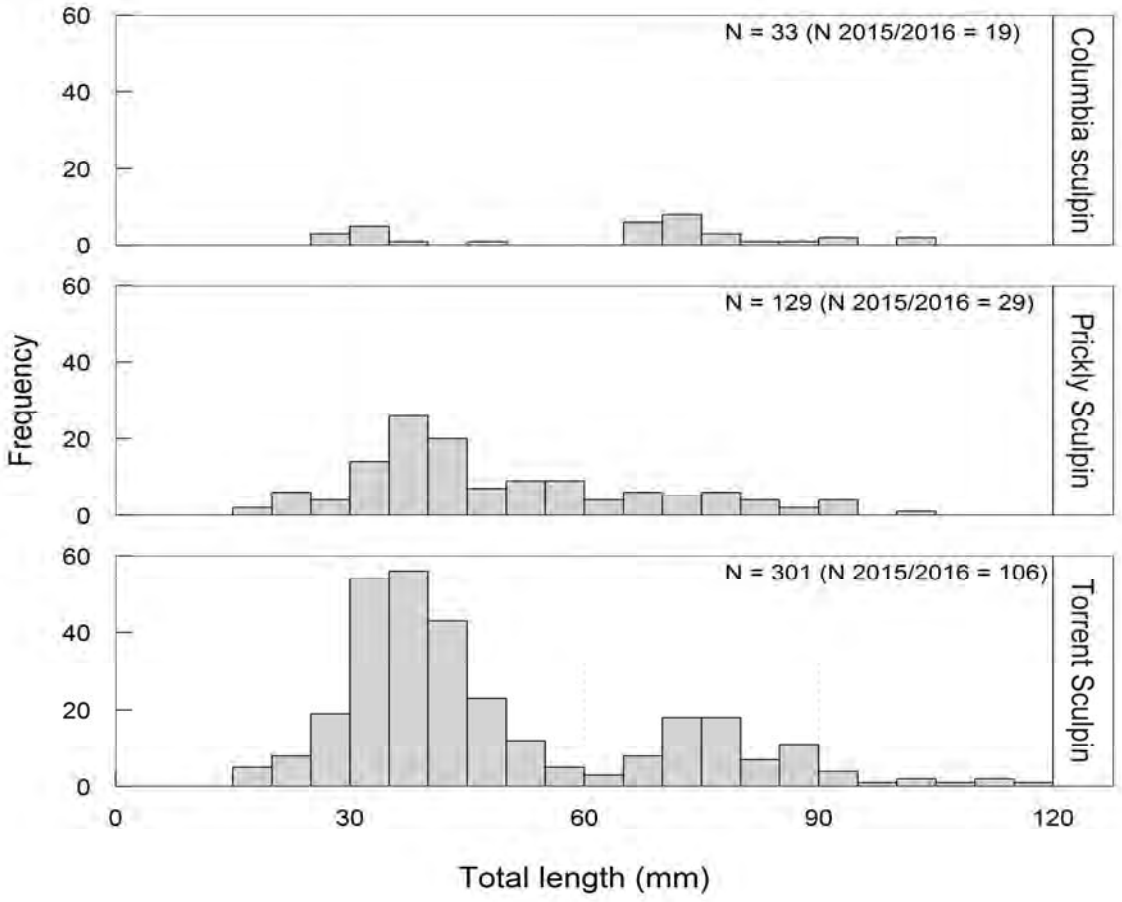

Figure 7: Total length frequencies for Columbia Sculpin, Prickly Sculpin and Torrent Sculpin collected during stranding assessments during the previous five years. Number of measured Sculpin in 2015/2016 represented in brackets.

3.2.1.1.3 Unidentified Fish

During this study period, only 10 unidentified fish were observed. All unidentified fish were larval fish found at Blueberry Creek (LUB) site during RE2015-07 on September 4, 2015.

There were 144 unidentified sculpin observed during this study year. The majority (n=110) of these unidentified sculpin were observed while shocking and were not captured or salvaged. The majority (90%) of the unidentified sculpin were found at the Genelle Mainland site.

Determining the species of young-of-the-year fish, including dace and sculpin species in the field continues to be a challenge. Collecting, preserving and laboratory identification of subsamples of these fish during subsequent reductions will continue to be a priority. During this study period approximately 153 mortalities associated with

reduction events were preserved. These include two juvenile sculpin spp. and one juvenile sucker spp. from Tin Cup RUB site during RE2015-07 and approximately 150 fish from the fish salvage response at Bear Creek site from RE2016-03. These samples were stored and can be used for species verification in the future.

3.2.1.1.4 Listed Fish Species

Currently, four resident fish species in the study area are considered at risk: Columbia Sculpin, Shorthead Sculpin (*Cottus confusus*), Umatilla Dace, and White Sturgeon (*Acipenser transmontanus*). Columbia Sculpin and Umatilla Dace were documented during the 2015/2016 stranding assessment period (Table 4).

Table 4: Summary of Listed Species Captured or Observed during Stranding Assessments, 1 April 2015 to 1 April 2016.

Site[a]	Risk Period[b]	Total Number of Visits	Number of Visits with Listed Species Present	Number of Listed Fish Stranded
Umatilla Dace				
Bear Creek (RUB)	Low	4	1	349
Fort Shepherd Eddy (LUB)	Low	5	1	44
Genelle (Mainland) (LUB)	Low	15	1	1
Gyro Boat Launch	Low	8	1	11
Kootenay River (LUB)	Low	11	2	39
Columbia Sculpin				
Genelle Mainland (LUB)	Low	15	1	3
Kootenay River (LUB)	Low	11	1	2
Lions Head (upstream of Norns Fan) (RUB)	Low	13	1	1
Norns Creek Fan (RUB)	Low	15	2	5
Tin Cup Rapids (RUB)	Low	12	3	11
Total				**466**

[a]Appendix A; Figures A1 through A7
[b]High Risk Period = June 1 to September 30 and Low Risk period = October 1 to May 31

Historically, the majority (88%) of listed species recorded in the Standing Database (from 2000 to present) were captured during the Low Risk period; however, it is possible that listed fishes were also stranded during the High Risk period, but were not identified to species because of their life stage (i.e., immature). Some of the unidentified fish documented during the study period may have been Umatilla Dace. Umatilla Dace probably spawn in the late spring or early summer similar to closely related species (McPhail 2007); therefore, larval stage Umatilla Dace numbers may be combined in the numbers of unidentified fish collected during RE2015-07 on 4 September 2015.

A total of 22 Columbia Sculpin were captured during the 2015/2016 study period and 11 of these were found at Tin Cup Rapids (RUB). All Columbia Sculpin were recorded during the Low Risk period. It is possible that a number of the 144 unidentified sculpin observed during the study period were Columbia Sculpin.

3.2.1.1.5 Exotic Fish Species

Only two exotic fish species were captured during the 2015/2016 study period. Four Brook Trout were recorded from Gyro Boat Launch, Fort Shepherd Launch (RUB) and Beaver Creek (RUB). One juvenile Yellow Perch was recorded at the Millenium Park (Tin Cup LUB) site on 19 December 2015.

Several exotic fish species have been identified and recorded during stranding assessments since 2000 in varying numbers. Species composition has remained constant. The majority (98%) of all of the exotic fish species recorded during stranding assessments were Smallmouth Bass (*Micropterus dolomieu*). The remaining 2% were Common Carp (*Cyprinus carpio*), Brook Trout, Tench (*Tinca tinca*) and Yellow Perch. Although exotic fish species were found throughout the study area, the majority (97%) were from the Fort Shepherd Launch RUB site before this site was re-contoured in January 2014. This site is approximately 2.5 km upstream from the Columbia River confluence with the Pend d'Oreille River, which is known to have an established population of Smallmouth Bass and other invasive species (Golder 2005b).

3.2.2 Historic Fish Stranding Summary

The results of fish stranding assessments conducted between January 2000 and April 2016 are summarized by site, water elevation and risk period (Table 5). This table can be used as a tool for personnel managing flow reductions to readily identify sites, flows, and seasons of high stranding risk. The classification of sites where listed species have been previously identified is included (yellow highlighted cells). An additional eight sites at a given river stage were identified as having listed species in 2015/2016. Four of these sites were not previously 'Effect' sites. More sites had listed species identified during the Low Risk period than in the High Risk period (36 versus 7 sites). The numbers of fishes are presented as the maximum number of fishes observed stranded at each site during a single assessment. For the majority of sites upstream of Trail, BC higher total fish numbers were recorded during the High Risk period irrespective of resultant discharge levels (Table 5).

In comparison to the Low Risk period, the High Risk period had a larger range of resultant Birchbank discharge (120 to 30 kcfs) where effects were recorded (Table 5). During the Low Risk period, resultant Birchbank discharges between 30 and 40 kcfs had the greatest number of stranded fishes of all sites (Table 5). Conducting surveys at sites with no previous data or insufficient data (surveyed less than five times) will continue to help identify sites that pose a high risk of fish stranding during flow reductions. Increased numbers of site surveys will lead to more data on REs.

During the present study, based on the database queries, 33% of total site visits were 'Effect' sites and 50% were 'Reconnaissance' sites. In order to confirm the accuracy of the database, 14 'Minimal Effect' sites and 11 'No Pools' sites were visited. All 'No Pool' designated sites were accurate except for Fort Shepherd Launch (RUB) during RE2015-08 where two pools were found and CPR Island (MID) during RE2015-15 where one pool was found. All 'Minimal Effect' sites visited in 2015/2016 were in fact minimal effect with less than 200 fish stranded.

Table 5 Summary of effects and corresponding responses for fish stranding on the lower Columbia River from flow reductions at Hugh L. Keenleyside Dam and Brilliant Dam sorted by time of year. (Based on data collected between 2000 and 2016)

Risk Period	Resultant Birchbank Discharge (kcfs)	Observed Effect																																			
		Columbia River										Kootenay River				Columbia River																							
		Lions Head		Norn's Creek Fan		CPR Island		Tin Cup Rapids		Millennium Park		Kootenay River (LUB)		Kootenay River (RUB)		Zuckerberg Island		Kinnaird Rapids		Blueberry Creek		Genelle Mainland		Genelle Upper Cobble Island		Genelle Lower Cobble Island		Gyro Boat Launch		Trail Bridge		Casino Road Bridge, Trail (u/s)		Casino Road Bridge, Trail (d/s)		Bear Creek		Beaver Creek (RUB)		Beaver Creek (LUB)		Fort Shepherd Eddy		Fort Shepherd Launch	
		Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits	Max. # of fish	# of visits
High Risk (1 June to 30 September)	≤30																	No Pools		No Pools								No Pools								No Pools		No Pools					
	30-40							13500	1					0	1	620	1	No Pools		No Pools				No Pools		No Pools								0	1					200	1		
	40-50	6	3	311	4	457	4	76	3	0	1	72	3	81	5							14302	3	No Pools		No Pools		464	2					207	2	No Pools							
	50-60	425	11	215	11			253	10	34	4	2894	7	2700	12	18	6	No Pools		No Pools		2865	13			No Pools		No Pools		0	1	0	1	11	4	0	2	1	1	27	1	0	1		
	60-70	16	8	423	20	0	1	258	11	0	5	492	21	2686	22	55	8	No Pools		1	1	37964	22			20	3	500	2	No Pools		0	0	0	1	500	7	1	6	0	1	0	0	2	4
	70-80	42	7	19	11	No Pools		219	7	0	3	1	6	35	9	48	8	No Pools		50	4	6000	11	54	1	0	1	500	3	No Pools		No Pools		0	1	0	1	8	4	No Pools		0	2	0	2
	80-90	2	4	88	9	No Pools		34	5	4	7	No Pools		12	3	No Pools		No Pools		0	4	90	6	No Pools		3	5	0	2	No Pools		No Pools		No Pools				0	2	No Pools		380	2		
	90-100	0	3	5	8	No Pools		458	10	26	4	No Pools		No Pools		No Pools						3060	10	No Pools		0	1	500	9	No Pools		No Pools		No Pools		No Pools		251	4	No Pools		No Pools		0	2
	100-110	No Pools		2	2	2	2	10307	4	7521	3	No Pools		No Pools		0	3	No Pools		0	1	20	3					500	2																
	110-120	0	2	No Pools		No Pools		1500	4	60	1	No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		0	1		
	>120	0	1	No Pools		No Pools		0	1	100	1	No Pools		No Pools		No Pools				0	1	No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools					
Low Risk (1 October to 31 May)	≤30	13	3	38	3	93	2	54	3	601	3	0	2	642	2	1	3	No Pools		No Pools		33	2					8	3	8	6	0	4	1	2	2013	2	No Pools		0	2	8	2	5	1
	30-40	717	19	5002	28	82	5	224	13	522	18	210	4	971	24	95	11	No Pools		No Pools		280	18	No Pools		No Pools		1455	11	19	5	0	3	1	3	12	3	38	2	0	2	80	3	3	3
	40-50	1445	32	623	35	147	26	117	29	92	18	450	27	1450	49	298	27	0	2	0	3	1414	30	No Pools		No Pools		755	22	5	6	4	7	4	5	2015	1	44	8	0	3	7	5	2	5
	50-60	176	21	320	24	4	7	59	16	52	19	157	23	332	33	71	17	7	3	No Pools		400	30	0	2	0	2	351	6	0	2	0	10	21	12	0	8	2	3	20	2	2	3	0	2
	60-70	8	12	39	22	16	6	11	15	0	15	103	24	529	29	109	21	0	1	2	4	520	24	1	4	0	3	4	7	No Pools		1	9	3	9	0	5	4	3	0	2	0	2	0	2
	70-80	0	3	79	10	No Pools		0	2	0	8	0	3	10	5	0	9	No Pools		0	2	7	6			0	1	No Pools		No Pools		No Pools		0	1	3	3	0	2	No Pools					
	80-90					No Pools		0	1	0	2	No Pools				No Pools		No Pools		0	1	1	3	No Pools		0	1			No Pools		No Pools		No Pools		0	1			No Pools					
	90-100	No Pools				No Pools						No Pools		No Pools		No Pools								No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools				No Pools		No Pools			
	100-110	No Pools										No Pools		No Pools														No Pools																	
	110-120			No Pools		No Pools				No Pools		No Pools		No Pools		No Pools				No Pools		No Pools						No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools					
	>120	No Pools		No Pools		No Pools		No Pools		No Pools		No Pools		No Pools														No Pools		No Pools						No Pools		No Pools							

Code	Description	Definition and Response
	No Pools	Site has been previously surveyed; pools have not been recorded at or near these flows. No Response.
	Minimal Effect	Site has been previously surveyed; isolated pools were observed; less than 200 fish were recorded during each reduction event under similar conditions (minimum of 5 visits under similar conditions). No Response.
	No Data or Insufficient Data	Site has been previously surveyed less than five times at or near these flows; less than 200 fish were recorded during each reduction event under similar conditions. Reconnaissance Survey.
	Effect	Site has been previously surveyed; isolated pools were observed; more than 200 fish were recorded during a single reduction event under similar conditions. Stranding Survey.
	Unlikely Discharge Range	Birchbank discharge has not been recorded at these levels during the specified time period (based on discharge data collected between 2000 and 2015).
	Listed species were captured or observed.	During at least one of the visits at these sites listed species were captured or observed, during these resultant discharge levels.

Does not include data pre-recontoring.

Includes all visits and fish until 1 April 2016.

4.0 DISCUSSION

4.1 CLBMON-#42(A) Lower Columbia River Fish Standing Assessment and Ramping Protocol Management Questions

Data necessary to address the first four management questions from BC Hydro Water Use Plan terms of reference were not collected during the current study period. These management questions were addressed using data presented in the 2009/2010 and 2010/2011 annual summaries. Since the new protocol was implemented, the program has focused on answering Question #5. Management Questions to be addressed by the program include:

1) *Is there a ramping rate (fast vs. slow, day vs. night) for flow reductions from HLK that reduces the number of fish stranded (interstitially and in pools) per flow reduction event in the summer and winter?*

   Information regarding ramping rates was obtained through a review of the fish stranding database for the lower Columbia and lower Kootenay rivers and presented in Golder and Poisson (2010), which found that the trend between ramping rate and fish stranding was not statistically significant. Furthermore, the historical data (2000 to 2016) from the current database showed no indication of a relation between ramping rate and number of stranded fishes.

2) *Does wetted history (length of time the habitat has been wetted prior to the flow reduction) influence the number of fish stranded (interstitially and in pools) per flow reduction event for flow reductions from HLK?*

   Previous analysis indicated a statistically significant increase in the number of fish stranded during assessments conducted after a wetted history of greater than 10 days versus a wetted history of less than ten days (Poisson 2009); however, there were insufficient data to define the size of the effect (proportion of the population affected and the response to wetted histories of variable lengths greater than 10 days). The determination of a response should continue to be based on factors including timing, river stage and the database query results in addition to wetted history.

3) *Can a conditioning flow (temporary, one step, flow reduction of approximately 2 hours to the final target dam discharge that occurs prior to the final flow change) from HLK reduce the stranding rate of fish?*

   Currently, conditioning flow reductions from HLK are not being considered as a management tool to reduce fish stranding. The value of implementing conditioning flows is still under consideration and further discussions regarding the operational risk versus biological rationale are needed. Two key concerns regarding the assumption that conditioning flow reductions reduce fish stranding were identified in a literature review (Golder and Poisson 2010). The first concern was the limited amount of data collected and preliminary stages of research on the suitability of conditioning flows for use on the Columbia and Kootenay rivers. The second concern was with the actual effectiveness of the method (i.e., some fishes may leave the area but the conditioning reduction may cause significant mortality within a short period of time, which would reduce the practicality of the method (Golder and Poisson 2010). Based on these previous analyses and literature review, abandonment of this strategy should be considered because of the risks of mortality with any intentional conditional stranding, regardless of duration.

4) *Can physical habitat works (i.e., re-contouring) reduce the incidence of fish stranding in high risk areas?*

Over the past 15 years, five previously identified high risk stranding sites have been re-contoured in an attempt to mitigate the occurrence and magnitude of fish stranding. The Genelle Lower Cobble Island site and Millennium Park site were re-contoured in 2001, Norn's Creek Fan site was re-contoured in 2002, Genelle Mainland site was re-contoured in 2003 and most recently Lions Head (upstream of Norns Fan) was re-contoured in April 2015. There were 13 stranding assessments conducted at Lions Head site after it was re-contoured. While initial assessments showed a reduced number in total numbers of fishes stranded, additional stranding assessments at different flow levels will be required to understand the effectiveness of this recontouring effort.

At Genelle Lower Cobble Island, Millennium Park, Norn's Creek Fan and Genelle Mainland re-contouring reduced the incidence of fish stranding (Golder and Poisson 2010); however, the effect size (the proportion of the population or the relative number of fish not stranded as a result of the physical habitat works) was not estimated due to limited data. Irvine et al. (2014) indicated significant benefits of re-contouring on reducing the rate of stranding using a data set from this system. This suggests that physical habitat alteration has benefits, particularly at sites that have high stranding potential and have physical conditions suitable for re-contouring.

The Fort Shepherd Launch (RUB) site was re-contoured by Columbia Power Corporation (CPC) as a component of the CPC Owner's Commitment #39 ([Revised November 10, 2006] [CPC 2011]). This commitment included the development of a Shallow-water Habitat Compensation Plan which was designed as the "Fort Shepherd Bar-Shallow-water Habitat Compensation Site" at the Fort Shepherd Launch (RUB) site. Twenty four stranding assessments have been conducted at this site since the re-contouring. Since this site was designated as a new site in the database it will require visits at most flow changes to populate with data and assess the effectiveness of this re-contouring. The previous Fort Shepherd Launch (RUB) site was renamed as 'Fort Shepherd Launch (RUB) Before Re-contouring'. CPC is investigating post-project benefits of these physical alterations at this site (Pers. Comm., Teal Moffat, CPC, July 2015).

5) *Does the continued collection of stranding data, and upgrading of the lower Columbia River stranding protocol, limit the number of occurrences when stranding crews need to be deployed due to flow reductions from HLK?*

The number of occurrences when stranding assessments were conducted due to flow reductions from HLK/ALH have fluctuated over the past seven years of data collection. Dating back to 2009/2010, the number ranged from 8 to 15 assessments, with an average of 82% conducted in response to reduction events from HLK/ALH. The total numbers of stranding assessments in response to reductions from BRD/X and combined facilities have decreased in the past seven years. The trend for total number of yearly stranding assessments has generally decreased since 2009/2010, although there was an increase from that general trend in 2015/2016. Discharge levels during the winter of 2015/2016 were below average; therefore, a greater number of stranding assessments were initiated to assess 'Reconnaissance' sites at these less common river stages. Additionally, the identification of listed species (i.e., Umatilla Dace, Columbia Sculpin) at sites where they had previously not been found has in some cases changed the

designation for those sites from 'Reconnaissance' to 'Effect' thereby increasing the priority for assessment. In 2015/2016 four new sites at a given river stage became 'Effect' sites due to the identification of listed species (Table 5)

The continued collection of data and the use of the Columbia River Stranding Protocol have focused stranding assessments when location, season and resultant discharge level posed an elevated risk to fish stranding. Since the majority of the data clusters around resultant Birchbank discharge between 70 and 30 kcfs (Table 5) the elimination of data gaps in less common discharge levels will further focus stranding assessment efforts.

5.0 RECOMMENDATIONS

- Fish species identification should continue to be a priority during stranding assessments, including young of-the-year fishes identification. Continued species verification through laboratory examination and external audits by qualified professionals will assist with species identification. When large numbers of fish are encountered, the collection of sub-samples for positive identification is recommended. This is important to determine if the stranding event has a potential to affect a population that is rare or listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or under the Species at Risk Act (SARA), or if the impact has only been on abundant species, such as Catastomidae spp. When a large number of fishes are observed in a pool and species identification is not possible due to field conditions and constraints (i.e., too large of pool to effectively sample), a voucher sample should be taken. Tools/methods used to identify young-of-the-year fish also should be improved, as it is currently not possible to identify larval or young-of-the-year fish of most species, which is an important limitation of the stranding assessment methods.
- Continue to collect fish length data for species where insufficient numbers have previously been collected (<510 based on advise of Thompson [1987]). This would include unusual lengths (i.e., large fish) or fish with previously sufficient numbers (Longnose Dace, Northern Pikeminnow, Rainbow Trout and Redside Shiner). It is recommended that length data continue to be collected for any listed species and for all sculpin species. Sculpin of all age classes have been recorded stranded, although the numbers for certain age classes are still insufficient. The relative impact of stranding on any given species population is dependent upon the life history stage impacted; larval stages being less impactful than adult or sub-adult stages. Since the life history stage for this study is defined through length measurements, increased sample sizes of length measurements for select species will help achieve a greater understanding of the impacts of stranding.
- Re-contouring is recommended at a number of areas, including sites that have previously been re-contoured because of recent changes in morphology, and sites that were not previously modified. The sites listed below are recommended as candidates for re-contouring because of high stranding risk relative to other sites, and their substrate is such that re-contouring is feasible. Re-contouring at these sites could be conducted using a phased approach, with higher priority sites (based on stranding risk, cost, and other factors) being enhanced first and other sites being re-contoured in subsequent years. Sites recommended for re-contouring are:

- Re-contour **Kootenay RUB** site to assist in the draining the Kootenay Oxbow.

  This would help reduce stranding at a public and logistically difficult place to salvage fish (very large, shallow pools with cobble substrate bottoms).

- Conduct additional re-contouring at the **Genelle Mainland LUB** site to reduce incidence of fish stranding. This site is a good candidate for re-contouring because of large abundance of fishes that are common in this area, a history of significant stranding events, and changes to the shoreline caused by river flow since the previous enhancements were completed. Suggested modifications include:

  a) improve drainage between the access road and the Whispering Pines Trailer Park; and

  b) make improvements to previously re-contoured area by removing a depositional berm that has formed since the original re-contouring.

- Re-contour the **Gyro Boat Launch RUB** site to reduce incidence of fish stranding.

  The site has a large artificial depression (potential storm drain exit) that is prone to fish stranding.

- Target sites designated as ‘Reconnaissance’ sites by the database query in order to continue to fill in data gaps. Additional ‘Reconnaissance’ site data will lead to a site designation of ‘No Pools’, ‘Minimal Effect’, ‘Effect’ or ‘Significant Fish Stranding’ thereby further refining the database. As the database becomes more refined so too will the decision to initiate stranding assessments. An additional emphasis should be made to visit stranding sites downstream of Trail, BC as the majority of data gaps at all flow levels during both risk periods occur for these sites.

- It is possible that not all stranded fishes are detected during assessments, leading to underestimates of the stranding risk in terms of the number of fishes. As the thresholds for an ‘Effect’ (>200 fish) or ‘Significant Fish Stranding’ (>5000 fish) are often based on visual estimates by observers that are highly experienced in fish stranding assessments, and these guidelines are used consistently over time, these methods are unlikely to seriously bias the stranding risk categories predicted by using the Lower Columbia River Fish Stranding Database; however, if managers wish to validate assumptions of this method or refine estimates of the number of stranded fishes, then additional studies or modifications to the assessment and survey protocols would be necessary.

- Assess the validity of keeping sites in the database that are never visited, unless access to these sites over a range of flow reductions is challenging. These would include sites that are accessed by boat (i.e., Upper and Lower Cobble Island sites in Genelle).

6.0 CLOSURE

We trust that this report meets your current requirements. If you have any further questions, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

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Aquatics Biologist

Bob Chapman, R.P.Bio.
Associate, Senior Fisheries Biologist

KL/BC/cmc

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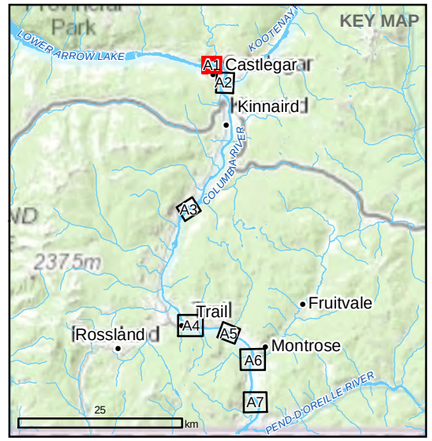
APPENDIX A

Site Maps

LEGEND

- STRANDING SITE



REFERENCE

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BC HYDRO

PROJECT
LOWER COLUMBIA RIVER AND
KOOTENAY RIVER FISH STRANDING

TITLE
STRANDING SITES: UPPER SECTION - COLUMBIA RIVER

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-02
PREPARED	CD
DESIGN	DB
REVIEW	CK
APPROVED	CK

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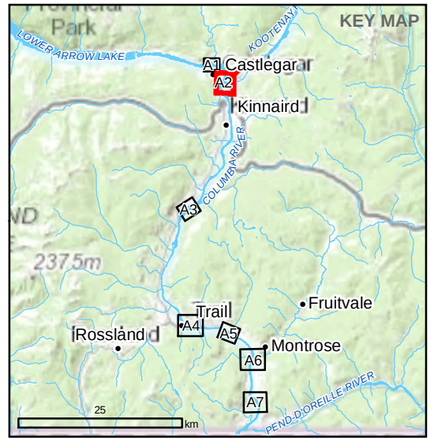

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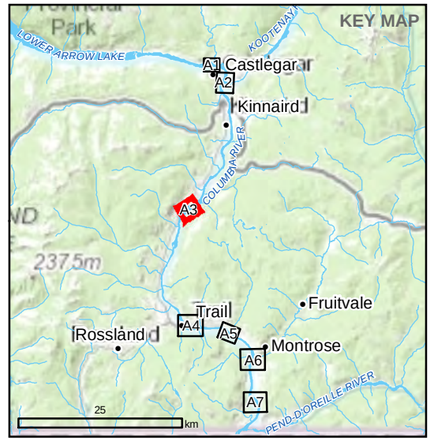

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PROJECT
LOWER COLUMBIA RIVER AND
KOOTENAY RIVER FISH STRANDING

TITLE
STRANDING SITES: MIDDLE SECTION - COLUMBIA RIVER

CONSULTANT
Golder Associates

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APPROVED	CK

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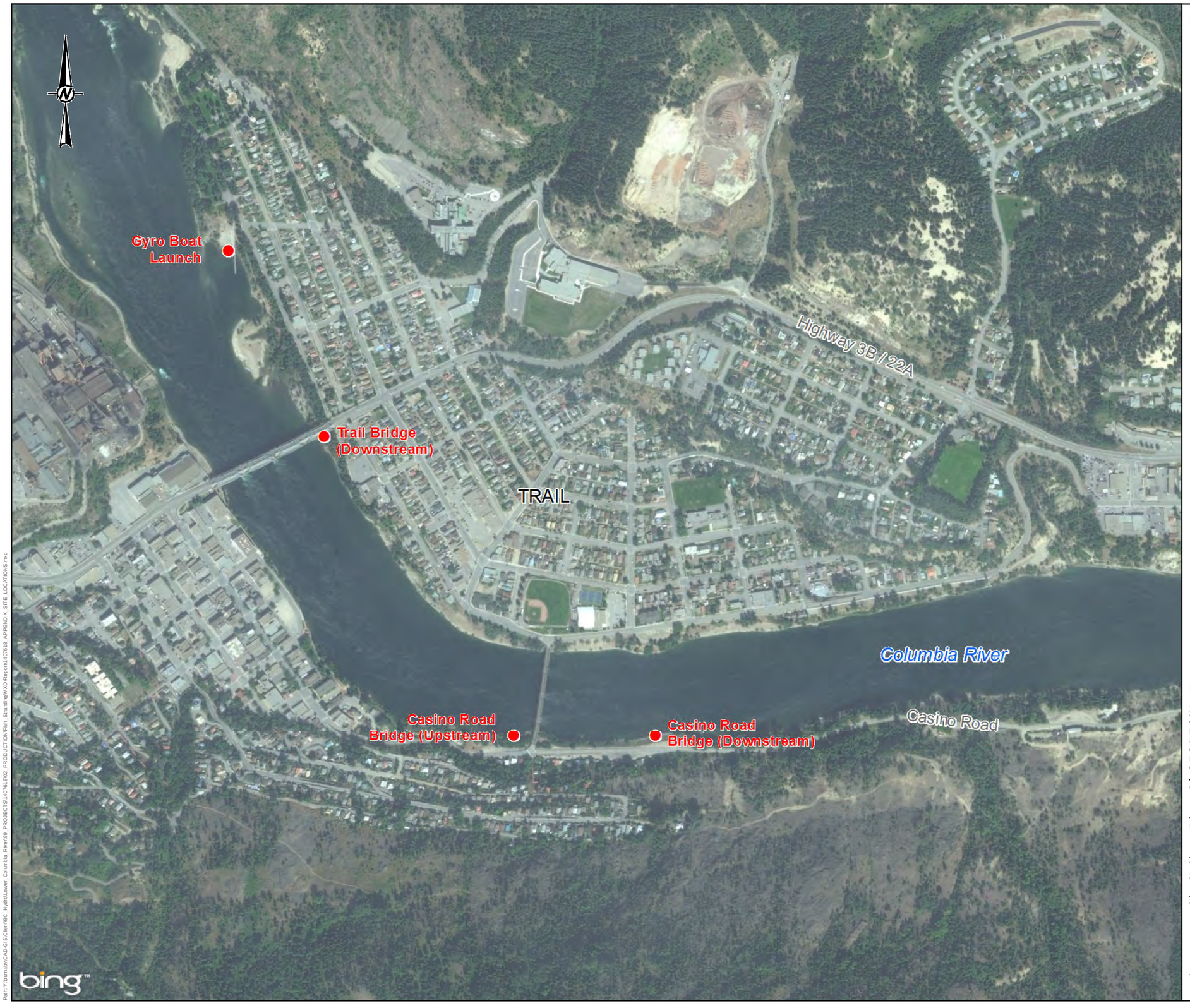

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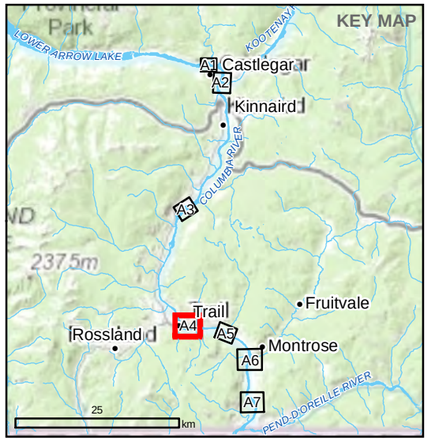

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PROJECT
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KOOTENAY RIVER FISH STRANDING

TITLE
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CONSULTANT
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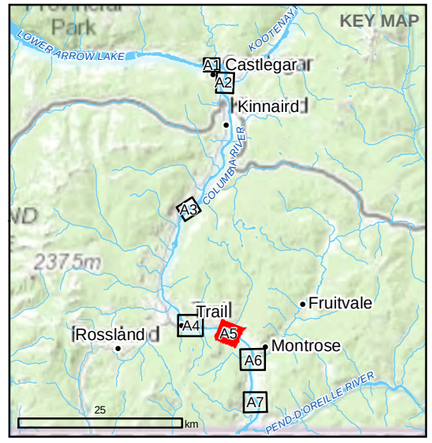

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BC HYDRO

PROJECT
LOWER COLUMBIA RIVER AND
KOOTENAY RIVER FISH STRANDING

TITLE
STRANDING SITES: LOWER SECTION - COLUMBIA RIVER

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-02
PREPARED	CD
DESIGN	DB
REVIEW	CK
APPROVED	CK

PROJECT No.	CONTROL	Rev.	FIGURE
1407618	1000	A	**A5**

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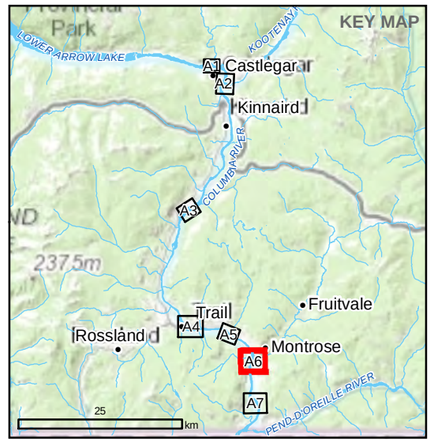
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 25mm

LEGEND

● STRANDING SITE

KEY MAP



REFERENCE

1. WATERCOURSE AND WATERBODY DATA OBTAINED FROM IHS ENERGY INC.
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PROJECT No.	CONTROL	Rev.	FIGURE
1407618	1000	A	**A6**

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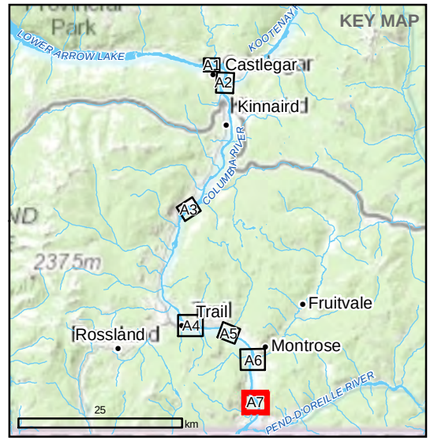
LEGEND

- STRANDING SITE



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APPROVED	CK

PROJECT No.	CONTROL	Rev.	FIGURE
1407618	1000	A	**A7**

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APPENDIX B

Database Query Example

Fish Stranding Data Query Results

Current Water Temp = **14.7 °C**

Current Birchbank Discharge = **62 kcfs**

Proposed Reduction Date = **04-Oct-14**

Resulting Birchbank Discharge = **47 kcfs**

Reduction Location = **Hugh L. Keenleyside Dam**

Site Name	Reduction Date	Reduction Event #	Max. BB Disch. (kcfs)	Min. BB Disch. (kcfs)	Water Temp. at BB (°C)	Total Number Unlisted Fish Stranded	Total Number of Stranded Listed Fish
Lions Head (upstream of Norns Fan) (RUB)	06-Oct-02	200217	57.3	51.9	14.1	0	
	29-Oct-03	200314	54.7	51.7	6.4	0	
	26-Oct-05	200522	63.2	60.8	10.0	0	
	29-Oct-05	200522	59.5	55.1	6.1	0	
	04-Nov-05	200523	54.5	49.9		0	
	07-Oct-06	200619	54.0	47.0	13.0	0	
	09-Dec-06	200625	62.0	50.9	5.0	3	
	01-Oct-07	200724	55.9	52.0	13.8	0	
	24-Nov-07	200726	66.8	56.3	5.8	1	
	08-Oct-11	201119	56.5	49.3	14.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 10 reductions) =						**3**	
Concern Category:						**Minimal Effect**	
Norns Creek Fan (RUB)	05-Oct-02	200217	61.9	57.2	12.3	9	
	06-Oct-02	200217	57.3	51.9	14.1	3	
	08-Oct-03	200313	63.3	58.3	13.0	32	
	21-Nov-03	200316	62.9	59.8	2.5	0	
	08-Oct-05	200521	63.7	61.3	10.5	1	
	26-Oct-05	200522	63.2	60.8	9.0	0	
	29-Oct-05	200522	59.5	55.1	4.8	2	
	04-Nov-05	200523	54.5	49.9		3	
	07-Oct-06	200619	54.0	47.0	9.0	0	
	09-Dec-06	200625	62.0	50.9	5.0	0	
	01-Oct-07	200724	55.9	52.0	15.8	0	
	24-Nov-07	200726	66.8	56.3	3.8	0	
	08-Oct-10	201016	54.3	48.9	14.0	19	
	08-Oct-11	201119	56.5	49.3	10.0	4	
Maximum number of fish stranded at this site during a single reduction (based on 14 reductions) =						**32**	
Concern Category:						**Minimal Effect**	

Site Name	Reduction Date	Reduction Event #	Max. BB Disch. (kcfs)	Min. BB Disch. (kcfs)	Water Temp. at BB (°C)	Total Number Unlisted Fish Stranded	Total Number of Stranded Listed Fish
CPR Island (MID)	06-Oct-02	200217	57.3	51.9	14.1	0	
	07-Oct-06	200619	54.0	47.0	13.0	10	**1**
	08-Oct-10	201016	54.3	48.9	14.0	0	
	08-Oct-11	201119	56.5	49.3	14.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 4 reductions) =						**10**	**1**
Concern Category:						**Effect**	
Tin Cup Rapids (RUB)	01-Oct-01	200119	62.0	52.8	12.7	86	
	05-Oct-01	200120	52.6	47.8	14.2	19	
	05-Oct-02	200217	61.9	57.2	13.1	0	
	06-Oct-02	200217	57.3	51.9		0	
	28-Oct-03	200314	63.0	54.7	12.0	8	
	29-Oct-03	200314	54.7	51.7	11.0	1	
	26-Oct-05	200522	63.2	60.8	12.0	0	
	29-Oct-05	200522	59.5	55.1	11.4	0	
	04-Nov-05	200523	54.5	49.9		6	
	07-Oct-06	200619	54.0	47.0		0	
	09-Dec-06	200625	62.0	50.9	4.0	0	
	24-Nov-07	200726	66.8	56.3	6.2	0	
	21-Oct-11	201121	53.4	52.0	12.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 13 reductions) =						**86**	
Concern Category:						**Minimal Effect**	
Millenium Park (Tin Cup LUB)	05-Oct-01	200120	52.6	47.8	14.2	0	
	21-Nov-01	200126	60.1	54.4	8.0	0	
	07-Oct-06	200619	54.0	47.0	13.0	0	
	01-Oct-07	200724	55.9	52.0	13.4	14	
	24-Nov-07	200726	66.8	56.3	6.2	0	
	21-Oct-11	201121	53.4	52.0	12.0	1	
Maximum number of fish stranded at this site during a single reduction (based on 6 reductions) =						**14**	
Concern Category:						**Minimal Effect**	

Site Name	Reduction Date	Reduction Event #	Max. BB Disch. (kcfs)	Min. BB Disch. (kcfs)	Water Temp. at BB (°C)	Total Number Unlisted Fish Stranded	Total Number of Stranded Listed Fish
Kootenay River (LUB)	15-Nov-00	200024	63.2	60.2	6.0	0	
	01-Oct-01	200119	62.0	52.8	16.0	3	
	06-Oct-02	200217	57.3	51.9	14.5	0	
	28-Oct-03	200314	63.0	54.7	12.0	97	**50**
	04-Nov-05	200523	54.5	49.9		0	
	07-Oct-06	200619	54.0	47.0	14.0	0	
	01-Oct-07	200724	55.9	52.0	14.4	0	
	04-Dec-08	200820	69.5	55.7	7.0	0	
	02-Oct-09	200916	58.1	53.6	16.0	34	
	08-Oct-11	201119	56.5	49.3	15.0	**208**	**13**
Maximum number of fish stranded at this site during a single reduction (based on 10 reductions) =						**208**	**50**
Concern Category:						**Effect**	
Kootenay River (RUB)	15-Nov-00	200024	63.2	60.2	6.0	0	
	05-Oct-01	200120	52.6	47.8	15.5	**1450**	
	21-Nov-01	200126	60.1	54.4	8.0	0	
	05-Oct-02	200217	61.9	57.2	13.2	22	
	06-Oct-02	200217	57.3	51.9	15.4	**318**	
	08-Oct-03	200313	63.3	58.3	14.0	0	
	28-Oct-03	200314	63.0	54.7	12.0	**332**	**6**
	08-Oct-05	200521	63.7	61.3	13.0	0	
	29-Oct-05	200522	59.5	55.1	10.4	0	
	04-Nov-05	200523	54.5	49.9		**313**	**5**
	07-Oct-06	200619	54.0	47.0	13.0	124	**1**
	09-Dec-06	200625	62.0	50.9	3.0	0	
	01-Oct-07	200724	55.9	52.0	14.4	5	
	04-Dec-08	200820	69.5	55.7	7.0	0	
	02-Oct-09	200916	58.1	53.6	16.0	62	
	08-Oct-10	201016	54.3	48.9	14.5	**377**	
	08-Oct-11	201119	56.5	49.3	15.0	**460**	**2**
	21-Oct-11	201121	53.4	52.0	9.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 18 reductions) =						**1450**	**6**
Concern Category:						**Effect**	

Site Name	Reduction Date	Reduction Event #	Max. BB Disch. (kcfs)	Min. BB Disch. (kcfs)	Water Temp. at BB (°C)	Total Number Unlisted Fish Stranded	Total Number of Stranded Listed Fish
Zuckerberg Island (LUB)	06-Oct-00	200020	58.0	52.8	13.0	0	
	15-Nov-00	200024	63.2	60.2	7.6	0	
	01-Oct-01	200119	62.0	52.8		0	
	05-Oct-01	200120	52.6	47.8	14.3	0	
	21-Nov-01	200126	60.1	54.4	8.0	0	
	05-Oct-02	200217	61.9	57.2	13.3	0	
	21-Nov-03	200316	62.9	59.8	6.7	0	
	08-Oct-05	200521	63.7	61.3	12.0	0	
	01-Oct-07	200724	55.9	52.0	13.4	1	
	24-Nov-07	200726	66.8	56.3	6.2	0	
Maximum number of fish stranded at this site during a single reduction (based on 10 reductions) =						**1**	
Concern Category:						**Minimal Effect**	
Kinnaird Rapids (RUB)							
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =							
Concern Category:						**No Pools**	
Blueberry Creek (LUB)	07-Oct-06	200619	54.0	47.0	9.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						**0**	
Concern Category:						**Reconnaissance Survey**	

Site Name	Reduction Date	Reduction Event #	Max. BB Disch. (kcfs)	Min. BB Disch. (kcfs)	Water Temp. at BB (°C)	Total Number Unlisted Fish Stranded	Total Number of Stranded Listed Fish
Genelle (Mainland) (LUB)	08-Oct-03	200313	63.3	58.3	13.5	2	
	28-Oct-03	200314	63.0	54.7	11.5	2	
	29-Oct-03	200314	54.7	51.7	11.1	0	
	21-Nov-03	200316	62.9	59.8	6.7	0	
	08-Oct-05	200521	63.7	61.3	12.0	**520**	
	26-Oct-05	200522	63.2	60.8	12.0	0	
	29-Oct-05	200522	59.5	55.1	10.5	0	
	04-Nov-05	200523	54.5	49.9		0	
	07-Oct-06	200619	54.0	47.0	14.0	0	
	09-Dec-06	200625	62.0	50.9	4.0	0	
	01-Oct-07	200724	55.9	52.0	14.5	28	
	24-Nov-07	200726	66.8	56.3	4.4	0	
	04-Dec-08	200820	69.5	55.7	7.0	0	
	02-Oct-09	200916	58.1	53.6	16.0	0	
	08-Oct-10	201016	54.3	48.9	15.0	12	
	21-Oct-11	201121	53.4	52.0	12.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 16 reductions) =						**520**	
Concern Category:						**Effect**	
Genelle Upper Cobble Island (MID)	21-Nov-03	200316	62.9	59.8	6.7	0	
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						**0**	
Concern Category:						**Reconnaissance Survey**	
Genelle Lower Cobble Island (MID)							
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						No Data	
Concern Category:						**Reconnaissance Survey**	
Gyro Boat Launch	07-Oct-06	200619	54.0	47.0	13.0	89	**5**
	21-Oct-11	201121	53.4	52.0	12.0	48	
Maximum number of fish stranded at this site during a single reduction (based on 2 reductions) =						**89**	**5**
Concern Category:						**Effect**	
Trail Bridge (RUB) (Downstream)							
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						No Data	
Concern Category:						**Reconnaissance Survey**	

Site Name	Reduction Date	Reduction Event #	Max. BB Disch. (kcfs)	Min. BB Disch. (kcfs)	Water Temp. at BB (°C)	Total Number Unlisted Fish Stranded	Total Number of Stranded Listed Fish
Casino Road Bridge, Trail (LUB) (Upstream)	28-Oct-03	200314	63.0	54.7	11.6	0	
	29-Oct-05	200522	59.5	55.1	10.7	0	
	09-Dec-06	200625	62.0	50.9	4.0	0	
	01-Oct-07	200724	55.9	52.0	14.0	0	
	24-Nov-07	200726	66.8	56.3	6.9	0	
Maximum number of fish stranded at this site during a single reduction (based on 5 reductions) =						**0**	
Concern Category:						**Minimal Effect**	
Casino Road Bridge, Trail (LUB) (Downstream)	20-Nov-01	200126	65.4	60.4	8.0	0	
	21-Nov-01	200126	60.1	54.4	8.0	21	
	05-Oct-02	200217	61.9	57.2	13.1	1	
	28-Oct-03	200314	63.0	54.7	11.6	1	
	29-Oct-03	200314	54.7	51.7	10.1	0	
	29-Oct-05	200522	59.5	55.1	10.7	0	
	09-Dec-06	200625	62.0	50.9	4.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 7 reductions) =						**21**	
Concern Category:						**Minimal Effect**	
Bear Creek (RUB)	28-Oct-03	200314	63.0	54.7	11.5	0	
	29-Oct-03	200314	54.7	51.7	10.0	0	
Maximum number of fish stranded at this site during a single reduction (based on 2 reductions) =						**0**	
Concern Category:						**Reconnaissance Survey**	
Beaver Creek (RUB)							
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						No Data	
Concern Category:						**Reconnaissance Survey**	
Beaver Creek (LUB)	29-Oct-03	200314	54.7	51.7	10.1	0	
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						**0**	
Concern Category:						**Reconnaissance Survey**	
Fort Shepherd Eddy (LUB)	29-Oct-03	200314	54.7	51.7	8.2	0	
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						**0**	
Concern Category:						**Reconnaissance Survey**	
Fort Shepherd Launch (RUB)							
Maximum number of fish stranded at this site during a single reduction (based on 1 reduction) =						No Data	
Concern Category:						**Reconnaissance Survey**	

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