BC Hydro
Power smart

Duncan Dam Project Water Use Plan

Lower Duncan River Fish Stranding Protocol

Implementation Year 10

Reference: DDMMON-15

Year 6-10 Update to Stranding Protocol

Study Period: 2014-2021

Wood Environment & Infrastructure Solutions
Nelson, BC

April 27, 2022

LOWER DUNCAN RIVER FISH STRANDING PROTOCOL

VERSION 4 DRAFT
27 APRIL 2022

Prepared For:
BC Hydro
Burnaby, BC

Prepared by:
Wood Environment & Infrastructure Solutions
Nelson, BC

This version of the Protocol is a revision of the BC Hydro procedure developed in 2004 and 2013. This protocol is based on knowledge gained since that time.

Executive Summary

The Duncan Dam Project, located at the north end of Kootenay Lake near Meadow Creek, BC, is part of BC Hydro's Columbia Basin Generation area. Duncan Dam (DDM) was completed in 1967 and was one of three dams built in Canada under the Columbia River Treaty (CRT). Although there are no power generation facilities at Duncan Dam its reservoir provides storage to improve hydroelectric generation and flood control downstream in the Kootenay and Columbia river basins. The Lower Duncan River (LDR) flows from DDM (via Low Level Outlets or Spillway) across a low gradient, wide valley flat, alternating between a single threaded, meander channel and multi-channelled braided sections for approximately 11 km to Kootenay Lake.

The LDR provides migration, spawning, egg incubation, and rearing habitat for several fish species. Although fish stranding in the LDR is known to result from both natural flow variation and DDM operations, and has occurred since dam construction, stranding was first raised as a significant issue by fisheries agencies and the public in October 2002. The Water Use Plan (WUP) process was in the initiation stage at that time and operational solutions to minimize fish stranding were explored. WUP Consultative Committee members focused on understanding the effects of flow fluctuations on habitat de-watering and fish stranding, seasonal opportunities to minimize habitat dewatering, and monitoring flow reductions to improve understanding of how DDM operations affect fish and fish habitat over the long-term.

BC Hydro has spent considerable effort in developing an understanding of fish habitat utilization, variables influencing fish stranding, and how to reduce the incidence of fish stranding in the LDR because of DDM operations since 2002. In 2013, an interim adaptive fish stranding protocol was developed to manage fish impacts in the LDR associated with flow reductions at DDM. Since this time, studies conducted in the LDR have compiled extensive knowledge on fish and fish habitats and fish stranding impacts.

This document is the current protocol for managing fish stranding impacts in the LDR associated with DDM flow reductions based on the data collected under BC Hydro's adaptive stranding protocol development program from 2002-2022. The primary objective of this protocol is to guide mitigation requirements for stranding risks to native fish species in the LDR during flow reductions from Duncan Dam. Where flow reductions are required, this protocol defines: i) the flow reduction planning process; ii) a flow reduction risk assessment and decision-making framework; iii) strategies and procedures for flow reduction monitoring and mitigation activities in relation to fish stranding risk; iv) requirements for information collection and post-reduction reporting; and v) annual review requirements.

The following table provides a summary of aquatic resource studies conducted during the Duncan WUP process including an overview of the management questions, responses, and implications for operations.

Project	Objectives	Management Questions	Response	Implications
DDDMON-15 Lower Duncan River Stranding Protocol Development and Finalization	Finalize a flow reduction protocol, including stranding response procedures, flow reduction procedures at Duncan Dam, internal and external correspondence procedures, stranding assessment methodology, and reporting requirements.	1. What are the best operating strategies at Duncan Dam to reduce the number of fish stranded on the lower Duncan River?	The best operating strategy appears to reduce flows during daytime and use ramping rates <10 cm/hr (28cms/hr) (DDM MON 1). DDM operations do not affect Burbot. Juvenile Rainbow Trout and Mountain Whitefish are most susceptible to stranding during late May (RB) and overall, during winter in side channels (DDMMON 2). The WUP flow reductions appear effective at reducing stranding: MW stranding mortalities are unlikely to result in population level effects, but RB mortalities may affect the population (DDMMON 16).	While the WUP flows appear effective at reducing stranding for most fish species, more information might be needed to assess the impacts of operations on the Lower Duncan Rainbow Trout population.

Table of Contents

TABLES

FIGURES

APPENDICES

Abbreviations

COFAC – Columbia Operations Fish Advisory Committee

CRT – Columbia River Treaty

DAL – BC Hydro Gauge in the Duncan Dam tailrace above the Lardeau River

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

DCP – Data Collection Platform

DDM – Duncan Dam

DFO – Fisheries and Oceans Canada

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

FLNRORD – Ministry of Forests, Lands, Natural Resource Operations and Rural Development

FVO – BC Hydro Fraser Valley Office

IJC – International Joint Commission

LDR – Lower Duncan River

LLOG – Low Level Operating Gate

MHD – Water Survey of Canada Gauge on the Lardeau River at Marblehead

MoE – British Columbia Ministry of Environment

NRS – BC Hydro Natural Resource Specialist

OPE – BC Hydro Operations Planning Engineer

PSOSE – BC Hydro Planning, Scheduling and Operations Shift Engineers

SAS – Stranding Assessment Supervisor

WLR – BC Hydro Water License Requirements

WSC – Water Survey of Canada

WUP – Water Use Plan

Contributors (sorted alphabetically)

BC Hydro

Alf Leake

Darin Nishi

David Wilson

Dean Den Biesen

Guy Martel

James Baxter

Katy Jay

Mark Sherrington

Matt Casselman

Trevor Oussoren

Vlad Plesa

Golder Associates Ltd.

Bob Westcott (2013 version)

Brad Hildebrand (2013 version)

Dana Schmidt (2013 version)

Poisson Consulting Ltd.

Robyn Irvine (2013 version)

Wood Canada Ltd. (Wood)

Louise Porto (2022 version)

1.0 BACKGROUND

The Duncan Dam Project is part of BC Hydro's Columbia Basin Generation area. Duncan Dam (DDM) was completed in 1967 and was one of three dams built in Canada because of the Columbia River Treaty (CRT); there are no power generation facilities at the dam. The Duncan Reservoir provides storage to improve hydroelectric generation and flood control downstream in the Kootenay and Columbia river basins (Duncan Dam Water Use Plan Consultative Committee 2005). DDM is located immediately upstream of the confluence of the Duncan and Lardeau rivers, approximately 11 km upstream of the north end of Kootenay Lake (Figure 1). The Lower Duncan River (LDR) flows from the dam (via low level outlets or spillway) to the confluence of the Lardeau River along a 1 km long discharge channel. From the Lardeau River confluence, the LDR flows across a low gradient, wide valley flat, alternating between a single threaded, meander channel and multi-channelled braided sections for approximately 10 km to Kootenay Lake (Northwest Hydraulic Consultants 2010) (Figure 1). The LDR channel is complex in nature with continuously changing channel morphology, debris jams, bars and islands (M. Miles and Associates 2002, Northwest Hydraulic Consultants 2010).

The influence of DDM operations on water levels in the LDR varies throughout the year. In January and February, DDM discharges are high and stable to supply water for downstream generation. Duncan Dam discharges are the majority of LDR flows in the winter. When Duncan Reservoir is drawn down to its lowest elevation in March and April, DDM discharge is reduced and adjusted as needed to match natural inflows while maintaining minimum LDR flows (73 m^3/s as per DDM Water License and Operating Orders; Section 3.0). During freshet in May and June, once tributary inflows to the LDR increase and exceed minimum flow requirements, DDM discharges are reduced to minimum levels (3 m^3/s) to fill Duncan Reservoir. While DDM discharges are at minimum, LDR discharge varies with natural changes to tributary inflows. Tributaries which influence LDR water levels include the Lardeau River, Meadow Creek, Hamill Creek, and Cooper Creek. The months of July, August, and September can see the largest changes in both DDM discharge and LDR water levels as the reservoir reaches its highest elevation (full pool) and stored water is released to maintain Kootenay Lake levels and provide water for downstream generation. High inflows and localized rain events in the summer can require temporary increases in DDM discharges to manage Duncan Reservoir levels while simultaneously increasing tributary inflows to the LDR. In late-September, natural inflows to the LDR decrease, and DDM discharges are reduced to just above the minimum LDR discharges to protect spawning Kokanee. In late-October after the Kokanee spawning protection period, DDM discharges are increased and maintained through to late-December until DDM discharges are increased to again supply water for downstream generation.

The LDR provides migration, spawning, egg incubation, and rearing habitat for several fish species (Golder and Poisson 2021; Table 1). Although fish stranding in the LDR is known to result from both natural flow variation and DDM operations, and has occurred since dam construction, stranding was first raised as a significant issue by fisheries agencies and the public in October 2002 (Duncan Dam Water Use Plan Consultative Committee 2005). The Water Use Plan (WUP) process was in the initiation stage at that time and operational solutions to minimize fish stranding were explored. WUP Consultative Committee members focused on understanding the effects of flow fluctuations on habitat de-watering and fish stranding, seasonal opportunities to minimize habitat dewatering, and monitoring flow reductions to improve understanding of how DDM operations affect fish and fish habitat over the long-term.

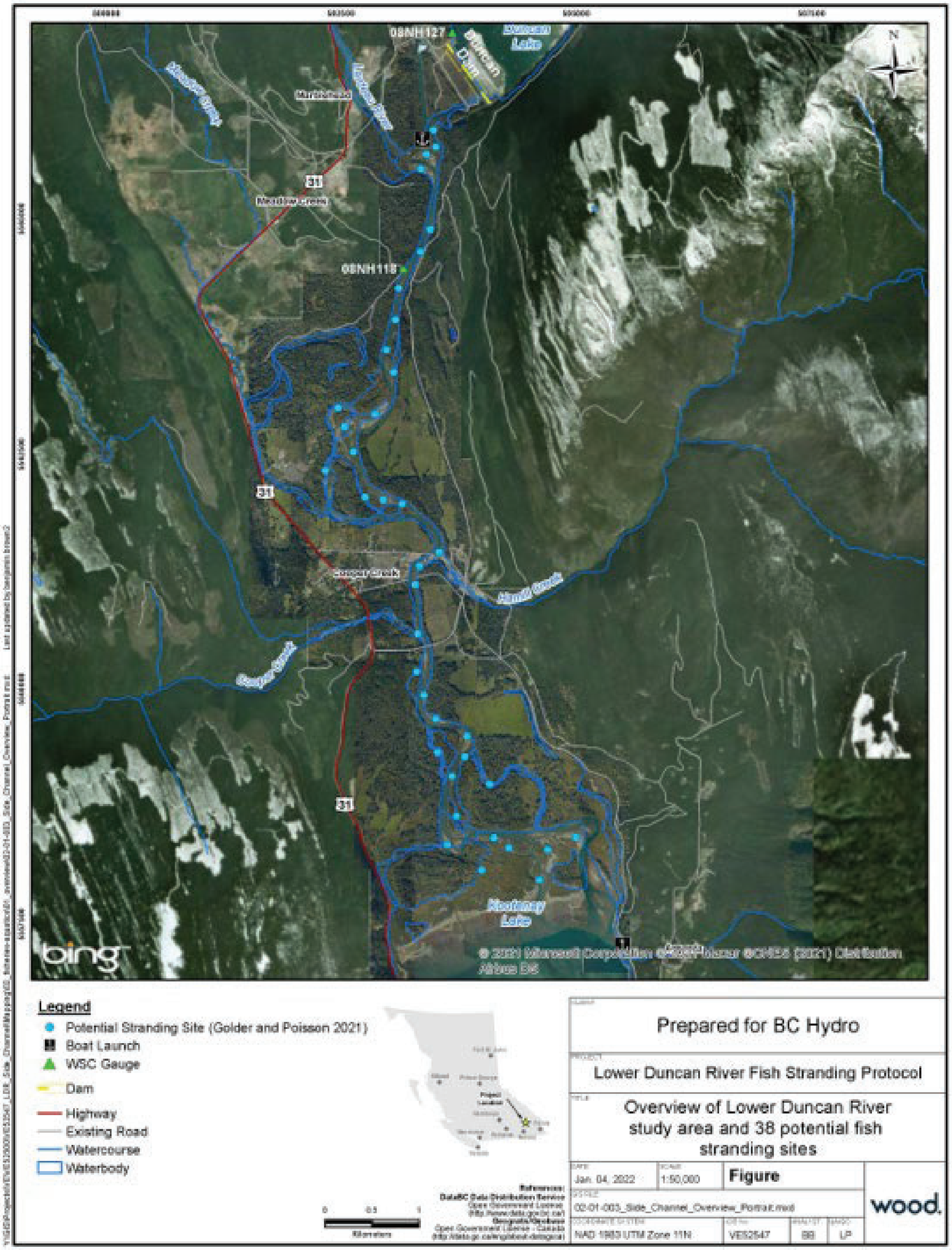

Figure 1: *Overview of Lower Duncan River study area and 38 potential fish stranding sites (Golder and Poisson 2021).*

Table 1: *Fish species encountered during fish stranding assessments on the Lower Duncan River (DDMMON-16), September 2006 to 2020 (adopted from Golder and Poisson 2021).*

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

Notes: [a]BC Ministry of Environment Fish Inventories Data Query fish species codes. (-) Not applicable; Yellow = Includes species or ecological communities that are apparently secure and not at risk of extinction.
Blue = Includes any native species or ecological community considered to be of Special Concern (formerly Vulnerable) in British Columbia. Species or ecological communities of Special Concern have characteristics that make them particularly sensitive or vulnerable to human activities or natural events. Red = Includes any native species or ecological communities that have, or are candidates for, Extirpated, Endangered, or Threatened status in British Columbia.

From the fall of 2002 to 2022, BC Hydro spent considerable effort in developing an understanding of fish habitat utilization, variables influencing fish stranding, and how to reduce the incidence of fish stranding in the LDR because of DDM operations. 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 two kilometres downstream of DDM for real time monitoring of downstream flows.
- Conducting fish stranding assessments of flow reduction events prior to WUP process from 2002 to 2004 (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 discharge reductions (BC Hydro 2002).
- Studying seasonal fish habitat utilization (Golder 2002).
- Undertaking a fluvial geomorphological assessment of the LDR (M. Miles and Associates 2002).
- Conducting flow ramping experiments (Golder 2007, 2008a, 2008b).

Efforts *within* the WUP process include:

- Development of performance measures to assess the influence of proposed operating alternatives on fish stranding (Duncan Dam Water Use Plan Consultative Committee 2005).
- Implementation of the Adaptive Stranding Protocol Development (ASPD) and Finalization program to address impacts of flow reductions on fish in the LDR (2010-2018) – DDMMON-15 (Golder 2010a, Golder and Poisson 2010, 2015; Amec Foster Wheeler 2018).
- Development of a HEC-RAS flow model for the LDR – DDMMON-3 (Northwest Hydraulics Consulting 2009, 2010, 2013).
- Undertaking a review of available information and assessment of data gaps in fish stranding knowledge for the LDR and conducting flow ramping experiments to understand the influence of DDM flow reductions on fish stranding – DDMMON-1 (Golder 2008a, Poisson and Golder 2010, Golder and Poisson 2021).
- Conducting fish stranding assessment for flow reduction events from 2005 to 2020 – DDMMON-16 (Golder 2009, 2010b, 2011, 2014, 2015, 2017a, 2017b, 2018; Golder and Poisson 2012, 2019a, 2019b, 2020, 2021).
- Implementation of fish habitat utilization studies throughout the year to determine species at risk of stranding and potential for population level impacts (2008-2011), which was then integrated into DDMMON-16 (above) after 2011 – DDMMON-2 (Porto et al. 2009, Thorley et al. 2010, 2011, 2012).

- Conducting Kokanee spawning monitoring studies in the LDR to determine spawning requirements and identify factors influencing spawning success from 2008-2018 – DDMMON-4 (AMEC 2009-2013, ONA et al. 2016-2018).
- Development of a Kokanee spawning/incubation habitat model for the LDR to evaluate the risk of how different protection flows affect Kokanee spawning success and identify feasible operating regimes that can mitigate operational impacts within BC Hydro's control – DDMWORKS-4 (Amec Foster Wheeler 2017, Wood 2022).

Based on knowledge gained from the above mentioned LDR studies and the ongoing flow reduction management of the Lower Columbia River system, BC Hydro developed and implemented an interim strategy for managing flow reductions on the LDR in 2004 (BC Hydro 2004c), which was updated in 2013 (Golder 2013). In addition, BC Hydro continued to collect long-term fish stranding data associated with DDM flow reductions to facilitate the development of DDM operations that reduce fish stranding impacts under DDMMON-16. This program initially identified 49 potential fish stranding sites, subsequently confirmed that 11 of these sites had a negligible risk to strand fish and concluded that 38 potential fish stranding sites are present in the LDR (Golder and Poisson 2021). In addition, it was concluded that fish stranding at locations outside of the current 38 potential fish stranding sites (Figure 1) were unlikely to occur (Golder and Poisson 2021).

This document is the current protocol for managing fish stranding impacts in the LDR associated with DDM flow reductions based on the data collected from 2002-2022.

2.0 PURPOSE AND SCOPE

The purpose of this protocol is to provide a standard procedure for BC Hydro internal and external communications, completion of stranding risk assessments, development of flow reduction strategies, and application of mitigation actions for fish stranding during planned and emergency flow changes at DDM. The protocol is carried out internally by BC Hydro staff, depends on coordination with external consultants for field services, and in some circumstances, requires communications between BC Hydro and external parties - Fisheries and Oceans Canada (DFO), Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD), and First Nations – on the appropriate strategies for flow reduction implementation, monitoring, and mitigation.

The primary objective of this protocol is to guide mitigation requirements for stranding risks to native fish species in the lower Duncan River during flow reductions from Duncan Dam.

Where flow reductions are required, this protocol defines:

- the flow reduction planning process;
- a flow reduction risk assessment and decision-making framework;
- strategies and procedures for flow reduction monitoring and mitigation of fish stranding risk;
- requirements for information collection and post-reduction reporting; and,
- annual review requirements.

3.0 DUNCAN DAM OPERATIONS

DDM operations are guided by Water License Number 27067, the Water Licence Order (December 21, 2007) associated with the DDM WUP (BC Hydro 2007), and storage and discharge requirements of the CRT. Annual target discharges for DDM are summarized in Figure 2.

Operations planning is the responsibility of the BC Hydro Generation System Operations (GSO) with day-to-day and long-term DDM operations managed by the Operations Planning Engineer (OPE). The OPE uses discharge data from a variety of hydrometric monitoring stations to plan operations and if warranted, will consult with the BC Hydro Environment Natural Resource Specialist (NRS) on the environmental risks of a particular operation. All DDM operating requirements are summarized in Generation Operating Order 3G-DDM-06. Actual flow changes at DDM are carried out by the on-site Duncan Dam caretakers – remote operations are not possible.

The following sections summarize the hydrometric monitoring infrastructure used for DDM operational planning and the typical hydrograph for the Lower Duncan River, Lardeau River, and Duncan Dam(Section 3.1), the three typical DDM operating conditions that occur annually (Section 3.2), and flow forecast communications (Section 3.3).

3.1 Hydrometric Monitoring Stations

3.1.1 Duncan River below Lardeau River (DRL) 08NH118

The DRL gauge station, used to monitor compliance with Water License targets, is located approximately 1 km downstream of the Duncan-Lardeau River confluence on the right downstream bank. Real-time and historic hydrometric data for DRL is publicly available from Water Survey of Canada. Three day running discharge and water temperature data are also available on the BC Hydro Hydrometeorological Monitoring Program intranet and external sites[1]. BC Hydro staff obtain real-time DRL readings through the BC Hydro PI system. BC Hydro DDM staff can also manually measure river stage at DRL and use a stage-discharge curve to estimate discharge. Current stage-discharge curves are available from BC Hydro if required. A staff gauge is also installed downstream of Argenta Bridge on the right (west) bank to visually monitor river stage during high flow events.

3.1.2 Duncan River above Lardeau (DAL)

In February of 2011, BC Hydro installed a real time data collection platform (DCP) 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 and dewatering risk in the tailrace area of DDM (immediately adjacent the DCP). The DCP also helps DDM staff, environmental specialists, and operations planners assess the conditions in the tailrace.

3.1.3 Lardeau River at Marblehead (MHD) 08NH007

The Lardeau River is the largest tributary entering the LDR. During the freshet period, the Lardeau River is the primary water contributor to the LDR and relied upon to meet the 73 m^3/s minimum discharge at DRL during the Duncan Reservoir refill period (Figure 3). The timing and volume of the Lardeau River freshet determines when DDM outflows can be reduced to the 3 m^3/s minimum. Lardeau River discharge can vary significantly, influencing

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

stranding risk in the spring and summer. Years with low water supply and naturally low flows on the Lardeau River may require temporary spring or summer releases from DDM to meet the DRL minimums. Real-time and historic hydrometric data for the Lardeau River are available from Water Survey of Canada.

3.1.4 Duncan River below B.B. Creek (DBC) 08NH119

This WSC gauge station is located upstream of the reservoir on the Upper Duncan River, downstream of B.B. Creek near the Duncan Lake forest service road (FSR) bridge. This gauge is used to monitor inflows from the Upper Duncan River to Duncan Reservoir and match Duncan Dam outflows with inflows during empty and full reservoir levels (Section 3.2). Real-time hydrometric data can be viewed on the Water Survey of Canada site.

3.1.5 Duncan Reservoir at Duncan Dam (08NH127)

Duncan Reservoir elevation are monitored at downstream end of the reservoir, immediately upstream of the low-level operating gate (LLOG) intake of Duncan Dam. Reservoir elevation data are used to determine how the reservoir is responding to inflows and calculate the combined total releases from the LLOGs. Duncan Reservoir elevation data are available on the Water Survey Canada site.

3.1.6 Kootenay Lake at Queens Bay (08NH064)

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. Backwatering effects of Kootenay Lake on the LDR are 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 (BC Hydro 2004c). Water Survey of Canada maintains a water level gauging station at Queen's Bay (08NH064) which can be accessed on the Water Survey of Canada or BC Hydro websites.

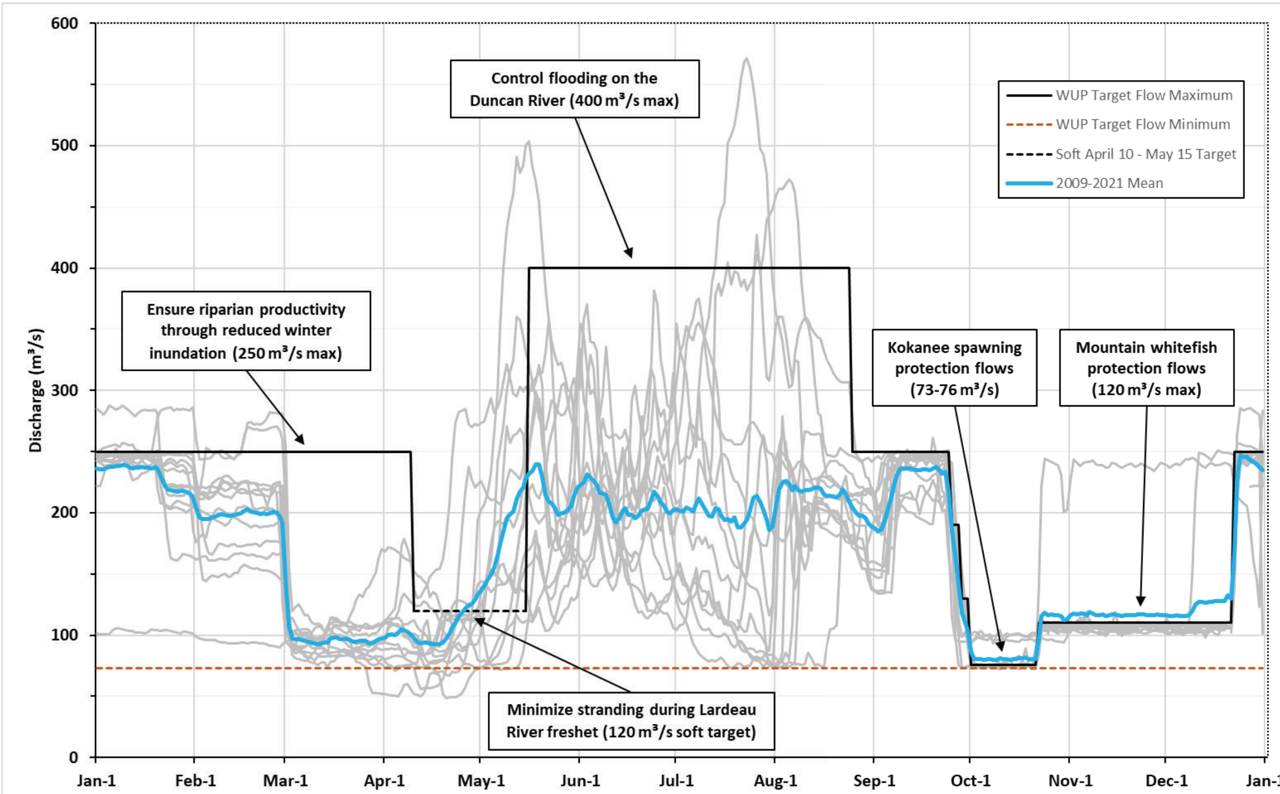

Figure 2: Maximum (black) and minimum (red) target flow schedule for Duncan Dam discharges as measured at the Duncan River below Lardeau (DRL) Water Survey Canada Station 08NH118. Historic annual (grey lines) and mean (blue line) discharges for 2009-2021 are shown. The Water Use Plan rationale for discharge maximums for each discharge period are in text boxes.

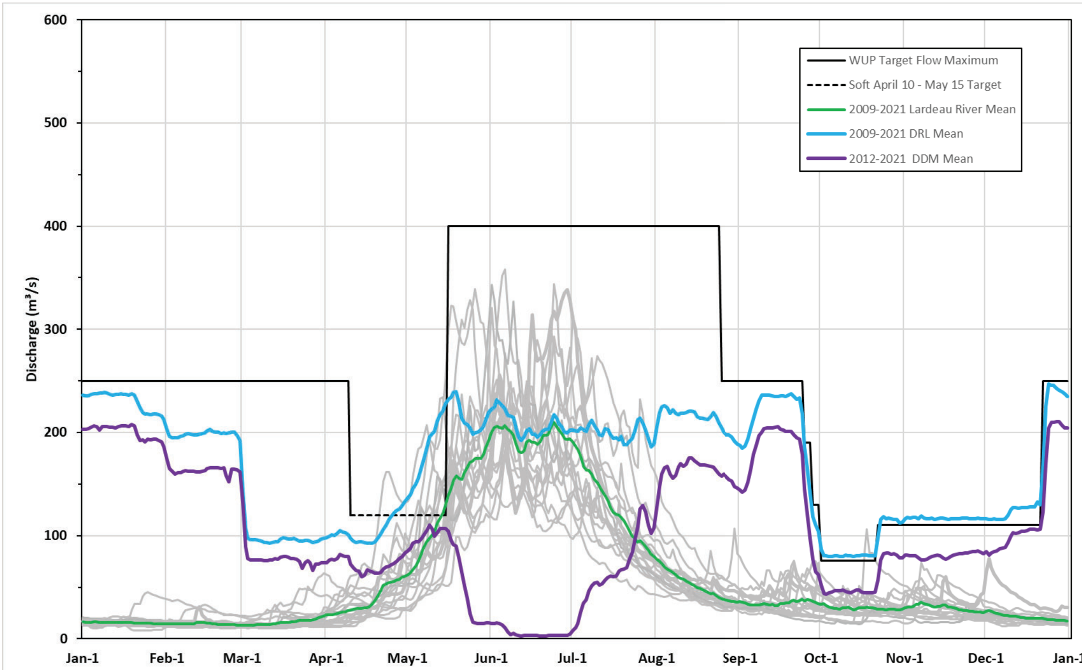

Figure 3: Lardeau River 2009-2021 historic annual (grey lines) and mean daily (green line) discharge relative to the mean daily discharge at the Duncan River below Lardeau (DRL) Water Survey Canada station (blue line) for the same period and the Duncan target flow schedule (black line). Mean daily Duncan Dam discharges for 2012-2021 are also shown (purple line).

3.2 Operating Conditions

DDM operations can be categorized into three general conditions based on the flow patterns of the DRL hydrograph, the time of year, and the associated fish stranding risk: stable or increasing flows in the fall and winter; seasonal flows in the spring and summer; or planned flow reductions in the spring and fall (Figure 3). Fish stranding risk is greatest for planned DDM flow reductions which occur approximately 6-8 days per year, with 2-3 day long reductions in September and March. Stable or increasing flows during October through February pose little or no risk of stranding to fish, while variation in seasonal flows may pose a risk of fish stranding depending on the timing and volume of discharge changes. Fish stranding risks associated with each condition and operational mitigation to avoid fish stranding are described below.

3.2.1 Stable or Increasing Flows

The LDR hydrograph has multiple periods throughout the year when discharges at DRL are increasing or remain relatively stable between flow changes and fish stranding risk is low. In October through to January, DDM operations draw down Duncan Reservoir and maintain high and stable discharges in the LDR. Discharge reductions typically occur in January and February, however, LDR flows are high and can remain stable for 1-2 months between reductions.

In March, Duncan Reservoir is at minimum elevations, LDR discharges are low, and there are typically only minor adjustments to DDM flows to ensure minimum discharges at DRL are maintained until the Lardeau River freshet increases flows in May to June. Short duration stable LDR flows also occur before and after DDM flows are decreased in late-September to meet the Order targets at DRL for Kokanee spawning (Figure 2).

DDM operations to pass inflows when the reservoir is at minimum elevations in March, or near full pool in September, may result in minor daily fluctuations at DRL that mimic natural conditions. During this period, DDM is operated according to Generation and Local Operating Orders (3G-DDM-06 and DDM 4G-41) and direction from the OPE. In this situation, DDM discharges are managed daily by DDM staff to maintain a target DRL discharge set by the OPE. Each day at 0800 hr DDM staff check reservoir level for changes over the previous 16 hours, assess weather conditions, debris program requirements (boat operation/debris collection), and Upper Duncan River inflows below B.B. Creek. The reservoir, river, and other conditions will be checked again at 1200 hr and again at 1600 hr to determine if the reservoir and river are responding according to plan with additional flow changes made at these times, if required. If larger operational changes are needed, the BC Hydro OPE will determine the most appropriate strategy to maintain DDM discharge within the desired flow range.

Duncan Dam operations to maintain stable flows result in minimal day-to-day variation at DRL (<5 m^3/s) which poses little to no risk of fish standing. Fish stranding risk will not be assessed in the LDR for daily DDM adjustments, and no communications will be provided. Likewise, changes in Lardeau River flows or Kootenay Lake levels are not normally communicated externally, except when there is potential for flooding in Meadow Creek.

3.2.2 Seasonal Flows

Seasonal flows occur in late-March and April after Duncan Reservoir is drawn down to target CRT flood control target elevations (January to March 1). The BC Hydro OPE will draw down Duncan Reservoir to the lowest flood control elevation for March 1 before reducing DDM discharges to sustain minimum reservoir elevations and minimum DRL discharges until the onset of freshet.

Low spring reservoir elevations combined with minimum downstream flow requirements at DRL can create challenging conditions for flow management in late-March through May. If freshet is delayed, DDM discharge may have to be reduced to maintain minimum reservoir elevations and DRL may decrease below the 73 m^3/s licensed minimum. On the other hand, short-term increases in DDM discharge may be required to maximize reservoir storage capacity prior to freshet.

The onset of freshet and increased discharge from the Lardeau River typically maintains minimum flows at DRL, allowing DDM discharge to be reduced to the 3 m^3/s minimum. However, the OPE will usually delay the reduction to minimum DDM discharge until there is high certainty the Lardeau River discharge will maintain DRL above 73 m^3/s. Typically, the Lardeau River must exceed and remain above 100 m^3/s for DDM to be reduced to minimum flows. Unexpected reductions in Lardeau River discharges during freshet may require flow increases from DDM to meet the DRL minimum.

Low or fluctuating DDM discharges prior to the onset of freshet have the potential to strand newly emerged Mountain Whitefish and Kokanee fry, which are particularly susceptible to stranding in April and May (Section 4.2). Rainbow Trout redds in the DDM tailrace may also be dewatered during April and May reductions. To minimize fish stranding during the transitional spring season, the following operating mitigation measures should be followed:

- If Duncan Reservoir requires additional draw down immediately prior to start of reservoir refill, the BC Hydro OPE will attempt to minimize the magnitude of the DDM discharge increase.
- Before decreasing DDM discharge to 3 m^3/s for reservoir refill, the BC Hydro OPE will monitor discharge at DRL and the Lardeau River discharge at Marblehead (MHD). The OPE will attempt to maintain water

levels at DRL or maintain discharge above minimum winter levels (+/- 5 m^3/s), using the increasing Lardeau River flows during freshet to augment the discharge reductions from DDM as possible.

In addition, the following should also be considered:

- BC Hydro obtained a permanent Order variance in 2015 to change the 120 m^3/s target maximum April 10 to May 15 to a soft-constraint. This operating flexibility allows the OPE to minimize the magnitude of spring flow changes and fish stranding through a relatively stable or increasing discharge at DRL. If 120 m^3/s at DRL is exceeded, BC Hydro will make best efforts to limit reductions to 47 m^3/s during this period. Fluctuations between 73 m^3/s and 120 m^3/s during this period also pose a risk to fish stranding.

3.2.3 Planned Flow Reductions

Planned flow reductions at DDM occur in March and September (Figure 2). The largest DDM reductions occur at the end of September to meet the WUP target flows of 73-76 m^3/s at DRL for Kokanee spawning protections October 1-21, and in the spring on or around March 1 once reservoir levels are reduced to the elevations required by CRT Flood Risk Management. Planned flow reductions may also occur in the spring and summer for local flood control management or to maintain reservoir target elevations in August and September.

Ramp down rates should be used to reduce the fish stranding risk for the large volume planned flow reductions in March and September and other times of year. Recommendations from WUP studies are to keep ramping rates less than 10 cm/hr to reduce fish stranding risk (Golder 2008b, Poisson and Golder 2010, Golder 2013, Golder 2017b). Several small reductions rather than one large reduction are preferred to allow fish to escape to deeper water habitats and allow monitoring crews to complete fish salvage as required. Discharge changes from DDM of 28 m^3/s per hour in 15-minute increments of 7 m^3/s provide average stage reduction rates <10 cm/hr throughout most of the LDR discharge range (e.g., Golder 2013).

The following operating procedures should be followed for planned reductions:

- Maximum flow reductions of 113 m^3/s per day are allowed under the CRT.
- Flow reductions will occur at a maximum rate of 28 m^3/s or less per hour and occur in 7 m^3/s increments every 15 minutes whenever possible.

3.3 Flow Forecast Communications

The BC Hydro OPE will provide internal and external parties with regularly updated Duncan Reservoir and DDM discharge operations forecasts. 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 BC Hydro OPE will provide this information to the distribution list as soon as possible. A longer-term operation forecast for Duncan Reservoir and DDM discharges is typically provided weekly with the operations forecast for the Columbia River Basin system.

4.0 FLOW REDUCTION PLANNING & FISH STRANDING RISK ASSESSMENT

The procedure for the management of planned flow reductions at Duncan Dam including communications, development of appropriate fish stranding response, and documenting outcomes is provided below. Procedural stages and applicable steps are summarized in Figure 4. A standardized procedure will ensure fish stranding risks on the LDR are appropriately managed. Management of unplanned or emergency flow reductions are covered in Section 5.0. Roles and responsibilities for flow reduction management are provided in Appendix A.

4.1 Flow Reduction Planning Stage

STEP 1 – Internal BC Hydro Planning

Each week prior to the regularly scheduled CRT planning meeting with the United States, the BC Hydro OPE and NRS hold a conference call to discuss the operations forecast and identify any potential fish stranding issues that may arise with upcoming operations (Figure 4). The NRS will provide an initial assessment of the fish stranding risk associated with the upcoming operations to inform CRT discussions. During the conference call, the OPE and NRS should review:

- the timing and magnitude of the planned DDM flow reduction;
- the expected flow change at DRL and the potential for fish stranding in the LDR;
- the drivers for the flow reduction;
- flexibility of the system to modify the flow reduction timing or magnitude;
- Lardeau River inflows and Kootenay Lake levels - both of which influence LDR water levels;
- consequences of implementing the change versus consequences of not implementing the change; and,
- a forecast of future changes for the following two weeks.

The OPE should provide as much notice as possible to the NRS of an upcoming flow reduction. Arranging a fish salvage crew can be difficult if flow reductions are scheduled for weekends or statutory holidays or during peak biology field season May through September. Advanced notice of a reduction provides the NRS with greater ability to obtain sufficient resources to respond to the flow reduction. It is preferable that notification of flow reductions be provided from the BC Hydro OPE to the NRS at least three working days in advance of the flow reduction.

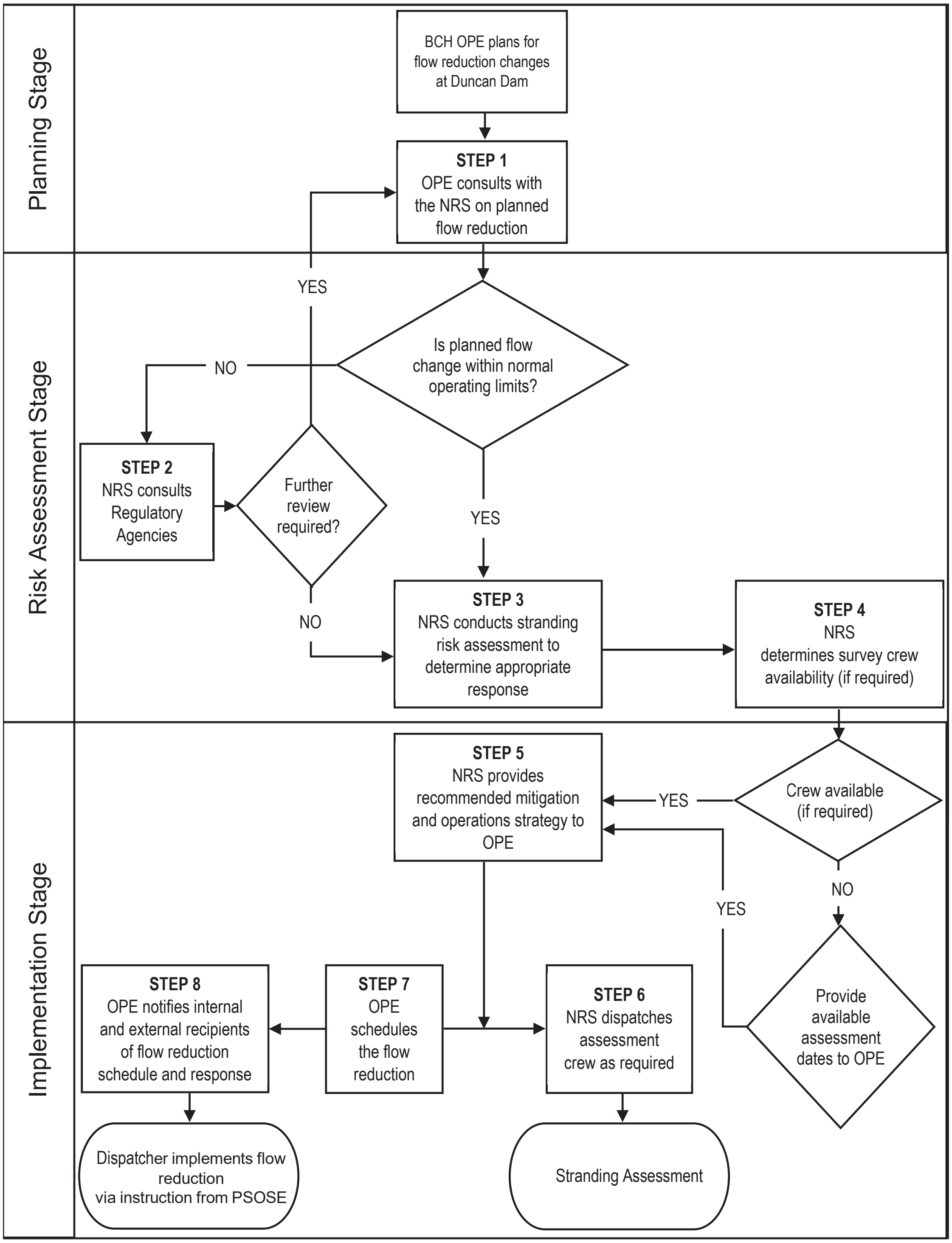

Figure 4: *Communication and consultation procedures for planned flow reductions at Duncan Dam. OPE = Operations Planning Engineer; NRS = Natural Resource Specialist; PSOSE = Planning, Scheduling and Operating Shift Engineer.*

4.2 Fish Stranding Risk Assessment Stage

Approximately 6 to 8 planned flow reductions occur at DDM each year, beyond matching inflows or minor adjustments to maintain Water License Order targets at DRL (Figure 2). BC Hydro will assess the fish stranding risk of all planned flow reductions from DDM. Fish salvage responses are possible for most reductions, if required, except when access is limited in the winter (e.g., ice and snow cover).

STEP 2 – Operations Review

The BC Hydro NRS will determine whether the proposed DDM flow reduction is within the facility's normal operating range and if the operation has occurred historically for that time of year (Figure 4). If the proposed change is outside normal operations, the BC Hydro NRS will work with the BC Hydro OPE to determine if it is possible to implement an alternative flow reduction within the normal operating range for DDM. If the BC Hydro NRS and OPE can develop a flow reduction within the normal operating range for DDM, the BC Hydro NRS will proceed to Step 3 and determine the fish stranding risk (Figure 4). If a flow reduction within the normal operating range cannot be developed, regulators must be consulted prior to making final operating decisions (Appendix B Contact List).

Examples of operations outside the normal operating range include exceeding the Water Licence target maximums or a rapid increase in inflows where a large flow increase and subsequent reduction at DRL is required. Timely communication is required between BC Hydro and regulators to ensure that operational decisions are not delayed. Regulators should also be consulted if fish stranding risk is considered high or an unusual flow change is expected to occur (Step 3). Consultation should occur after multiple flow reduction alternatives have been developed and Steps 2 – 4 completed for each alternative.

STEP 3 – Fish Stranding Risk Assessment & Mitigation Requirements

The assessment of fish stranding risk for a flow reduction is based on the reduction timing and magnitude, fish species life history, in-season conditions, and the results of past stranding assessments. The BC Hydro NRS will consider the time of year, the life stages and habitat use of fish species present, the target minimum flow relative to known habitat features (e.g., side channels that may disconnect), any in-season stranding data from prior fish salvage, and past instances of fish stranding during similar past reductions (Figure 4). Additional information on current fish stranding risk (e.g., observations of Kokanee spawning) may also be available from First Nations, FLNRORD, DFO, external consultants, the public, or other individuals working on the river.

Section A and ***B*** of ***Lower Duncan River Fish Stranding Assessment Summary Form*** in Appendix C will be used to complete the fish stranding risk assessment. These two sections of the form are further described below.

Section A – Proposed Reduction Details

Proposed reduction details include the date of the DDM flow change, current DDM discharge, total magnitude of the reduction, and estimating the initial and resulting DRL with consideration of the Lardeau River discharge. These parameters will be used to create stranding database query input parameters to search for relevant past stranding data. The BC Hydro NRS 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 ***Section A*** of the ***LDR Fish Stranding Assessment Summary Form*** (Appendix C).

Section B – Database Query Results and Risk Assessment

The BC Hydro NRS will input the parameters in Section A into the LDR Fish Stranding Database and Management Tool to assist with the stranding risk assessment (see Section 6.1). The database query will return a summary of past stranding events that occurred at known LDR stranding sites within the discharge range inputted for the query (see sample query in Appendix D). The database classifies fish stranding risk at each site into three categories based on the number of assessments previously conducted and fish stranding observed:

- **Major Effect – High Priority**. Sites where at least five assessments have been conducted and the maximum number of fish stranded from previous assessments is greater than or equal to 100.
- **No Data/Reconnaissance Survey – Moderate Priority**. Sites where fewer than five assessments have been conducted, regardless of the current maximum number of fish stranded.
- **Minor Effect – Low Priority**. Sites where at least five assessments have been conducted and the maximum number of fish stranded from previous assessments is less than 100.
- **No Pools – Negligible**. Sites where at least five assessments have been conducted and isolated pools are not present.

The BC Hydro NRS will summarize the query results in ***Section B*** (Appendix C) and review the results with consideration of the following stranding risk factors to define the level of fish stranding risk. Although some of the fish species and fish stage considerations listed below cannot be effectively salvaged (e.g., incubating Mountain Whitefish eggs) they are important to identify when planning discharge reductions and assessing risk.

- **Stage and Discharge**. Stranding risk is typically lower at DRL flows from 190 to >250 m^3/s because the channel morphology is steep, and the dewatered area is limited. The probability of stranding fish increases slightly at 130-190 m^3/s but is greatest at 73-130 m^3/s because the near shore gradient typically decreases at lower river levels and therefore the amount of habitat dewatered with a similar sized reduction increase (Golder and Poisson 2021). Larger total reduction magnitudes pose higher risks to strand fish (Golder and Poisson 2021).
- **Season.** The season during which a proposed flow reduction occurs influences fish stranding risk because of the different fish life stages and species present in shallow water habitat. For example, DDMMON-16 observed that stranding rates for Rainbow Trout juveniles during fall reductions are significantly higher with a median of 5.20 juveniles stranded per isolated pool compared to 0.76 juveniles per isolated pool during spring reductions (Golder and Poisson 2021; Figure 5). However, less is known about LDR fish stranding risk outside of the spring and fall because most (63 of 80) DDMMON-16 stranding assessments from 2008-2020 occurred in response to planned DDM reductions between March and May (30 assessments) and between September and October (33 assessments; Golder and Poisson 2021). Season should therefore be considered in combination with fish species and life stage to estimate fish stranding risk for reductions in the remaining months of the year (see below).

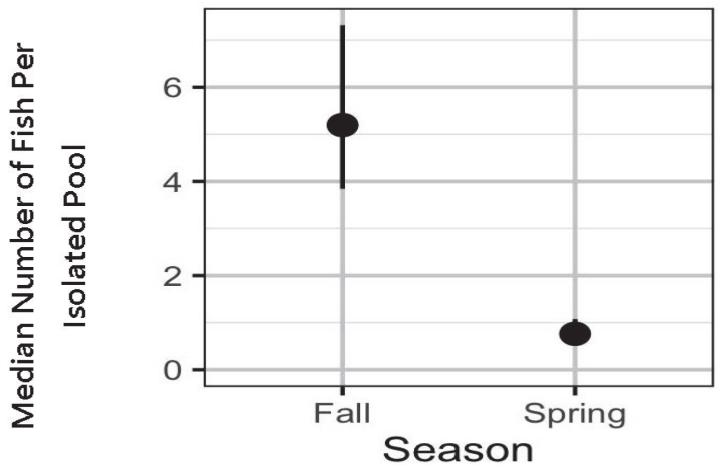

Figure 5: The median number of Rainbow Trout juveniles per isolated pool during a typical reduction event during the fall and spring in the lower Duncan River. Information for winter is not available. Error bars are 95% credibility intervals. (Adapted from Figure 22 in Golder and Poisson (2021)).

- **Fish Species and Life Stage.** Fish species and life stages present in shallow water habitat of special consideration for the Lower Duncan River include:
  - Kokanee Migration and Spawning (August – October) – Adult Kokanee migrate through the LDR to reach Meadow Creek and Lardeau River spawning grounds and are known to spawn in the LDR from August through early November (Amec Foster Wheeler 2017, Wood 2022). Spawning Kokanee are routinely present during the late-September DDM reductions.
  - Mountain Whitefish Spawning (October – December) and Incubation (October – May) – Mountain Whitefish stage in the LDR in September, spawn from late-October to mid-December, with egg incubation from mid-October to early-May (Thorley et al. 2012). The WUP target flows October-December are meant to limit Mountain Whitefish egg dewatering in the spring.
  - Larval Emergence (February – May) – During spring, newly emerged Mountain Whitefish and Kokanee are susceptible to stranding. Kokanee fry out-migration from LDR, Lardeau River and Meadow Creek systems to Kootenay Lake occurs at night from February through May. During the daytime, Kokanee fry will seek shelter and hide in nearshore areas, making them prone to stranding (Amec Foster Wheeler 2017, Golder and Poisson 2021, Wood 2022).
  - Rainbow Trout Migration and Spawning (March – June) – Adult Rainbow Trout are known to spawn at the tailout of Duncan Dam just above the Duncan and Lardeau rivers confluence. Reductions from DDM prior to the Lardeau River freshet can dewater redds (e.g., Thorley et al. 2012). Review of available spawning distribution and redd elevation data will be required for a flow reduction during this time.
- **Side Channel Status** Major side channels (Figure 6) are present on the LDR that can change from being wetted to isolated or dewatered at different LDR stages during reductions (Table 2). Isolation of side channels increases the risk of fish stranding at these sites (e.g., AMEC 2012, Golder and Poisson 2021).

- **Site Level Effects.** The risk of fish stranding has historically varied by site as illustrated in Figure 7 for Rainbow Trout juveniles. Not all sites will be at risk of dewatering during a ramp down. Risk at a specific site will be primarily determined using the query results from the LDR Fish Stranding Database and Management Tool.
- **Daylight Availability.** Under normal DDM operations, flow reductions occur during daylight hours as fish stranding assessments are not possible at night. It is recommended that flow reductions from DDM continue to occur during daylight hours to allow sufficient time for conducting fish stranding assessments unless there is an emergency (Section 5.0). Although daytime flow reductions may minimize the risk of stranding juvenile Mountain Whitefish (e.g., Golder and Poisson 2021), caution is required during the Kokanee fry outmigration period (February through May) as fry will migrate at night in deeper areas, but they shelter and hide during the day in nearshore areas that are prone to stranding (e.g., Wood 2022).

After reviewing the database query results and considering the stranding risk factors listed above, the BC Hydro NRS will define the level of fish stranding risk as a Major Effect (High), No Data/Reconnaissance Survey (Moderate), Minor Effect (Low), or No Pools (Negligible).

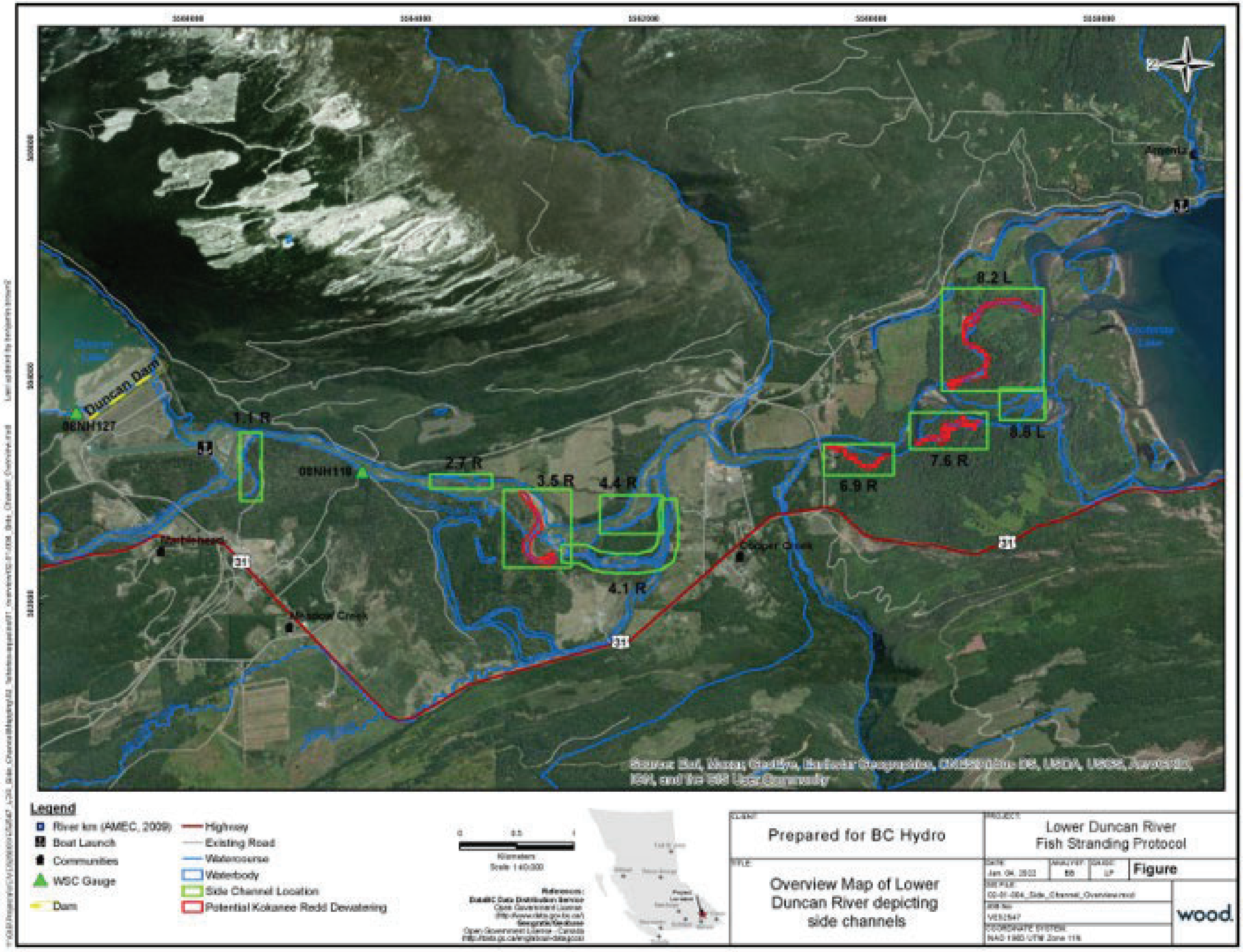

Figure 6: *Overview of Lower Duncan River side channels.*

Table 2: Side channel status (ON, OFF, BW, FW) in the lower Duncan River at flows (downstream of the Lardeau River confluence) from 75 m^3/s to 400 m^3/s. Bolded side channels are critical areas where Kokanee redds have been observed to dewater in fall. Highlighted cells indicate discharges associated with risk of Kokanne redd dewatering in fall. Adopted from Tables 6 and 8 in Wood (2022).

Side Channel	DRL Gauge Flow (m^3/s)													
	75	**100**	**125**	**150**	**175**	**200**	**225**	**250**	**275**	**300**	**325**	**350**	**375**	**400**
1.1R	BW	BW	BW	BW	BW	BW	BW	BW	ON	ON	ON	ON	ON	ON
2.7L	FW/BW	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
3.5R	BW	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
4.1R	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
4.4R	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
6.9R	OFF	OFF	FW	FW	FW	FW	ON	ON	ON	ON	ON	ON	ON	ON
7.6R	OFF	FW/BW	FW/BW	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
8.2L	BW	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
8.8L	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON

Notes: Definitions: ON = fully flowing state where surface flows enter the channel and the side channel is fully connected; OFF = dewatered condition ignoring groundwater and seepage; BW = backwatered where the outlet and portion of the side channel is watered, but there is no surface flow entering the inlet (NHC 2010). FW = forewatered where water is present at the upstream end to halfway down channel but does not reach downstream end of channel; FW/BW = side channel is both FW and BW, but water is separated by dewatered area and not connected (Wood 2022).

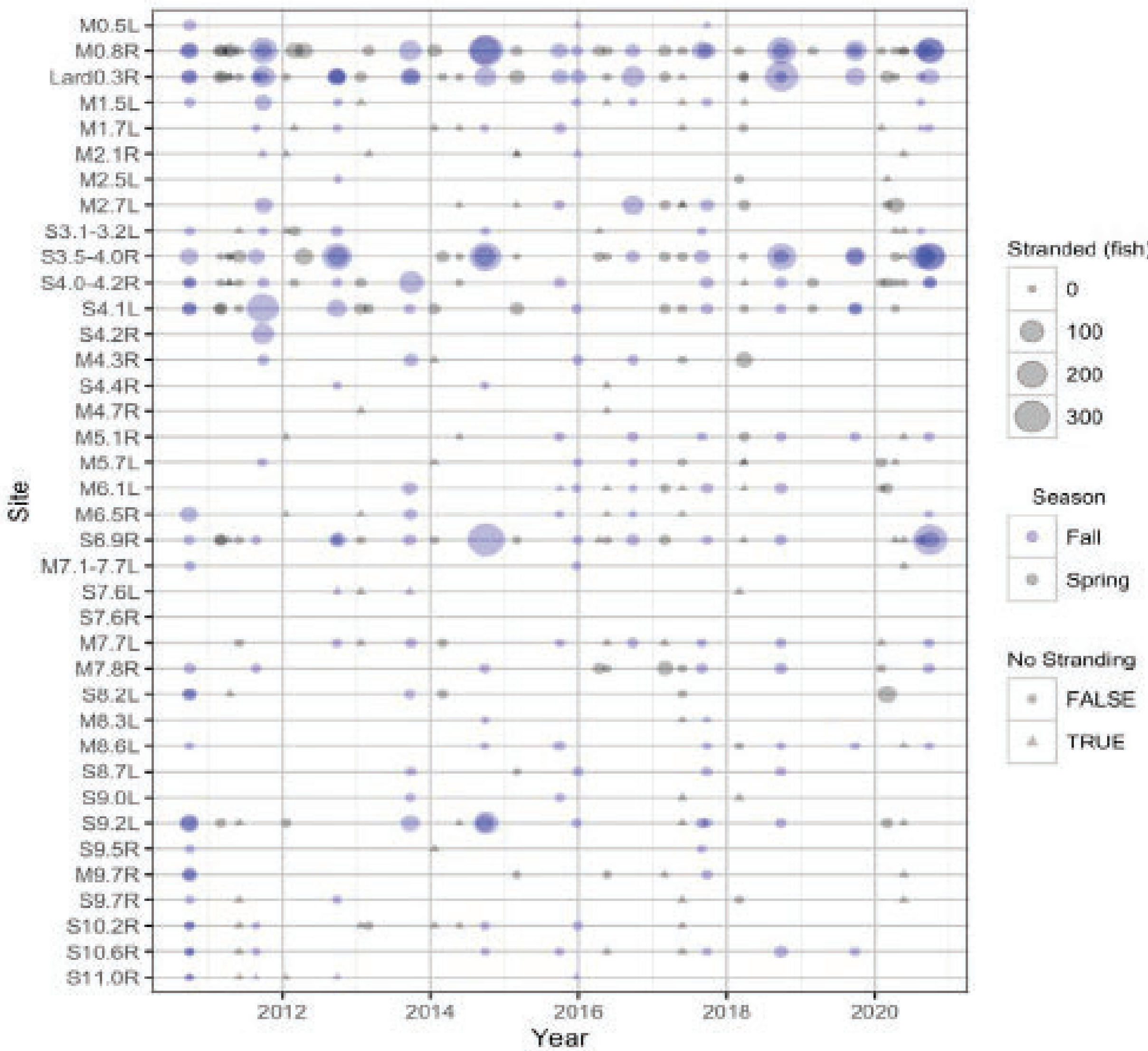

Figure 7: *Total number of Rainbow Trout juveniles stranded (combined for pool and interstitial stranding) by site, assessment date and season for 38 sites where stranding has been observed. False and True are used to represent whether there was no stranding (adopted from Figure 30 in Golder and Poisson (2021)).*

Fish Stranding Mitigation Requirements

The level of fish stranding risk identified in Step 3 (Figure 4) will determine whether the flow reduction can proceed as planned, if flow reduction alternatives should be considered, or if a fish salvage crew is required for the reduction. Results of Step 3 may demonstrate a low level of fish stranding risk and the BC Hydro NRS can direct the BC Hydro OPE to complete the flow reduction as planned without a fish salvage response. However, flow reductions with moderate or high stranding risk should be re-examined by the BC Hydro NRS and OPE to determine if an alternative flow reduction could reduce fish stranding risk.

Operations that should be considered by the BC Hydro NRS and OPE when examining alternative flow reductions to reduce fish stranding risk are:

- **Multi-day reductions.** Single flow reductions that are less than the maximum licensed 113 m^3/s in 24 hours for Duncan Dam can be split into smaller reductions across multiple days. The strategy for multi-day reductions can vary according to operation requirements, fish stranding risk, and river stage.

  For example, a flow reduction could be separated into two days: Day 1 could include the high discharge portion of the reduction with lower stranding risk (as determined by Step 3). Day 2 could include a smaller reduction when the river stage is low, fish stranding risk higher, and a fish salvage is needed. Similarly, a small reduction with high risk could separated into multiple days to allow field crews to complete more extensive fish salvage. The appropriate division of flow reductions across days can be examined using multiple database queries and the considerations in Step 3 above (e.g., side channel status).

- **Ramp down rates.** Flow reductions at less than the 28 m^3/s per hour licensed ramp rate can be used to provide more-gradual flow reductions and better allow fish to exit habitats that are at risk of isolation. Slower ramp rates may not be possible under all circumstances as prolonged reductions during a rapid decrease in inflows could have large consequences on reservoir water supply. In addition, slower ramp rates may not always be advantageous when salvage crews are present. Pools may not quickly isolate during a gradual reduction, preventing crews from carrying out effective fish salvage along the full length of the LDR.

If alternative flow reduction operations are not possible or do not sufficiently mitigate fish stranding risk, fish salvage crews can be used as additional mitigation:

- **Single or Multiple Fish Salvage Crews.** Fish salvage during most LDR reductions can be completed by a single boat-based two-person crew. One crew can typically complete fish salvage at 6-7 sites on the LDR in a single day. However, if operations cannot be modified to reduce a high risk of fish stranding, a single three-person crew or multiple crews can be used to increase the capacity of the fish salvage response.

  Multiple crews may also be needed to address physical barriers on the river (e.g., log jams) that in some years may prevent a single crew from traveling the full extent of the river. The BC Hydro NRS can use the LDR Fish Stranding Database and Management Tool query results to estimate the number of stranding sites and the required crew complement for a flow reduction. Crew complement should be reviewed with the Stranding Assessment Supervisor (SAS), an external consultant (Step 4; Figure 4).

Operations should always be examined during flow reduction planning for opportunities to help mitigate fish stranding risk. Fish salvage can be used in combination with operational changes where stranding risk remains high or where alternative operations are not possible. In most cases, a combination of mitigation techniques will likely need to be used to manage fish stranding risk for a flow reduction.

Fish salvage responses may be recommended during low-risk reductions to collect data on stranding risk. Fish stranding data can be used to validate risk assessment results or fill data gaps and improve the LDR Fish Stranding Database and Management Tool. Ongoing data collection across all reduction scenarios will help refine DDM operations and fish salvage responses to better mitigate stranding risk during future flow reductions.

STEP 4 – Crew Availability

The BC Hydro NRS will determine the need for a fish salvage crew, the size or number of crews, and determine crew availability to undertake the salvage, as required (Figure 4). The BC Hydro NRS will contact the SAS to ensure that sufficient resources are available to undertake the fish salvage efforts. If fish salvage is required for the flow reduction and the appropriate crew cannot be arranged for the proposed date, the flow reduction should be re-scheduled if possible or other mitigation measures implemented.

4.3 Implementation Stage

STEP 5 – Flow Reduction Confirmation

The BC Hydro NRS will provide the BC Hydro OPE with a summary of the potential fish stranding risk, salvage crew requirements and availability, and a recommended flow reduction schedule (timing, magnitude, and ramping). This information will be recorded in ***Section C*** of the ***LDR Fish Stranding Assessment Summary Form*** (Appendix C). The BC Hydro OPE will provide final confirmation the flow reduction to be implemented at DDM.

STEP 6 – Fish Salvage Planning & Crew Mobilization

Once the flow reduction decision is confirmed, the BC Hydro NRS will notify the SAS, as necessary, to arrange for crew deployment. Preparation for field activities, deployment of field crews, and fish salvage are to follow standardized methods as set out in Appendix E including equipment checklists, field and data collection procedures and reporting requirements.

STEP 7 – Flow Reduction Scheduling

The BC Hydro OPE is responsible for scheduling the flow reduction and providing the reduction schedule to DDM staff. The BC Hydro NRS is responsible for scheduling salvage crews and notifying DDM staff that crews will be present during the reduction.

STEP 8 – Flow Reduction Notification & Implementation

The BC Hydro OPE will provide a summary of the flow reduction and fish stranding risk mitigation strategy to internal and external recipients. The BC Hydro OPE will distribute an email notice of the flow change schedule and response strategy to agencies and First Nations that have requested to be informed of flow changes. Alternatively, BC Hydro Community Relations staff may summarize the information in a weekly flow forecast report and distribute the information.

4.4 Post Flow Change Communication/Data Collection

The BC Hydro NRS is responsible for maintaining a record of the fish stranding risk assessment and fish salvage result associated with discharge reductions implemented at DDM. This involves recording all information pertinent to the flow change for the ***LDR Fish Stranding Assessment Summary Form*** (Appendix C) including query results, decision rationale, communications with the BC Hydro OPE and the SAS. In addition, the actual discharge reduction details will be recorded in Section D and the results of the fish salvage will be recorded in Section E (if implemented) in the ***LDR Fish Stranding Assessment Summary Form*** (Appendix C).

4.4.1 Without Monitoring

When a flow reduction does not include a fish salvage response due to logistical constraints (i.e., snow and/or ice prohibit effective and safe assessment) or the fish stranding risk for the reduction is Low or Negligible as dictated by the Fish Stranding Risk Assessment Stage (Section 4.2), the information on the flow reduction and the rationale for not deploying crews will be included in the ***LDR Fish Stranding Assessment Summary Form*** (Appendix C). The flow reduction information will be incorporated into the LDR Fish Stranding Database and Management Tool. The following parameters are required to complete the form:

- 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 DRL gauge; and,
- the rationale for no response with reference to the stranding risk assessment or other seasonal considerations (Section 4.2).

4.4.2 With Monitoring

In addition to maintaining a record of each discharge reduction, additional reporting needs to be completed following a flow change where fish salvage has been carried out. For each stranding assessment, all boxes in **Section D and E** of the ***LDR Fish Stranding Assessment Summary Form*** (Appendix C) will be completed and submitted to BC Hydro within **72 hours** of a fish stranding assessment.

The record will include all information relevant to the stranding assessment: ***LDR Fish Stranding Assessment Summary Form*** (Appendix C), LDR Fish Stranding Database and Management Tool query results, and email results summary. Emails from the SAS to the BC Hydro NRS will have a subject line that includes the Reduction Event (RE) number and the facility from which the reduction occurred (e.g., RE2010-04 DDM). There is no requirement to distribute the results to external parties except for significant stranding events that will be distributed to regulators.

5.0 UNPLANNED OR EMERGENCY FLOW REDUCTIONS

Duncan Dam may need to operate outside of the licensed hydrograph 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 releases and subsequent reductions are addressed by the Emergency Planning Guide for Columbia Basin Dams (BC Hydro 2011). Typically, emergency flow changes are delayed, which allows for planning of discharges; however, in the case of immediate flow reductions this is not always the case. The following section discusses the necessary communications (Sections 5.1 and 5.4) and procedure for addressing fish stranding risk during either immediate (Section 5.2) or delayed (Section 5.3) unplanned emergency flow reductions.

5.1 Communications

In the event of an immediate unplanned or emergency flow reduction, the BC Hydro NRS will notify fisheries agencies as soon as possible. However, if the flow reduction for the unplanned or emergency situation is delayed, flow reduction planning with the BC Hydro OPE and a fish stranding risk assessment should be completed prior to notifying regulators. Responses to immediate and delayed flow reductions are differentiated on Figure 8.

Regardless of whether the flow reduction is immediate or delayed, the following communications should occur within **24 hours** once an unplanned or emergency flow reduction has occurred or the need for an unplanned or emergency flow reduction is identified:

- The BC Hydro OPE will contact the BC Hydro NRS to provide information on the reason, timing and magnitude of the flow reduction.
- The BC Hydro NRS will provide a summary of the fish stranding risks and, if possible, a recommended flow reduction strategy to the BC Hydro OPE.
- The final decision for the flow reduction strategy will rest with the BC Hydro OPE who will make the decision based on system constraints and the recommended response strategy.
- The BC Hydro NRS will notify regulators of the flow reduction and the response strategy, if available. Information provided to regulators will include a description of the situation, the flow reduction options that were reviewed and the final strategy, and an assessment of the potential fish stranding impacts.
- **Note:** Agencies request **48 hours** advance notice to allow time for contact and response development.

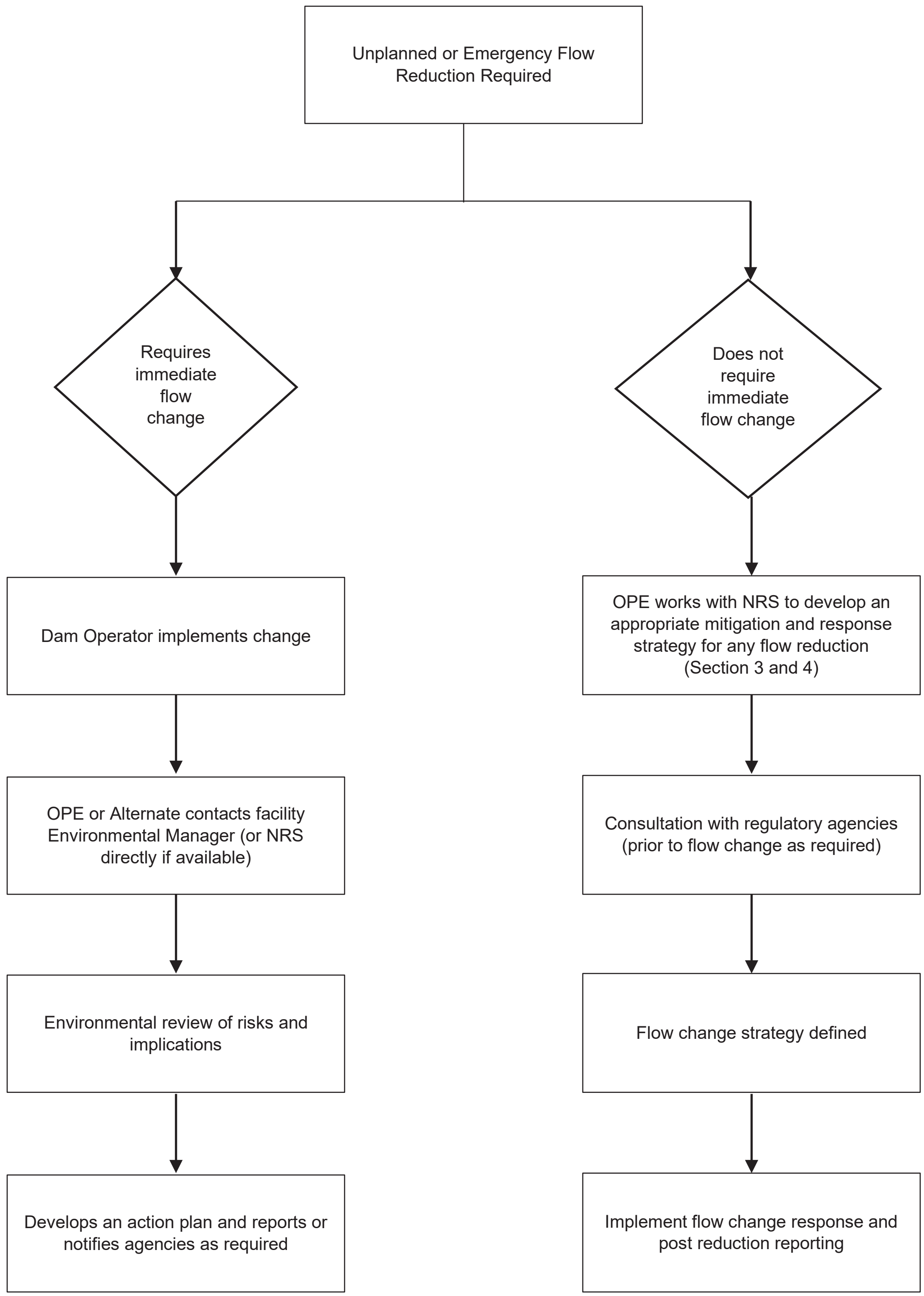

Figure 8: Notification procedures for unplanned or emergency flow reductions.

5.2 Immediate Unplanned or Emergency Flow Reductions

In the event of an immediate unplanned or emergency flow reduction, planning or monitoring is not always possible because the operation may have occurred, and flows restored by the time environmental staff are contacted. Management for unplanned flow reductions occurs through Local Operating Order 3G-DDM-06.

There is a low risk of mechanical failure causing an immediate flow reduction from DDM because water is discharged through low-level outlets or spillways with manually operated gates. However, in immediate life-threatening situations that require a flow reduction, the following procedures are followed:

- The Dam Caretaker will reduce the discharge immediately.
- The Dam Caretaker will notify the Plant Manager and FVO.
- FVO will inform the PSOSE Shift Engineer who will inform a BC Hydro CRT contact.
- The Plant Manager will contact the BC Hydro Environment Manager or the NRS to develop an appropriate environmental response strategy to the flow change.

Contact and consultation with regulators will not always be possible prior to implementation of an immediate flow reduction. However, non-life-threatening situations may allow the BC Hydro NRS time to gather information from the Plant Manager and BC Hydro OPE, develop a response or monitoring strategy, and communicate plans to regulators as soon as possible (see contact list in Appendix B).

5.3 Delayed Unplanned or Emergency Flow Reductions

Delayed flow reductions for dam-related emergencies (e.g., non-life-threatening situations, gate failures) or following flooding, typically allow for flow reduction planning that can follow the principles for planned reductions (Section 3.2.3). The BC Hydro OPE will work with the BC Hydro NRS to determine all potential environmental issues, including fish stranding, and develop an appropriate flow reduction strategy. Notifications to regulators should be provided as outlined in Section 5.4.

5.4 Post-Reduction Communications

Regulators will be provided with a memo summarizing the unplanned or emergency flow reduction and fish stranding assessment within **two weeks** of any monitoring.

If no stranding response was mobilized, a qualitative assessment of fish stranding risk will be performed. The assessment will include searching the LDR Fish Stranding Database and Management Tool for previous records of fish stranding associated within the flow reduction range and season. Other stranding risk factors listed in Section 4.2 should be considered and integrated into the assessment of stranding impacts from the flow reduction.

If a field stranding assessment or salvage was conducted in response to the emergency flow reduction, the BC Hydro NRS will provide regulators with a summary of the fish stranding results in addition to the above qualitative assessment. A qualitative assessment of risk is important to verify field results, particularly if crew responses were delayed or conditions did not allow for a comprehensive stranding assessment.

For all reductions the BC Hydro NRS will maintain records following the procedures outlined in Section 4.4.

6.0 INFORMATION MANAGEMENT AND ANNUAL REPORTING

6.1 Fish Stranding Database and Management Tool

The LDR Fish Stranding Database and Management Tool is a searchable MS Access database of all flow reduction and fish stranding data collected in the LDR. Database searches, or queries, are used to help anticipate the fish stranding potential of a proposed flow change and determine the need for a fish stranding response. The database is updated as new information becomes available. BC Hydro will maintain, or have access to, the most current version of the database.

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 are followed:

1) Enter the following into the Query Parameters form that appears upon opening the database:
   - The date of the proposed reduction;
   - The current discharge at DRL (m^3/s);
   - The resulting discharge at DRL after the flow reduction (m^3/s); and,
   - The current LDR Sample Season.
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.

An example of the queried output from the LDR Fish Stranding Database and Management Tool is provided in Appendix D.

6.2 Hydrometric Data Records

Historic records of discharge, temperature, elevation and stage data for the Duncan system are compiled, quality assured, and retained by BC Hydro Power Records. Data from Power Records can be requested post-season by the NRS or by external parties if they contact the NRS. The NRS can access in-season and historic data through the PI System but these data are not quality assured. Both historic and real-time data are available from all sources listed in Section 3.1; however, the time series and frequency of data records varies between stations.

6.3 Annual Reporting

Results of LDR fish stranding responses will be summarized in an annual memorandum. The memorandum will generally follow the same format as past DDMMON-16 reports; however, examination of the WUP management questions and a discussion are not required.

Key components of the report will include but are not limited to:

- Summary of the number and timing of Duncan Dam reductions and responses in that year;
- Summary of the fish stranding results by reduction, site, fish species, and number of fish;
- A comparison of the database query results of predicted stranding risk with actual field data;

- Description of physical conditions at stranding sites and any significant site changes observed; and,
- Evaluation of the stranding risk, salvage effectiveness, and recommendations for improvement.

7.0 PROTOCOL REVIEW AND UPDATES

The objective of Protocol reviews are to determine if the present flow reduction strategies and fish stranding response as defined within the Protocol are effectively mitigating fish stranding risk in the LDR. To the extent possible under the CRT and Duncan WUP, the Protocol will be updated based on the most up-to-date information from fish stranding assessments, operations, regulatory requirements, and other sources of information such as First Nations knowledge and scientific data from peer-reviewed sources. Regular reviews will ensure the Protocol is up to date with the current state of knowledge and any changes in fish stranding risk on the LDR.

Minor updates to the current version of Lower Duncan River Fish Stranding Protocol will be made as required and a record of all changes retained in the Protocol document itself. If there are changes to Duncan Dam operations or the understanding of fish stranding risk that substantially change the Protocol or the risk assessment process, a new version of the Protocol should be drafted. Minor protocol updates will be reviewed annually at Columbia Operations Fish Advisory Committee (COFAC) meetings. Updated version of the Protocol should be reviewed an approved by regulators prior to implementation.

BC Hydro staff will be responsible for maintaining an up-to-date version of the Protocol, with minor updates tracked with either track changes or a summary table.

8.0 REFERENCES

AMEC. 2003a. Duncan River Kokanee and Fall Flow Assessment Data Report: April 2003. Submitted to BC Hydro and Power Authority. 42 pp.

AMEC. 2003b. Diel fish use of Aquatic habitats in the Lower Duncan River, BC. Data Report October 2002. Submitted to BC Hydro and Power Authority. 31 pp.

AMEC. 2003c. Lower Duncan River stranding assessment: May 10, 2003. Memo to BC Hydro, Kootenay Generation Area. 10 pp.

AMEC. 2003d. LDR Stranding Assessment September 15, 2003. 7pp.

AMEC. 2004a. LDR Stranding Assessment November 01, 2003. 13 pp.

AMEC. 2004b. LDR Stranding Assessment January 21, 2004. 10 pp.

AMEC. 2004c. LDR Stranding Assessment February 2, 2004. 10 pp.

AMEC. 2004d. Flow change and stranding assessment protocol memo. 9 pp.

AMEC. 2009. Lower Duncan River Kokanee Spawning Monitoring. Year 1 Data Report (2008). Report Prepared for BC Hydro, Castlegar, BC. AMEC File: VE51828. 37 pp. + 5 app.

AMEC. 2010. Lower Duncan River Kokanee Spawning Monitoring. Year 2 Data Report (2009). Report Prepared for BC Hydro, Castlegar, BC. AMEC File: VE51905. 43 pp. + 7 app.

AMEC. 2011. Lower Duncan River Kokanee Spawning Monitoring. Year 3 Data Report (2010). Report Prepared for BC Hydro, Castlegar, BC. AMEC File: VE51905. 35 pp. + 4 app.

AMEC. 2012. Lower Duncan River Kokanee Spawning Monitoring (DDMMON-4). Year 4 Synthesis Report. Report Prepared for: BC Hydro, Castlegar. AMEC File: VE51905. 60 pp + 8 app.

AMEC. 2013. Lower Duncan River Kokanee Spawning Monitoring (DDMMON-4). Year 5 Data Report. Report Prepared for: BC Hydro, Burnaby. AMEC File: VE51905. 22 pp + 2 app.

Amec Foster Wheeler. 2017. DDMWORKS-4 Lower Duncan River Kokanee Spawning/Incubation Habitat Modelling. Report Prepared for BC Hydro, Burnaby, BC. AFW Report No: VE52598-2016. 19 pp + 3 app.

Amec Foster Wheeler. 2018. Update on BC Hydro Lower Duncan River Stranding Protocol Development and Finalization (DDMMON-15). Memo Prepared for BC Hydro, Burnaby, BC. AFW Project No: VE52547-2015. 6 pp.

BC Hydro. 2002. Lower Duncan River helicopter overflight videos at varying discharges. Available in the BC Hydro Castlegar Office.

BC Hydro. 2004a. LDR Stranding Assessment November 18-19, 2002. 8 pp.

BC Hydro. 2004b. LDR Stranding Assessment December 17, 2002. 7 pp.

BC Hydro. 2004c. Strategy for managing fish stranding impacts associated with flow reductions at Duncan Dam. Lower Duncan River. Working Draft. Prepared by BC Hydro Columbia Basin Generation. February 2004. 19 pp. + 6 app.

BC Hydro. 2007. Columbia Basin Generation Local Operating Order 3G-DDM-08: Duncan Dam (DDM) Dam and Discharge Facilities. 16 pp.

BC Hydro. 2011. Emergency planning Guide: Columbia Basin Dams. Report prepared by BC Hydro. 26 pp.

Duncan Dam Water Use Plan Consultative Committee. 2005. Consultative Committee Report: Duncan Dam Water Use Plan.

Golder Associates Ltd. (Golder). 2002. Fish and Aquatic Habitat Resources in the LDR – 1998-1999 Investigations. Prepared for BC Hydro, Castlegar, BC. RL&L Report No 741D.

Golder. 2007. LDR Flow Ramping Assessment, Fall 2006 Investigations. Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 06-1480-035F.

Golder. 2008a. Memo Report on Gap Analysis for LDR Ramping Program DDMMON-1 – Section 1.2.3.1. Prepared for BC Hydro Columbia Generation Area. 33 pp.

Golder. 2008b. LDR Flow Ramping Assessment, Fall 2007 Investigations. Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 07-1480-0062F.

Golder. 2009. DDMMON #16 Lower Duncan River fish stranding impact monitoring: Year 1 summary report (February 2008 to April 2009). Report prepared for BC Hydro, Castlegar, B.C. Golder Report No. 09-1480-0007F: 13 pp. + 1 app.

Golder. 2010a. DDMMON-15 Lower Duncan River stranding protocol development and finalization. Year 1 (2009). Report prepared for BC Hydro, Castlegar, BC. March 23, 2010. Golder Report No. 09-1492-5010: 19 pp. + 3 app.

Golder. 2010b. DDMMON #16 Lower Duncan River fish stranding impact monitoring: Year 2 summary report (April 2009 to April 2010). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 09-1480-0007F: 32 pp. + 4 app.

Golder. 2011. DDMMON-16 Lower Duncan River fish stranding impact monitoring: Year 3 summary report (April 2010 to April 2011). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 10-1492-0110F: 27 pp. + 3 app.

Golder. 2013. Adaptive stranding protocol for managing fish impacts in the Lower Duncan River associated with flow reductions at Duncan Dam. Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 0914925010-001-R-Rev0: 32 pp. + 6 app.

Golder. 2014. DDMMON-16 Lower Duncan River fish stranding impact monitoring: Year 5 data report (April 2012 to April 2013). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 12-1492-0117F: 25 pp. + 3 app.

Golder. 2015. DDMMON-16 Lower Duncan River fish stranding impact monitoring: Year 6 report (April 2013 to April 2014). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 12-1492-0117F: 49 pp. + 3 app.

Golder. 2017a. DDMMON-16 Lower Duncan River Fish Stranding Impact Monitoring: Year 7 Report (April 2014 to April 2015). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 12-1492-0117: 59 pp. + 3 app.

Golder. 2017b. DDMMON-16 Lower Duncan River fish stranding impact monitoring: Year 8 report (April 2015 to April 2016). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 1535517F: 54 pp. + 3 app.

Golder. 2018. DDMMON-16 Lower Duncan River fish stranding impact monitoring: Year 9 report (April 2016 to April 2017). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 1535517D: 69 pp. + 3 app.

Golder Associates Ltd. and Poisson Consulting Ltd. (Golder and Poisson). 2010. DDMMON-15 Lower Duncan River stranding protocol development and finalization: Year 2 (2010). Report prepared for BC Hydro, Castlegar, BC. December 15, 2010. Golder Report No. 09-1492-5010: 45 pp.

Golder and Poisson. 2012. DDMMON-16 Lower Duncan River fish stranding impact monitoring: Year 4 summary report (April 2011 to January 2012). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 10-1492-0110D: 39 pp. + 2 app.

Golder and Poisson. 2015. DDMMON-15 Lower Duncan River stranding protocol development and finalization: Year 5 (2012-2013). Report prepared for BC Hydro, Burnaby, BC. September 9, 2015. Golder Report No. 09-1492-5010: 75 pp. + 2 app.

Golder and Poisson. 2019a. DDMMON-16 Lower Duncan River fish stranding impact monitoring: Year 10 report (April 2017 to April 2018). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 18107549D: 50 pp. + 3 app.

Golder and Poisson. 2019b. DDMMON-16 Lower Duncan River fish stranding impact monitoring: Year 11 report (April 2018 to April 2019). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 18107549F: 52 pp. + 3 app.

Golder and Poisson. 2020. DDMMON-16 Lower Duncan River fish stranding impact monitoring: Year 12 report (April 2019 to April 2020). Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 18107549D: 56 pp. + 3 app.

Golder and Poisson. 2021. DDMMON-16 Lower Duncan River fish stranding impact monitoring: Year 13 report (February 2008 to December 2020) Synthesis Report. Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 18107549D: 92 pp. + 3 app.

Higgins, P. 2002. Generation Environmental Services: Watershed Management Corrective Action Proposal: LDR Flow Ramping Protocol Development. 4 pp.

M. Miles and Associates. 2002. Channel Stability Assessment: LDR. Report prepared for BC Hydro and Power Authority.

Northwest Hydraulic Consultants Ltd. 2009. Duncan Dam Water Use Plan: DDMMON-3 LDR Hydraulic Model. Prepared for BC Hydro. February 1, 2009. 21 pp. + 4 app.

Northwest Hydraulic Consultants Ltd. 2010. Duncan Dam Water Use Plan: DDMMON-3 LDR Hydraulic Model. Prepared for BC Hydro. 90 p. + 7 app.

Northwest Hydraulic Consultants Ltd. 2013. Duncan Dam Water Use Plan: DDMMON-3 LDR Hydraulic Model Year 5. Prepared for BC Hydro. October 31, 2013. 42 p. + 1 app.

Okanagan Nation Alliance (ONA), Poisson Consulting Limited and LGL Limited. 2016a. 2013 Lower Duncan River Kokanee Spawning Monitoring (DDMMON-4). Year 6 Data Report (September-October 2013). 23 p. + 1 app.

Okanagan Nation Alliance (ONA), Poisson Consulting Limited and LGL Limited. 2016b. 2014 Lower Duncan River Kokanee Spawning Monitoring (DDMMON-4). Year 7 Data Report (September-October 2014). 35 p. + 1 app.

Okanagan Nation Alliance (ONA), Poisson Consulting Limited and LGL Limited. 2016c. 2015 Lower Duncan River Kokanee Spawning Monitoring (DDMMON-4). Year 8 Data Report (September-October 2015). 39 p. + 1 app.

Okanagan Nation Alliance (ONA), Poisson Consulting Limited and LGL Limited. 2017. 2016 Lower Duncan River Kokanee Spawning Monitoring (DDMMON-4). Year 9 Data Report (September-October 2016). 36 p. + 1 app.

Okanagan Nation Alliance (ONA), Poisson Consulting Limited and LGL Limited. 2018. 2017 Lower Duncan River Kokanee Spawning Monitoring (DDMMON-4). Implementation Year: Year 10 Data Report and Conclusions 2008-2017. Study Period: September – October 2017. May 2018. 33 pp. + 1 app.

Poisson Consulting Ltd. and Golder Associates Ltd. (Poisson and Golder). 2010. DDMMON-1 - Lower Duncan River ramping rate monitoring: Phase V investigations. Report prepared for BC Hydro, Castlegar, BC. Golder Report No. 08-1480-0054F: 41 pp. + 6 app.

Porto, L., J. Thorley, J. Hagen and J. Baxter. 2009. Lower Duncan River Habitat Use Monitoring - Study Needs Assessment and Information Review (Year 1). Prepared by AMEC Earth & Environmental, Poisson Consulting Ltd. and Mountain Water Research, Nelson BC. Prepared for BC Hydro, Castlegar, B.C. 59 pp. + 4 app.

Thorley, J., L. Porto, J. Baxter and J. Hagen. 2010. Lower Duncan River Habitat Use (DDMMON-2). Year 1 Data Report. Report Prepared for: BC Hydro, Castlegar. Prepared by: AMEC Earth & Environmental Ltd., Poisson Consulting Ltd., Mountain Water Research and John Hagen and Associates Ltd. 59 pp. + 4 app.

Thorley, J, J. Baxter, R. Irvine, J. Hagen and L. Porto. 2011. Lower Duncan River Habitat Use (DDMMON-2). Year 2 Final Report. Report Prepared for: BC Hydro, Castlegar. Prepared by: AMEC Earth & Environmental Ltd., Poisson Consulting Ltd., Mountain Water Research and John Hagen and Associates Ltd. 131 pp.

Thorley, J.L., R.L. Irvine, J.T.A. Baxter, L. Porto, C. Lawrence. 2012. Lower Duncan River Habitat Use (DDMMON-2). Year 3 Final Report. Report Prepared for: BC Hydro, Castlegar. Prepared by: AMEC Environment & Infrastructure Ltd., Poisson Consulting Ltd., and Mountain Water Research. 86 pp. + 2 app.

Wood. 2022. DDMWORKS-4 Lower Duncan River Kokanee Spawning/Incubation Habitat Modelling - 2022. Report Prepared for BC Hydro, Burnaby, BC. Wood Report No: VE52598.2021.003. 21 pp. + 2 app.

APPENDIX A

ROLES AND RESPONSIBILITIES

BC Hydro Roles and Responsibilities

Operations Planning Engineer (OPE)

The OPE works in Generation Systems Operations (GSO). OPEs plan generation and reservoir operations at all BC Hydro and IPP facilities, for the next-day to one-year time horizon, to meet power generation and water management requirements, in consideration of constraints and forecasted conditions and in support of the system outages and needs. There is a primary OPE for each river system, with supporting back-ups in the team. In addition to planning and scheduling of operations and providing operation instructions, the OPE has the responsibility of communicating planned flow changes at Duncan Dam with:

- DDM Plant Manager and DDM Caretakers;
- The Natural Resource Specialist;
- Community Relations; and,
- Agencies and stakeholders, as required.

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-06: DDM and Discharge Facilities.

Planning Scheduling and Operating Shift Engineers (PSOSE)

PSOSE directs the real-time operation of the BC Hydro generation system and water release facilities. This includes scheduling hourly generation of the BC Hydro system and contracted Independent Power Producers. PSOSE operates a 24/7 Generation Shift Office and a Next Day Planning office at Edmonds.

Natural Resource Specialist (NRS)

The regional NRS works in Environment Field Operations (EFO) and is responsible for managing environmental risks associated with BC Hydro Generation System Operations (e.g. flow changes) and Station Field Operations (e.g. work at dam facilities) The responsibilities of the NRS coordinating DDM flow changes include:

- Providing environment-related communication to the OPE, DDM Plant Manager and Caretaker, and consulting with the fisheries agencies as required;
- Mobilizing monitoring crews;
- Notifying agencies and stakeholder(s) of any unexpected situations as soon as possible; and,
- Maintaining records of flow reduction impact assessments.

The NRS is the first individual contacted by the monitoring crew supervisor if fish salvage crews find stranding risk during a reduction is inconsistent with that expected by the Stranding Risk Assessment or if additional actions may be warranted (e.g., changing the flow reduction schedule, mobilizing additional field staff, etc.).

APPENDIX B

CONTACT INFORMATION

Table B1: Key Contacts Lower Duncan River Fish Stranding Protocol

Organization / Group	Name	Position / Office Location	Work	Cell	Email
BC Hydro Generation Systems Operations	Wuben Luo	Duncan/Kootenay OPE (Edmonds)	604-528-2848	604-842-6118	Wuben.Luo@bchydro.com
BC Hydro Generation Systems Operations	Gillian Kong	Columbia OPE (Edmonds)	604-528-2793	604-908-8416	Gillian.Kong@bchydro.com
BC Hydro PSOSE	Shift Office	PSOSE Office (Burrard)	604-891-5098	-	PSOSEOffice@bchydro.com
BC Hydro Environment Field Operations	Matt Casselman	Natural Resource Specialist (Castlegar)	250-365-4569	604-258-8148	Matt.Casselman@bchydro.com
BC Hydro Environment Field Operations	Marco Marrello	Natural Resource Specialist (Castlegar)	250-365-4588	250-354-5378	Marco.Marrello@bchydro.com
BC Hydro Stations Field Operations	Brian Light	DDM Plant Manager (Hugh Keenleyside Dam)	250-304-1001	250-551-0852	Brian.Light@bchydro.com
BC Hydro Stations Field Operations	Ron Greenlaw Martin Tremblay Kris Weins	Duncan Dam Caretaker (Duncan Dam)	250-366-4257	-	Ron.Greenlaw@bchydro.com Martin.Tremblay@bchydro.com Kris.Weins@bchydro.com
Ktunaxa Nation Council	Misun Kang	Aquatic Ecologist	250-427-5964	-	mkang@ktunaxa.org
Okanagan Nation Alliance	Michael Zimmer	Team Lead, Region Fisheries (Columbia)	250-707-0095	-	mzimmer@syilx.org
Columbia Power Corporation	Wendy Horan	Manager, Environmental Projects	250-304-6032	250-304-5255	Wendy.Horan@columbiapower.org
Fisheries and Oceans Canada	Dean Watts	Senior Water Use Biologist (Kelowna)	250-851-4861	-	Dean.Watts@dfo-mpo.gc.ca
FLNRORD	Will Warnock	Ecosystem Biologist	-	-	Will.Warnock@gov.bc.ca
FortisBC	Maureen Grainger	Environmental Lead	250-359-0789	250-304-9805	Maureen.Grainger@fortisbc.com

APPENDIX C

LDR FISH STRANDING ASSESSMENT SUMMARY FORM

Form 1: Lower Duncan River Fish Stranding Risk Assessment

Reduction Event #:	REYEAR-00	Location of Reducton:	DDM	Fish Salvage?	
Risk Assessment Date:		Target Reduction Volume:		Other Mitigation?	
Completed By:		Reduction Date:			

A - Proposed Discharge Reduction Details

DATE / CONDITIONS	
Date of Proposed Reduction:	
	°C
DRL Water:	
DRL Air:	
Day of Year:	
Risk Period (Date Range):	
Period of Concern:	
Upcoming Flow Changes:	

PROPOSED PLANT REDUCTION	
	kcfs
Current DDM Q:	
Resulting DDM Q:	
Current DRL Q:	
Resulting DRL Q:	34
Estimated Lardeau River Q	
(m)	

QUERIED DRL REDUCTION	
	kcfs
Initial DRL Q:	
Resulting DRL Q:	
Wetted History (Days)	
Wetted History (Date)	

B - Summary of Database Query Results

QUERY STRANDING RISK	
Site Classification	No. of Sites
NO POOLS[a]	
NO DATA /RECONNAISANCE[b]	
MINOR EFFECT[c]	
MAJOR EFFECT[d]	

NOTABLE SITES FOR EFFECT	
Site	Comments

ESTIMATED CREW REQUIREMENTS[f]		PAST SIGNIFICANT STRANDING?	

[a] No Pools - Negligible: Sites where at least five asessments have been conducted and isolated pools are not present.
[b] No Data/Reconnaissance - Moderate: Sites where fewer than five assessments have been conducted, regardless of the current maximum number of fish stranded.
[c] Minor Effect - Low: Sites where at least five assessments have been conducted and the maximum number of fish stranded from previous assessments is less than 100.
[d] Major Effect - High: Sites where at leas five assessments have been conducted and the maximum number of fish stranded from previous assessments is greater than or equal to 100.

C - Fish Stranding Risk Assessment and Reduction Planning

Operations Planning Engineer: ______ BC Hydro NRS ______

Stranding Risk Asssessment

a) Proposed discharge change and drivers.	Insert text
b) Fish stranding risk assessment.	Insert text
c) Stranding Mitigation Recommendation (if any)	Insert text
d) External/Regulator Review	Insert text
e) Future Considerations	Insert text

BC Hydro Power smart

APPENDIX D

DUNCAN DAM FISH STRANDING DATABASE AND MANAGEMENT TOOL SAMPLE QUERY OUTPUT

Duncan River Stranding Summary

Current DRL Discharge (m^3/s):	175.6
Resultant DRL Discharge (m^3/s):	96.3
Proposed Date:	01-Mar-19
Sample Season:	Winter
Included Seasons:	Winter

SiteName	Reduction Event	DRLQ (m^3/s) Previous	DRLQ (m^3/s) Resultant	Sample Date	Number of Pools Present	Number of Pools Sampled	Season	Number of Fish
Lard0.3R	2004-02	186.00	107.00	02-Feb-04	NR	NR	Winter	
	2006-01	249.00	167.00	01-Feb-06	7	7	Winter	15
	2006-02	160.00	104.00	01-Mar-06	1	1	Winter	8
	2010-02	190.00	101.00	01-Mar-10	14	14	Winter	12
	2011-02	205.00	120.00	02-Mar-11	8	8	Winter	5
	2014-02	166.00	109.00	01-Mar-14	4	2	Winter	0
	2015-02	187.00	110.00	02-Mar-15	4	3	Winter	6
	2015-06	160.00	115.00	29-Dec-15	10	4	Winter	5
	2017-02	147.00	99.00	02-Mar-17	17	13	Winter	49
				Minor Effect	Min: 0	Max: 49	Sum: 100	Avg: 13
M0.5L	2015-06	160.00	115.00	29-Dec-15	0	0	Winter	
				No Pools	Min:	Max:	Sum:	Avg:
M0.6-1.7L	No Data							
				No Data - Recon. Survey	Min:	Max:	Sum:	Avg:
M0.8R	2006-01	249.00	167.00	01-Feb-06	22	22	Winter	8
	2006-02	160.00	104.00	01-Mar-06	41	41	Winter	25
	2009-01	224.00	96.00	28-Feb-09	20	20	Winter	17
	2010-02	190.00	101.00	01-Mar-10	13	13	Winter	13
	2011-02	205.00	120.00	02-Mar-11	14	12	Winter	4
	2012-02	215.00	113.00	01-Mar-12	30	26	Winter	24
	2013-02	200.00	110.00	01-Mar-13	9	5	Winter	4
	2014-01	238.00	160.00	21-Jan-14	21	9	Winter	8
	2015-05	237.00	175.00	22-Dec-15	11	6	Winter	2
	2017-01	205.00	147.00	01-Mar-17	19	13	Winter	5
	2018-01	145.00	103.00	01-Mar-18	22	22	Winter	9
				Minor Effect	Min: 2	Max: 25	Sum: 119	Avg: 11

NR = Not Recorded.

SiteName	Reduction Event	DRLQ (m^3/s) Previous	DRLQ (m^3/s) Resultant	Sample Date	Number of Pools Present	Number of Pools Sampled	Season	Number of Fish
M1.1-1.7R	No Data							
				No Data - Recon. Survey	Min:		Sum:	
					Max:		Avg:	
M1.7L	2012-02	215.00	113.00	01-Mar-12	2	2	Winter	
				Recon. Survey	Min:		Sum:	
					Max:		Avg:	
M2.1R	2013-02	200.00	110.00	01-Mar-13	0	0	Winter	
				No Pools	Min:		Sum:	
					Max:		Avg:	
M2.5L	2018-01	145.00	103.00	01-Mar-18	1	1	Winter	2
				Recon. Survey	Min:	2	Sum:	2
					Max:	2	Avg:	2
M2.7L	2017-02	147.00	99.00	02-Mar-17	7	6	Winter	4
				Recon. Survey	Min:	4	Sum:	4
					Max:	4	Avg:	4
M4.3R	2014-01	238.00	160.00	21-Jan-14	0	0	Winter	
	2015-06	160.00	115.00	29-Dec-15	3	3	Winter	1
				Recon. Survey	Min:	1	Sum:	1
					Max:	1	Avg:	1
M5.7L	2014-01	238.00	160.00	21-Jan-14	0	0	Winter	0
	2015-06	160.00	115.00	29-Dec-15	1	1	Winter	0
				Recon. Survey	Min:	0	Sum:	0
					Max:	0	Avg:	0
M6.0R	No Data							
				No Data - Recon. Survey	Min:		Sum:	
					Max:		Avg:	
M6.1L	2015-05	237.00	175.00	22-Dec-15	4	4	Winter	1
	2017-02	147.00	99.00	02-Mar-17	16	7	Winter	6
				Recon. Survey	Min:	1	Sum:	7
					Max:	6	Avg:	4
M7.1-7.7L	No Data							
				No Data - Recon. Survey	Min:		Sum:	
					Max:		Avg:	
M7.2-7.8R	No Data							
				No Data - Recon. Survey	Min:		Sum:	
					Max:		Avg:	

NR = Not Recorded.

SiteName	Reduction Event	DRLQ (m^3/s) Previous	DRLQ (m^3/s) Resultant	Sample Date	Number of Pools Present	Number of Pools Sampled	Season	Number of Fish
M7.7L	2014-02	166.00	109.00	01-Mar-14	1	1	Winter	2
	2017-01	205.00	147.00	01-Mar-17	2	1	Winter	0
				Recon. Survey	Min: 0	Max: 2	Sum: 2	Avg: 1
M7.8R	2017-02	147.00	99.00	02-Mar-17	12	4	Winter	10
				Recon. Survey	Min: 10	Max: 10	Sum: 10	Avg: 10
M8.4L	No Data							
				No Data - Recon. Survey	Min:	Max:	Sum:	Avg:
M8.6L	2018-01	145.00	103.00	01-Mar-18	5	5	Winter	1
				Recon. Survey	Min: 1	Max: 1	Sum: 1	Avg: 1
M9.7R	2004-02	186.00	107.00	02-Feb-04	NR	NR	Winter	15
	2017-01	205.00	147.00	01-Mar-17	6	4	Winter	1
				Recon. Survey	Min: 1	Max: 15	Sum: 16	Avg: 8
S10.2R	2004-02	186.00	107.00	02-Feb-04	NR	NR	Winter	7
	2013-02	200.00	110.00	01-Mar-13	6	5	Winter	3
	2014-01	238.00	160.00	21-Jan-14	0	0	Winter	
				Recon. Survey	Min: 3	Max: 7	Sum: 10	Avg: 5
S10.6R	2004-02	186.00	107.00	02-Feb-04	NR	NR	Winter	6
				Recon. Survey	Min: 6	Max: 6	Sum: 6	Avg: 6
S11.0R	2015-05	237.00	175.00	22-Dec-15	0	0	Winter	
				No Pools	Min:	Max:	Sum:	Avg:
S11.5R	No Data							
				No Data - Recon. Survey	Min:	Max:	Sum:	Avg:
S3.1-3.2L	2012-02	215.00	113.00	01-Mar-12	3	3	Winter	3
				Recon. Survey	Min: 3	Max: 3	Sum: 3	Avg: 3

NR = Not Recorded.

SiteName	Reduction Event	DRLQ (m^3/s) Previous	DRLQ (m^3/s) Resultant	Sample Date	Number of Pools Present	Number of Pools Sampled	Season	Number of Fish
S3.5-4.0R	2004-02	186.00	107.00	02-Feb-04	NR	NR	Winter	
	2006-01	249.00	167.00	01-Feb-06	19	19	Winter	25
	2006-02	160.00	104.00	01-Mar-06	15	15	Winter	5
	2010-02	190.00	101.00	01-Mar-10	6	6	Winter	10
	2014-02	166.00	109.00	01-Mar-14	6	5	Winter	8
	2017-01	205.00	147.00	01-Mar-17	22	10	Winter	6
				Minor Effect	Min:	5	Sum:	54
					Max:	25	Avg:	11
S3.5-4.2R	No Data							
				No Data - Recon. Survey	Min:		Sum:	
					Max:		Avg:	
S4.0-4.2R	2004-02	186.00	107.00	02-Feb-04	NR	NR	Winter	
	2006-01	249.00	167.00	01-Feb-06	12	12	Winter	12
	2006-02	160.00	104.00	01-Mar-06	0	0	Winter	
	2010-02	190.00	101.00	01-Mar-10	5	5	Winter	0
	2012-02	215.00	113.00	01-Mar-12	4	3	Winter	162
				Major Effect	Min:	0	Sum:	174
					Max:	162	Avg:	58
S4.0R	No Data							
				No Data - Recon. Survey	Min:		Sum:	
					Max:		Avg:	
S4.1L	2004-02	186.00	107.00	02-Feb-04	NR	NR	Winter	14
	2006-01	249.00	167.00	01-Feb-06	13	13	Winter	22
	2006-02	160.00	104.00	01-Mar-06	10	10	Winter	29
	2010-02	190.00	101.00	01-Mar-10	1	1	Winter	2
	2011-02	205.00	120.00	02-Mar-11	5	5	Winter	9
	2013-02	200.00	110.00	01-Mar-13	9	4	Winter	5
	2014-01	238.00	160.00	21-Jan-14	6	4	Winter	3
	2015-02	187.00	110.00	02-Mar-15	10	4	Winter	11
	2015-05	237.00	175.00	22-Dec-15	3	3	Winter	0
	2017-02	147.00	99.00	02-Mar-17	16	9	Winter	2
				Minor Effect	Min:	0	Sum:	97
					Max:	29	Avg:	10
S4.1R	No Data							
				No Data - Recon. Survey	Min:		Sum:	
					Max:		Avg:	

NR = Not Recorded.

SiteName	Reduction Event	DRLQ (m^3/s) Previous	DRLQ (m^3/s) Resultant	Sample Date	Number of Pools Present	Number of Pools Sampled	Season	Number of Fish
S6.9R	2004-02	186.00	107.00	02-Feb-04	NR	NR	Winter	2
	2006-01	249.00	167.00	01-Feb-06	3	3	Winter	7
	2006-02	160.00	104.00	01-Mar-06	2	2	Winter	3
	2008-01b	199.00	137.00	21-Jan-08	3	0	Winter	0
	2009-01	224.00	96.00	28-Feb-09	7	4	Winter	3
	2011-02	205.00	120.00	02-Mar-11	1	1	Winter	1
	2015-02	187.00	110.00	02-Mar-15	5	3	Winter	1
	2017-01	205.00	147.00	01-Mar-17	13	6	Winter	7
				Minor Effect	Min:	0	Sum:	24
					Max:	7	Avg:	3
S7.6L	2018-01	145.00	103.00	01-Mar-18	2	2	Winter	0
				Recon. Survey	Min:	0	Sum:	0
					Max:	0	Avg:	0
S7.6R	No Data							
				No Data - Recon. Survey	Min:		Sum:	
					Max:		Avg:	
S7.7R	No Data							
				No Data - Recon. Survey	Min:		Sum:	
					Max:		Avg:	
S8.2L	2014-02	166.00	109.00	01-Mar-14	12	3	Winter	3
				Recon. Survey	Min:	3	Sum:	3
					Max:	3	Avg:	3
S8.7L	2015-02	187.00	110.00	02-Mar-15	1	1	Winter	0
	2015-06	160.00	115.00	29-Dec-15	1	1	Winter	0
				Recon. Survey	Min:	0	Sum:	0
					Max:	0	Avg:	0
S9.2L	2004-02	186.00	107.00	02-Feb-04	NR	NR	Winter	
	2015-05	237.00	175.00	22-Dec-15	5	5	Winter	0
				Recon. Survey	Min:	0	Sum:	0
					Max:	0	Avg:	0
S9.5R	No Data							
				No Data - Recon. Survey	Min:		Sum:	
					Max:		Avg:	
S9.7R	2018-01	145.00	103.00	01-Mar-18	17	17	Winter	4
				Recon. Survey	Min:	4	Sum:	4
					Max:	4	Avg:	4

NR = Not Recorded.

SiteName	Reduction Event	DRLQ (m³/s) Previous	DRLQ (m³/s) Resultant	Sample Date	Number of Pools Present	Number of Pools Sampled	Season	Number of Fish
SLard0.3R	2012-02	215.00	113.00	01-Mar-12	13	7	Winter	2
				Recon. Survey	Min:	2	Sum:	2
					Max:	2	Avg:	2

Report Generated on 2/21/2019.

NR = Not Recorded.

APPENDIX E

STRANDING PROTOCOL FIELD METHODS & FORMS

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

Site #	Side Channel or Mainstem	Pool or Interstitial ID (i.e. P1 or I1)	Time at Stranding Mechanism	Area (m^2)	Complexity (Zero to Low or Moderate to High)	Substrate (sizes and dominance)	Cover Types (LWD, SWD, OV, CB, DP, SP, INT, N/A) and Percentage				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)

18107549: DDMMON-16 Duncan River Fish Stranding Survey Form - Years 11 - 13

Crew:			
Site Name:			
Index or Non-Index Site:			
UTM Zone:	UTM Easting:		UTM Northing:
Date:		Estimated Verticle Drop (m)[1]:	
Time:		Previous Discharge (kcfs):	
Weather:		Resulting Discharge (kcfs):	
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

Follow-up Required (If so, why)?
Future flow reduction problems (next 0.5m decrease)?
Ramping Description:
Comments:

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

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

Planning and Mobilization

The LDR is inaccessible by road for most 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.

Depending on predicted effects of the discharge change, 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 fish salvage will depend on the fish stranding risk assessment, based on initial conditions and the magnitude of flow reduction planned, and the number of sites to be assessed. Current experience indicates one two-person crew is capable of completing LDR fish salvage during typical flow reductions.

The general procedures on the flow reduction day are as follow:

1) A stranding assessment supervisor (external consultant on-site crew supervisor) will be assigned for all monitored flow changes and will meet with field crew(s) and DDM staff at the DDM office before starting work to sign in, discuss safety information and confirm flow reduction timing and magnitude.

2) Crews will record general information relevant to the flow reduction including:

   - Survey date;
   - Crew members;
   - Time and magnitude of planned discharge changes at the DDM;
   - Start and resulting discharge (m^3/s) from DDM;
   - Discharge data for the Lardeau River;
   - 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 LDR 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 Environment.

4) The assessments are to be targeted in High and Moderate priority sites as determined by the LDR Fish Stranding Database and Management Tool query. Low priority sites should be targeted with a frequency sufficient to continue to assess risk. Sites will be assessed for both pool and interstitial stranding following the methodologies outlined below.

5) Fish species and length are assessed for all fishes where possible, except for sculpins (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.

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 the project SharePoint. 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 and Management Tool using discharge information provided by BC Hydro. Determine current river temperature at: https://www.bchydro.com/energy-in-bc/operations/transmission-reservoir-data/hydrometeorologic-data.html. Distribute query to BC Hydro NRS.

4) Organize flow reduction schedule, communication protocol and accommodations with the BC Hydro NRS.

Field Sampling

1) If feasible, travel to Meadow Creek or Kaslo the day before the scheduled reduction and stay overnight.

2) Identified stranding sites will be assessed as dictated by the LDR Fish Stranding Database and Management Tool query and BC Hydro NRS.

3) Field crew(s) will be onsite at the BC Hydro boat launch downstream of DDM and ready to start field work as the last flow reduction is made. Sample selected sites in order from upstream to down. This approach ensures that the field crew does not move ahead of the receding water levels.

4) 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. Single pass electrofishing will be conducted in one pool at each site (to maintain statistical power related to wetted pool stranding rate estimation). The pool to be sampled will be selected at random.

5) With a GPS, record waypoints of every pool and interstitial habitat sampled.

6) For each isolated pool encountered, associated cover types (and percentages within the pool) will be recorded on the Stranding Habitat and Fish Record data sheet (see below).

7) During sampling, the habitat association of each fish encountered will also be recorded on the fish record data sheet, if possible (see below).

8) 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.

9) To assess interstitial stranding at each surveyed site, census areas of randomly selected dewatered habitat within a site that the prior stratification analysis indicated would have a reasonable probability to strand fish. Consistent effort (i.e., a maximum of approximately twenty minutes) will be conducted at each site to ensure an adequate number of sites along the entire LDR are sampled during each assessment. The total area and dominant substrate within these areas will be recorded. If this method is not possible due to conditions at the sample site, a maximum of 10 transects will be conducted within dewatered interstitial habitats with gradients and substrates with the potential to strand fish will be sampled. A measuring tape will be laid on the substrate from the wetted edge to the top of the dewatered area, and the length recorded. The substrate near the tape will then be visually assessed (0.5 m on either side of the tape along its entire length).

10) Pools that have completely dewatered as a result of the flow reduction will be assessed visually for stranded fish and recorded separately from interstitial and wetted pools. As the size of the pool and habitat it encompassed when it isolated from the mainstem and dewatered will not be able to be accurately determined upon inspection, only the substrate at the deepest point of the dried pool will be recorded.

11) Record the length of each fish enumerated (in wetted or dried pools or on dewatered substrate). Sampled fish numbers may be high, and time may not allow measuring all fish at a site. In such situations, a subsample of all salvaged fish will be measured (estimate number of fish by species in pool, length measurements will be taken of at least 30 but no more than 50 of each species).

12) To be consistent with past studies (fish stranding assessments and ramping experiments), the dominant and subdominant substrate in each stranding habitat type (interstitial, dried and wetted pools) will be recorded using the Modified Wentworth Scale.

13) Ensure that all relevant sections of data sheets are completed (see below).

14) If a reduction is going to dewater a small side channel then, following discussions with the BC Hydro NRS, the program will consider snorkeling the entire side channel to census the fish populations then sampling all the pools and interstitial habitat with the potential to strand fish to census the stranded population. This would allow an estimate of the stranding rate for a small side channel which will inform stranding rate estimation for the entire study area.

Equipment List

The following equipment should be prepared for field work:

- Truck with proper hitch

- Jet boat and appropriate safety gear
- Ice auger (if winter survey)
- Aquaview (if winter survey)
- Electroshocker
- Electroshocker batteries (fully charged) X2
- Pair of linesmen gloves X2
- 30 m measuring tape
- Beach seine
- Long handled net
- Dip net X2
- 5 gallon bucket X2
- Fish sample kit for preservation of voucher specimens
- Level 1 First Aid kit
- Bear Safety 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, and the LDR Stranding Protocol
- Fish measuring board
- Satellite phone
- VHF Radio with BC Hydro frequencies (frequencies provided by BC Hydro)
- Laser Rangefinder
- Digital Camera
- GPS (WAAS Enabled)
- Thermometer
- Conductivity Meter
- Laminated Maps for identification of fish stranding sites (Duncan River Orthophotos)

<u>Personal Gear</u>

- Lifejacket

- Hat
- Polarized sunglasses
- Rain gear
- Chest waders
- Wading belt
- Dry bag with spare clothes
- Snowshoes (if winter survey)
- Survival/Floater suit (if winter survey)

Post Sampling

1) Upon return from field work, all relevant equipment with data will be downloaded (i.e. camera, GPS) and put in the corresponding reduction folder.
2) Visit the BC Hydro Hydromet website and save data for the DRL station as a text file in reduction folder.

https://www.bchydro.com/energy-in-bc/operations/transmission-reservoir-data/hydrometeorologic-data.html.

3) All data is to be entered into the LDR Fish Stranding Database.
4) Within 72 hours of the assessment, complete the LDR Fish Stranding Assessment Summary Form (see below) and distribute to the BC Hydro NRS.