To: Rio Tinto Water Engagement Initiative participants

From: Rahul Ray, Jason Collier, and Jayson Kurtz

Date: October 3, 2019

Re: Rio Tinto Water Engagement Initiative: Structured Decision Making Backgrounder

INTRODUCTION

As discussed during our Water Engagement Initiative (WEI) Main Table meetings and outlined in Section 2.1 of the process Guiding Principles (https://www.getinvolvednechako.ca/7037/documents/18050) , “the WEI Process is intended to provide a vehicle to share interests, review information, develop alternative operating options, and select a preferred option for Rio Tinto to implement in the Nechako region. This option will remain responsive, rather than a plan that ‘sits on a shelf’. The WEI Process builds on principles and approaches outlined in the Province of British Columbia’s Water Use Plan Guidelines (1998).”

Much of the success of past Water Use Plans (WUPs) has been attributed to the use of Structured Decision Making (SDM). The WEI Process is using SDM approaches to work through the broad range of water flow-related interests being brought forward by WEI Participants and to develop viable flow alternatives to meet as many interests as possible.

The SDM process involves strategic elements as well as more technical analyses. The Main WEI Table will set the strategic direction, supported by the Technical Working Group (TWG) who will conduct technical analyses at the request of the Main Table and provide the results in an approachable manner.

Structured Decision Making is an effective tool for outlining, evaluating, and selecting an alternative flow regime for Rio Tinto Nechako operations. However, as we have discussed, not all the topics being raised through the WEI can be addressed within the formal SDM structure. Other interests are being raised that are still important, but will be addressed through other mechanisms as part of the WEI. They will not be lost, just addressed as part of the broader WEI effort.

This document provides background information about the SDM process, outlines the steps the WEI Table will be working through, and provides examples from processes that have addressed similar issues to those faced in the Nechako region.

WHAT IS STRUCTURED DECISION MAKING?

Structured Decision Making, or SDM, is an organized approach to identifying and evaluating creative options and making choices in complex decision situations.

SDM is designed to deliver insight to decision makers about how well their objectives may be satisfied by potential alternative courses of action. It helps find 'win-win' solutions across groups, clarifies the irreducible trade-offs that may exist between alternate potential courses of action and helps to communicate how people view these various options.

Why Are We Using It?

The SDM approach was used in the 23 water use plans (WUPs) that BC Hydro undertook. The overall objective was to make adjustments to BC Hydro operations to benefit (or balance) power generation, fish, wildlife, cultural heritage, social (e.g., recreation), and other values. Most of the WUPs undertaken reached consensus.

KEY STRUCTURED DECISION MAKING STEPS

The key steps in an SDM process are presented below. At the next WEI Table meeting, the focus will be on Defining Objectives that capture the interests expressed by WEI Participants or expressed previously.

The text below is from http://www.structureddecisionmaking.org/, based on the book, “Structured Decision Making: A Practical Guide to Environmental Management Choices” by Gregory et al. (2012).

The primary steps in SDM include:

Step 1: Clarify the Decision Context

The first step in good decision making involves defining what question or problem is being addressed and why, identifying who needs to be involved and how, establishing scope and bounds for the decision, and clarifying the roles and responsibilities of the decision team.

Step 2: Define Objectives and Evaluation Criteria

The core of SDM is a set of well-defined objectives and evaluation criteria. Together they define “what matters” about the decision, drives the search for creative alternatives, and becomes the framework for comparing alternatives.

Examples are provided later in this document, but sample objectives that may be developed by the WEI Table include:

Fish:

- Maximize fish abundance and diversity.

Flood Management (and Erosion Protection):

- Minimize the flood damage to people and property on the Nechako River.

Wildlife:

- Maximize the quality and quantity of available habitat area for wildlife.

Step 3: Develop Alternatives

Step 3 is to develop a range of creative management alternatives designed to address the objectives identified in Step 2. Alternatives should reflect substantially different approaches to the problem or different priorities across objectives, and should present decision makers with real options and choices.

Step 4: Estimate Consequences

Step 4 is an analytical exercise in which the performance of each alternative is estimated in terms of the evaluation criteria developed in Step 2. Care must be taken to determine the focal areas of uncertainty and to ensure that these are represented properly in the analysis.

Step 5: Evaluate Trade-Offs and Select

Step 5 involves evaluating and selecting a preferred alternative. SDM is not a black box, and group discussion should always play a central role in evaluating preferences for alternatives. In many cases, preference assessment techniques are used to help people understand the trade-offs between preferred alternatives.

An alternative comparison table from the Ash River Water Use Plan is provided below. In the WEI process, the WEI Table will develop objectives, and with the support of the TWG, develop Evaluation Criteria, and build alternatives. The alternative comparison table may be like that below.

Step 6: Implement and Monitor

The last step in the decision process is to: (1) identify mechanisms for on-going monitoring to ensure accountability with respect to on-ground results, (2) research to improve the information base for future decisions, and (3) a review mechanism so that new information can be incorporated into future decisions.

Step 6 is made so that success of the selected alternative can be evaluated, or to make changes, if needed.

Alternative No. of Interest: 1

Colour key: Better / Equal / Worse

PM#	PM — Alternative name:	1 WL	2 E	3 B	4 C	5 F	6 D	7 G2	8 H	9 I1	10 I2	11 I3	12 J	13 K
1	Flood Free (days <650 m^3/s at Somass)	12,017	12,017	12,017	12,017	12,017	12,017	12,017	12,017	12,008	12,017	12,017	12,016	11,995
2	Reservoir Rec. days >329.5 m 24 May-15 Oct	82	58	56	57	53	79	63	56	0	0	0	35	0
4	Reservoir Fishing days > 329.5 Apr-Jun	91	79	69	71	66	31	91	69	0	5	5	21	0
5	Arch No Unauthorized Collection days >328 m	302	234	217	221	217	262	264	217	0	79	84	146	45
6	Arch Erosion, days avoid 327 m - 328.5 m	347	336	325	325	325	267	337	339	365	347	346	325	353
7	FN Traditional Use & Study - Reservoir Days	0	0	0	0	0	0	0	0	5	4	4	0	6
8	River naturalized hydrograph 1=Yes 0=No	0	0	0	0	0	0	0	0	0	0	0	1	1
11	Reservoir Trout Spawning m^2	0.0	0.0	0.0	0.0	0.0	50.8	0.0	0	12,934	25	25	10	266
12	Reservoir Trout Rearing m	0.0	0.0	4.4	4.4	4.4	8.8	0.0	4	5,348	5,220	4,002	874	5,630
13	Wildlife habitat Drawdown Zone ha	22	48	52	52	50	39	36	52	216	193	167	73	219
15	Elsie. Steelhead Parr Rearing m	0.8	11.9	11.9	11.9	17.0	2.9	0.8	11.9	11.9	11.9	11.9	11.9	11.9
22	Moran. Steelhead Parr Rearing m	6.1	16.7	17.6	16.7	20.2	6.2	6.1	17.7	17.2	17.2	17.0	17.2	16.7
23	Moran. Steelhead Spawning m	16.2	23.9	26.9	26.9	26.9	16.2	16.2	26.9	23.0	26.5	26.5	28.4	27.9
24	Moran. Coho Fry rearing WUW m	2.3	5.6	5.7	5.6	5.9	2.4	2.3	5.7	5.7	5.7	5.7	5.6	5.6
25	Moran. Coho Spawning m	3.2	4.4	5.1	5.0	5.1	2.8	2.8	5.1	14.5	5.1	5.1	7.1	7.2
29	GCL Shoreline incubation M m^3	29.2	32.8	32.8	32.8	32.8	32.8	32.8	32.8	18.1	32.8	32.8	32.8	32.8
30	GCL Stamp R. migration M m^3	65.4	64.4	64.1	64.4	58.2	33.8	65.5	64.1	15.3	15.3	19.8	59.3	13.9
33	$ Value of energy (millions)	9.6	10.3	10.2	10.2	9.9	9.8	10.9	9.6	6.0	8.1	9.1	9.1	7.1

Figure 6-1: Interactive Colour Coded Excel Spreadsheet to Assist In Comparing Ash River Water Use Plan Operating Alternatives

WATER ENGAGEMENT INITIATIVE PROCESS

The WEI Process is now moving to **Defining Objectives and Evaluation Criteria.** The Objectives and Evaluation Criteria developed by the WEI Table will form the basis for alternative scenarios that are developed, evaluated, and ultimately selected to address as many interests as possible.

At our next meeting, on Tuesday, October 8 in Vanderhoof, we focus on defining objectives. These objectives will form the foundation for the remainder of the WEI Process and build on the issues identified through discussions to date.

Below is a background on setting effective objectives (reproduced from http://www.structureddecisionmaking.org/) to help guide the discussions at the WEI Table.

Objectives

There are many considerations to keep in mind when defining objectives and evaluation criteria. However, the bottom line is that objectives and evaluation criteria form the framework for evaluating alternatives. They should:

- focus decision makers on what matters in the decision, even when what matters is hard to quantify;
- generate creative ideas about alternatives, and be used proactively to design good alternatives;
- provide a basis for consistently and transparently comparing alternatives, with emphasis on exposing key differences in performance (trade-offs) and critical uncertainties; and
- focus and streamline data collection and modeling to ensure an efficient decision-relevant information base.

The five basic steps in identifying objectives are:

- brainstorm the "things that matter" of an identified interest;
- state the objectives;
- separate them into means and ends;
- create an objectives hierarchy; and
- test your objectives to make sure they will be "useful."

Key Elements of Effective Objectives

Some of the characteristics of good objectives include that they are:

- **Complete:** they capture all of the things that matter (i.e. interests) in evaluating proposed alternatives including environmental, social, economic, health, and cultural outcomes that may be affected;
- **Concise:** nothing is unnecessary or ambiguous;
- **Sensitive:** objectives are influenced by the alternatives under consideration;
- **Understandable:** stated in a way that is understandable to everyone;

- **Independent:** contribute independently to the overall performance of an alternative.

Duncan Water Use Plan Example

Appendix A provides objectives and evaluation criteria from the Duncan WUP. We recognize that each system is unique, as are the Indigenous communities and stakeholders with interests in the region, but there are enough similarities between the Nechako system and the Duncan system to provide a good example and serve as a reference. Jayson Kurtz, coordinator for the WEI Technical Working Group was part of the technical team for the Duncan WUP. He can share his experience from that process.

APPENDIX A: DUNCAN WATER USE PLAN EXAMPLE

The information from the Duncan Water Use Plan (WUP) is presented here to provide information and context to support the discussions at the Water Engagement Initiative (WEI) Table.

The key interests identified as part of the Duncan WUP included:

- Cultural Resources and Heritage
- Fish
- Flood Management (Erosion Protection)
- Power Generation
- Quality of Life – Mosquitoes
- Recreation and Tourism
- Wildlife.

The Duncan WUP Consultative Committee (equivalent to the WEI Main Table) explored issues and interests affected by operation of BC Hydro's Duncan Dam facility and agreed to the following fundamental **objectives** for the Duncan Dam Water Use Plan:

Cultural Resources

- Protect cultural sites and resources from erosion in the Duncan Reservoir.
- Protect cultural sites and resources from exploitation in the Duncan Reservoir.
- Provide opportunities for archaeological investigation in the Duncan Reservoir.
- Maintain the cultural, aesthetic and ecological context of important cultural resources and spiritual sites.
- Maximize abundance and diversity of fish and wildlife populations to support First Nations harvesting and associated activities in the reservoir and along the lower Duncan River.

Fish

- Maximize fish abundance and diversity.

Flood Management (and Erosion Protection)

- Minimize the flood damage to people and property on the lower Duncan River.

Power Generation

- Minimize economic impacts to both the Kootenay River and the Columbia River generation system.

Quality of Life – Mosquitoes

- Maximize the quality of life for residents in the Duncan Dam area.

Recreation

- Maximize the quantity and quality of the recreational experience.

Wildlife

- Maximize the quality and quantity of available habitat area for wildlife.

Recreation

4.5.3 Objective and Sub-objectives

Table 4-3 summarizes the Recreation objective and sub-objectives developed by the Consultative Committee for the Duncan Dam water use planning process.

Table 4-3: Recreation Objective and Sub-objectives

Objective	Maximize the quantity and quality of the recreational experience
Sub-objectives	Maximize Reservoir Access (boating, shoreline facilities, etc.)
	Minimize mosquitoes[1]
	Maximize visual quality (aesthetics)
	Maximize safety (people stranding, debris and stump hazards)[2]

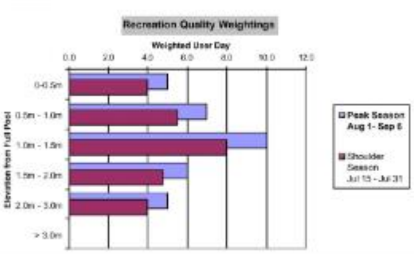
[1] No mosquito-human issues were associated with the reservoir area.

[2] While acknowledging that safety issues are important, it was recognized that none of the identified reservoir issues (in the Issues Report) were known to occur with any regularity and that the debris management program has greatly assisted with minimizing debris hazards.

4.5.4 Performance Measures

Table 4-4 summarizes the Duncan Reservoir Recreation performance measure used by the Consultative Committee to evaluate operating alternatives for the Duncan Dam facility. No performance measures were identified for recreation on the lower Duncan River.

Table 4-4: Duncan Reservoir Recreation Performance Measure

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Recreation Quality	Number of weighted user days the reservoir is at preferred elevations	Weighted usable recreation days based on reservoir levels during the peak recreation season. Where $Weight_{Day}$ is determined from the following table:  	Duncan Reservoir	See dates in description

The ***Recreation Quality*** performance measure is defined as ***the number of weighted user days the Duncan Reservoir is at preferred elevations***. This performance measure estimates the quality of recreation in the reservoir under different operating alternatives.

Quality of Life-Mosquitoes

Table 4-6: Quality of Life – Mosquitoes Objective and Sub-objectives

Objective	Maximize the quality of life for residents in the Duncan Dam area
Sub-objectives	Minimize the nuisance from mosquitoes[1]
	Minimize high coliform bacteria levels in Duncan Reservoir
	Minimize infectious diseases spread by mosquitoes(West Nile)

[1] No mosquito issues were associated with the Duncan Reservoir area.

4.6.4 Performance Measure

Table 4-7 summarizes the Quality of Life – Mosquitoes performance measure used by the Consultative Committee to evaluate operating alternatives for the Duncan Dam facility.

Table 4-7: Quality of Life – Mosquitoes Performance Measure

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Mosquito Breeding Habitat[1]	Weighted area-days inundated after Lardeau freshet 1 July to 31 August	Calculates the weighted inundated area based on the following weightings: • 1st Inundation: weight = 1 • 2nd Inundation: weight = 0.5 • 3rd Inundation: weight = 0.05	Lower Duncan River	1 July to 31 August

[1] This performance measure was merged with the Flood Risk performance measure into the Flood/Mosquito Risk performance measure because they behaved identically.

Fish

Table 4-11: Fish Objective and Sub-objectives

Objective	Maximize fish abundance and diversity
Sub-objectives	Duncan Reservoir: • Maximize littoral productivity • Maximize pelagic productivity • Minimize fish stranding • Minimize egg mortality associated with tributary backwatering • Minimize entrainment risk • Maximize white sturgeon populations • Maximize burbot spawning success • Maximize bull trout populations • Maximize tributary access to spawning tributaries • Maximize nutrient loading in the North Arm of Kootenay Lake from Duncan Reservoir Lower Duncan River: • Minimize fish stranding risk • Minimize total gas pressure (TGP) effects • Minimize temperature effects • Maximize tributary access • Maximize habitat suitability • Maximize food availability • Minimize any fish passage issues in the mainstem

4.7.5 Performance Measures

4.7.5.1 Duncan Reservoir

Table 4-12 summarizes the Duncan Reservoir Fish performance measure.

Table 4-12: Duncan Reservoir Fish Performance Measure

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Fish Stranding Risk	*Average Daily Dewatered Area m^2*	*Days where reservoir elevations are decreased, the average dewatered area is calculated and reported for the year.*	*Duncan Reservoir*	*Year-round*

The ***Fish Stranding*** performance measure is defined as ***the average daily dewatered area in the Duncan Reservoir***. This performance measure estimates the relative risk of fish stranding in Duncan Reservoir under different operating alternatives.

Table 4-13: Duncan River Fish Performance Measures

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Kokanee and Whitefish Effective Spawning Habitat	Hectares of effective spawning habitat	HEC modelling results are integrated with instream flow data to determine the amount of spawning habitat that remains effective to the end of incubation.	Lower Duncan River Mainstem and Sidechannels	Kokanee: spawning 7 September to 21 October and incubating to 15 June Whitefish: spawning 21 October to 21 December and incubating to 31 May
Whitefish Effective Spawning Habitat Lost	Hectares of effective spawning habitat lost	HEC modelling results are integrated with instream flow data to determine what habitat was available during spawning, but subsequently dewatered during incubation.	Lower Duncan River Mainstem	Whitefish: spawning 21 October to 21 December and incubating to 31 May
Rainbow Effective Rearing Habitat Lost	Hectares of effective rearing habitat lost	HEC modelling results are integrated with instream flow data to determine the amount of rearing habitat that is dewatered over a running 10-day rearing period.	Lower Duncan River Mainstem	Rainbow: rearing 1 April to 31 October
Significant Events (>0.2 m and >0.45 m) Measures	*Number of stranding events*	*Based on HEC modelled overall river stage versus flow relationship, counts the number of times dam operations cause a downstream stage change >0.2 m and 0.45 m*	*Lower Duncan River Mainstem*	*Year-round*

Table 4-13: Duncan River Fish Performance Measures (cont'd)

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Total Gas Pressure Days/Events	*Number of Total Gas Pressure Days and Events*	*Based on an empirical relationship between spill magnitude and TGP concentration, counts the number of days TGP exceeds 115% through spilling and the number of events where consecutive days exceed 115%.*	*Lower Duncan River (spillway plunge pool)*	*Year-round (bull trout transfer set 1 May to 15 September)*
Whitefish and Kokanee Effective Spawning Habitat Lost	Hectares of effective spawning habitat lost	HEC modelling and field validation is integrated with instream flows to calculate sidechannel-wetted areas. The amount of habitat available during spawning but subsequently lost over incubation is calculated.	Lower Duncan River Sidechannels	Kokanee: spawning 7 September to 21 October and incubating to 15 June Whitefish: spawning 21 October to 21 December and incubating to 31 May
Rainbow Effective Rearing Habitat	*Hectares of effective rearing habitat*	*HEC modelling and field validation is integrated with instream flows to calculate sidechannel-wetted areas. The minimum amount of habitat available over a running 10-day period is calculated.*	*Lower Duncan River Sidechannels*	*Rainbow: Rearing 1 April to 31 October*
Rainbow and Kokanee Effective Rearing Area Lost	*Hectares of effective rearing habitat lost*	*HEC modelling and field validation is integrated with instream flows to calculate sidechannel-wetted areas. The amount of rearing habitat dewatered over a running 10-day period is calculated.*	*Lower Duncan River Sidechannel*	*Kokanee: emigration 1 April to 31 May* *Rainbow: Rearing 1 April to 31 October*

Cultural Resources

4.8.3 Objective and Sub-objectives

Table 4-15 summarizes the Cultural Resources objectives developed by the Heritage and Cultural Subcommittee and presented to the Consultative Committee for the Duncan Dam water use planning process.

Table 4-15: Cultural Resources Objectives

Objectives	Protect cultural sites and resources from erosion in the Duncan Reservoir
	Protect cultural sites and resources from exploitation in the Duncan Reservoir
	Provide opportunities for archaeological investigation in the Duncan Reservoir
	Maintain the cultural, aesthetic and ecological context of important cultural resources and spiritual sites
	Maximize abundance and diversity of fish and wildlife populations to support First Nations harvesting and associated activities in the reservoir and along the lower Duncan River (*included in Fish and Wildlife Performance Measures*)

Cultural Resource Performance Measures

Table 4-16: Cultural Resources Performance Measure

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Cultural Site Erosion	Number of weighted days reservoir is operated within specified bands	The number of days the reservoir elevation is operated in each band where cultural sites exist multiplied by a weighting factor to consider the impacts of dewatering or inundation.	Duncan Reservoir	Year-round
Exploitation Impacts	*Number of weighted days reservoir is at undesirable elevations*	*The duration of time the reservoir is operated within elevation bands where cultural sites exist by a weighting factor describing site importance.*	*Duncan Reservoir*	*Key times in the spring, summer and fall*

The ***Cultural Site Erosion*** performance measure is defined as ***the number of weighted days the reservoir is operated within specified bands***. This performance measure estimates the impact of Duncan Dam operations on the protection and integrity of cultural sites identified in the Duncan Reservoir drawdown zone within two ranges of reservoir elevations (1) 552 m to 567 m, and (2) above 575 m, under different operating alternatives.

Wildlife

4.9.3 Objective and Sub-objectives

Table 4-19 summarizes the Wildlife objective and sub-objectives developed by the Consultative Committee for the Duncan Dam water use planning process.

Table 4-19: Wildlife Objective and Sub-objectives

Objective	Maximize the quality and quantity of available habitat area for wildlife
Sub-objectives	• Maximize riparian (wetland) production for breeding and migration habitat • *Maintain a diversity (species and age classes) of riparian habitats in the lower Duncan River using cottonwood as an indicator* • *Maximize herbaceous and shrub communities in the Duncan Reservoir*

Table 4-20: Duncan Reservoir Wildlife Performance Measures

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Riparian Productivity - Long-term Median	Hectares of herbaceous riparian habitat	Calculates the area between full pool and the long-term median elevation over the growing season that has been shown in other reservoirs to be a good approximation of grassland habitat.	Duncan Reservoir drawdown zone	Growing season 1 April to 31 October
Riparian Productivity - Inundation Tolerance	Hectares of herbaceous (grass/sedge) area Hectares of shrub (sedge/willow) area	Using inundation tolerances based on results in other reservoirs and professional opinion, calculates the area of potential riparian growth divided between shrubs and herbaceous within the drawdown zone.	Duncan Reservoir drawdown zone	Growing season 1 April to 31 October

The ***Riparian Productivity - Long-term Median*** performance measure is defined as ***the area of herbaceous vegetation in the drawdown zone above the long-term median reservoir elevation mark.***

The ***Riparian Productivity - Inundation Tolerance*** performance measures are defined as ***the area of potential grassland and shrub growth areas in the reservoir drawdown zone.***

Table 4-21: Lower Duncan River Wildlife Performance Measure

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Cottonwood hydrograph weighted index	0 to 1 scale where 1 represents an optimal cottonwood hydrograph	Three criteria define a cottonwood hydrograph: a. Peak flows in July; b. Recession of flows by late August; and c. Lower base flows until the following freshet.	Lower Duncan River	Year-round
	It was also represented as a percentage	The performance measure quantifies the difference between the operation and the cottonwood hydrograph targets.		

Flooding

Table 4-22: Flood Issues

Issue	Description and Action
Local Inundation	When high flow events occur on the lower Duncan River, there are a several areas of private property within the floodplain known to have inundation problems. These include Cooper Creek Sawmill, other low lying property and several hay fields including Rempell and Deer farms. Observations of locations and discharge flows at which flooding started to occur was documented during the high flow event in July 2002. Flooding in the lower Duncan River occurs as a result of water table increase and seepage through dikes and natural barriers at combined Lardeau/Duncan rivers discharges of approximately 400 m^3/s. Above this flow, surface water begins to flow over natural barriers and dikes increasing the degree to which low lying areas are being flooded. Three levels of risk were defined based on observed flooding impacts: **400 m^3/s** – No surface water pooling in farmland, **450 m^3/s** – Water overtop banks at Cooper Creek Cedar, low level flooding at Rempell and Jacobs properties, and **500 m^3/s** – Water into electrical shed at Cooper Creek Cedar – mill shut down. Extensive flooding of low lying hayfields. Timing of flooding (after 7 August) could benefit hay farmers; however, timing would not impact flooding impacts at Cooper Creek.

Table 4-22: Flood Issues (cont'd)

Issue	Description and Action
Local Inundation (cont'd)	It is known that localized flooding can and does occur because of uncontrolled discharges of Meadow Creek and the Lardeau River (independently of discharges from the Duncan Dam). The carrying capacity of Meadow Creek channel is currently below that of freshet flows and, therefore, flooding impacts are exacerbated by constrictions associated with culvert and bridge crossings on Highway 21. The Lardeau River is also known to cause flooding events when the Duncan Dam is releasing its minimum flow release. Flooding in the lower portions of the river are also known to be exasperated when Kootenay Lake levels are high (which is typically the case during freshet flows in the late spring). BC Hydro is developing a communication protocol, which would provide advanced notice of potential flooding for farmers and other property owners subject to flooding in the floodplain to assist in proactive response to potential flooding. A performance measure was developed.
Erosion	Erosion was an important issue for some local residents. Erosion was speculated to have increased as a result of higher flows being released in the winter time, which causes scouring behind the frozen face of the banks of the river and sidechannels, and then the outer frozen face of the bank caving in once temperatures increase. Erosion problems are thought to exist adjacent to two properties: (1) owned by Chris von Ruh (formerly owned by Roy Lakes); and (2) referred to as the Wasden farm. M. Miles and Associates (2002) undertook a review of channel stability in the lower Duncan River with an overview assessment of erosion. Erosion is thought to be an ongoing process in the lower Duncan River, which will continue regardless of dam operations and can be influenced by man's activities (cutting of riparian vegetation, land use patterns, etc.) (Miles, 2002b). A performance measure was not developed.

4.10.3 Objective and Sub-objectives

Table 4-23 summarizes the Flood objective and sub-objectives developed by the Consultative Committee for the Duncan Dam water use planning process.

Table 4-23: Flood Objective and Sub-objectives

Objective	Minimize the flood damage to people and property on the lower Duncan River
Sub-objective	• Minimize flooding on the lower Duncan River • Minimize effects of erosion and sediment deposits • Maximize flexibility of operations to deal with flooding issues • *Minimize log jams in the lower Duncan River*

4.10.4 Performance Measures

Table 4-24 summarizes the Flood Risk performance measure used by the Consultative Committee to evaluate operating alternatives for the Duncan Dam facility.

'able 4-24: Flood Performance Measure

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Flood Risk[1]	Annual average number of days that flows in the lower Duncan River exceed threshold levels	Three threshold levels have been identified as follows: • 400 m^3/s • *450 m^3/s* • *500 m^3/s* These flows include tributary inflows from the Lardeau River.	Lower Duncan River	Year-round

This performance measure was merged with the Mosquito Breeding Habitat performance measure into Flood/Mosquito Risk performance measure because they behaved identically.

The ***Flood Risk*** performance measure is defined as ***the number of days that flows in the lower Duncan River exceeds threshold levels***. This performance measure estimates the quantity of flooding under different operating alternatives.

Performance measure results for >450 m^3/s and >500 m^3/s flood threshold indicated a lack of sensitivity across the range of operating alternatives, and were therefore dropped from further consideration. The >400 m^3/s flood threshold was utilized throughout the Duncan Dam water use planning process.

4.10.3 Objective and Sub-objectives

Table 4-23 summarizes the Flood objective and sub-objectives developed by the Consultative Committee for the Duncan Dam water use planning process.

Table 4-23: Flood Objective and Sub-objectives

Objective	Minimize the flood damage to people and property on the lower Duncan River
Sub-objective	• Minimize flooding on the lower Duncan River • Minimize effects of erosion and sediment deposits • Maximize flexibility of operations to deal with flooding issues • *Minimize log jams in the lower Duncan River*

Power Generation

4.11.3 Objective and Sub-objectives

Table 4-25 summarizes the Power Generation objective and sub-objectives developed by the Consultative Committee for the Duncan Dam water use planning process.

Table 4-25: Power Generation Objective and Sub-objectives

Objective	Minimize economic impacts to both the Kootenay River and the Columbia River generation system.
Sub-objectives	• Maximize revenue from energy sales • Minimize negative impacts to Kootenay Lake (e.g., IJC Order) • Minimize negative impacts on ancillary services

4.11.4 Performance Measures

Table 4-26 summarizes the Power Generation performance measures used by the Consultative Committee to evaluate operating alternatives for the Duncan Dam facility.

Table 4-26: Power Generation Performance Measures

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Operation Flexibility	Number of days that operations are constrained	Impacts to other Columbia River projects (U.S./Canada)	All plants in Canada affected by Duncan operations	Year-round
Power – Kootenay River	*Megawatt-hours (MWh)*	*The average annual power from the combined power generation of the Kootenay River plants*	*Kootenay River plants*	*Year-round*
Financial Revenue - Kootenay River and Lower Columbia River	*Net Annual Average of Generation $/year compared to Alt A – Current Operations*	*The estimated average annual value of electricity (VOE) from the combined power generation of the Kootenay River and lower Columbia River plants.*	*All plants in Canada affected by Duncan operations*	*Year-round*
Financial Revenue – Kootenay River	Net Annual Average of Generation $/year compared to Alt A – Current Operations	The VOE from the combined power generation of the Kootenay River plants.	Kootenay River plants	Year-round
Financial Revenue – Lower Columbia River	Net Annual Average of Generation $/year compared to Alt A – Current Operations	The VOE from the power generation at ALGS on the lower Columbia River.	ALGS	Year-round

REFERENCES

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