Duncan Dam Project Water Use Plan

Duncan Reservoir River Stranding Protocol Development and Finalization

Implementation Year 3

Reference: DDMMON-15

Study Period: 2011

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VERSION 3 FINAL

ADAPTIVE STRANDING PROTOCOL FOR MANAGING FISH IMPACTS IN THE LOWER DUNCAN RIVER ASSOCIATED WITH FLOW REDUCTIONS AT DUNCAN DAM

Submitted to:
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This version of the Protocol is a revision of the BC Hydro procedure developed in 2004 and is based on local and global knowledge gained since that time.

This version of the protocol (Dated January 7, 2013) was reviewed and approved by the Columbia Operations Fish Advisory Committee (COFAC).

REPORT

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BC Hydro - 5 copies
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GLOSSARY

Abbreviations (Sorted Alphabetically)

ASPD – Adaptive Stranding Protocol Development

CCRIFC – Canadian Columbia River Inter-Tribal Fishery Commission

COFAC – Columbia Operations Fish Advisory Committee

DAL – Duncan above Lardeau

DBC - Water Survey of Canada Gauge on the Upper Duncan River below BB Creek

DCC – Discharge Change Coordinator

DCP – Data Collection Platform

DDM – Duncan Dam

DFO –Department of Fisheries and Oceans Canada

DRL - Water Survey of Canada Gauge on the Lower Duncan River below the confluence with the Lardeau River

ERM – BC Hydro Environmental Risk Management Department

FLNR – Ministry of Forests, Lands and Natural Resource Operations

FSIMP – Fish Stranding Impact Monitoring Program

FVCC – BC Hydro Fraser Valley Control Centre

IJC – International Joint Commission

LDR – Lower Duncan River

LLOG – Low Level Operating Gate

MoE – British Columbia Ministry of Environment

OPE – BC Hydro Operations Planning Engineer

PSOSE – BC Hydro Next Day Planning Engineers

SAS – Stranding Assessment Supervisor

WLR – BC Hydro Water License Requirements

WSC – Water Survey of Canada

WUP – Water Use Plan

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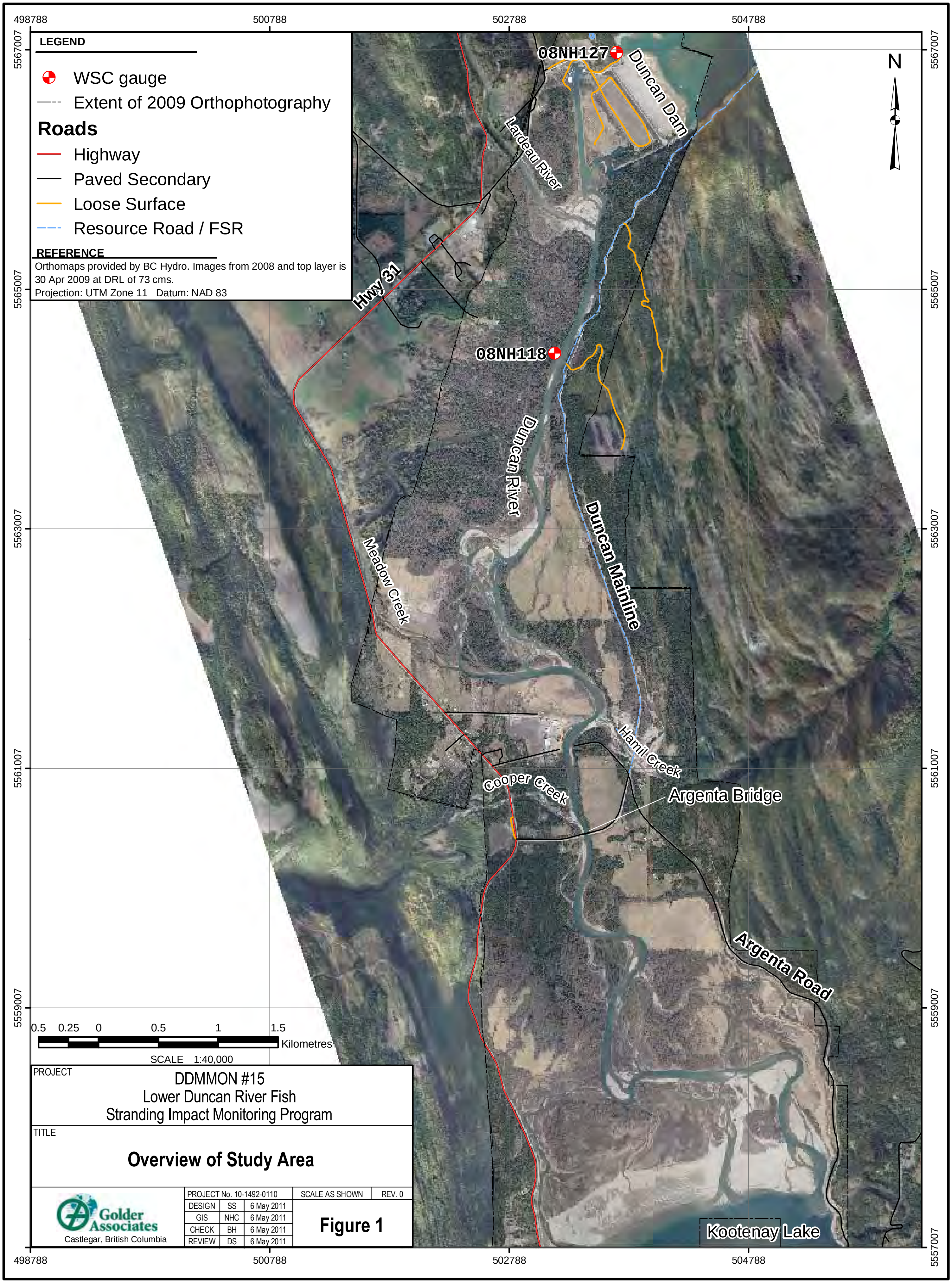
1.0 BACKGROUND

The Lower Duncan River (LDR) flows from the Duncan Dam (DDM), for approximately 11 km to the north end of Kootenay Lake. The river flows from the dam (via Low Level Outlets or Spillway) to the confluence of the Lardeau River along a 1 km long man-made channel. From the Lardeau confluence, the river runs through alternating single and braided channel sections for approximately 10 km to Kootenay Lake (Figure 1). The LDR channel is complex in nature with continuously changing channel morphology, debris jams, bars and islands (M. Miles and Associates 2002). The section of river from the Lardeau confluence to Kootenay Lake is expected to form a single meandering channel over an unknown time period. Additional influences on LDR daily water level variation include tributary inflows and the level of Kootenay Lake - all of which can influence fish stranding.

Although fish stranding in the LDR is known to result from natural flow variation and dam operation and has occurred since dam construction (1967), it was first raised as a significant issue by the fisheries agencies and public in October 2002 (Duncan Dam Water Use Plan Consultative Committee 2005). The Water Use Planning (WUP) process was in the initiation stage at that time and operational solutions to minimize fish stranding were explored. WUP Committee members focused on understanding the effects of flow fluctuations on habitat de-watering and resultant fish stranding, seasonal opportunities to minimize habitat dewatering, and monitoring flow reductions to create a better understanding of this activity on fish and fish habitat over the long-term. It is expected that further monitoring and assessment of fish stranding in the LDR will lead to a better understanding of the effects of DDM flow changes on this issue and result in mitigation measures (e.g., ramping rates) to minimize potential impacts to fish populations.

Between the fall of 2002 and present, BC Hydro has spent considerable effort in developing an understanding of fish stranding impacts in the LDR. The efforts outside the WUP process include:

- development of a Fish Stranding Corrective Action Plan (Higgins 2002);
- installation of a Data Collection Platform at the Water Survey of Canada Gauge (DRL) approximately 2 km downstream of DDM for real time monitoring of downstream flows;
- conducting fish stranding assessments of flow reduction events from September 24, 2002 to 2005 (AMEC 2003 a-d, 2004 a-d and BC Hydro 2004 a and b);
- undertaking a helicopter survey of LDR and videotaping potential stranding habitats resulting from 141 to 24 m^3/s discharges (BC Hydro 2002);
- studying seasonal fish habitat utilization (Golder 2002);
- undertaking a fluvial geomorphological assessment of the LDR (Mike Miles and Associates 2002); and,
- conducting flow ramping experiments (Golder 2007, 2008a, 2008b).



LEGEND
WSC gauge
Extent of 2009 Orthophotography
Roads
Highway
Paved Secondary
Loose Surface
Resource Road / FSR
REFERENCE
Orthomaps provided by BC Hydro. Images from 2008 and top layer is 30 Apr 2009 at DRL of 73 cms.
Projection: UTM Zone 11 Datum: NAD 83
498788
500788
502788
504788
5567007
5565007
5563007
5561007
5559007
5557007
N
08NH127
08NH118
Duncan Dam
Lardeau River
Hwy 31
Duncan River
Duncan Mainline
Meadow Creek
Hamil Creek
Cooper Creek
Argenta Bridge
Argenta Road
Kootenay Lake
0.5 0.25 0 0.5 1 1.5
Kilometres
SCALE 1:40,000
PROJECT
DDMMON #15
Lower Duncan River Fish
Stranding Impact Monitoring Program
TITLE
Overview of Study Area
Golder Associates
Castlegar, British Columbia
PROJECT No. 10-1492-0110
SCALE AS SHOWN
REV. 0
DESIGN SS 6 May 2011
GIS NHC 6 May 2011
CHECK BH 6 May 2011
REVIEW DS 6 May 2011
Figure 1

Efforts within the WUP process include:

- development of performance measures to assess the influence of proposed operating alternatives on fish stranding (BC Hydro 2005);
- development of a HEC-RAS flow model for the LDR – DDMMON-3 (Northwest Hydraulics Consulting, 2010);
- undertaking flow ramping experiments to understand the influence of DDM flow reductions on fish stranding – DDMMON-1 (Poisson and Golder 2010);
- conducting fish stranding assessment for flow reduction events from 2005 to present (Golder 2011, ongoing);
- implementation of fish habitat utilization studies throughout the year to determine species at risk of stranding and potential for population level impacts (ongoing) – DDMMON-2, -16; and,
- undertaking a review of available information and assessment of data gaps in fish stranding knowledge for the LDR – DDMMON-1 (Golder 2008a).

2.0 PURPOSE AND SCOPE

The purpose of this document is to provide, to the extent possible, pre-determined communications and flow reduction strategies (i.e., ramping rates, timing), and monitoring/response actions related to planned and emergency flow changes from DDM. This protocol defines a systematic approach for establishing communications between BC Hydro, regulatory agencies - Fisheries and Oceans Canada (DFO), Ministry of Forests, Lands and Natural Resource Operations (FLNR), First Nations interests, as well as appropriate strategies for flow reduction implementation, monitoring, mitigation and reporting based on information gained both locally and through a review of available literature. It is expected that gaps in understanding will continue to be addressed throughout the WUP monitoring phase.

The protocol takes a conservative approach to flow change decision making, focusing on slow flow reduction rates and assessing fish stranding impacts, with a long-term objective to develop appropriate operational and other mitigation strategies to manage fish stranding impacts associated with DDM operations.

Lower Duncan River Hydrology

The influence of DDM operations on water levels in the LDR throughout the year is variable. When the reservoir is either at its lowest elevation or at full pool (highest elevation), dam discharge mimics natural inflows with gate changes occurring as inflows change. During the freshet period, DDM discharges are reduced to minimum levels to allow the reservoir to fill and tributary inflows downstream of DDM account for the majority of inflows. Historically, the largest changes in Duncan discharge occur in the August through December period when stored water is released to maintain Kootenay Lake levels and provide water for downstream power generation. During this period, flow releases are also constrained by seasonal restrictions on DDM operations for the protection of Kokanee and Mountain Whitefish spawning populations in the lower Duncan River (Figure 2).

Tributaries which influence LDR water levels include: Lardeau River, Meadow Creek, Hamil Creek, and Cooper Creek. The Duncan watershed inflows are primarily snowmelt in spring, but the system is also subject to high inflows in the summer and fall months as a result of localized rainfall events. The Lardeau River discharge gauge near Marblehead is still operational and is available for manual discharge readings taken by local staff, although the stage-discharge curve is outdated. Figure 3 provides a historical summary of Lardeau River discharge for the period 1946 to 1999. The other tributaries are not currently gauged.

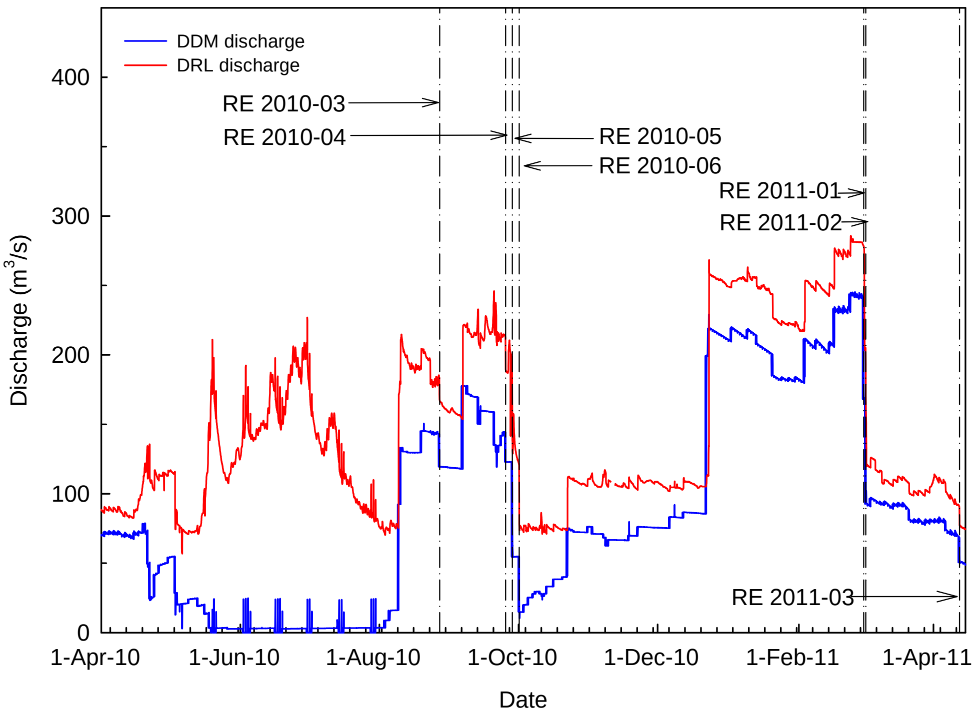


Figure 2: Annual Hydrograph for the LDR , April 1, 2010 to April 1, 2011, indicating DDM and LDR discharge and identifying flow reduction events monitored (e.g., RE 2010-03).

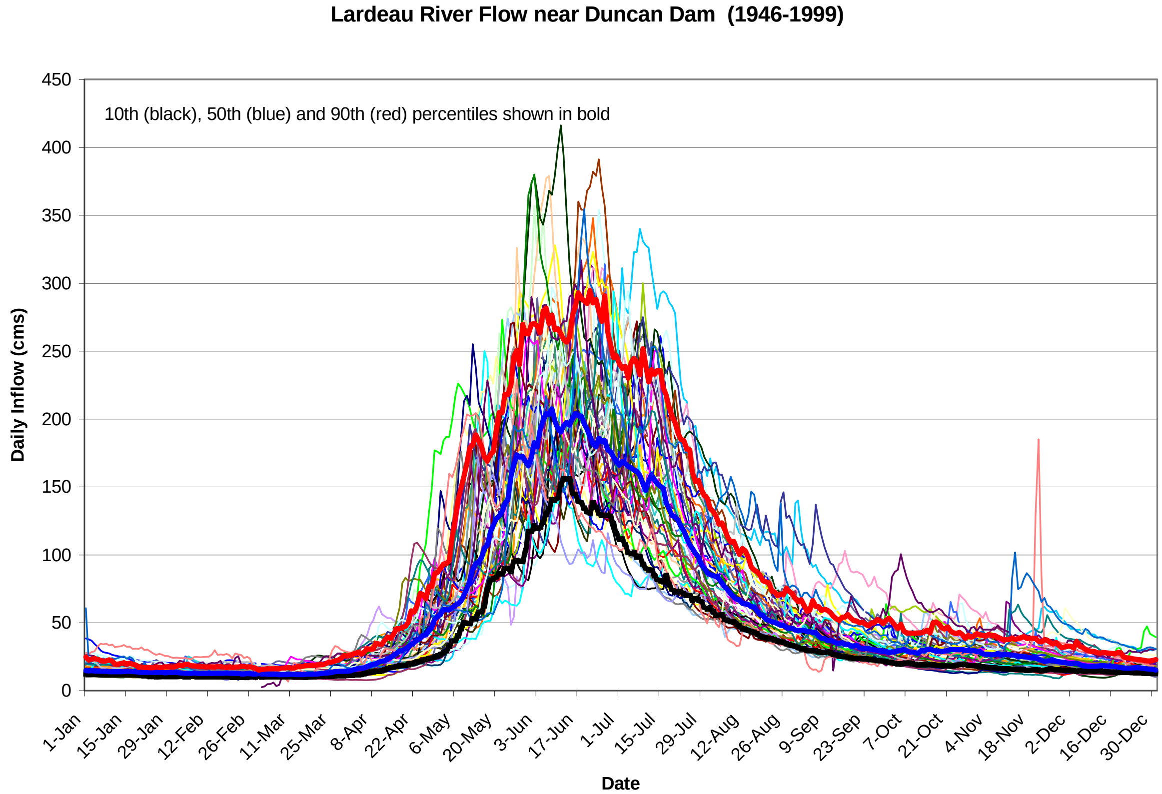


Figure 3: Annual Lardeau River near DDM discharge for the period 1946 – 1999.

Duncan Dam Operations

Planned flow reductions at DDM outside of matching inflows or targets are relatively infrequent (e.g., occur on a weekly to monthly time-step). Drivers for flow changes may include flood control, water for generation requirements at downstream projects, maintaining reservoir recreation water level targets, and fish flows (including Arrow Reservoir Releases). BC Hydro operates DDM according to the Water Licence Requirements, Treaty obligations, and WUP operating parameters. In some cases, DDM operations trade-offs will be required between Arrow and Libby operations and require consultation between BC Hydro Environmental Risk Management staff (ERM) and BC Hydro Operations Planning Engineers (OPE).

DDM operations are guided by Water License Number 27067 and the Water Licence Order (December 21, 2007) associated with the DDM WUP (Province of BC 2007). System Operations Planning is the responsibility of the BC Hydro Generation Resource Management group with DDM operating requirements summarized under Generation Operating Order 4G41. Actual operational changes at DDM are carried out by on-site staff. Table 1 and Figure 4 provide DDM discharge parameters and WUP operational targets respectively. Further details can be located in Generation Operating Order 4G41.

Table 1: Duncan Dam Discharge Parameters.

Parameter	Description
Normal Maximum Discharge	283.17 m^3/s
Emergency Maximum Discharge	566.34 m^3/s
Maximum DDM Discharge Rate Change	113.27 m^3/s per day
Minimum Instantaneous Discharge	0 m^3/s
Minimum Average Daily Flow	3 m^3/s
LLOG - 2 Maximum Discharge during bull trout transfers	3 m^3/s

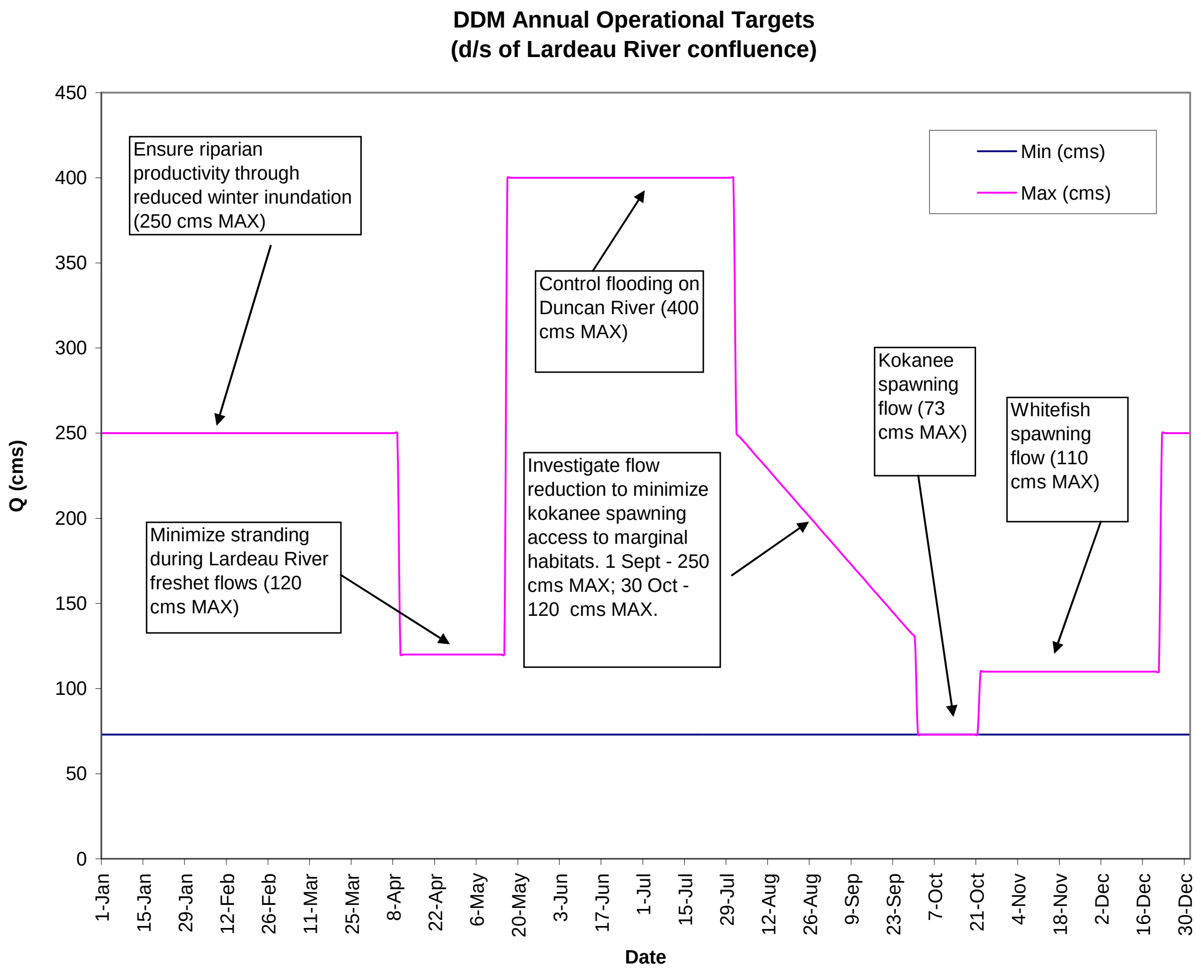


Figure 4: Summary of DDM Annual Operational Targets (downstream of the Lardeau River confluence) based on WUP recommendations.

Lower Duncan River Gauging Stations

Water Survey Canada Duncan River below Lardeau River (DRL) 08NH118

The DRL monitoring station, used to monitor compliance with Water License targets, is located approximately 1 km downstream of the Duncan-Lardeau confluence on the right downstream bank. Three day running discharge and water temperature data can be located on the BC Hydro intranet at (http://w3.bchydro.bc.ca/g/resource/dcp/drl.shtml) and external to BC Hydro at (http://www.bchydro.com/info/res_hydromet/data/drl.txt). There is also the potential to call up the gauge for hourly readings through the BC Hydro PI/OI system[1]. BC Hydro DDM staff also have a system for gauging the stations on LDR and a stage-discharge curve for crews to access while in the field. Current stage-discharge curves are also available in the ERM office for use as needed.

BC Hydro Duncan above Lardeau (DAL)

In February of 2011, a real time data collection platform (DCP) was installed in the tailout area of DDM, approximately 100 m upstream of the BC Hydro boat launch. The DCP records hourly water level, water temperature, and air temperature data. The station is independent: it is powered through solar panels and the data collected are sent via satellite to the BC Hydro data collection system. The primary purpose of the DAL gauging station is to assist in the monitoring and assessment of Gerrard Rainbow Trout spawning use in the tailout area of DDM (immediately adjacent the DCP). The DCP also helps dam staff, environmental specialists, and operations planners to assess the conditions of the tailrace. A staff gauge is also installed downstream of Argenta Bridge on the left bank to visually monitor stage changes during high flow events.

Kootenay Lake Level Monitoring

Kootenay Lake water levels are regulated by Corra Linn Dam on the Kootenay River and at Grohman Narrows above Corra Linn Dam when the lake discharge is unrestricted during freshet. The actual influence of Kootenay Lake levels on the LDR as a result of backwatering is not fully understood, but it is known from past stranding assessments that Kootenay Lake can influence river levels from the mouth to approximately 2 km upstream. The Water Survey of Canada maintains a water level gauging station at Queen's Bay (08NH064) which can be accessed on the BC Hydro Hydrometric website (http://www.bchydro.com/info/res_hydromet/data/qby.txt).

Fish Stranding Risk

Available information on fish and fish habitat in the LDR was originally summarized in DVH Consulting (DVH 2001) and the relationship between operations and fish stranding risk is the subject of an ongoing study (DDMMON-16: Lower Duncan River Fish Stranding Impact Monitoring). The LDR provides habitat for migration, spawning, egg incubation, and rearing for a number of fish species that can vary seasonally. Commonly encountered species include Bull Trout, Kokanee, Largescale Sucker, Longnose Dace, Longnose

[1] The BC Hydro external site posting of water level information is delayed by 3 hours

Sucker, Mountain Whitefish, Northern Pikeminnow, Peamouth Chub, Rainbow Trout, Redside Shiner and Slimy Sculpin. Brook Trout, Cutthroat Trout, Lake Chub, Pygmy Whitefish, and White Sturgeon have also been identified in this section of river. A complete fish species list (including Latin names) of fish encountered during DDMMON-16 sampling is provided in Appendix A.

Fish stranding in the LDR primarily affects juvenile fish, alevins and fish eggs of both large and small bodied fish of all life stages (e.g., sculpin and dace). The number of fish stranded during a flow reduction event depends on of how many fish are available to stranding, represented by the density of fish in the zone that will be dewatered by the flow reduction (the varial zone), multiplied by the probability that each individual will strand. Operational and environmental factors can affect either separately, or simultaneously, fish density or probability of stranding. Not all fish that strand perish and the mortality rate of stranded fish depends on water and ambient air temperature, how quickly water levels go back up after the stranding event, life stage and species of fish, and post stranding rates of predation.

Information on fish stranding collected to date from experiments and studies on the LDR, and gleaned from the literature, has shown that there is substantive variability in the stranding responses of fish in relation to environmental and operational variables (Golder 2008a, Poisson and Golder 2010). The following summarizes those factors influencing fish stranding and their applicability to the LDR:

- Experimental results from the multi-year DDMMON-1 Lower Duncan River Ramping Rate Monitoring Program showed a trend for higher juvenile fish stranding rates in the LDR at night (Poisson and Golder, 2010). At present there is little data on the effect of time of day on fish stranding in the LDR since stranding surveys have not been conducted at night.
- The effect of season or time of year on fish stranding rates in the LDR has not been analysed at this point. The database on fish stranding rates and times of year continues to grow and if deemed a high priority, will be analyzed during future DDMMON-16 analysis.
- The rate at which a dam reduces discharge (ramping rate) was assessed during experimental and monitoring work in and outside the Columbia Basin, and there has been a consistent trend of increased probability of fish stranding with higher ramping rates (Saltveit 2001; Golder Associates Ltd. 2008b). The current best standard for operations based on all available information is to ramp flows at a rate that results in a stage change of 10 cm/h or less throughout the affected area.
- There are several habitat variables that may increase the probability of fish stranding including bank slope of less than 4% (Bauersfeld 1978; Flodmark 2004), the presence of larger substrate types (cobbles and gravels), and the presence of wood or other cover (Poisson and Golder 2010; Golder 2011).
- There is increased risk of stranding associated with longer periods of wetted history of nearshore areas. This trend is consistent across the LDR and Columbia watersheds.

LDR monitoring activities to date have identified 50 sites where flow reductions have the potential to strand fish. Fish are most susceptible to strand at 11 of these sites (index sites), and have worked to determine variability in the stranding response between index sites and the other 39 non-index sites along the river. Pool stranding has been the primary focus of the surveys to date. Under WUP monitoring, the information collected will be reviewed and recommendations for monitoring and further fish stranding assessments will be provided.

The Duncan Water Use Plan Fish Technical and Consultative Committees also considered the implications of flow changes on Kokanee and Rainbow Trout redd dewatering, and the implications of spring flow changes on newly emerged fry, acknowledging the limited information available relating to Mountain Whitefish spawning and incubation periods and requirements. The focus was on creating flow alternatives and operating protocols to minimize impacts, or on obtaining sufficient information to generate operating alternatives. The seasonal fish habitat use studies and Kokanee and Mountain Whitefish spawning assessments on the LDR will be used to evaluate this direction over the next several years, after which time the current direction will be re-evaluated.

The present document outlines a working strategy for managing fish stranding risks on the LDR. Once the current DDM WUP studies are completed or additional information becomes available, this document will be updated to reflect the best available information and will be used to manage fish stranding impacts until the WUP review (currently planned for 2018).

3.0 FLOW REDUCTION PLANNING & FISH STRANDING RISK ASSESSMENT

Internal communication, planning within BC Hydro, external communication and consultation with the regulatory agencies requires a transparent approach to ensure that fish stranding risks are appropriately managed. The approach outlined in the following sections provides strategies for managing each planned flow change including communications, development of appropriate responses to flow changes, communicating outcomes, and responding to unexpected events. BC Hydro roles and responsibilities for flow reduction management are provided in Appendix B.

In the case of non-emergency situations that require a change in discharge at DDM (and when not passing inflows)[2], the procedures outlined in Figure 5 are followed to facilitate timely and effective communication/consultation and response within BC Hydro.

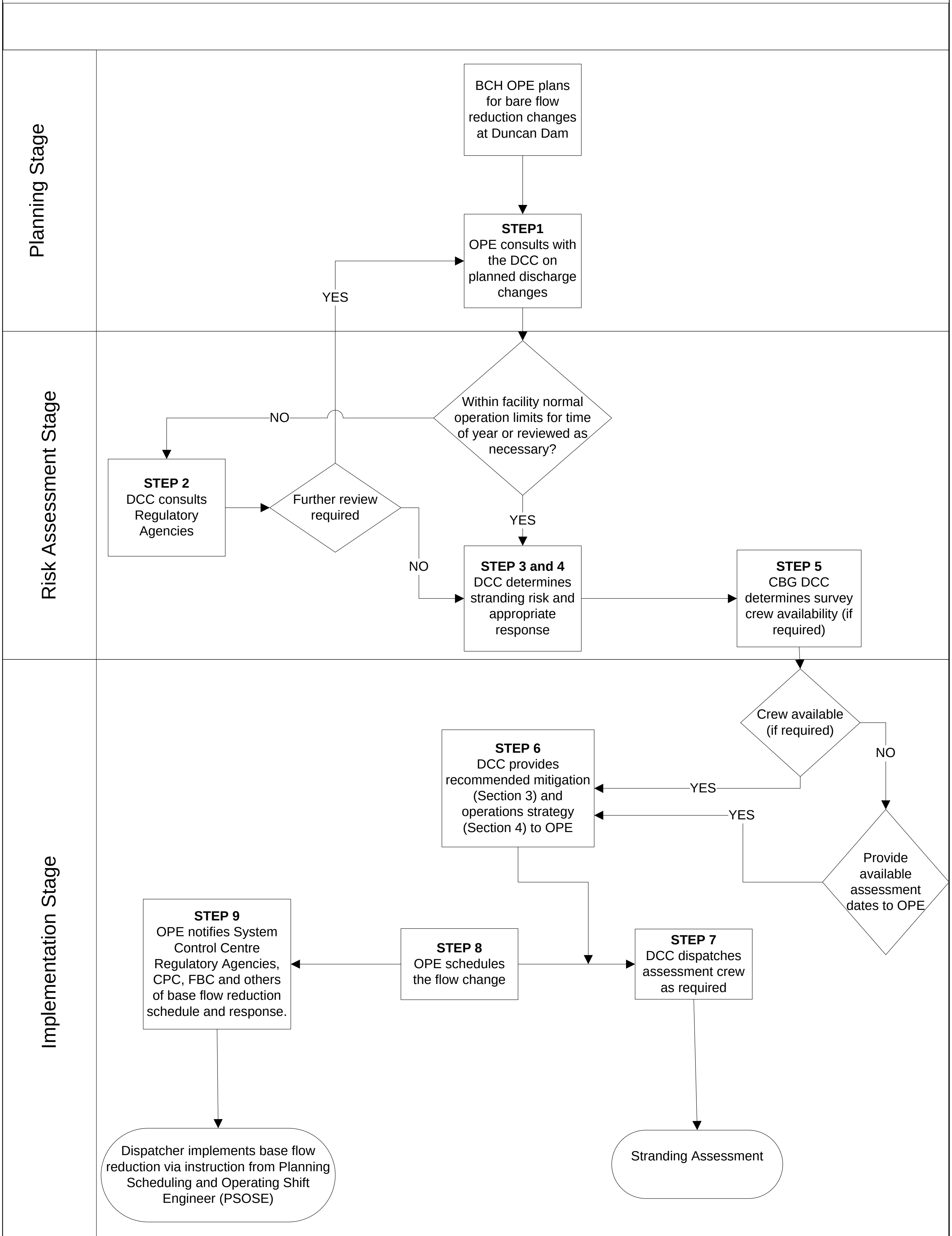
3.1 Flow Forecast Communication

BC Hydro Weekly Call

Each week, BC Hydro OPE and ERM will hold a conference call, prior to the regularly scheduled Columbia River Treaty planning call with the United States, to discuss operation forecasts and identify any potential environmental issues that may arise during weekly flow negotiations.

[2] When inflows are passed, the reservoir is either near full pool or minimum elevation and operators often make changes daily to match inflows. It is proposed that these changes mimic natural conditions and that neither contact nor environmental response be required to address fish stranding.

Figure 5: Routine Communication and Consultation Procedure from Flow Change Planning through Implementation And Assessment.



Duncan Dam Operations Forecast Communication

The BC Hydro OPE will provide interested internal and external parties with regularly updated operations forecasts for DDM (reservoir and discharge) in a timely manner. A seven-day DDM operations forecast, coordinated with Kootenay system operations, will be provided each Friday by e-mail. However, if mid week changes are necessary, the OPE will provide this information to those persons listed on the distribution list as soon as possible. A longer term operation forecast (three to six months) is provided monthly, or more frequently as updates become available.

3.2 Flow Reduction Planning

The following sections describe the details associated with each flow reduction planning step identified in Figure 5.

STEP 1 - Internal BC Hydro Planning

The OPE for DDM, who is responsible for planning and directing operations at DDM, will consult BC Hydro ERM by phone regarding a planned flow reduction at DDM. ERM is responsible for providing advice on environmental issues and coordinating any response and will assign a discharge change coordinator (DCC) for the flow change. The consultation should include information on:

- the timing and magnitude of the planned discharge change;
- the drivers for the discharge change;
- flexibility of the system to modify the discharge change or timing of change;
- Lardeau River inflows and Kootenay Lake levels - both of which influence LDR water levels;
- consequences (environmental, social, Columbia River Treaty) of implementing the change vs. consequences of not implementing the change; and,
- a forecast of future changes for the following two weeks.

As it can be difficult to arrange for a stranding assessment crew to monitor discharge changes scheduled for weekends or statutory holidays or during peak biology field season (May through September), advance notice provides a greater ability for consultation with agencies and obtaining sufficient resources to respond to the flow change. It is preferable that notification be provided from OPE to ERM at least three working days in advance of the flow reduction.

3.3 Fish Stranding Risk Assessment – STEPS 2 TO 5

There are approximately 6 – 8 flow reductions each year from DDM beyond matching inflows or maintaining Water License Order targets. Currently, BC Hydro assesses the impacts of the majority of planned flow reductions except when winter access is limited (e.g., ice and snow cover) or when there is a limited fish stranding risk (e.g., small water level reduction (<10 cm stage change or 14.16 m^3/s reduction from DDM) reduce the benefits of a fish stranding assessment. LDR flow reduction operating decisions and assessments are based on the following information:

- flow reduction targets related to operational and environmental requirements;
- a query of the LDR Fish Stranding Database and Management Tool for:
  1) estimates of dewatered habitat (for entire LDR and by stranding site);
  2) side channel status (wetted, dewatered, to be isolated);
  3) past stranding assessment results for that time of year and discharge level; and,
  4) fish species and life stages present in shallow-water habitat during the time of year; and,
- availability of trained environmental personnel to undertake the assessment, and number of hours of daylight available to undertake the necessary assessment.

The following sections outline guidelines for flow ramping and the methodology for risk assessment.

STEP 2 - Operation Review

The DCC will define whether the proposed discharge change is within the facility's normal operating limits and also query the LDR Fish Stranding Database and Management Tool to determine if the operation has occurred historically for that time of year. If the proposed change is outside the normal operating range, the regulatory agencies must be consulted prior to making final operating decisions (Appendix C Contact List). DFO should also be consulted when fish stranding risk is considered high or an unusual flow change is expected to occur. This would include operation outside the Water Licence (including WUP) operating limits and normal flow reduction rates or a rapid increase in inflows where a large flow reduction is likely to occur. Timely communication is required between BC Hydro and agencies to ensure that operational decisions are not unduly delayed.

STEP 3 - Fish Stranding Risk Assessment

The assessment of fish stranding risk is based on both current environmental conditions and the results of past stranding assessments. The coordinator will consider seasonal conditions of the ecosystem in the area and the significance of the planned flow reduction in relation to fish stranding risk. In performing this evaluation, BC Hydro ERM will rely on past stranding assessments and knowledge of fish life history (LDR Fish Stranding Database and Management Tool and available data). Additional information on current fish stranding risk (e.g., Kokanee spawning) may also be available from FLNR, DFO, external consultants, or other knowledgeable individuals.

Phase 1 – Reduction Timing

The season during which a proposed flow reduction occurs influences fish stranding risk. Operating decisions in August and September must include consideration of adult Kokanee migration in the system and the potential to isolate Kokanee adults in side channels as water levels are reduced at the beginning of October. Adult Kokanee utilize the LDR for migration to Meadow Creek and the Lardeau River, as well as for spawning in the LDR between the last week of August and middle of October. During the spring, newly emerged Mountain Whitefish and Kokanee are very susceptible to stranding when water levels recede. In addition, rainbow trout redds are susceptible to dewatering in the tailrace of Duncan Dam from March to the end of June.

Under normal DDM operations, flow reductions occur during daylight hours as DDMMON-16 stranding assessments are not possible at night. It is recommended that flow reductions from DDM continue to occur during daylight hours unless there is an emergency (Section 5.1). This will minimize the risk of stranding juvenile fish and allows sufficient time for fish stranding assessment. Flow ramping experiments in September 2009 found significant strandings of juvenile Mountain Whitefish during night time flow reductions. Day time flow reductions have not resulted in a similar scale of impacts to date, although a comparatively rapid reduction has not been conducted during day time.

Phase 2 – Review Available Information

When defining fish stranding risk, the DCC will review available information to assist with decision making as follows:

- Define the proposed change in river stage that will result at the Duncan below Lardeau Water Survey of Canada (WSC) Gauging Station from the proposed flow reduction. The LDR Fish Stranding Database and Management Tool (sample query output provided in Appendix D) will assist with assessment planning by providing the stage rate curve and information on potential dewatered area for individual sites or the entire LDR. The probability of fish stranding increases at lower river stage levels because the near shore gradient typically decreases at lower river levels and, therefore, the amount of habitat dewatered with a similar sized reduction increases. There are also certain water levels at which LDR side channels are isolated which increase the risk of fish stranding - these levels are identified through the Fish Stranding Management Tool.
- The DCC will consider seasonal conditions when determining the significance of the planned flow reduction in relation to fish stranding risk. In performing this evaluation, the DCC will rely on the historic stranding assessment results (LDR Fish Stranding Database and Management Tool; see Section 6.1.2 for a brief description on conducting a query of the database) and recent observations (e.g., fish stranding, Rainbow Trout or Kokanee redd monitoring). The DCC should also utilize knowledge from external resources who may be working on the river at the time of year.
- If a flow reduction is proposed to occur in the spring (March to June) during the Rainbow Trout spawning and incubation period, a review of available spawning distribution and redd elevations will be required. Since 2004, a redd and spawner monitoring program has been ongoing. It includes several objectives including determining redd distribution, habitat use, and timing. If a redd is anticipated to dewater based on a given operation, redd excavation may be required; alternatively, if it is a temporary operation, maintaining water flow over the redd(s) may be required (e.g., through sprinklers). The DCC or designate will record the

proposed date and time of flow reduction, current discharge, and resulting discharges and any other information that may be applicable to the flow reduction on the LDR Fish Stranding Assessment Summary Form (Appendix E). **Note**: The dewatering of rainbow trout redds at the Duncan and Lardeau rivers' confluence are known to occur as a result of flow reductions. Procedures for responding specifically to Rainbow Trout redd dewatering issues are addressed under separate agreements. Response of stranding crews to these incidents will be directed by BC Hydro (if required) prior to any field activities.

STEP 4 – Flow Change and DDMMON-16 Assessment Requirements

The DCC, in consultation with the OPE and DDM facility staff as necessary, will define a suggested ramping rate, schedule, and contingency plan (see Section 4). The ramping rate will be implemented in multiple, small increments where possible to minimize stranding risk.

The primary goal of the DDMMON-16 LDR Fish Stranding Assessments is to collect long-term fish stranding data associated with dam flow reductions to facilitate the development of dam operations that reduce fish stranding impacts. The program is designed to assess the implications of flow reductions on fish stranding and fish populations, salvage fish and return to river where practical, to fill data gaps, and to monitor stranding impacts over time to allow future analyses (current DDMMON-16 sampling methodology provided in Appendix F).

STEP 5 – Fish Stranding Assessment Crew Availability

The DCC will determine the need for a stranding assessment crew and determine crew availability to undertake the assessment efforts, as required. It is anticipated that the majority of flow changes will be monitored. Flow reductions at higher discharge levels pose a lesser risk of fish stranding because the channel morphology is steep and the dewatered area is limited. For discharge reductions above 226 m^3/s, the Fish Stranding Database and Management Tool will be used to define fish stranding risk for the proposed flow change based on habitat expected to be dewatered and mobilize a fish stranding assessment crew when needed.

3.4 Flow Change Implementation – STEPS 6 TO 11

STEP 6 - Crew Mobilization

The DCC will contact the Stranding Assessment Supervisor (SAS) to ensure that sufficient resources are available to undertake the fish stranding assessment and salvage efforts. If fish stranding assessment is required for the flow reduction and the appropriate stranding crew cannot be arranged for the proposed date, the flow reduction should be re-scheduled unless other mitigation measures can be implemented.

STEP 7 - Flow Reduction Confirmation

The DCC will contact the OPE to relay information regarding potential fish stranding risk and monitoring crew availability, along with a recommended flow change schedule (ramping strategy, timing) and monitoring effort. This information will be recorded in the LDR Fish Stranding Assessment Summary Form (Appendix E). The OPE will provide final confirmation of flow change to be implemented at DDM by email.

The OPE is responsible for making the operating decision and approving the discharge reduction strategy for DDM based on input from the DCC.

STEP 8 - Stranding Crew Mobilization

Once the flow reduction decision is confirmed, the DCC will notify the stranding assessment supervisor, as necessary, to arrange for crew deployment.

Preparation for field activities, deployment of field crews, and stranding assessments are to follow standardized methods as set out in Appendix F including:

- equipment checklists;
- field and data collection procedures; and,
- reporting requirements.

STEP 9 - Flow Reduction Scheduling

At the same time as the DCC is scheduling assessment crews, the OPE schedules the flow reduction and informs the BC Hydro Next Day Planning Engineers (PSOSE) to schedule the dam discharge change. PSOSE sends an email note that identifies the flow reduction strategy to the DDM staff for implementation as described.

STEP 10 - Flow Reduction Implementation

The Duncan Dam Caretaker implements the flow change according to instructions from PSOSE.

STEP 11 - Flow Reduction Notification

The OPE will provide information regarding the flow change and response strategy to internal and external recipients. The OPE will distribute an email notice of the flow change schedule and response strategy to agencies and First Nations personnel that have requested to be informed of flow changes.

Or BC Hydro Community Relations staff summarizes the information and inputs it into a weekly flow forecast report and distributes the information to the fisheries agencies and to First Nations (in addition to others).

3.5 Stranding Assessment Reporting

For each index stranding assessment, the completed LDR Fish Stranding Assessment Summary Form will be completed and submitted to BC Hydro within 72 hours of a fish stranding assessment. In cases when extreme or unusual stranding is observed, BC Hydro can request additional reporting (i.e., brief summary memo) for individual assessments. The timeline for the submission of requested additional reporting will be determined at the time the request is made.

3.6 Fish Stranding Identified by Member of the Public

If a member of the public contacts BC Hydro, DFO, or British Columbia Ministry of Environment (MoE) to raise the issue of stranding on the LDR, BC Hydro ERM and Nelson DFO will be made aware of the issue within 24 hours. A decision on any required response will then be determined through consultation between DFO and BC Hydro ERM. Contacting the person(s) raising the concern will be the responsibility of DFO. DFO will then outline to BC Hydro any actions to be taken or information to be gathered with respect to the public's concerns.

4.0 DISCHARGE REDUCTION IMPLEMENTATION

4.1 Flow Reduction Implementation

Discharge changes are planned by the OPE and implemented by DDM staff using instructions from PSOSE. BC Hydro has developed, through fish stranding monitoring and consultation with others, the following DDM flow reduction strategies to minimize fish stranding impacts. As noted above, significant flow changes from DDM occur approximately 6 – 8 times per year and are typically larger in the fall and early winter periods. The strategies to minimize fish stranding have been organized by season and operation.

Matching Inflows (Reservoir Full or Empty) or Managing Target Seasonal Discharges

DDM operations mimic natural conditions (on a daily basis) when the reservoir is empty and at full pool. During this period, DDM is operated according to System and Local Operating Orders (BC Hydro 2007 and 2008) and direction from the OPE. In addition, daily flow changes may take place when managing target discharges in the LDR (e.g., spawning flows). In both of these situations, DDM operation responsibility is transferred to the Dam Caretaker (through the Plant Manager). During this period, a reservoir/flow management strategy is defined by Generation Resource Management in consultation with the Plant Manager and local staff. When passing inflows, each day at 0800 h, DDM staff check reservoir level records (Stevens Gauge) for changes over the previous 16 hours, assesses weather conditions, debris program requirements (boat operation/debris collection), and Upper Duncan River inflows and the Water Survey of Canada Gauging Station below BB Creek (DBC). The Dam Caretaker will make flow changes of 28 m^3/s increments or less per hour depending on the reservoir management requirements to match daily operating requirements and will make the changes in four distinct 7 m^3/s increments every 15 minutes whenever possible. The reservoir, river, and other conditions will be checked again at noon, and again at 1600 h to determine if the reservoir or river is responding according to plan, with additional changes made at these times. OPEs, the Plant Manager, and staff will determine the most appropriate strategy to maintain DDM discharge within the desired range.

It is assumed dam operation mimics natural inflow conditions on a daily basis when matching inflows or maintaining target water levels in the LDR and as a result, monitoring of fish stranding will not occur in the LDR. Changes in tributary or Kootenay Lake levels are not normally communicated to the regulating agencies or external parties, with the exception of when flooding becomes an issue. If a significant tributary discharge event occurs, or Kootenay Lake levels are anticipated to have a fish-related impact on the LDR, a phone call to DFO will assist this agency in responding to any unforeseen tributary or lake level impacts on fish and fish habitat in the LDR.

Reservoir Refill

Under the Columbia River Treaty agreements addressing flood control, the reservoir is to be evacuated to specified levels, depending on date and snowpack levels. In addition, BC Hydro may evacuate the reservoir as required within International Joint Commission (IJC) limitations on Kootenay Lake in mid-April/May to maximize storage opportunities in Duncan Reservoir. This can result in a short term increase in discharge prior to the beginning of spring flow increases (freshet). This is typically followed by a reduction in dam discharge to 3 m^3/s on average over a 24 hour period for several months during freshet to capture inflows and refill the reservoir (May-July). Newly emerged Mountain Whitefish and Kokanee fry are particularly susceptible to stranding from reduced flows at this time, as well as the potential for dewatering or deoxygenating of Rainbow Trout redds.

To minimize fish stranding impacts during the reservoir refill period, the following operating constraints[3] are to be followed:

- If the reservoir needs to be evacuated immediately prior to start of reservoir refill, OPEs will work with the ERM department to attempt to minimize the magnitude of the DDM discharge increase(s).
- Before dropping DDM discharge to 3 m^3/s for reservoir refill, the OPE will monitor the LDR discharge at the Duncan below Lardeau WSC Gauge. The OPE will attempt to maintain water levels in the LDR at, or above, winter minimum levels (+/- 5 m^3/s) using the Lardeau River flows (freshet) to augment the discharge reduction from the dam as required.
- The current target maximum during April/May (120 m^3/s) is instituted to minimize the magnitude of spring flow changes but still presents a risk of fish stranding, should water levels fluctuate between 120 m^3/s and 73 m^3/s.
- Weather conditions may limit the success of this strategy should Duncan Reservoir storage be eliminated prior to freshet.

Flow Reduction (ramping) rates

A flow reduction (ramping) rate from DDM of 28 m^3/s/h or less provides average stage reduction rates of less than 10 cm/h throughout most of the LDR discharge range. Current recommendations from the WUP studies are to keep the rate less than 10 cm/h. This ramping rate is expected to reduce fish stranding by allowing fish to escape receding water levels. There remains uncertainty on whether a lower ramping rate would further

[3] Water Use Plan Operating protocols will take precedence over this wording once developed.

minimize stranding risk, and at what flows fish stranding risk is highest (low sloping-high risk habitats are suspected at certain elevation bands). This is the focus of ongoing seasonal fish habitat assessments and stranding assessments. It is expected that flow reductions will require further monitoring/experimentation to refine ramping rates, but as an interim strategy, flow reductions will occur as follows:

- The WUP process recommended an operating regime that balances water management interests. The resulting operating constraints result in flow fluctuations and, to the extent possible, OPE should endeavour to minimize the frequency and magnitude of flow fluctuations through forecasting operations and smoothing flows.
- Flow reductions to a maximum of 113 m^3/s/day are allowed under the Columbia River Treaty.
- When a flow reduction occurs, the flow reduction will occur at a maximum rate of 28 m^3/s or less per hour and will make the changes in four distinct 7 m^3/s increments every 15 minutes, whenever possible, to allow fish to escape to deeper water habitats and allow monitoring crews to assess fish stranding (as required). The preferred approach to reductions is several small reductions that sum to the amount required, rather than one large reduction. BC Hydro ERM will work with Duncan Staff and the OPE to develop a flow reduction strategy and contingency plans for the flow change as required.

4.2 Fish Stranding Assessment – Planning and Mobilization

Fish stranding assessment surveys on the LDR began in 2002 and the number of stranding assessments has varied from year to year. The first Lower Duncan River Stranding Protocol was finalized in 2004 and has been modified to make the data more compatible to that collected on the Lower Columbia River and to address data gaps and uncertainties identified for the Duncan River system as part of the WUP process.

The LDR is inaccessible by road for the majority of its length and log/debris jams influence the ability of the crew to safely access the river in some locations. Boat operators must be trained in river boating and will not access areas that are unsafe. During low water, the use of multiple boat launches (BC Hydro Launch, Argenta Launch) may be required to access the entire length of the LDR. The primary objective of all assessments is to evaluate the flow reduction influence on fish stranding, with the secondary objective being fish salvage.

Depending on discharge change predicted effects, the crew should be on site no later than 30 minutes after the initiation of the final flow reduction, as this is the time it takes to notice a flow change at the Duncan/Lardeau confluence. The number of crews required to undertake the assessment will depend on the extent of dewatering expected, based on initial conditions, the magnitude of flow reduction planned, and the number of sites to be assessed. Current experience indicates one two person crew is capable of monitoring the LDR during standard assessments. Fish stranding assessments will include the following:

1) A stranding assessment supervisor (on-site crew supervisor) will be assigned for all monitored flow changes and will meet with field crew(s) and BC Hydro staff at the DDM facility before starting work, to discuss safety information, potential hazards, crew deployment, and review expected effects and monitoring activities.

2) General Information relevant to the flow reduction will be captured for each flow reduction event assessed for fish stranding and should include:

- Survey date;
- Crew members;
- Time and magnitude of discharge changes at the DDM;
- Previous and resulting discharge (m^3/s) from DDM;
- Discharge data for the Lardeau River (DDM discharge subtracted from DRL discharge). If required, Lardeau River discharge data can be obtained from the WSC Lardeau River near Marblehead gauge by contacting WSC staff (~3 month delay unless specially requested);
- Estimated vertical drop of the water level at the DRL (can be calculated from stage-discharge curve); and,
- Water and air temperature.

3) The current protocol requires that all relevant materials be filed in an event folder for each fish stranding response identified by date and reduction number (i.e., RE2011-04 April 19, 2011). The Fish Stranding Database and Management Tool query output is designed as a tool for each event and will be filed in the event folder and given to BC Hydro ERM.

4) The assessments are to be carried out in randomly selected sites, consisting of both index and non-index sites along the LDR. The representation of these two categories being proportional to the amount of each that will be dewatered by the current reduction. Ten sites (or as many as can be accurately surveyed in a day) will be assessed for both pool and interstitial stranding following the methodologies outlined in detail in Appendix F.

5) Fish species and length are assessed for all fishes where possible, with the exception of sculpins species (time constraints during assessment do not allow identification of sculpins to species), and a subsample is taken where fish are too numerous to census effectively. Total cover, pool complexity, dominant, and sub-dominant substrate will also be assessed.

Monitoring of fish stranding in the LDR will be conducted according to procedures outlined in the Year 3 DDMMON-16 Lower Duncan River Fish Stranding Assessment Report (Golder 2011) to maintain sufficient details to allow long-term data analysis. The established boundaries of each stranding site visited will continue to be modified on a yearly basis to ensure that stranding assessment information is representative of the entire river and that methodology is sufficient to allow long-term analysis of stranding variables.

4.3 Post Flow Change Communication/Data Collection

The DCC is responsible for maintaining a record of environmental actions associated with discharge reductions implemented at DDM. This involves recording all information pertinent to the flow change (Lower Duncan River Fish Stranding Risk Assessment Summary) and the assessment results from all field assessments.

4.3.1 Without Monitoring

When a flow reduction does not include a fish stranding assessment (e.g. when logistical constraints [i.e. snow and/or ice prohibit effective and safe assessment] or the magnitude and the anticipated risk of the reduction are negligible [i.e., <10 cm stage change at DRL or 14.16 m^3/s reduction from DDM within normal license operating targets]), the information on the flow reduction and the rationale for not deploying crews will be provided to the organization managing the fish stranding database using the Lower Duncan River Fish Stranding Risk Assessment Summary (Appendix E). The flow reduction information will be incorporated into the fish stranding database. The following parameters are required:

- the date and time of flow change;
- flow reduction details at DDM including individual gate change flow reductions, the daily maximum and minimum discharge recorded at the Duncan below Lardeau WSC gauge; and,
- the rationale for no response with reference to the fish species and life stages of potential concern (see Section 3.2).

4.3.2 With Monitoring

In addition to maintaining a record of each discharge reduction as identified in Section 4.3.1, a number of additional reporting requirements need to be met following a flow change where a fish stranding assessment has been carried out. For each stranding assessment, all boxes in Section E of the LDR Fish Stranding Assessment Summary Form will be completed and submitted to BC Hydro within 72 hours of a fish stranding assessment.

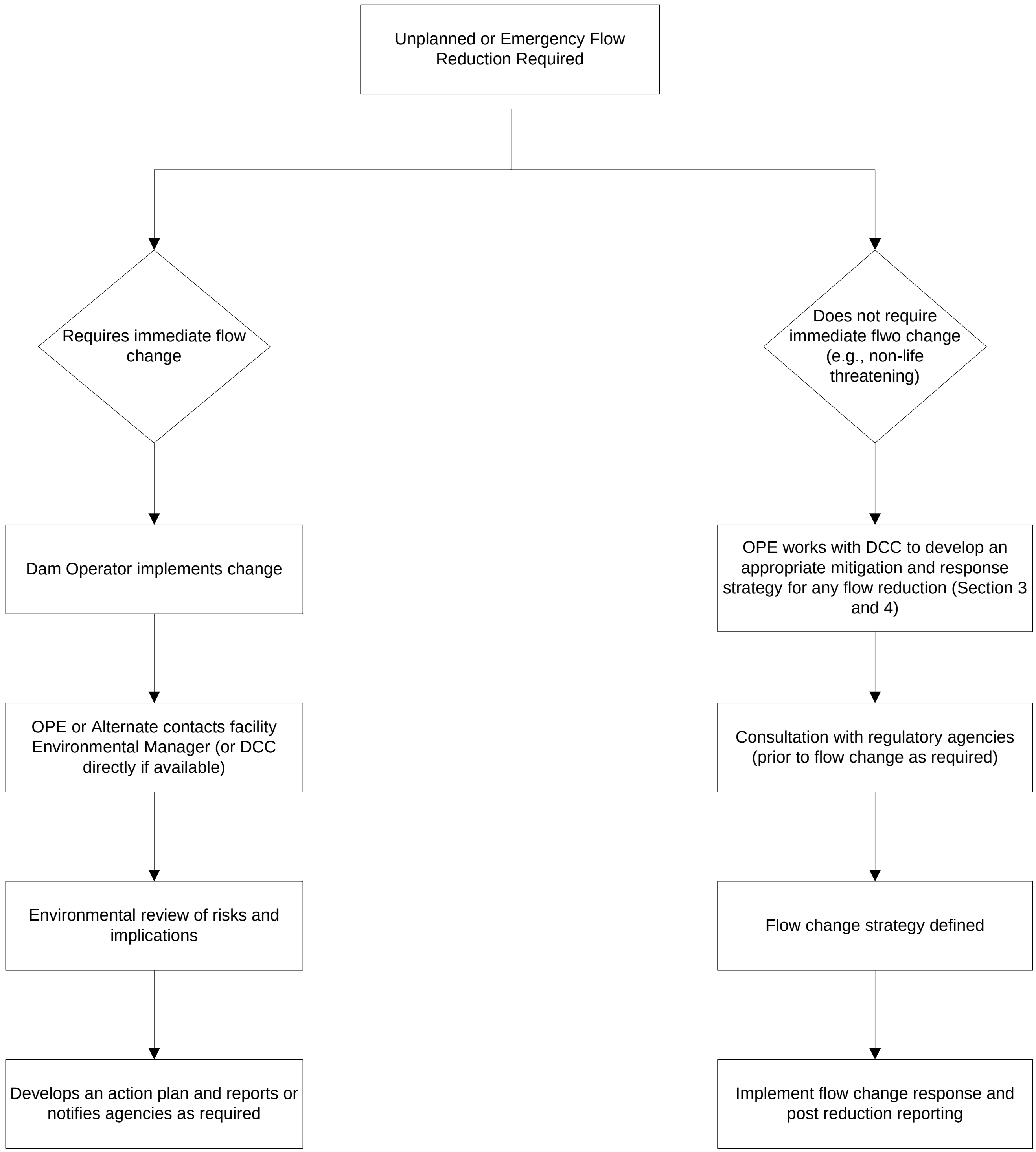
The DCC will maintain a record of each flow reduction. The record will include all information relevant to the stranding assessment (Lower Duncan River Fish Stranding Risk Assessment Summary, LDR Fish Stranding Database and Management Tool query, and email results summary) in a single file. Emails from the Stranding Assessment Supervisor to the DCC will have a subject line that includes the Reduction Event Number and the facility from which the reduction occurred (e.g., Lower Duncan River Fish Stranding Assessment Summary RE2010-04 DDM). There is no requirement to distribute the results to external parties with the exception of significant strandings which will be distributed to regulatory agencies.

A single PDF record of the fish stranding event will be prepared including: Flow Reduction Details and Stranding Risk Assessment Form, email notification of fish stranding results, and flow change notification email along with any formal assessment memos prepared. This record will then be forwarded to the DCC.

5.0 UNPLANNED OR EMERGENCY FLOW REDUCTIONS

Facilities may operate in an alternate manner in the event of an emergency, a dam safety requirement, or an extreme hydrologic event (i.e., flood routing, or potential loss of life upstream/downstream). Emergency flow reductions are addressed by the Emergency Planning Guide for Columbia Basin Dams (BC Hydro, 2011). Typically, there is a warning period in which planning for dam emergencies can occur.

Figure 6: Emergency Flow Reduction Planning Procedure.



5.1 Immediate (unplanned-emergency) Flow Reduction Strategy

In the event of an **unplanned operation or emergency**, planning is not always possible because the operation may have occurred and flows restored by the time environmental staff are contacted. Flow management for unplanned operations occurs through Local Operating Orders. The flow reduction strategy associated with an unplanned flow reduction can range from an immediate cessation of flows to a flow reduction that can be planned with some advance notice. The following sections summarize operations for immediate flow reductions.

There is a low risk of immediate flow reductions from DDM because water is discharged through spillways or low level ports using human operated controls. In emergency situations, the following notification procedures should be followed within 24 hours (Figure 6).

- The Dam Operator will confirm the flow change with the Fraser Valley Control Centre (FVCC).
- The Dam Operator will contact the Plant Manager for the facility unless contact has already been made.
- FVCC will inform the PSOSE Shift Engineer.
- The Plant Manager will contact the BC Hydro ERM Manager or the coordinator to develop an appropriate environmental response strategy to the flow change.
- Community and outside agency contacts will be made aware of the emergency according to the DDM Emergency Plan and the Flood Notification Local Operating Order (BC Hydro 2007).

Contact and consultation with fisheries agencies will not always be possible prior to implementation of an emergency flow change. However, BC Hydro will contact the fisheries agencies with information and response strategies (and consult where possible) as soon as possible (see contact list in Appendix C). A report outlining the dam emergency or unplanned operations and any environmental monitoring results will be provided to the regulatory agencies within 2 weeks of completion of any monitoring.

An emergency situation at the dam may result in either an increase or decrease in discharge from DDM. As noted previously, there may or may not be an opportunity to mitigate or monitor fish stranding impacts. If the opportunity exists, BC Hydro will undertake the following actions where possible:

- Decrease DDM discharge from existing to the target discharge at a rate of 28 m^3/s/h - unless the flow reduction is to save lives, prevent major damage, or reduce LDR flooding (downstream tributary discharge increase), in which case, the operation objective will be to minimize damage/flooding which may require rapid drops in discharge.
- Where possible, monitor fish stranding at index sites as outlined in Section 4.2 and undertake fish salvage opportunistically at sites where pools with large numbers of fish are present and are susceptible to stranding/mortality.

5.2 Delayed (unplanned or emergency) Flow Reduction Strategy

Operating decision making for dam-related emergencies (e.g., equipment problems, dam problems) typically allow time for flow reduction planning that can utilize the flow reduction guidelines outlined in Sections 3 and 4. The OPE will work with the facility staff and the BC Hydro ERM department in defining all potential environmental issues (e.g., fish stranding, recreation access, public safety) and developing an appropriate flow reduction strategy.

In the event of a flow reduction that occurs without the necessary planning and responses identified above, the regulatory agencies require an assessment of fisheries impacts within two weeks.

5.3 Pre-Change Communication

Due to the urgent nature of an emergency flow change (e.g., dam emergency, unplanned spill with high inflows) there isn't always the opportunity to provide notification or consult with the regulatory agencies in advance of the operation. In the event of this occurrence, the ERM Department will notify fisheries agencies via telephone (in addition to email) as soon as possible.

In the case of emergency situations at DDM including flood routing, or potential loss of life upstream/downstream that allow **delayed reductions** in discharge, the following notification procedures should be followed within 24 hours (Figure 6):

- The DCC will consult with the regulatory agencies via telephone in developing a flow reduction and response strategy. **Note:** Agencies request 48 hours advance notice to allow time for contact and response development.
- The DCC will provide a recommended response strategy to the OPE via e-mail.
- The OPE will make the final response decision based on system constraints and the recommended response strategy and forward information on the planned flow change and response to the regulatory agencies prior to implementing the flow change. Information provided will include a description of the situation, flow change descriptions, and a qualitative assessment of the potential fish stranding impacts associated with the flow reduction.

5.4 Post Reduction Communication

When emergency flow reductions occur, an email summarizing the event will be prepared within 24 hours. A more detailed memo will be provided within two weeks. The memo should provide all details of the flow reduction, including impact assessment and mitigation. If a stranding assessment/salvage is conducted in response to the emergency flow change, the DCC will provide the fisheries agencies with a copy of the fish stranding assessment summary information. Qualitative assessments will include searching the LDR Fish Stranding Database and Management Tool for previous records of fish stranding associated within the flow reduction range and same season. In addition, an assessment of impacted habitats (from the database) and any field observations will also be recorded. The database and field observations will be used to prepare an impact statement for habitat and fish species impacts.

If fish impact monitoring is conducted in response to the emergency flow change, BC Hydro will provide fisheries agencies with a summary of flow monitoring information within two weeks. If there is no ability to respond to the flow reduction (i.e., flows are restored before an assessment can be carried out), BC Hydro will provide the agencies with a qualitative assessment of the potential impacts of the flow change on fish stranding.

Note: In addition to normal data filing requirements, the BC Hydro DCC will assess the severity of the incident and determine if completion of an Environmental Incident Report is required.

6.0 INFORMATION MANAGEMENT AND ANNUAL REPORTING

6.1 Information Management

6.1.1 Fish and Egg Stranding References

The maintenance of information sources related to fish stranding on the lower Duncan and Columbia rivers is required to support long-term management of this issue. To satisfy this objective, BC Hydro, Castlegar, will maintain an electronic reference list of all information related to fish stranding including, but not limited to, strategies and procedures, fish/redd/egg stranding impact reports and publications, stranding risk assessments, and memos.

6.1.2 Fish Stranding Database and Management Tool

The LDR Fish Stranding Database and Management Tool is a data management and planning tool that archives historic flow reduction assessment data and the extent of pool and interstitial fish stranding within the LDR to help anticipate potential impacts of proposed flow changes. The data from each stranding survey are entered into a MS Access database. The completed fish salvage field data sheets are entered into the database quarterly. BC Hydro will maintain (or have access to) completed field data sheets and the most current version of the database. The planning component of the tool maintains information on spawning/incubation timing, as well as information from the hydraulic model to assist in estimating the amount of habitat dewatered and when side channels become dewatered. All information will be kept current as new information becomes available.

To conduct a query of the LDR Fish Stranding Database and Management Tool to find relevant historic stranding assessment results for a planned flow reduction, these steps should be followed:

1) Complete the Query Parameters form that appears upon opening the database by entering the following data into its corresponding box:

   - The date of the proposed reduction;
   - The current discharge at the DRL (m^3/s);
   - The resulting discharge at the DRL after the flow reduction (m^3/s); and,
   - The current LDR water temperature. The water temperature can be found on the BC Hydro Regional Hydromet Data website at http://www.bchydro.com/info/res_hydromet/data/drl.txt.

2) Press the “Generate a Stranding Report” button at the bottom of the form.

3) When the query output is generated, it can be saved as a PDF and then distributed.

Several summary tables appear on the first page of the query output that provide an overview of; the habitat dewatered, fish life history periodicity at the time of the proposed flow reduction, side channel connection to the mainstem DRL, and previous fish stranding observations during similar flow reductions (Appendix D). After the summary tables, all relevant fish stranding data is presented for each of the 50 identified stranding sties.

6.1.3 Lower Duncan River Discharge - Temperature – Stage Databases

Discharge, temperature, elevation and stage data from DDM have been compiled into a database. Depending upon the variable, the data spans the time period from 1963 or later to present and is accessed through the Duncan River WUP project manager at BC Hydro.

Data fields include:

- Hourly discharge at each of the spillway and low level gates and for the overall dam releases (m^3/s);
- Hourly discharge at DBC (m^3/s);
- Hourly stage (water elevation) at WSC station DRL (m);
- Hourly water temperature at DRL (°C);
- Hourly water temperature at DAL (°C);
- Hourly stage (water elevation) at DAL (m);
- Hourly air temperature at DAL (°C);
- Hourly DDM Forebay elevation (m);
- Hourly elevation at Queen’s Bay, Kootenay Lake (m); and,
- Hourly Air temperature at the forebay of the dam (°C).

6.2 Annual Report

To facilitate effective communication of fish stranding impacts and determine effectiveness of the Lower Duncan Adaptive Stranding Protocol, the DDMMON-16 annual report for the period of April 15 to April 15 of the following year will be prepared each year by June. This reporting period corresponds with the beginning of freshet and lasts one annual hydrologic cycle. The ERM is responsible for ensuring:

- Copies of the annual summary report are provided to COFAC members in June of each year.
- To satisfy the regulatory requirements of fish collection permits, a copy of the annual summary report will be uploaded to the Ministry of Forests, Lands, and Natural Resource Operations: Scientific Fish Collection Report: Reporting Website by organization(s) holding a Scientific Fish Collection Permit related to LDR Fish Stranding Assessments.

The annual report will be created according to the following format (See Golder 2011 for an example):

- BC Hydro Water License Requirements (WLR) Cover Page;
- Executive Summary; and,
- Data Summary which includes:
    1. A listing of the flow changes for the year including: event number, reduction date, risk period, pre and post change discharge data for DDM, the LDR at DRL, ramping rate and purpose of reduction.
    2. Identification of those flow reductions where an assessment occurred.
    3. Number of stranded fish, documented during each reduction by species and life stage for pools and interstitial areas. Although not a focus for the stranding assessments, anecdotal information collected on stranded eggs and redds will be presented as well.
    4. Inter-annual comparisons of fish stranding assessment information (i.e., number of flow changes by system, number and species of fish stranded).
    5. Review of the mitigation and field sampling protocol processes and define any recommended fish stranding impact management changes with input from BC Hydro and regulatory agencies as appropriate.

In addition, the following WUP management questions and hypotheses will be reviewed annually to address water license requirements associated with DDM.

As stated in the Lower Duncan River Water Use Plan Terms of Reference (BC Hydro 2008), the overall management question to be addressed within the Adaptive Stranding Protocol Development (ASPD) program is:

What are the best operating strategies at DDM to reduce fish stranding in the lower Duncan River?

The specific management questions associated with this monitoring program are:

1. How effective are the operating measures implemented as part of the ASPD program?
2. What are the levels of impact to resident fish populations associated with fish stranding events on the lower Duncan River?

To address the specific management questions associated with this monitoring program, the primary objectives of the Fish Stranding Impact Monitoring Program (FSIMP) are:

i. To determine the effectiveness of the operating measures implemented as part of the ASPD program.
ii. To determine the levels of impact to resident fish populations associated with fish stranding events on the lower Duncan River.

The specific hypotheses that are addressed in this report as part of the second objective are:

H_{O1}: Fish stranding observed at index sites along the lower Duncan River floodplain is representative of overall stranding.

H_{O2}: Fish populations in the lower Duncan River are not significantly impacted by fish stranding events.

7.0 STRATEGY ANNUAL REVIEW AND UPDATES

The preceding protocol is adaptive and will be updated as information on fish habitat use and effects of flow fluctuations on fish stranding is collected through 2012. The WUP objective is to collect sufficient information to develop mitigation strategies (e.g., ramping rates) to address outstanding issues.

There will be an annual review of the effectiveness of this protocol, fish stranding monitoring, and other relevant data collected over the preceding year (April 15 to April 15 of the following year), along with recommendations to improve the protocol under DDMMON-16 – Fish Stranding Impact Assessment Monitoring. This review is to occur during the first Columbia Fisheries Advisory Committee (COFAC) meeting following April 1 and will take place in conjunction with annual reviews of the Lower Columbia & Kootenay River Flow Reduction Strategies to utilize synergies in information collected for the two programs.

The objectives of the Annual Review are to determine the adequacy of information provided through monitoring and assessment activities, the effectiveness of the flow communication, flow reduction and response strategies as defined within the protocol, and additional information requirements for future assessments to improve the effectiveness of managing fish impacts associated with flow reductions. Any changes that may influence system operations and stranding assessment procedures will be reviewed with the appropriate individuals prior to bringing potential changes forward to COFAC. BC Hydro staff will be responsible for maintaining an up to date protocol document, with previous updates accepted and annual updates to strategy identified in 'Track Changes' to highlight annual differences, and make the document available to appropriate parties.

Periodic Data Review

In addition to the implementation of DDMMON-16 (2008 to 2017), variables influencing fish stranding are anticipated to be reviewed through the implementation of DDMMON-15 (2009 to 2018) and complementary studies included within the Adaptive Stranding Protocol (e.g., DDMMON-1, -2, -3, and -4). The next major protocol review is anticipated in 2018, during the final year of DDMMON-15 implementation. This would build on the literature review and stranding database analysis conducted in 2007 (Golder 2008) with attention focused on the WLR management questions and hypotheses. Between 2012 and 2017 protocol modifications will occur on an as needed basis.

8.0 CLOSURE

We hope this document meets your requirements. Should you have and questions please contact Brad Hildebrand at 250.365.0344.

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APPENDIX A

Lower Duncan River Fish Species List

Table A1: Scientific names of fish species encountered during DDMMON-16 fish stranding assessments on the lower Duncan River.

Category	Species	Scientific Name	Species Code[a]
Sportfish	Rainbow/Gerrard Trout	*Oncorhynchus mykiss*	*RB*
	Bull trout	*Salvelinus confluentus*	*BT*
	Mountain Whitefish	*Prosopium williamsoni*	*MW*
	Pygmy Whitefish	*Prosopium coulteri*	*PW*
	Kokanee	*Oncorhynchus nerka*	*KO*
	Burbot	*Lota lota*	*BB*
Non-sportfish	Longnose Dace	*Rhinichthys cataractae*	*LNC*
	Dace Spp.	*Cottus species*	*DC*
	Slimy Sculpin	*Cottus cognatus*	*CCG*
	Torrent Sculpin	*Cottus rhotheus*	*CRH*
	Prickly Sculpin	*Cottus asper*	*CAS*
	Sculpin Spp.	*Cottus species*	*CC*
	Sucker Spp.	*Catostomus species*	*SU*
	Redside Shiner	*Richardsonius balteatus*	*RSC*
	Northern Pikeminnow	*Ptychocheilus*	*NSC*
	Peamouth Chub	*Mylocheilus caurinus*	*PCC*
	Lake Chub	*Couesius plumbeus*	*LKC*

[a] As defined by the BC *Ministry of Environment*.

APPENDIX B

Roles and Responsibilities

BC Hydro Roles and Responsibilities

Operations Planning Engineer

In addition to planning and scheduling of operations and providing all of the operation instructions, the Operations Planning Engineer (OPE) has the prime responsibility of communicating planned flow changes at Duncan Dam with:

- BCH Operation and Energy Purchase Shift Office, DDM Plant Manager, and DDM Operator.
- CBG E&SI Department.
- Notifying agencies, CCRIFC and environmental stakeholders of flow change and response information.

Requirements for notification of discharge changes to stakeholders and other interested parties for non-fisheries related issues (e.g., flooding) are specified in Local Operating Order 3G-DDM-08: Duncan Dam (DDM) and Discharge Facilities.

CBG E&SI Department

The responsibilities of the BC Hydro ERM personnel coordinating the flow change (ERM) include:

- providing all environment-related communication to the OPE, the DDM Facility Staff, and consultation with the fisheries agencies as required.
- mobilizing monitoring crews.
- notifying agencies and environmental stakeholder(s) of any unexpected situations as soon as possible.
- maintaining records of flow reduction impact assessments.

The coordinator is the first individual contacted by the monitoring crew supervisor in the event that field observations from the monitoring/salvage survey indicates additional actions may be warranted (e.g., change of flows, more field staff required, etc.). See Section 6.0 for further details.

Community Relations

BC Hydro Community Relations Department has the following responsibilities:

- Contacting external parties as outlined in the Flood Notification LOO (pending), contacting government officials and external stakeholders.
- Maintaining the BC Hydro Reservoir Information Line and developing the Weekly Update.

APPENDIX C

Contact Information

LOWER COLUMBIA AND KOOTENAY RIVER FLOW REDUCTION: FISH IMPACT CONTACTS

Organization	*Name*	*Position*	*Work #*	*Cell #*	*Email*
BC Hydro	Shift Engineer	PSOSE	604-891-5098	**n/a**	PSOSEoffice@bchydro.com
BC Hydro	James McNaughton	OPE (Kootenay)	(604) 528-1739	n/a	james.mcnaughton@bchydro.bc.ca
BC Hydro	Vlad Plesa	OPE (Kootenay)	604-528-2240	604-317-4712	Vladimir.plesa@bchydro.com
BC Hydro	Gillian Kong	OPE (Columbia)	604-528-2793	604-908-8416	Gillian.kong@bchydro.com
BC Hydro	Kelly Gallway	OPE (Columbia)	**604-529-5692**	**604-561-2534**	kelly.galway@bchydro.com
BC Hydro	James Stark	Plant Manager, HLK	250-365-4573	**(250) 304-5580**	James.Stark@bchydro.com
BC Hydro	Chris Dahl	Plant Manager, KCL	250-359-6777	**250-365-9466**	Chris.dahl@bchydro.com
BC Hydro	Doug Johnson	CBG, Environment and Social Issues Manager	250-365-4569	**250-608-0545**	Doug.johnson@bchydro.com
BC Hydro	Trevor Oussoren	CBG Environmental Biologist	250-365-4551	250-304-9518	Trevor.oussoren@bchydro.com
BC Hydro	David DeRosa	CBG Environmental Biologist	250-365-4557	250-304-9568	David.DeRosa@bchydro.com
Canadian Columbia River Inter-Tribal Fisheries Commission	Bill Green	Director, CCRIFC	250-417-3474	250-427-0498	ccrifc@cyberlink.bc.ca
Okanagan Nation Alliance	Heidi McGregor			250- 551-0306	hmcgregor@syilx.org
Columbia Power Corporation	Llewellyn Matthews	Director, Environmental Affairs	250-365-9932	250-365-1930	Llewellyn.Matthews@columbiapower.org
Columbia Power Corporation	Wendy Horan	Manager, Environmental Projects	250-304-6032	250-304-5255	Wendy.horan@columbiapower.org
Department of Fisheries and Oceans	Tola Coopper	Senior Habitat Biologist	(250) 352-0893		tola.coopper@dfo-mpo.gc.ca
Ministry of Water, Land and Air Protection, Columbia River	Jeff Burrows	Sr. Fisheries Biologist	250-354-6928		Jeff.A.Burrows@gov.bc.ca
Ministry of Water, Land and Air Protection, Columbia River	Kristen Murphy	Ecosystem Biologist	(250) 354-6948		Kristen.Murphy@gov.bc.ca
FortisBC	Control Centre		250-368-0541	250-368-3891	BCTRSCCH@fortisbc.com
FortisBC	Danielle Royer	SCC Operations Engineer	250-365-0643	250-304-9575	Danielle.royer@fortisbc.com
FortisBC	Sheila Street	Environmental Lead	250-368-0317	250-231-0071	Sheila.street@fortisbc.com

APPENDIX D

Duncan Dam Fish Stranding Database and Management Tool Sample Query Output

Duncan River Stranding Query

Date of Proposed Reduction:	20-Apr-12	Current Discharge (m^3/s):	150.0
Water Temperature:	4.8	Resulting Discharge (m^3/s):	125.0

Current DRL Water Elevation: 2.003 m   Resulting DRL Water Elevation: 1.893 m   Change In DRL Water Elevation: 0.11 m

Side Channel Summary

Site 1.1R	Channel is and will remain a backwater area (i.e., connected at its downstream end)
Site 2.7L	Channel is and will remain connected to the mainstem
Site 3.5R	Channel is and will remain connected to the mainstem
Site 4.1R	Channel is and will remain connected to the mainstem
Site 4.4R	Channel is and will remain connected to the mainstem
Site 6.9R	Channel will go from Connected to Disconnected
Site 7.6R	Channel is and will remain connected to the mainstem
Site 8.2L	Channel is and will remain connected to the mainstem
Site 8.8L	Channel is and will remain connected to the mainstem

Fish Summary

Sample Date	Total Number of Fish Stranded
01-Nov-03	316
30-Sep-05	84
15-Sep-06	156
21-Jan-08	0
28-Sep-09	186
28-Sep-10	374

Total Stranded

1116

Number of Reductions

6

Life History Periodicity Summary

Rainbow Trout Spawning Season
Rainbow Trout Incubation Season
Bull Trout Incubation Season
Mountain Whitefish Incubation Season
Pygmy Whitefish Incubation Season
Longnose Sucker Spawning Season
Longnose Sucker Incubation Season

Exposed Area Summary

Exposed Area (Index Sites):	41214 m^2
Exposed Area (Non-Index Sites):	27617 m^2
Exposed Area (All Sites):	68831 m^2

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Lardeau	Lard0.3R	1.0	01-Nov-03	2003-03	170	57	239	130	0		NR	NR	NFR	0
			30-Sep-05	2005-04	200	85	316	148			4	4	CCG	2
			15-Sep-06	2006-03	208	96	233	129		11.6	11	11	CC	3
											11	11	LNC	3
											11	11	RB	7
			28-Sep-09	2009-04	143	95	180	127		12.0	3	3	NFR	0
			28-Sep-10	2010-05	123	54	199	129			7	7	CC	3
											7	7	RB	10

Lard0.3R Total

BB	BT	CAS	CC	CCG	CRH	DC	KO	LDC	LKC	LNC	MW	NPC	PCC	PW	RB	RSC	SU	UNI	Total
			6	2						3					17				**28**

Number of Surveys = 5

Approximate area of Lard0.3R that will be dewatered (in metres): 6328

River	Site Name	River KM	
Lardeau	SLard0.3R	1.1	Not Sampled

Approximate area of SLard0.3R that will be dewatered (in metres): 449

River	Site Name	River KM	
Duncan	M0.5L	0.5	Not Sampled

Approximate area of M0.5L that will be dewatered (in metres): 0

Query generated on: 20-Apr-12 at 15:46

All discharges are in cubic meters per second (cms).

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	M0.6-1.7L	0.6											Not Sampled	
									Approximate area of M0.6-1.7L that will be dewatered (in metres):					117
Duncan	M0.8R	0.8	01-Nov-03	2003-03	170	57	239	130	13236		NR	NR	BT	2
											NR	NR	CC	13
											NR	NR	KO	1
											NR	NR	LNC	1
											NR	NR	MW	4
											NR	NR	RB	24
											NR	NR	SU	3
			30-Sep-05	2005-04	200	85	316	148	12678		10	10	CCG	11
											10	10	LNC	4
											10	10	MW	3
											10	10	PW	2
											10	10	RB	6
			15-Sep-06	2006-03	208	96	233	129	13203	12.4	16	16	LNC	2
											16	16	RB	2
			28-Sep-09	2009-04	143	95	180	127	9921	12.0	10	10	CC	3
											10	10	DC	2
											10	10	RB	4
											10	10	UNI	1
			28-Sep-10	2010-05	123	54	199	129	11235		15	15	CC	2
											15	15	LNC	8
											15	15	RB	12
											15	15	SU	3
											15	15	UNI	3

M0.8R Total

BB	BT	CAS	CC	CCG	CRH	DC	KO	LDC	LKC	LNC	MW	NPC	PCC	PW	RB	RSC	SU	UNI	**Total**
	2		18	11		2	1			15	7			2	48		6	4	**116**

Number of Surveys = 5

Approximate area of M0.8R that will be dewatered (in metres): 6597

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	M1.1-1.7R	1.1											Not Sampled	
									Approximate area of M1.1-1.7R that will be dewatered (in metres):					94
Duncan	M1.5L	1.5											Not Sampled	
									Approximate area of M1.5L that will be dewatered (in metres):					666
Duncan	M1.7L	1.7	28-Sep-09	2009-04	143	95	180	127	708	9.5	2	2	UNI	1
									Approximate area of M1.7L that will be dewatered (in metres):					322
Duncan	M2.1R	2.1											Not Sampled	
									Approximate area of M2.1R that will be dewatered (in metres):					571
Duncan	M2.5L	2.5	28-Sep-09	2009-04	143	95	180	127	0	9.5	0	0	NFR	0
									Approximate area of M2.5L that will be dewatered (in metres):					0
Duncan	M2.7L	2.7											Not Sampled	
									Approximate area of M2.7L that will be dewatered (in metres):					437

All discharges are in cubic meters per second (cms).

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S2.7L	2.7	28-Sep-09	2009-04	143	95	180	127	21	9.5	0	0	NFR	0

Approximate area of S2.7L that will be dewatered (in metres): 208

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S3.1-3.2L	3.1											Not Sampled	

Approximate area of S3.1-3.2L that will be dewatered (in metres): 563

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S3.5-4.0R	3.5	01-Nov-03	2003-03	170	57	239	130	14066		NR	NR	BT	1
											NR	NR	CC	3
											NR	NR	LNC	25
											NR	NR	RB	6
											NR	NR	SU	1
			30-Sep-05	2005-04	200	85	316	148	15536		5	5	KO	1
											5	5	RB	1
			15-Sep-06	2006-03	208	96	233	129	13493	12.5	19	19	LNC	4
											19	19	RB	4
											19	19	UNI	1
			28-Sep-09	2009-04	143	95	180	127	6319	13.0	11	11	CC	1
											11	11	DC	5
											11	11	KO	4
											11	11	RB	18
			28-Sep-10	2010-05	123	54	199	129	8870		4	3	CC	3
											4	3	KO	2
											4	3	RB	36

S3.5-4.0R Total

BB	BT	CAS	CC	CCG	CRH	DC	KO	LDC	LKC	LNC	MW	NPC	PCC	PW	RB	RSC	SU	UNI	**Total**
	1		7			5	7			29					65		1	1	**116**

Number of Surveys = 5

Approximate area of S3.5-4.0R that will be dewatered (in metres): 3044

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S4.0-4.2R	4.0	01-Nov-03	2003-03	170	57	239	130	6441		NR	NR	LNC	30
											NR	NR	RB	14
			30-Sep-05	2005-04	200	85	316	148	10940		0	0	NFR	0
			15-Sep-06	2006-03	208	96	233	129	5819	12.5	1	1	LNC	8
											1	1	UNI	70
			28-Sep-09	2009-04	143	95	180	127	2098	12.0			NFR	0
			28-Sep-10	2010-05	123	54	199	129	3050		4	4	LNC	23
											4	4	RB	4
											4	4	SU	17

S4.0-4.2R Total

BB	BT	CAS	CC	CCG	CRH	DC	KO	LDC	LKC	LNC	MW	NPC	PCC	PW	RB	RSC	SU	UNI	**Total**
										61					18		17	70	**166**

Number of Surveys = 5

Approximate area of S4.0-4.2R that will be dewatered (in metres): 921

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S4.0R	4.0											Not Sampled	

Approximate area of S4.0R that will be dewatered (in metres): 78

All discharges are in cubic meters per second (cms).

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S4.1L	4.1	01-Nov-03	2003-03	170	57	239	130	11155		NR	NR	CC	1
											NR	NR	LNC	5
											NR	NR	RB	26
			30-Sep-05	2005-04	200	85	316	148	15275		8	8	LNC	1
											8	8	RB	36
			15-Sep-06	2006-03	208	96	233	129	10500	12.7	21	21	RB	3
			28-Sep-09	2009-04	143	95	180	127	4930	13.0	5	5	CCG	3
											5	5	KO	1
											5	5	RB	9
											5	5	UNI	1
			28-Sep-10	2010-05	123	54	199	129	6735		0	0	CC	1
											0	0	RB	14
											0	0	SU	2

S4.1L Total

BB	BT	CAS	CC	CCG	CRH	DC	KO	LDC	LKC	LNC	MW	NPC	PCC	PW	RB	RSC	SU	UNI	**Total**
			2	3			1			6					88		2	1	**103**

Number of Surveys = 5

Approximate area of S4.1L that will be dewatered (in metres): 1980

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S4.1R	4.1											Not Sampled	
Approximate area of S4.1R that will be dewatered (in metres):														108
Duncan	S4.2R	4.2	28-Sep-09	2009-04	143	95	180	127	1933	13.0	0	0	NFR	0
Approximate area of S4.2R that will be dewatered (in metres):														1296
Duncan	M4.3R	4.3											Not Sampled	
Approximate area of M4.3R that will be dewatered (in metres):														325
Duncan	S4.4R	4.3	28-Sep-09	2009-04	143	95	180	127	78	11.5	3	3	NFR	0
Approximate area of S4.4R that will be dewatered (in metres):														0
Duncan	M4.7R	4.5	28-Sep-09	2009-04	143	95	180	127	276	11.5	1	1	NFR	0
Approximate area of M4.7R that will be dewatered (in metres):														94
Duncan	M5.1R	5.1	28-Sep-09	2009-04	143	95	180	127	1004	9.5	5	5	KO	1
Approximate area of M5.1R that will be dewatered (in metres):														373
Duncan	M5.7L	5.7	28-Sep-09	2009-04	143	95	180	127	910	11.5	1	1	NFR	0
Approximate area of M5.7L that will be dewatered (in metres):														385
Duncan	M6.0R	6.0	28-Sep-09	2009-04	143	95	180	127	326	9.5	2	2	NFR	0
Approximate area of M6.0R that will be dewatered (in metres):														172
Duncan	M6.1L	6.1	28-Sep-09	2009-04	143	95	180	127	774	9.5	1	1	NFR	0
Approximate area of M6.1L that will be dewatered (in metres):														402

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	M6.5R	6.5	28-Sep-09	2009-04	143	95	180	127	1164	9.5	1	1	CC	10
											1	1	DC	5
											1	1	RB	30
			28-Sep-10	2010-05	123	54	199	129	1677		1	1	BT	1
											1	1	CC	17
											1	1	CCG	2
											1	1	LNC	24
											1	1	RB	38

M6.5R Total

BB	BT	CAS	CC	CCG	CRH	DC	KO	LDC	LKC	LNC	MW	NPC	PCC	PW	RB	RSC	SU	UNI	Total
	1		27	2		5				24					68				**127**

Number of Surveys = 2

Approximate area of M6.5R that will be dewatered (in metres): 514

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S6.9R	6.9	01-Nov-03	2003-03	170	57	239	130	3055		NR	NR	BT	2
											NR	NR	CC	9
											NR	NR	LNC	4
											NR	NR	RB	13
			30-Sep-05	2005-04	200	85	316	148	4571		2	2	BT	3
											2	2	CCG	2
											2	2	KO	11
			15-Sep-06	2006-03	208	96	233	129	2852	12.7	5	5	MW	1
											5	5	RB	12
			21-Jan-08	2008-01b	170	113	199	137	1457		3	0	NFR	0
			28-Sep-09	2009-04	143	95	180	127	1107	9.5	0	0	NFR	0
			28-Sep-10	2010-05	123	54	199	129	1629		5	5	NFR	0

S6.9R Total

BB	BT	CAS	CC	CCG	CRH	DC	KO	LDC	LKC	LNC	MW	NPC	PCC	PW	RB	RSC	SU	UNI	Total
	5		9	2			11			4	1				25				**57**

Number of Surveys = 6

Approximate area of S6.9R that will be dewatered (in metres): 521

River	Site Name	River KM	Species
Duncan	M7.1-7.7L	7.1	Not Sampled

Approximate area of M7.1-7.7L that will be dewatered (in metres): 494

River	Site Name	River KM	Species
Duncan	M7.2-7.8R	7.2	Not Sampled

Approximate area of M7.2-7.8R that will be dewatered (in metres): 98

River	Site Name	River KM	Species
Duncan	S7.6L	7.6	Not Sampled

Approximate area of S7.6L that will be dewatered (in metres): 13

River	Site Name	River KM	Species
Duncan	S7.6R	7.6	Not Sampled

Approximate area of S7.6R that will be dewatered (in metres): 2317

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	M7.7L	7.7	01-Nov-03	2003-03	170	57	239	130	4297		NR	NR	BT	1
											NR	NR	CC	2
											NR	NR	LNC	9
											NR	NR	MW	3
											NR	NR	RB	7
			28-Sep-09	2009-04	143	95	180	127	3763	9.5	5	5	CC	1
											5	5	LNC	9
											5	5	RB	2

M7.7L Total

BB	BT	CAS	CC	CCG	CRH	DC	KO	LDC	LKC	LNC	MW	NPC	PCC	PW	RB	RSC	SU	UNI	**Total**
	1		3							18	3				9				**34**

Number of Surveys = 2

Approximate area of M7.7L that will be dewatered (in metres): 1810

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S7.7R	7.7											Not Sampled	

Approximate area of S7.7R that will be dewatered (in metres): 182

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	M7.8R	7.8											Not Sampled	

Approximate area of M7.8R that will be dewatered (in metres): 2380

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S8.2L	8.2	01-Nov-03	2003-03	170	57	239	130	14950		NR	NR	BT	2
											NR	NR	CC	6
											NR	NR	LNC	15
											NR	NR	RB	14
			28-Sep-09	2009-04	143	95	180	127	5355	9.5	6	5	LKC	1
											6	5	LNC	30
											6	5	RB	5
											6	5	SU	39
			28-Sep-10	2010-05	123	54	199	129	8314		7	7	CCG	1
											7	7	LNC	9
											7	7	PW	2
											7	7	RB	2

S8.2L Total

BB	BT	CAS	CC	CCG	CRH	DC	KO	LDC	LKC	LNC	MW	NPC	PCC	PW	RB	RSC	SU	UNI	**Total**
	2		6	1					1	54				2	21		39		**126**

Number of Surveys = 3

Approximate area of S8.2L that will be dewatered (in metres): 2342

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	M8.3L	8.3											Not Sampled	

Approximate area of M8.3L that will be dewatered (in metres): 423

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	M8.4-9.1R	8.4											Not Sampled	

Approximate area of M8.4-9.1R that will be dewatered (in metres): 15

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	M8.4L	8.4											Not Sampled	

Approximate area of M8.4L that will be dewatered (in metres):

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	M8.6L	8.5	28-Sep-10	2010-05	123	54	199	129	3873	11.0	3	3	LNC	7

Approximate area of M8.6L that will be dewatered (in metres): 1618

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S8.7L	8.7	28-Sep-09	2009-04	143	95	180	127	5797	9.5	1	1	NFR	0

Approximate area of S8.7L that will be dewatered (in metres): 4802

All discharges are in cubic meters per second (cms).

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S9.0L	9.0											Not Sampled	

Approximate area of S9.0L that will be dewatered (in metres): 237

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S9.2L	9.2	01-Nov-03	2003-03	170	57	239	130	12050		NR	NR	BT	2
											NR	NR	CC	5
											NR	NR	LNC	60
											NR	NR	RB	2
			30-Sep-05	2005-04	200	85	316	148	10078		0	0	MW	1
			15-Sep-06	2006-03	208	96	233	129	12049	12.7	1	1	NFR	0
			28-Sep-10	2010-05	123	54	199		9556	11.0	12	12	CC	2
											12	12	CCG	13
											12	12	LNC	48
											12	12	RB	21

S9.2L Total

BB	BT	CAS	CC	CCG	CRH	DC	KO	LDC	LKC	LNC	MW	NPC	PCC	PW	RB	RSC	SU	UNI	**Total**
	2		7	13						108	1				23				**154**

Number of Surveys = 4

Approximate area of S9.2L that will be dewatered (in metres): 3834

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S9.5R	9.5											Not Sampled	

Approximate area of S9.5R that will be dewatered (in metres): 1982

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	M9.7R	9.7	01-Nov-03	2003-03	170	57	239	130	4676		NR	NR	NFR	0
			30-Sep-05	2005-04	200	85	316	148	2188		2	2	NFR	0
			15-Sep-06	2006-03	208	96	233	129	4820	12.7	5	5	LNC	31
											5	5	RB	3
											5	5	SU	1
			28-Sep-10	2010-05	123	54	199		4478	11.0	12	12	CC	3
											12	12	LNC	36
											12	12	RB	1
											12	12	SU	4

M9.7R Total

BB	BT	CAS	CC	CCG	CRH	DC	KO	LDC	LKC	LNC	MW	NPC	PCC	PW	RB	RSC	SU	UNI	**Total**
			3							67					4		5		**79**

Number of Surveys = 4

Approximate area of M9.7R that will be dewatered (in metres): 3267

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S9.7R	9.7											Not Sampled	

Approximate area of S9.7R that will be dewatered (in metres): 1238

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S10.2R	10.2	01-Nov-03	2003-03	170	57	239	130	15626		NR	NR	NFR	0
			30-Sep-05	2005-04	200	85	316	148	18577		0	0	NFR	0
			15-Sep-06	2006-03	208	96	233	129	15237	12.7	5	5	LNC	1
			28-Sep-10	2010-05	123	54	199		10485	11.0	0	0	NFR	0

S10.2R Total

BB	BT	CAS	CC	CCG	CRH	DC	KO	LDC	LKC	LNC	MW	NPC	PCC	PW	RB	RSC	SU	UNI	**Total**
										1									**1**

Number of Surveys = 4

Approximate area of S10.2R that will be dewatered (in metres): 4060

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S10.6R	10.6	28-Sep-10	2010-05	123	54	199	129	15387	15.0	1	1	NFR	0

Approximate area of S10.6R that will be dewatered (in metres): 8387

River	Site Name	River KM	Date	Reduction Event	Previous DDQ	Resultant DDQ	Previous DRLQ	Resultant DRLQ	Exposed Area	Water Temp.	Pools Present	Pools Sampled	Species	Number
Duncan	S11.0R	10.6	28-Sep-10	2010-05	123	54	199	129	10415	15.0	1	1	NFR	0
													Approximate area of S11.0R that will be dewatered (in metres):	2276
Duncan	S11.5R	11.5											Not Sampled	
													Approximate area of S11.5R that will be dewatered (in metres):	544

All discharges are in cubic meters per second (cms).

APPENDIX E

LDR Fish Stranding Assessment Summary

Lower Duncan River Fish Stranding Assessment Summary

Version Date: April 2012

A - Proposed Reduction Details

Reduction Event Number: ____________

	Date
Date of Proposed Flow change:	

	°C
DRL Water Temperature:	
Air Temperature:	

Upcoming Flow Changes:

If yes, which dates:

Proposed Reductions:	**(m^3/s)**
Current DDM Q:	
Resulting DDM Q:	
Estimated Lardeau River Discharge:	

	(m)
Estiamted Vertical Drop of Water Level at DRL based on stage rate curve:	

QUERY INPUT

	(m^3/s)
Current DRL Q:	
Resulting DRL Q:	
Queried by:	
Query Date:	

B - Summary of Query Results (details provided separately)

Randomly Selected Sites		
Site Name	**Index or Non-Index**	**Site Area (m^2)**

Total Area Dewatered at Index Sites (m^2)	
Total Area Dewatered Non-Index Sites (m^2)	
Total Area Dewatered at All Sites (m^2)	

Previous Significant Stranding Event (> 1000 fish previously sampled):	
Site(s):	

C - Discharge Change Section (To be completed by BC Hydro representative)

DCC: ______ Operations Planner: ______

Impact Information

a) Flow Reduction Strategies	
b) Assessment/Salvage	
c) Actual Response (if different from above)	
d) Driver for change	

Consultation with agencies or others: ______ If yes define: ______

D - Additional Information For the Reduction Event

OTHER INFORMATION

Flow Ramping (multiple reductions)? ______

No. Ramped Reductions? ______

From (m^3/s)		Time	
To (m^3/s)			
From (m^3/s)		Time	
To (m^3/s)			
From (m^3/s)		Time	
To (m^3/s)			
From (m^3/s)		Time	
To (m^3/s)			
From (m^3/s)		Time	
To (m^3/s)			
From (m^3/s)		Time	
To (m^3/s)			

E - Assessment Results

Crew Descpription:	
Number of Sites Visited:	
Number of Fish Isolated:	
Observations:	
Concerns Next Reduction:	

APPENDIX F

Stranding Protocol Forms

Prior to Field work:

1. Upon notification of a required fish stranding assessment response to a flow reduction at Duncan Dam from BC Hydro, create a new reduction event folder in: N:\Active_2010\1492 Biology\10-1492-0110 Lower Duncan River Fish Stranding Impact Monitoring Years 3 and 4\Reductions. Event numbers should be sequential.
2. All relevant correspondence for the reduction should be placed in reduction event folder.
3. Create fish stranding query from the Lower Duncan River Fish stranding Database using discharge information provided by BC Hydro. Determine current river temperature at: http://www.bchydro.com/info/res_hydromet/data/drl.txt. Distribute query to BC Hydro contract authority.
4. Organize flow reduction schedule, communication protocol and accommodations with contract authority: Trevor Oussoren: 250-365-4551.

Field Sampling:

1. Field sampling during an index fish stranding assessment is to be conducted according to the Duncan Fish Stranding Protocol (2004) and in a manner consistent with previous fish stranding assessments, with the following changes to methodology to ensure consistency with the WLR study requirements:
    a. If feasible, travel to Meadow Creek or Kaslo the day before the scheduled reduction and stay overnight in staff house (arrangements to be made with Len Wiens 250-366-4257) or at the Kaslo Motel (Front Desk 250-353-2431). With the field crew staying overnight in Meadow Creek or Kaslo, reductions can be initiated earlier the following day, which will allow field crews more time to conduct assessments.
    b. In total, 10 previously identified stranding sites will be selected at random for assessment. This will be accomplished prior to the field work by creating two strata (index and non-index) and then randomly selecting sites from each stratum to sample. The number of sites in each stratum selected for sampling will be proportionate to the area dewatered in each stratum as a result of the assessed DDM flow reduction. The DDM flow reduction information will be entered into the DDMMON-16 Site Area Regression Excel Spreadsheet. The calculated areas will then be transferred to Tables 1 to 3 of the DDMMON-16 Random Site Selector Excel Spreadsheet. This spreadsheet then randomly picks sites for assessment based on the portion of dewatered area at both index and non-index sites.
    c. Field crew should be onsite and ready to start field work as the last flow reduction is made.
    d. Once sampling commences, isolated pools as a result of the DDM flow reduction will be enumerated and their surface area estimated as they are identified. The field crews will then single pass electrofish 50% of the pools at each site, up to a maximum of three. The pools to be sampled will be selected at random. Field crew are also equipped with small numbered flags to allow identification of the pools if crews have to come back to them.
    e. Each field crew will have a GPS and record waypoints of every pool and interstitial grid sampled.
    f. For each pool electrofished, associated cover types (and percentages within the pool) from the following list in the pool are recorded on the Stranding Habitat and Fish Record data sheet:
        i. Small woody debris (woody debris with diameter of <10 cm),

ii. Large woody debris (woody debris with diameter of >10cm),
iii. Aquatic vegetation,
iv. Submerged Terrestrial Vegetation,
v. Organic debris (leaves, bark etc.),
vi. Overhanging vegetation,
vii. Cut bank,
viii. Shallow pool,
ix. Deep pool,
x. Other (metal, garbage, etc.).

g. During sampling, if possible the habitat association of each fish will also be recorded on the fish record data sheet.
h. To determine the observer (capture) efficiency distribution during stranding assessments, multi-pass electrofishing will occur at a subset of electrofished pools, selected at random. As observer efficiency will likely differ with the amount of cover present in each pool, the pools will be divided into two categories:

    i. Zero to Low Complexity; and,
    ii. Moderate to High Complexity.

    Zero to Low Complexity pools have 0-10% of the total area of the pool occupied by cover, with sand or small gravel substrate that would not be large enough to hide juvenile fish. Zero to Low Complexity pools are generally smaller in size so that fish could be captured readily by backpack electrofishing. Moderate to High Complexity pools have >10% total cover and are likely to have: larger surface areas, larger substrate that could provide cover to fish including larger cobble and gravel or boulder, and some portions of the pool that are not visible due to woody debris or other cover types.

    Estimation of total cover:

    i. Visually assess all wood (any diameter) affecting the availability of cover in the pool and determine what percentage of the pool would be covered by the wood.

    ii. Assess whether there is any other types of cover that would afford fish ability to hide in the pool (deep water, undercut banks, vegetation, large substrate, etc.). Mentally visualize all of these types of cover stacked together to determine what area is affected by this. Add this percentage onto that of the wood cover.

    Each field crew will conduct double pass removal in one Zero to Low Complexity pool and two Moderate to High Complexity pools per assessment. The effort for each subsequent pass will be as consistent as possible with the first pass. The fish salvaged and effort for each pass will be recorded separately.

i. Dewatered habitat at each site will be assessed by conducting a minimum of twenty randomly placed interstitial grids ($0.5m^2$) if possible. The substrate and all cover will be removed from each grid and the stranded fish enumerated. When selecting a location for each grid, the field crew will use a random number table to determine how many steps to take before placing the next grid to be sampled.
j. Field crews will record the length of each fish enumerated (in pools or on dewatered substrate). If numbers of fish are high and time does not allow measuring all fish, a

subsample of all salvaged fish should be measured (estimate number of fish by species in pool, length of 30-50 of each species).

k. To be consistent with past studies (fish stranding assessments and Ramping experiments), if time allows, the dominant and subdominant substrate in each stranding mechanism (interstitial and pool) should be recorded using the Modified Wentworth Scale.

l. Field crews will ensure that all relevant sections of data sheets are completed. In the comments section of the Survey Form, field crews should document observations on the following if possible:
    i. Lardeau River Flows and if they fluctuate daily, how will that have influenced fish stranding
    ii. MW and KO stranding if flows reduce a small amount in future

Post Sampling:

1. Once the crew returns to the office, all relevant equipment with data should be downloaded (i.e. camera, GPS) and put in the corresponding reduction folder.
2. The crew leader will visit the BC Hydro Hydromet website and save data for DCN, DRL, QBY and DBC stations as text files in reduction folder. http://www.bchydro.com/about/our_system/hydrometric_data/columbia.html.
3. All data sheets should be placed in the 10-1492-0110 unentered data folder in top drawer of right fireproof filing cabinet.

Equipment List

The following equipment should be prepared for field work:

- Truck with proper hitch
- G3 boat and appropriate safety gear
- Ice auger (if winter survey)
- Aquaview (if winter survey)
- Electroshocker
- 2 electroshocker batteries (fully charged)
- 2 or 3 (if available) pairs of linesmen gloves
- 2 interstitial grids (0.5m^2)
- Beach seine
- Long handled net
- 2 dip nets
- 1 bucket
- Fish sample kit
- Level 1 First Aid kit
- Bear kit
- Clipboard with Duncan River Fish Stranding Survey Form and Duncan Stranding Habitat and Fish Record datasheets on waterproof paper, scientific fish collection permit, HASP, BC Hydro South Interior Radio System Info sheet, WPP Local Component for Duncan Dam Info sheet, pencils, Fish ID key, Modified Wentworth Substrate Key, Duncan Stranding Protocol (2004), 10-1492-0110 Specific Work Instructions (this document)
- Fish measuring board
- Satellite phone
- VHF Radio with BC Hydro frequencies (Provided by BC Hydro)
- Laser Rangefinder
- Digital Camera

- GPS (WAAS Enabled)
- Thermometer
- Laminated Maps for identification of fish stranding sites (Duncan River Orthophotos)

Personal Gear

- Lifejacket
- Hat
- Polarized sunglasses
- Rain gear
- Waders
- Wading belt
- Dry bag
- Personal 1st Aid kit
- Snowshoes (if winter survey)

Random Number Table

05 38 04 41 45 20 08 06 00 18 15 37 08 32 37 34 45 48 12 33 34 43 02 48 26 41 09 28 47 42 31 11 20 21 19 24 09 02 09 39 01 00 16 20 22 14 39 03 46 31 13 15 35 12 17 31 41 10 23 11 48 24 46 45 21 03 20 07 11 36 11 22 16 34 31 02 24 48 40 36 48 13 28 49 37 46 18 13 42 44 25 16 21 29 19 50 08 08 06 11

10-1492-0110 Duncan River Fish Stranding Survey Form

Crew:			Follow-up Required (If so, why)?
Site Name:			
Index or Non-Index Site:			Future flow reduction problems (next 0.5m decrease)?
UTM Zone:	UTM Easting:	UTM Northing:	
Date:		Estimated Verticle Drop (m)[1]:	Ramping Description:
Time:		Previous Discharge (kcfs):	
Weather:		Resulting Discharge (kcfs):	**Comments:**
Air Temperature:		Flow Ramping? (yes or no):	
Mainstem Water Temperature:			

Isolated Pool Stranding

No. New Pools Present:	Number of pools connected:
No. Pools Sampled:	
Sampling Gear Used:	

Interstitial Egg & Fish Stranding

Substrate checked? Yes / No if not, why?	Size of area sampled (m^2):
Recon survey? Yes / No OR Detailed survey with separate datasheet? Yes / No	
Substrate Type (circle major types that apply): Sand / Gravel / Cobble / Boulder	

Photodocumentation

Camera Type (e.g., 35 mm, digital)

Image #	Orientation	Comments

1 The estimated vertical drop from the drawdown zone of the previous water elevation to the current water elevation.

BC Hydro Stranding Survey Field Data Form

Site Sketch (Reference the Duncan River Mainstem with arrow indicating direction of flow)	Area of site

10-1492-0110 Duncan Stranding Habitat and Fish Record

Date:_______________ **Crew:**____________________ **Weather:**____

Site #	Side Channel or Mainstem	Pool or Interstitial ID (i.e. P1 or I1)	Time at Stranding Mechanism	Area (m^2)	Cover Types (LWD, SWD, OV, CB, DP, SP, INT, N/A) and Percentage				Complexity (Zero to Low or Moderate to High)	Substrate (sizes and dominance)	Species	Length (mm)	Salvaged	Cover Association	Number of Fish Remaining in Pool	Comments (Is fish marked? Which pass, settings, effort and time on each pass)

10-1492-0110 Duncan Stranding Habitat and Fish Record

Date:_______________ Crew:___________________ Weather:______________________________________

Site #	Side Channel or Mainstem	Pool or Interstitial ID (i.e. P1 or I1)	Time at Stranding Mechanism	Area (m^2)	Cover Types (LWD, SWD, OV, CB, DP, SP, INT, N/A) and Percentage				Complexity (Zero to Low or Moderate to High)	Substrate (sizes and dominance)	Species	Length (mm)	Salvaged	Cover Association	Number of Fish Remaining in Pool	Comments (Is fish marked? Which pass, settings, effort and time on each pass)

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