



COLUMBIA RIVER TREATY REVIEW

Environmental Discussion Paper November 2012



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About the Discussion Paper

The discussion paper focuses on those interests which may be impacted by potential alterations in reservoir elevations and discharge levels at storage facilities in the Columbia River Basin that are related to the Columbia River Treaty.

The first two chapters of this discussion paper summarize the various environmental interests as they relate to water management in the Columbia River Basin and give examples of activities and initiatives conducted to address those interests. Following chapters will build on these interests and explore how different potential water management scenarios reflecting future Columbia River Treaty decision options could impact or enhance key environmental values in the Canadian Columbia Basin.

The discussion paper was commissioned by the Ministry of Energy, Mines and Natural Gas of British Columbia and is based on the report of the spring 2012 consultations conducted by the Columbia River Treaty review team, BC Hydro's Non-Treaty Storage Agreement consultation reports, Water Use Plans, Summary Report of local consultations conducted by the Columbia Basin Trust, and other documentation. It was prepared by Dr. Glen Hearn, of Aristos Consulting, and does not necessarily reflect the position or opinion of the Province.

Acronyms and Definitions

AOP	Assured Operating Plan	The prescribed operations of the Columbia River Treaty facilities 5 years in advance
	Canadian Entity	BC Hydro, and the Province for the disposal of the Canadian Entitlement
CBT	Columbia Basin Trust	A provincial Crown Corporation with a mandate to invest in the economic, social and environmental well-being of residents in the Canadian Columbia Basin
CRT	Columbia River Treaty	An agreement between the US and Canada to build storage facilities in Canada to optimise for flood control and power generation in both Canada and the US
DOP	Detailed Operating Plan	The operations of the Columbia River Treaty facilities as agreed to each year
DFO	Department of Fisheries and Oceans	Federal Agency primarily responsible for managing ocean fisheries and Species At Risk Act listed fish species
EC	Environment Canada	Federal Agency primarily responsible for protection of water resources, conservation of wildlife (under the Species At Risk Act and Migratory Birds Convention Act) and prediction of weather and climate conditions
	Entrainment	Entrainment is narrowly defined in this report as the killing or physical damage of fish from turbine abrasion and/or spillways at hydro-electric facilities
kcfs	thousand cubic feet per second	Measure of volume of water flow: 1 kcfs = 28 m ³ /s
m ³ /s	cubic meters per second	Measure of volume of water flow: 28 m ³ /s = 1 kcfs
MOE	Ministry of Environment	Provincial agency responsible for fish and wildlife management in British Columbia
NTSA	Non-Treaty Storage Agreement	A commercial agreement between Bonneville Power Administration and BC Hydro to address additional storage built when constructing Columbia River Treaty dam.
SARA	Species at Risk Act	Federal legislation protecting species at risk across Canada
	US Entity	US Army Corps of Engineers and Bonneville Power Administration
TDG	Total Dissolved Gas (also TGP – Total Gas Pressure)	Level of saturation of water with gases that can occur during spill events at hydro generating stations and naturally at waterfalls and rapids
WLR	Water License Requirements	The Water Act requires BC Hydro to hold licenses for water storage and to operate facilities. These may involve operations, physical works, studies, and engagement processes. Requirements include the provision of public access and mitigation measures to address impacts to non-power interests such as fish and wildlife

Columbia River Treaty: Environmental Issues Discussion Paper

Introduction

The paper is for discussion purposes to provide a starting point for Columbia Basin residents and the Province to identify ecosystem function and environmental interests inside and outside of the scope of the Columbia River Treaty. This understanding will help to inform the provincial strategic decision around the future of the Columbia River Treaty.

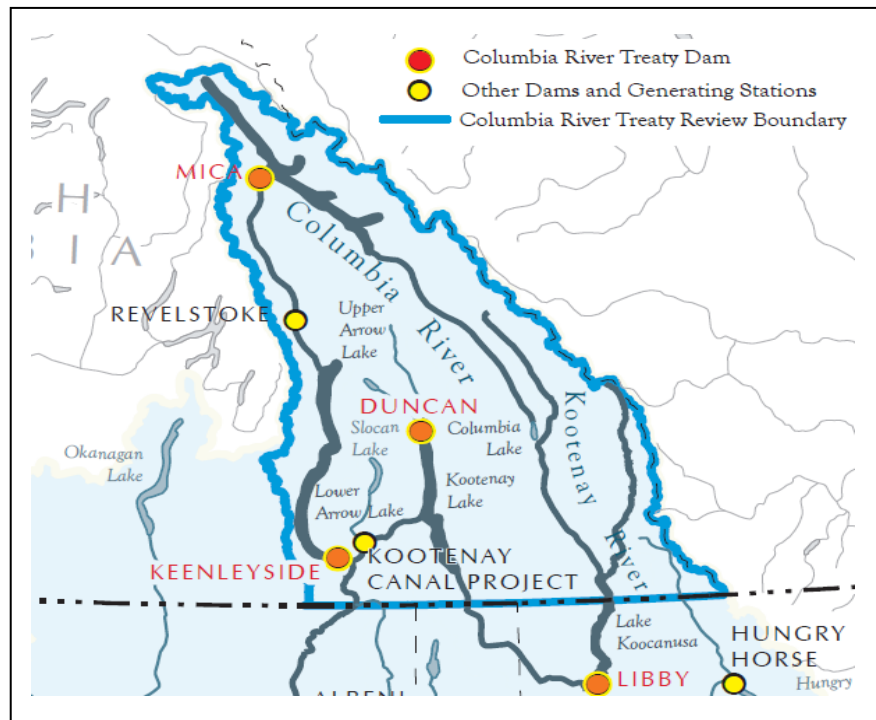
This *Discussion Paper* is being developed in stages throughout the review process. The first two chapters summarize the various environmental interests as they relate to water management in the Columbia Basin and gives examples of activities and initiatives conducted to address those interests. These chapters are based on a literature review focusing on BC Hydro's Non-Treaty Storage Agreement (NTSA) consultation reports, Water Use Plans (WUP), Fish and Wildlife Compensation Plan (FWCP) reports and other documentation, and public consultation undertaken by the Province in spring 2012. It does not necessarily reflect the position or opinion of the Province.

The Water Use Plan process, the Non-Treaty Storage Agreement and the FWCP are all based on forward looking approaches; in other words, the recognition that environmental and social impacts have occurred in the Columbia River Basin with dam building, but incremental operational changes at the hydro-electric facilities, and physical works in the Basin can be undertaken to offset some of these impacts. This report does not provide an in-depth accounting of what has been impacted, but rather a summary of the mitigation and compensation efforts to date resulting from the WUP, NTSA, FWCP and other processes.

Subsequent chapters will build on the interests identified during the Treaty Review, and explore how different potential water management scenarios reflecting future Columbia River Treaty decision options could impact or enhance key environmental values in the Canadian Columbia Basin. Hydrological modelling studies will form the basis of this evaluation. Related input and feedback received throughout the review process will also be reflected.

The geographical scope of the research encompasses the main-stem of the Columbia River from Kinbasket reservoir and tributaries and the Columbia River to its headwaters, to the border with the United States; the Duncan watershed, Kootenay Lake and the lower Kootenay River to the confluence with the main stem Columbia River; the Kooconusa watershed and Kootenay River as it enters into Kootenay Lake. Okanagan Basin issues are being addressed in a separate process.

Columbia River Treaty Review Area Map:



The Columbia River Treaty

The Columbia River Treaty (the Treaty) is an agreement between the United States (U.S.) and Canada to develop and operate upstream storage in B.C. in order to provide a regulated flow on the Columbia and Kootenay¹ rivers, and optimise flood control and power generation in both countries. Under the agreement, 15 Million Acre Feet of active storage would be built in Canada at Mica, Hugh Keenleyside and Duncan dams. The Treaty provides for the U.S. to compensate Canada for the ‘downstream benefits-increased power generation’ the U.S. could realize (under the assumed conditions); and it permitted the U.S. to construct the Libby dam and associated Kooconusa reservoir, which extends into B.C. Most of the benefits and obligations under the Treaty were transferred to BC in the separate 1963 Canada-BC Agreement.

There is no official ‘expiry date’ of the Treaty. The Treaty can be terminated by either Canada or the U.S. by giving a minimum 10 years notice to the other. The earliest possible termination is in 2024, and therefore 2014 is the latest year that notice can be given to terminate the Treaty at its earliest date.

It is critically important therefore to review environmental interests potentially affected by the Treaty to assist the government in developing a strategy with respect to 2014.

The Non-Treaty Storage Agreement refers to the extra storage Canada built in Canada. When Mica dam was constructed an extra 5 Million Acre Feet of storage was constructed. The Revelstoke dam was also constructed but is not part of the Treaty. The filling and use of the extra storage at Mica as well as the filling of the storage at Revelstoke had to be agreed to by the US and was done under the initial Non-Treaty Storage Agreement. This agreement was renegotiated periodically and a long term Non Treaty Storage Agreement was signed in April 2012 to last until 2024.

¹ The spelling is Kootenai in the U.S.

The improved regulation (smoothing out of seasonal variations in stream flows) on the Kootenay River provided by Duncan and Libby made additional generation on the Kootenay River economic. This was provided for by the construction of the Kootenay Canal project (KCL) in parallel with Cominco's & West Kootenay Power's (WKP) existing Corra Linn, Upper Bonnington, Lower Bonnington and South Slokan projects. This more efficient BC Hydro owned project was coordinated with the existing projects under the terms of the Canal Plant Agreement (CPA) - a "one-operator" co-ordination agreement. Under the terms of this agreement, BC Hydro directs the operation of all the projects and retains the actual generation of all the projects. In return the Entitlement Parties (Cominco, FBC and CPC/CBT) receive a specified amount of electricity (capacity and energy) referred to as the Basic Supply or CPA entitlement.

Chapter 1: Environmental Interests in the Columbia Basin.

This chapter examines environmental interests and values in the Columbia Basin and their relation to water management and the operations of storage facilities. Interests and values included in this chapter reflect perspectives shared during Water Use Plans, consultations for the Non-Treaty Storage Agreement, Revelstoke 5 and Mica 5/6 upgrades, and public consultation undertaken by the Province in Spring 2012. Awareness and education sessions conducted by the Columbia Basin Trust in the fall of 2011, as well as a Columbia River Treaty young leader's event in winter 2012 also drew out perspectives from across the basin.²

1.1 Groups Involved with Environmental Interest Setting in the Columbia Basin

Various groups, agencies and levels of governments have expressed environmental interests and have participated in mitigation activities in the Columbia Basin including, but not limited to:

First Nations: First Nations have well developed and long standing interests in environmental matters and associated constitutionally protected aboriginal rights. Principles of environmental stewardship are of central and profound cultural importance for many Columbia Basin First Nations. Many express their perspective that all species and ecosystems are important to their cultures. That said they have expressly emphasised certain elements or areas that are of particular spiritual, cultural, or ceremonial significance as well as those that enable them to harvest for foods or medicines. Columbia Basin First Nations have also over the years articulated a strong desire to have anadromous salmon populations returned to historic harvesting and habitat areas in the upper Columbia River.

Local communities and the Columbia Basin Trust: Local communities have expressed environmental interests in a number of ways, including maintaining ecosystem functioning, climate change impacts, conservation of specific species and sustainable use of resources including recreational fishing and hunting.

Columbia Basin Trust: The Columbia Basin Trust was created by the Province in 1995 and helps create and support mechanisms for Basin residents to actively and meaningfully participate in water management decisions at local and regional levels and actively participated in both the Columbia and Duncan Water Use Plans. The Columbia Basin Trust has directly contributed to the enhancement of fish and wildlife by providing over \$3 million in funding over the past five years for environmental conservation, restoration, stewardship and education projects across the Basin.

² <http://gov.bc.ca/columbiarivertreaty/community-sessions/>; and http://www.cbt.org/crt/assets/pdfs/2011InformationSessionSummaries_CRTSummaryReport.pdf

Provincial Ministry of Environment (MOE) and Ministry of Forests, Lands and Natural Resources Operations (MFLNRO): MOE and MFLNRO are the provincial natural resource agencies that manage the province's ecological and biodiversity heritage. MOE supports BC in leading in sustainable environment management by ensuring clean and safe water, land and air, and healthy and diverse native species and ecosystems. MFLNRO delivers integrated natural resource management services for British Columbians. It is the main agency responsible for establishing the policy and conditions for access to, and use of the province's forest, land and natural resources (including the management of fish and wildlife for recreational purposes). The agencies' activities, with regard to species and ecosystems conservation and management, are guided by a number of strategic documents – the Conservation Framework and Program Plans for Fisheries, Wildlife and Ecosystems. MOE and MFLNRO are key partners in the Fish and Wildlife Compensation Program and participated in the Water Use Plans held in the region.

Federal government – Departments of Fisheries and Oceans and Environment Canada: The Federal government has environmental interests in the Columbia Basin that are executed primarily through the activities of the Department of Fisheries and Oceans and Department of Environment. Under the Fisheries Act, the Department of Fisheries and Oceans is the primary agency responsible for conserving and managing Canada's fisheries, including Pacific salmon. It does so through management and monitoring of fisheries, protection of fish habitat, and pollution prevention (note: Environment Canada administers section 36 of the Fisheries Act, the key pollution prevention provision, prohibiting the deposit of harmful substances into waters frequented by fish unless otherwise authorized under regulation). The Policy for the Management of Fish Habitat (1986) has an overall objective of "net gain" of fish habitat and helps guide the implementation of fish habitat protection through collaboration with relevant provincial agencies.

Environment Canada is the lead federal agency for implementation of the *Migratory Birds Convention Act* (MBCA) and the *Species at Risk Act* (SARA). The MBCA implements the Migratory Birds Convention (1916 Canada-U.S. treaty) and establishes Environment Canada has the lead agency for the conservation of migratory bird populations listed under the MBCA. This includes most birds, with the notable exception of raptors (hawks, eagles, falcons, owls etc) as well as a handful of other species. Similar legislation in the United States protects birds species found in that country, with minor differences. An important mechanism for implementing bird conservation across North America are the 'joint ventures', partnerships between governments, conservation organizations, industry and others. The Canadian Intermountain Joint Venture covers the entirety of the Columbia Basin in Canada and includes BC Environment and many other partners. The focus of the JV is on 'all bird' (i.e. provincial and federal species) habitat conservation. BC Hydro has traditionally been a partner in the CIJV.

Responsibility for the conservation of species at risk in British Columbia is shared between the federal and provincial governments. The *Accord for the Protection of Species at Risk*, an agreement between Canada and her provinces, identifies high level commitments. Federal responsibilities for species at risk conservation are articulated in Canada's *Species at Risk Act* (SARA). The Species at Risk Act mandates species assessment, listing, protection and recovery for species listed under Schedule 1 of the act. SARA also requires, to the extent possible, consultation or cooperation with directly affected parties, particularly First Nations. Responsibilities under SARA are shared, with the Minister of Fisheries responsible for aquatic species managed under the *Fisheries Act* and Environment Canada or Parks Canada responsible for terrestrial species (the latter only where species at risk occur on lands under their jurisdiction, such as National Parks). In recognition of established jurisdictions, SARA contemplates provincial leadership for species that are not managed under the *Fisheries Act* or the *Migratory Bird Convention Act*, or which occur off of federal lands, but does contain mechanisms for broader application to facilitate species recovery.

The *Canada-British Columbia Agreement on Species at Risk* articulates respective roles and responsibilities and as well establishes planning, coordination and information sharing mechanisms. In most circumstances, recovery planning for species other than aquatic species or migratory birds is led by BC Environment. Provincial recovery documents are then adopted, with some modifications to meet SARA requirements, by federal agencies.

In addition to wildlife protection roles and responsibilities, Environment Canada is engaged in water management activities through implementation of a hydrometric monitoring agreement (Water Survey of Canada) and a water quality monitoring agreement with British Columbia. The Department of Environment Act specifies a role in relation to the management of boundary waters under the International Joint Commission. Also of relevance to water management responsibilities is the *International River Improvements Act (IRIA)*. This Act provides for licensing of “improvements” on waters flowing from Canada to the U.S. (e.g. dams, obstructions, canals, reservoirs or other works that can alter trans-boundary flows). The three Canadian dams constructed under the Columbia River Treaty are licensed by Environment Canada under the *IRIA*, as are other non-treaty dams on the Canadian Columbia and Kootenay systems.

BC Hydro: As the operator of the major storage facilities in the region, BC Hydro plays a critical role addressing environmental interests. It does so primarily through funding and participating in the Fish and Wildlife Compensation Program, engaging in Water Use Planning and conducting operational changes, physical works and monitoring studies as part of water licensing requirements (WRL). BC Hydro is the Canadian Entity under the Columbia River Treaty and is able to negotiate through mutual consent with its counterparts in the United States modifications to the Assured Operating Plan (AOP) flow in the Columbia River to benefit environmental issues in Canada.

Columbia Operations Fisheries Advisory Committee (COFAC): COFAC was established in 1994 to provide a structured forum for the exchange of information pertaining to the coordination of activities between utilities related to the operation of hydro projects on the Columbia River system in Canada and associated fisheries issues.³ The mandate of the Committee is to share information regarding hydro-power operations in the Columbia system and associated fisheries issues; provide recommendations on project operations, identify where further agency involvement is needed, and to facilitate agency approval for operational changes, including communication and cooperative action to enhance the operation of the Columbia River system for the benefit of Canadians.

1.2. Regional Environmental Interests

Table 1 outlines a preliminary list of the different interests expressed by various groups in a range of different processes. In listing regional values, it should be emphasized that communities throughout the region have expressed an interest in ensuring sustainability in dealing with water management in the future.⁴ In the spring 2012 public consultations conducted by the Province, many residents, particularly youth, expressed a desire for greater transboundary collaboration to enhance ecosystem function at the basin-level. In effect, there is a growing interest in a mechanism for discussing governance of ecosystems, fish and wildlife across the Basin than currently exists.

The Spring 2012 consultation also underscored the importance of climate change. Some climate models suggest that there may be increased winter precipitation combined with glacial recession⁵

³ Membership includes: BC Hydro (BC Hydro), the Federal Department of Fisheries and Oceans (DFO), and the provincial Ministry of Environment, Lands, and Parks [now the Ministry of Environment], Canadian Columbia River Inter-Tribal Fisheries Commission (CCRIFC), West Kootenay Power (now FortisBC), Columbia Power Corporation (CPC), Teck Cominco Metals Ltd. (TCML) and Okanagan Nation Alliance (ONA).

⁴ CBT – Engagement and Education Report 2012.

⁵ Bruce, J. M., H; Alden, M, Mortsch, L; Mills, B (2003). Implications of climate change for Canada-U.S. Boundary Water Agreements. *Report for Natural Resources Canada*. Annex A

which will have implications for flood control as well affecting water levels in the Columbia Basin. The overall contribution from B.C. to the Columbia River is thus expected to increase under climate change scenarios. Residents expressed an interest to understand the implications of these changes, what adaptation strategies are being considered, and how the future of the Treaty may ensure flexibility to respond to change.

In numerous forums and processes, a desire has been expressed to restore salmon to the Columbia River in Canada if it can be technically and economically feasible. This is a key priority among First Nations.

Table 1 : Regional Interests in the Columbia Basin with Respect to Water Management

Category	Main Interest	Specific interests and values
General	Sustainability	The future of water management in the Basin should address a wide range of interests including social, economic and environmental values.
Environment and Climate Change	Climate Change	Minimize negative impacts associated with climate change. Understand and develop adaptation strategies. Ensure flexibility in the Columbia River Treaty to respond to climate change impacts.
	Ecosystem function and resilience	Maximize the diversity, productivity and resilience of the ecological systems, including supporting nutrient programs, supporting a more natural hydrograph, flooding for riparian (cottonwood) productivity, flushing flows, preservation, enhancement of wetlands etc.
	Fish and Aquatic Resources	Maximize the abundance, diversity and condition of wild, indigenous fish stocks and conservation, protection and restoration of fish habitat in the Columbia River system, including lakes and reservoirs, and rivers. In particular for rainbow trout, white sturgeon, cutthroat trout, bull trout (Dolly Varden), kokanee, whitefish, and burbot. This includes access to tributaries for spawning, minimum flows, gravel additions and stream complexing, entrainment, TGP, etc. It also includes a desire to restore salmon to the Canadian Columbia River if technically and financially feasible.
	Wildlife and vegetation	Maximize the wildlife abundance and diversity in the Columbia River system, including shorebirds, spring nesting and fall migratory birds (in particular refuge habitat for Great Blue Heron), resident birds, amphibians, bats, reptiles and species associated with hunting interests. Maximize riparian and wetland habitat, diversity and productivity. Including floodplain ecology, grasslands, protected areas, riparian habitat and drawdown zone, wetlands, littoral productivity, and wildlife and nesting habitat. There is a special emphasis on plants for traditional use as well as herbaceous and shrub communities.
Culture and Heritage	Understand and protect cultural artefacts, and archaeological and cultural sites	Maximise understanding of sites and their location. Minimize erosion impacts on potential archaeological zones. Minimize the impact of destructive human behaviour such as traffic and pot hunting on potential archaeological zones. Allow access to archaeological sites by appropriate people.
	Support / ensure First Nations' ability to harvest for food, cultural and ceremonial purposes.	Maximize availability of traditional plants. Maximize abundance and diversity of fish and wildlife populations to that First Nations use for harvesting and associated activities.
	Traditional transportation routes	Maximise ability to move through water system.
Flood & Erosion	Property	Minimize damage to property and injury to people.
Learning	Learning/monitoring and	Maximize learning about the impacts of operations on non-

Category	Main Interest	Specific interests and values
	studies	power objectives and understanding fisheries management plans that are in place, or that need to be developed. Understanding the process for advancing environmental interests, including what legal requirements exist in Canada and the U.S. to include ecosystem function in the Columbia River Treaty.
Recreation and transportation	Commercial transport	Minimize disruptions to commercial navigation/transport.
	Access	Maximize the community benefits from quality and diversity of recreation and tourism.
	Aesthetic Boater Safety	Maximize water and shoreline access, visual quality and boating/swimming safety
Power Generation	Provincial Revenue	Maximize the power benefits <ul style="list-style-type: none"> • Maximize financial value of power. • Maximize ancillary service capability. • Minimize negative impacts to Kootenay Lake (IJC)
Quality of Life	Mosquitos (Duncan River)	Maximize the quality of life for residents (health and nuisance issues)

Table 1 shows the range of interests that have been expressed regarding water management in the Columbia Basin. While some of the interests overlap they have been categorized to simplify discussion and help determine the focus on environmental interests (those in **bold**). Some issues transcend different interest areas. For example flooding and erosion are generally considered as important due to the loss and damage to property; however, they also impact riparian vegetation. Erosion on the one hand may have negative consequences as banks may be removed, however, flooding can provide important vehicles for riparian production such as cottonwood forests. Also, flooding can provide flushing flows important for cleaning the substrate.⁶ These situations are considered as part of **ecosystem function and resilience** and are therefore part of environmental interests.

While the environmental interests outlined in Table 1 pertain to most of the basin, there are specific interests at the local level which are addressed in Table 3 (Chapter 2). Some interests such as entrainment may occur at multiple areas such as Mica, Revelstoke and Keenleyside; whereas other interests are more localised, such as preserving habitat for Blue Heron on Waldie Island.

1.3. Trade-offs

In balancing different interests, trade-offs across the system need to be considered. For example, in many instances, changing operations to meet the needs of fish may have impacts on power generation or flooding of property. In the case of Mica dam it was estimated in the Water Use Plan that restricting operations for fish benefits would cost between \$16M and \$25M/year depending on the operational scenario. In this instance the benefits to fish and recreation were not deemed to outweigh the cost of lost power generation. The trade-offs in some cases will look different depending whether the Treaty continues or is terminated, where in others the trade-off is the same and the issue is purely a domestic issue. This topic of trade-offs is discussed further in Chapter #3.

In some cases there are trade-offs within environmental interests, for example:

- Maintaining high water levels in the autumn to allow kokanee to access spawning channels in Arrow Lakes may negatively impact fall migratory birds.
- There is a hypothesis that burbot spawn in the Duncan reservoir at the interface between the reservoir and the tributaries. Thus stable reservoir levels (+/- 0.25 meters) are believed to be beneficial during incubation (February 15-April 15) to reduce egg loss through

⁶ These were discussed for the lower Columbia River.

dewatering or suffocation from bank erosion. This is at odds with releasing flows that would benefit fish in the lower Duncan River (between the dam and Kootenay Lake) at the same time.

In addition, as dams are interdependent, interests in one location may have negative impacts in another. The ability to manage these different interests will be different if the Treaty continues or is terminated. Examples of some current trade-offs between locations are:

- Rainbow trout flows in the lower Columbia, between April 1 and June 30, have a negative impact on reservoir vegetation and nesting habitat in the Arrow Lakes reservoir. However, they are a benefit to fall migratory birds there.
- Maintaining reservoir levels high in Duncan for tributary access of bull trout and Kokanee may negatively affect tributary access of Kokanee in the Arrow Lakes. The latter of which is a much larger population.

Chapter 2: How Environmental Interests are Currently Managed

This chapter outlines activities, programs and the flexibility within the Treaty that address the negative impacts on environmental interests in the Columbia Basin at both regional and localised levels.

2.1. Communication and Coordination

Dams and their operations necessarily have a great impact to the environment in the Columbia Basin. In conducting operations BC Hydro is in regular communication with the Ministry of Environment, DFO, Environment Canada, First Nations, local power producers, local communities and other groups such as the CBT. Multi-stakeholder groups, such as the Columbia Operations Fisheries Advisory Committee (COFAC), also assist in developing recommendations for operations of storage facilities with the specific interests of fish.

2.2. Fish and Wildlife Compensation Program

The Fish and Wildlife Compensation Program (FWCP) for the Columbia River Basin was originally created in 1995 when several of the existing Columbia Basin fish and wildlife compensation programs were consolidated and a fund was established to provide money in perpetuity to **offset the footprint impacts of BC Hydro dams and reservoirs on fish and wildlife in the Basin.**⁷ An Administrative Agreement was signed in 1999 between the B.C. Ministry of Environment and BC Hydro to formalize the management of the program, which was developed to satisfy the obligations regarding fish and wildlife attached to the Arrow, Duncan, Mica, Kootenay Canal, Seven Mile and Revelstoke project water licenses. The Department of Fisheries and Oceans is also a key partner in the Fish and Wildlife Compensation Program. First Nations and local communities participate in FWCP program planning and administration. Greater First Nation and local communities' participation is currently being sought, to ensure more active local involvement in the planning and delivery of the compensation program.

The FWCP currently does not address footprint impacts in the Koocanusa Reservoir.

The Fish and Wildlife Compensation Program for the Columbia Basin invests approximately **\$4.3 million**⁸ annually and in perpetuity in projects – in total some \$50 million to date.⁹ The Fish and

⁷ Note BC Hydro has been involved with fish and wildlife projects since the 1980's.

⁸ Note that \$3.2 million/annum is indexed for inflation on 1995 dollars in 2011 the amount is \$4.3 million.

⁹For a complete list of completed projects see: <http://www.fwcpolumbia.ca/>

Wildlife Compensation Program funds the Basin Planning process and a wide variety of restoration and conservation projects including research and inventory, restoration and habitat enhancement including land acquisition, monitoring and evaluation. A significant portion of the funding in the Columbia Basin is directed toward the Aquatic Nutrient Restoration Program on Kootenay Lake and Arrow Lakes Reservoir. The nutrient restoration programs were designed to replace nutrients that are lost as a result of upstream impoundments (Duncan dam and Libby dam in the case of Kootenay Lake and Mica and Revelstoke dams in the case of Arrow Lakes), and to restore overall ecosystem productivity in the lakes.

Examples of stream and river systems enhancement are the development of spawning Channels (eg. Meadow Creek); in stream Habitat Complexing (eg. Sproule Creek); and gravel additions (eg. Boulder Creek). This type of restoration work is undertaken to offset the losses from dam construction. The Fish and Wildlife Compensation Program also conducts studies and work to enhance riparian areas and wetlands (eg. Yaqaan Nuki Wetlands).

In addition to aquatic resources and riparian areas, the Fish and Wildlife Compensation Program has also worked with upland areas to restore habitat. This is of particular importance for enhancing winter ranges for ungulates. Conservation work also plays an important role in the projects funded by the Fish and Wildlife Compensation Program (eg. Northern Leopard frog rearing and release; painted turtle nest site protection).

2.3. Water Use Planning and Water License Requirements

BC Hydro requires licenses to store and divert water for hydropower production. As part of license requirements BC Hydro undertook extensive consultation to develop Water Use Plans at Mica, Revelstoke, Hugh Keenleyside, Duncan, Whatshan, Seven Mile, Aberfeldie, Elko, Walter Hardman and Spillamacheen facilities between 2000 and 2005.¹⁰ The process was a consultative planning process involving BC Hydro, provincial and federal governments, First Nations, local communities and other interest groups. The process was conducted to make recommendations on how **incremental changes to operations of the facilities might have positive impacts on a variety of different interests**. In many circumstances benefits were achieved through physical works in lieu of changes to operations. For example wetlands in the Arrow Lakes were enhanced as opposed to meeting hard-set criteria for reservoir levels or flows at specific times of the year. Recommendations also included monitoring programs and information gathering for future decision making.

There is currently no Water Use Plan for the Kootenay River plants, although an agreed to minimum flow is provided in the management of the facilities.

Following the Columbia and Duncan Water Use Plans the following constraints were placed on operations to, in part, to mitigate environmental interests:

- **Kinbasket Reservoir and Mica dam:** no operational constraints placed on either Kinbasket Reservoir or Mica dam;
- **Revelstoke Reservoir and Revelstoke dam:** no operational constraints were placed on Revelstoke Reservoir. A year round minimum flow of 5 kcfs (141.58 m³/s) was

¹⁰ This report reviewed the Columbia Water Use Plan dealing with Mica, Revelstoke and Hugh Keenleyside and the Duncan Water Use Plan. In 2007, the Comptroller of Water Rights (CWR) approved the Columbia Water Use Plan (COL-Water Use Plan) including an addendum with additional recommendations to address the incremental impacts of operations due to Revelstoke Unit 5. In August 2010 the CWR approved amendments to the Columbia Water Use Plan to include monitoring programs associated with Mica Generating Unit 5 and 6 (BC Hydro, 2012b). The CWR approved of the Duncan Water Use Plan in 2007.

recommended to be released at Revelstoke dam costing an estimated \$3 million/annum.¹¹ It should be noted that First Nations have expressed an interest for minimum flows of 10-15 kcfs (Dennis, 2012). Also, an experimental flow release program (1 July and 31 August) was agreed to in the Middle Columbia (Revelstoke Reach) to benefit juvenile recruitment of sturgeon up to a cap of \$5 million over a ten year period.

- **Middle Columbia River, Arrow Lakes Reservoir and Keenleyside Dam:** There were no operational changes for the Arrow Lakes Reservoir; however, ‘soft constraints’ (preferred operating ranges for different interests such as fish, wildlife, vegetation, cultural and heritage, recreation and erosion that have conflicting water elevation ranges. These soft constraints help inform BC Hydro operators on impacts) are in place to balance wildlife, recreation, fisheries, culture and heritage, shore conditions, and power generation (Table 2). A conservation aquaculture program is in place for White Sturgeon in the Middle Columbia and Arrow Lakes and involves assessing the effectiveness of flow releases as opposed to providing a fixed regime. The aquaculture program is estimated to cost \$0.5M /annum (Columbia-Water Use Plan, 2005 & 2007).

Table 2 Soft Constraints on Arrow Lake Reservoir-Environmental Interests¹²

Interest	Summary of soft constraint
Vegetation	If vegetation showing signs of stress (May-June) target lower reservoir levels in the fall. Preserve vegetation at/above 434 meters.
Wildlife	Make sure reservoir levels inundating bird habitat in the early summer is no worse than 1984-1999 statistics. Bird habitat for the fall should be better than 1984-1999 statistics. Draft reservoir quickly after full pool reached - target 438m (or lower) by 7 Aug.
Fish	Keep levels high enough in fall for tributary access for kokanee spawning (August-November). Levels below 434 meters could cause problems for tributary access.

- **Lower Columbia:** BC Hydro is to continue to pursue Mountain Whitefish flows (reducing outflows from Arrow Lakes during Whitefish spawning, 1 January – 31 March); and Rainbow Trout flows (avoid decreasing river levels from 1 April to 30 June) under the Treaty.
- **Duncan:** Reach full pool (576.4 meters and 576.7 meters) between 1 and 10 August After full pool is reached or after 10 August, decrease reservoir elevation to 575.5 m and maintain within 0.3 m of this level until 5 September; 2.6 kfs (73 m³/s) minimum year-round; 10.1 kcfs (283 m³/s) normal maximum year-round.¹³

In addition to the operational changes recommended in the Columbia and Duncan Water Use Plans, BC Hydro and its partners have undertaken a number of monitoring and physical works under management plans,¹⁴ including:

- Kinbasket Reservoir Fish and Wildlife Information Plan - \$9.9 million (over 10 years).

¹¹ Kcfs indicates *thousand cubic feet per second*. m³/s indicates *cubic meters per second*. 1 kcfs = 28 m³/s. It should be noted that First Nations have expressed an interest for minimum flows of 15 kcfs (Dennis, 2012).

¹² Adapted from Columbia Water Use Plan (2005)

¹³ Note this is the maximum, there are various maximum discharge levels throughout the year. See the Duncan Water Use Plan for more details.

¹⁴ Detailed reports of the plans can be found at

http://www.bchydro.com/about/sustainability/conservation/water_use_planning/southern_interior.html

- Kinbasket and Arrow reservoirs Revegetation Management Plan - \$16.6 million (over 10 years).
- Kinbasket and Arrow Recreation Management Plan - \$18.6 million (total over 10 years).
- Mica Management Plan
- Revelstoke Flow Management Plan - \$8.8 million (total over 10 years).
- Columbia River White Sturgeon Management Plan - \$35 million (total over 10 years).
- Arrow Reservoir Operations Management Plan - \$12.5 million (total over 10 years).
- Arrow Reservoir Wildlife Management Plan - \$3.8 million (total over 10 years).
- Lower Columbia River Fish Management Plan - \$9.8 million (total over 10 years).
- Duncan Management Plan - \$13 million (Total program)

The overall value of the Water Use Plan in the Columbia River is \$120 million over 12 years. The Arrow Lakes and Lower Columbia are slated to be reviewed 5 years after implementation to evaluate the effectiveness of operations and physical works. A full review of the Columbia Water Use Plan is scheduled for 2020, and the Duncan Water Use Plan is scheduled for 2018.¹⁵

2.4. Species at Risk, Recovery Strategies and Management Plans

The Government of British Columbia engages in recovery planning for species at risk in cooperation with the federal government. Recovery Strategies and Management Plans have been developed for specific species, populations and ecosystems that are listed under schedule 1 of the **Species at Risk Act** (SARA). These documents typically address issues across a geographic range and identify specific objectives for recovery or management. These documents may include specific performance measures and targets. Recovery strategies are developed and implemented by Provincial and Federal agencies partnering with other organizations and groups.¹⁶

Species and ecosystems in the Columbia Basin that are listed under SARA include:¹⁷

¹⁵ See Columbia Water Use Plan ‘Revised for Acceptance by the Comptroller of Water Rights’ 11 January, 2007 and Duncan Water Use Plan ‘Revised for Acceptance by the Comptroller of Water Rights’ 20 December, 2007.

¹⁶ Marine Species : lead agency is Department of Fisheries and Oceans; Freshwater species: lead agencies are Ministry of Environment and Department of Fisheries and Oceans; most terrestrial species: the lead agency is Ministry of Environment;

¹⁷ Copies of Provincial Government Recovery Documents are available at:

http://www.env.gov.bc.ca/wld/recoveryplans/recovery_doc_table.html

Federal Government Recovery Documents are available at: http://www.sararegistry.gc.ca/default_e.cfm

Table 2:

Taxon	English Name	Scientific Name	COSEWIC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
Mammals	American Badger jeffersonii subspecies	Taxidea taxus jeffersonii	E (2000)	1-E	Grassland/Shrub Steppe; Grassland/Herbaceous; Forest Needleleaf; Rock/Sparsely Vegetated Rock	Low (mainly terrestrial species)
	Grizzly Bear - Western Population	Ursus arctos	SC (2012)	No Schedule	Alpine/Tundra; Forest; Grassland/Shrub Steppe; Wetland; Stream/River; Rock/Sparsely Vegetated Rock; Shrubland	Moderate (uses wetlands, streams, rivers)
	Little Brown Myotis		E (2012)	No Schedule	Uses caves, hollow trees, human-made structures for resting and maternity sites; forages generally in woodlands near water. In winter, a relatively constant temperature of about 40 F and 80% relative humidity is required; uses caves, tunnels, abandoned mines	Moderate (forages near water)
	Northern Myotis	Myotis septentrionalis	E (2012)	No Schedule	Forest; Wetland; Rock/Sparsely Vegetated Rock;	Moderate (uses wetland habitat)

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Taxon	English Name	Scientific Name	COSEWIC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
					Subterranean; Urban	
	Woodland Caribou - Southern Mountain Population	Rangifer tarandus pop. 1	T (2000)	1-T	Alpine/Tundra; Forest Needle leaf; Rock/Sparsely Vegetated Rock	Low (mainly terrestrial species)
	Wolverine - Western Population	Gulo gulo luscus	SC (2003)	No Schedule	Alpine/Tundra; Forest; Grassland/Shrub Steppe; Rock/Sparsely Vegetated Rock; Shrubland	Low (mainly terrestrial species)
Birds	Barn Swallow	Hirundo rustica	T (2011)	No Schedule	Agricultural; Estuary; Grassland/Shrub Steppe; Lakes; Wetland; Stream/River; Rock/Sparsely Vegetated Rock	Moderate (uses wetlands, lakes, streams, rivers)
	Bobolink	Dolichonyx oryzivorus	T (2010)	No Schedule	Agricultural; Grassland/Shrub Steppe; Grassland/Herbaceous; Wetland; Rock/Sparsely Vegetated Rock	Moderate (uses wetlands)
	Common Nighthawk	Chordeiles minor	T (2007)	1-T	Agricultural; Forest; Grassland/Shrub Steppe; Lakes; Wetland; Stream/River; Rock/Sparsely Vegetated Rock; Shrubland	Moderate (uses wetlands, lakes, streams, rivers)
	Flammulated Owl	Otus flammeolus	SC (2010)	1-SC	Forest; Woodland Needle leaf; Rock/Sparsely	Low (mainly terrestrial species)

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Taxon	English Name	Scientific Name	COSEWIC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
					Vegetated Rock	
	Lewis's Woodpecker	Melanerpes lewis	T (2010)	1-T	Agricultural, Cropland/Hedgerow, Old Field; Forest (Needleleaf, Broadleaf, Woodland, Snag/Hollow Tree); Grassland/Shrub Steppe; Grassland/Herbaceous; Rock/Sparsely Vegetated Rock; Wetland, Riverine/riparian	Moderate (uses wetlands, riparian)
	Long-billed Curlew	Numenius americanus	SC (2011)	1-SC	Estuary; Grassland/Shrub Steppe; Grassland/Herbaceous; Wetland; Rock/Sparsely Vegetated Rock	Moderate (uses estuaries, wetlands)
	Olive-sided Flycatcher	Contopus cooperi	T (2007)	1-T	Forest; Wetland; Rock/Sparsely Vegetated Rock	Moderate (uses wetlands)
	Peregrine Falcon anatum/tundrius	Falco peregrinus anatum/tundrius	SC (2007)	1-SC	Estuary; Rock/Sparsely Vegetated Rock	Moderate (uses wetlands)
	Rusty Blackbird	Euphagus carolinus	SC (2006)	1-SC	Agricultural; Forest; Grassland/Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock; Shrubland	Moderate (uses wetlands)
	Short-eared Owl	Asio flammeus	SC (2008)	1-SC	Agricultural; Alpine/Tundra; Estuary; Grassland/Shrub	Moderate (uses wetlands, palustrine/riparian)

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Taxon	English Name	Scientific Name	COSEWIC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
					Steppe; Grassland/Herbaceous; Wetland; Rock/Sparsely Vegetated Rock; Palustrine/riparian	habitat)
	Western Grebe	<i>Aechmophorus occidentalis</i>	Candidate (2011)	No Schedule	Estuary; Lakes; Ocean; Wetland; Stream/River; Shallow water	High (waterfowl)
	Western Screech-Owl, macfarlanei subspecies	<i>Megascops kennicottii</i>	T (2012)	1-T	Agricultural; Forest Mixed; Wetland; Rock/Sparsely Vegetated Rock; Shrubland; Riverine/Riparian	Moderate (uses wetlands, riverine/riparian habitat)
	Williamson's Sapsucker	<i>Sphyrapicus thyroideus</i>	E (2005)	1-E	Forest (Broadleaf, Needleleaf, Snag/Hollow tree; Rock/Sparsely Vegetated Rock	Low (mainly terrestrial species)
	Yellow Rail	<i>Coturnicops noveboracensis</i>	SC (2009)	1-SC	Agricultural; Estuary; Grassland/ Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock	Moderate (uses estuary, wetland habitat)
	Yellow-breasted Chat auricollis subspecies Southern Mountain population	<i>Icteria virens auricollis</i>	E (2011)	1-E	Agricultural; Wetland; Rock/Sparsely Vegetated Rock; Shrubland	Moderate (uses wetland, riverine/riparian habitat)
Reptiles	Great Basin Gophersnake	<i>Pituophis catenifer deserticola</i>	T (2002)	1-T	Grassland/Shrub Steppe; Lakes; Wetland; Stream/River; Rock/Sparsely	Moderate (uses lakes, riparian, wetland habitats)

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Taxon	English Name	Scientific Name	COSEWIC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
					Vegetated Rock; Shrubland	
	Painted Turtle - Intermountain - Rocky Mountain Population	<i>Chrysemys picta</i> pop. 2	SC (2006)	1-SC	Wetland; Stream/River; Palustrine: pond, grassland; Lacustrine: Deep Water, Course Woody Debris, Shallow Water	High (aquatic/semi- aquatic)
	Rubber Boa	<i>Charina bottae</i>	SC (2003)	1-SC	Forest; Grassland/Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock; Shrubland	Moderate (uses wetland habitat)
	Western Skink	<i>Plestiodon skiltonianus</i>	SC (2002)	1-SC	Forest (Needleleaf); Grassland/Shrub Steppe; Grassland/Herbaceous; Wetland; Rock/Sparsely Vegetated Rock; Talus/Boulders; Shrubland	Moderate (uses wetland habitat)
	Western Yellow-bellied Racer	<i>Coluber constrictor</i> mormon	SC (2004)	1-SC	Grassland/Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock; Shrubland; Subterranean	Moderate (uses wetland habitat)
Anthropods	Monarch	<i>Danaus plexippus</i>	SC (2010)	1-SC	Agricultural; Forest; Grassland/Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock; Sand/	Moderate (uses wetland habitat)

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Taxon	English Name	Scientific Name	COSEWIC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
	Vivid Dancer	<i>Argia vivida</i>	Candidate (2011)	No Schedule	Dune; Shrubland Stream/River; Associated with cool or hot springs; Palustrine: Herbaceous Wetland	High (dependent on aquatic habitats)
Molluscs	Magnum Mantleslug	<i>Magnipelta mycophaga</i>	SC (2012)	No Schedule	Forest Needleleaf; Rock/Sparsely Vegetated Rock; Under moist logs, pieces of bark, in depressions in moist earth and within talus in cool, moist coniferous forests	Low (mainly terrestrial species)
	Pygmy Slug	<i>Kootenaia burkei</i>	Candidate (2011)	No Schedule	Forest Mixed, Forest Needleleaf; Wetland; Riverine/ Riparian; Rock/Sparsely Vegetated Rock	Moderate (uses wetland, riverine/riparian habitat)
Amphibians	Coeur d'Alene Salamander	<i>Plethodon idahoensis</i>	SC (2007)	1-SC	Wetland; Stream/River; Subterranean	High (aquatic/semi-aquatic)
	Northern Leopard Frog - Rocky Mountain Population	<i>Lithobates pipiens</i>	E (2009)	1-E	Grassland/Shrub Steppe; Lakes; Wetland; Stream/River; Rock/Sparsely Vegetated Rock	High (aquatic/semi-aquatic)
	Rocky Mountain Tailed Frog	<i>Ascaphus montanus</i>	E (2000)	1-E	Forest Needleleaf; Wetland; Riparian-Stream/River, Creek; Rock/Sparsely Vegetated Rock	High (aquatic/semi-aquatic)

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Taxon	English Name	Scientific Name	COSEWIC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
	Western Toad	<i>Anaxyrus boreas</i>	SC (2002)	1-SC	Agricultural; Forest; Grassland/Shrub Steppe; Lakes; Wetland; Stream/River; Rock/Sparsely Vegetated Rock	High (aquatic/semi-aquatic)
Vascular Plants	Giant Helleborine	<i>Epipactis gigantea</i>	SC (1998)	3-SC	Seepage Slope, Forest Broadleaf, Cliff; Lakes; Wetland; Stream/River; Beach; Temporary Pool; Bog/Fen	Moderate (semi-aquatic species)
	Southern Maidenhair Fern	<i>Adiantum capillus-veneris</i>	E (2011)	1-E	Riverine: Stream/River, Spring Brook; Rock/Sparsely Vegetated Rock	Moderate (semi-aquatic species)
	Spalding's Campion	<i>Silene spaldingii</i>	E (2005)	1-E	Forest; Grassland/Shrub Steppe; Rock/Sparsely Vegetated Rock	Low (mainly terrestrial species)
	Whitebark Pine	<i>Pinus albicaulis</i>	E (2010)	1-E	Within montane forests and on thin, rocky, cold soils at or near timberline. 1300 - 3700 meters	Low (mainly terrestrial species)
Mosses	Alkaline Wing-nerved Moss	<i>Pterygoneurum kozlovii</i>	T (2004)	1-T	Alkali Pond/Salt flat; Grassland/Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock; on soil	Moderate (grows at/near ponds, wetlands)
	Banded Cord-moss	<i>Entosthodon fascicularis</i>	SC (2005)	1-SC	Forest; Wetland;	Moderate (grows

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Taxon	English Name	Scientific Name	COSEWIC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
					Stream/River; Rock/Sparsely Vegetated Rock	at/near wetlands, streams, river)
	Margined Streamside Moss	Scouleria marginata	E (2012)	1-E	Forest; Wetland; Stream/River; Rock/Sparsely Vegetated Rock	Moderate (grows at/near wetlands, streams, river)
Lichens	Cryptic Paw	Nephroma occultum	SC (2006)	1-SC	Forest - Epiphytic; Old Forest; Rock/ Sparsely Vegetated Rock	Low (mainly terrestrial species)
Freshwater Fish	White Sturgeon (Kootenay River Designatable Unit)	Acipenser transmontanus	EN (2012)	1-EN	Distribution: Kootenay River, Kootenay Lake. Habitat: varies with life stage; spawning - side channels with gravel, cobble, or sand bottoms, at depths of 3.0 to 4.5 m; In regulated systems - turbulent water flowing rapidly over a clean substrate of large rocks. Adult sturgeon are typically found in deep near-shore areas, adjacent to heavy, turbulent flows, with bottoms of sand and fine gravel. In winter, the sturgeon prefers shallow, calm areas.	High (aquatic)

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Taxon	English Name	Scientific Name	COSEWIC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
	White Sturgeon (Upper Columbia River Designatable Unit)	Acipenser transmontanus	EN (2012)	1-EN	Distribution: Columbia River, Arrow Lakes, 2km of Kootenay River downstream of Brilliant Dam. Habitat: varies with life stage; spawning - side channels with gravel, cobble, or sand bottoms, at depths of 3.0 to 4.5 m; In regulated systems - turbulent water flowing rapidly over a clean substrate of large rocks. Adult sturgeon are typically found in deep near-shore areas, adjacent to heavy, turbulent flows, with bottoms of sand and fine gravel. In winter, the sturgeon prefers shallow, calm areas.	High (aquatic)
	Shorthead Sculpin	Cottus confusus	SC (2010)	1-TH* (proposed for re-listing as SC; decision due in March 2013)	Distribution: Columbia River (mainstem and tributaries), Slocan River, Kettle River. Habitat: small rivers draining mountainous regions; moderate to swift current;	High (aquatic)

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Taxon	English Name	Scientific Name	COSEWIC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
					moderately cool water; riffle habitats with stones or gravel, used for shelter and breeding.	
	Columbia Sculpin	Cottus hubbsi	SC (2010)	1-SC	Distribution: Columbia River, Flathead River, Similkameen River, Kettle River, and small tributary streams. Habitat: rocky riffle habitats in rivers and streams, but may sometimes occur in lakes as well.	High (aquatic)
	Westslope Cutthroat Trout	Oncorhynchus clarkii lewisi	SC (2006)	1-SC	Distribution: Kootenay River and major tributaries (White, Lussier, Wild Horse, St. Mary, Bull, and Elk rivers as well as Findlay, Skookumchuk, and Mather creeks), Moyie River, Goat River, Flathead River, Upper Columbia Headwaters and lakes, South Thompson River (specifically the Shuswap system). Habitat: large rivers and lakes, wide range of	High (aquatic)

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Taxon	English Name	Scientific Name	COSEWIC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
					habitats; intact lotic environments; cold clean water and varied forms of cover (i.e., undercut banks, pool-riffle habitat, and riparian vegetation).	
	Umatilla Dace	Rhinichthys umatilla	TH (2010)	3-SC	Distribution: Similkameen, Kettle, Columbia, Slocan and Kootenay river drainages. Habitat: riverine habitat with cobble and stone cover; fast current to prevent siltation; river banks at depths less than 1m; low elevation waters.	High (aquatic)
	Rocky Mountain Sculpin (Westslope Population)	Cottus sp.	SC (2010)	No Schedule	Distribution: Flathead River. Habitat: almost entirely unknown, but more abundant in riffle and run habitats containing rocks, rubble, and boulders.	High (aquatic)

2.5. Flexibility within the Columbia River Treaty/Non-Treaty Storage Agreement

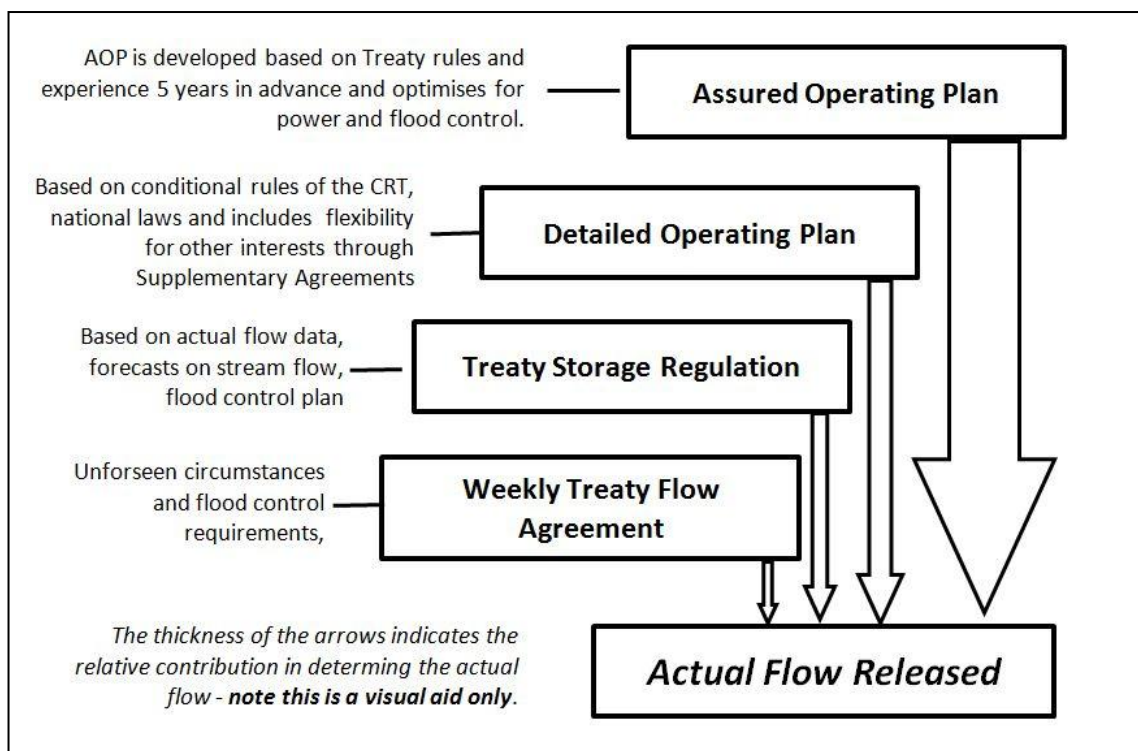
The Columbia River Treaty dictates what flows should pass across the Canada–U.S. border and what flood control capacity should exist within Canada at certain times during the year. The bulk of flow is determined through the **Assured Operating Plan** which is developed 5 years in advance and is designed to achieve optimum power benefits and flood control. The actual flow in the river is more complicated and is determined through a number of different means (Figure 1).

The **Detailed Operating Plan** is based on the Assured Operating Plan. The Entities may prepare an annual Detailed Operating Plan that may achieve more advantageous operation than would result under the Assured Operating Plan.¹⁸ It must be accepted by mutual agreement of the Canadian Entity and U.S. Entity, or the Assured Operating Plan for that particular year is applied. The Detailed Operating Plan may include Supplementary Operating Agreements for non-power and non-flood control benefits (see below). The Detailed Operating Plan is implemented via **Treaty Storage Regulation** studies that determine the monthly storage rights and obligations for Duncan, Mica and Arrow/Keenleyside dams. Studies are conducted twice monthly to determine the end of month targets of the reservoir levels in Canadian Treaty facilities. The Treaty Storage Regulation uses actual inflows to date plus the forecast stream flows, along with current reservoir conditions. The Treaty Storage Regulation specified operation can, and is often, modified by mutual agreement from the Entities.

The actual operation of the Canadian Treaty Storage facilities (Duncan, Mica and Arrow/Keenleyside), is finalized on a weekly basis through a Treaty Flow Agreement for the following week. The U.S. provides information for Libby dam at the weekly meetings for coordination operations on the Kootenay River.

Related to the Columbia River Treaty is the Non-Treaty storage agreement (NTSA). In April 2012 the new NTSA was signed and will last until 2024. It does not require any particular storage space but allows for coordinated use of non-Treaty storage in Canada to shape flows within the year for power production and fisheries benefits. It provides up to an additional 0.5 Million Acre Feet to benefit fish in the lowest water conditions.¹⁹

Figure 1: General influence of various stages of decision making on actual flow



Unilateral Actions

The Columbia River Treaty allows for flexibility to operate individual dams for maximum Canadian benefits, provided storage operations remain within the constraints of the Flood Control Operating Plan and flow across the Canada / U.S. border remains unchanged from the agreed flows. This flexibility allows BC Hydro to move water between Mica, Revelstoke,²⁰ Arrow/Keenleyside and, to some extent, Duncan in response to various power, social and environmental interests. For example:

- *Decisions entirely internal to Canada to deviate from Treaty Storage Regulations may be made with respect to flows below Mica or Revelstoke, providing discharges from Arrow are not affected and flood control is protected. For instance, negotiations may occur with DFO for flooding to improve survivability of Kokanee in certain stretches along the river above Arrow/Keenleyside.*
- *Discharges from Duncan may diverge from Treaty Storage Regulations, provided discharges from Arrow are adjusted to make up the difference at the border with the U.S.*

Mutual Consent

The Detailed Operating Plan is developed annually and spells out the operating rules that define how water will be drawn from dams and systems throughout the year. It is based on the Assured Operating Plan but may deviate from it by mutual agreement, **and for mutual benefit**,²¹ either at the stage of developing the DOP, the treaty storage regulation or at the weekly level through the weekly agreement and conference call.²² Supplemental Operating Agreements such as the *Non-power Uses Agreements* and the *Canadian/Libby Swap Agreement* have been negotiated to address primarily recreation interests but also include fisheries interests in Canada such as rainbow trout and whitefish.

The *Non-power Use Agreement* includes:

- Flow management for rainbow trout spawning in the Canadian Columbia River to maintain river levels at Norns Creek Fan below Keenleyside between 1 April and 30 June.
- The Whitefish Operating Agreement, which allows storage at Kinbasket and Arrow Lakes reservoirs during the 1–15 January period to reduce Arrow outflow by 20 kcfs for enhancement of Whitefish spawning.
- The Fall Provisional Storage Agreement and March Whitefish Flow Agreement, which allows for a provisional draft of Arrow Lakes Reservoir during the September–October period in compensation to the U.S. for lost energy benefits associated with maintaining stable minimum flows to minimize the dewatering of whitefish eggs until 31 March.

2.6. Local Interests and Mitigation Measures

Table 3 outlines the major environmental interests and the mitigation measures which have been adopted to address them in the Columbia Basin.

²⁰ Revelstoke dam is not a Treaty dam.

²¹ Under the Treaty – deviations from the Assured Operating Plan are to be mutually agreed upon and for mutual benefit.

²² These include requested variances from the Columbia River Treaty Flood Control Rule Curves as laid out in the Flood Control Operating Plan, however, it is also not uncommon that small alterations to releases will be requested based on unforeseen circumstances throughout the week. Note that flood control requests can be on a daily basis, while requests dealing with power are typically done at the weekly conference call and weekly agreement.

Table 3: Specific Environmental interests and Mitigation Measures

General			
Category	Sub-Category	Specific Interests	Mitigation
Ecosystem function and resilience	Species conservation	Maintaining or improving the populations and ranges of species at risk, or species of interest in the Basin.	<p>Fish and Wildlife Compensation Program, and specific work with species at risk such as the Northern Leopard Frog project; Vaux's swift nesting habitat, etc.</p> <p>Conducting inventory and identification of species at risk, such as the Columbia Basin Amphibian Inventory.</p> <p>Establishing teams, developing and implementing recovery plans, such as the Columbia River White Sturgeon Management Plan under BC Hydro's Water License Requirements. Coordinating with other power producers, such as Columbia Power Corporation operating requirements take into account sturgeon as part of their license. These requirements are coordinated with BC Hydro.</p>
Vegetation	Riparian and wetland habitat	<p>Maintain or maximise the abundance and diversity of riparian and wetland habitat.</p> <p>Maximize effective habitat for wildlife.</p>	Fish and Wildlife Compensation Program and physical works and operational changes under the Water Use Plans. And associated management plans: Arrow Reservoir Operations Management Plan, Arrow Reservoir Wildlife Management Plan, Kinbasket Reservoir Fish and Wildlife Information Plan, Mica Management Plan.
Fish	Total Dissolved Gas ²³	<p>Minimize the effects of increased Total Dissolved Gas below facilities. Gas levels are normally elevated in the tailwater of any project that is spilling or within units in synchronous condense mode of operation.</p> <p>Provincial guidelines call for 110% as a goal, while, federal guidelines list 103% as a goal if fish reside in less than one metre of depth.</p>	BC Hydro is undertaking a system wide review of Total Dissolved Gas and developing a strategy for mitigation. As part of the review risk assessments are being conducted and management plans are being developed in partnership with DFO, MOE, and First Nations. Reasonable efforts are made in operations to avoid prolonged sync-condense operations.
	Entrainment	Minimize the impact of fish entrainment on species.	Fish entrainment was not addressed in the Water Use Plans but is part of BC Hydro's Fish Entrainment Strategy. BC Hydro conducted a systems review between 2005-2006 and developed risk assessment methodologies (2007) and draft principles of operation (2007). Action planning and implementation is a technical process that has been undertaken on a case by case basis between BC Hydro, DFO, Ministry of Environment, and First

²³ Also known as Total Gas Pressure (TGP) or gas supersaturation.

General			
Category	Sub-Category	Specific Interests	Mitigation
			<p>Nations.</p> <p>Fish Entrainment Action Plans have been completed for Mica and Revelstoke.</p> <p>Several performance measures have been developed for Arrow Lakes and these were used in the NTSA consultation.</p>
Salmon		Particularly among First Nations there is an interest to re-introduce Sockeye and Chinook salmon in upper Columbia.	To date only studies have been conducted, for example the Upper Columbia Aquatic Management Partnership solicited a feasibility, impacts and benefit report.

Mica Dam and Kinbasket Reservoir			
Category	Sub-Category	Specific Interests	Mitigation
Vegetation	Riparian Habitat	Maximize riparian habitat area on Kinbasket area (i.e. vegetative growth in the drawdown zone). In general, the later the refill date is during the growing season, the greater the riparian recruitment potential there is (especially in the flat deltas in Canoe Reach, Columbia Reach and Bush Arm). With a seeding program, goal was to establish the top 7m in these areas as riparian vegetation.	WLR monitoring studies are being conducted to provide information on vegetation in the drawdown zone. Reservoir re-vegetation management plan. Re-vegetation is done with local species and there is incorporation of traditional plants in re-vegetation plan where possible (BC Hydro 2011). NTSA looked at inundation statistics.
Fish	Pelagic and Littoral Productivity	Maximize pelagic and littoral productivity in Kinbasket reservoir. Generally, an earlier filled reservoir that is kept higher and maintained during summer months is better for pelagic productivity (June 1 to Sep 30). Littoral productivity is dependent on a number of factors including stable and fuller levels through the growing season (~April through October).	The costs for altering operational changes at Mica (between \$16 Million - \$25 Million per year) for environmental benefits would outweigh the gains, so no operational changes are being done. Assessments of Kinbasket Kokanee population have been conducted. WRL studies are collecting photosynthetically active radiation data – and there is no significant difference in performance of the scenarios evaluated under the NTSA consultation.
	Total Dissolved Gas	Minimise negative impacts of TDG.	System review and TDG Strategy being developed. Avoid prolonged periods where units spin without generating power, where the incoming water becomes supersaturated with dissolved gas, also known as sync-condense operations. At Mica this includes flushing the supersaturated water out of the unit for 15 minute or 30 minutes for every 10 to 12 hours of sync condense operation.
	Entrainment	Minimize fish entrainment.	Fish entrainment plans have been developed as an independent initiative on BC Hydro’s Columbia system (see below). At Mica Kokanee and Bull Trout were highlighted at high and moderate risks (respectively) to entrainment.

Revelstoke Dam and Reservoir, and Mid-Columbia

Category	Sub-Category	Specific Interests	Mitigation
Fish	General Productivity of various species	Maximizing reservoir stability (minimize frequency of events that the reservoir exceeds a threshold over the summer months). Reducing the number of events where the reservoir drops more than 0.25m over 1 and 3 day periods from Jun 1 to Sep 30.	The reservoir is operated for no more than 0.8m/day (2.5 ft/day) for draft or refill, and 1.5m/day (5ft/day) in emergencies.
	Large River species	Maximizing ecological productivity and increasing juvenile fish use. Maximizing adult fish abundance, condition, growth and fecundity. Triggering rainbow trout spawning. Minimum flows below Revelstoke were considered under the Water Use Plan to increase large river habitat in the mid-Columbia for fish (Rainbow and Bull trout, sculpins, dace and possibly sturgeon). A 5kcfs minimum flow was recommended by the Water Use Plan. First Nations recommended levels of 15 kcfs.	A 5 kcfs minimum flow below Revelstoke dam have been implemented year round. The cost of minimum flows is related to restrictions on heavy load hour (HLH) and light load hour (LLH) pricing.
	Total Dissolved Gas	Minimize the impact of TDG. Studies in 2003 showed that elevated levels of TDG levels of 150% were found directly below the tailrace, while these dropped to 120% in the plunge pool and 110% by the Revelstoke Golf Course.	Assessment being conducted under the system review and at TDG Strategy being developed. The minimum flow of 5kcfs acts to dilute and dissipate high levels of TDG.
	White Sturgeon	There is a population of White Sturgeon in the Mid-Columbia. Recruitment is a problem due to predation, particularly at the larval stage. It is considered that high flows at key periods of time (August) would help reduce predation. Experimental flows (30 kcfs for 4 weeks in August) combined with monitoring were recommended under the Water Use Plan.	Columbia River White Sturgeon Management Plan is being implemented. Conservation aquaculture program in Middle Columbia and Arrow Lakes to estimate effectiveness of experimental flow release (Columbia-Water Use Plan, 2005 & 2007). The actual experimental flows have not yet been implemented. High natural inflows over the last 2 years have however allowed monitoring to be undertaken on flow levels that virtually mimic the proposed experimental flow releases. The monitoring results are helping shape the ongoing work and studies. Monitoring has indicated that spawning is occurring 6/10 years in August. Optimizing spawning in the Mid Columbia would accompany low reservoir levels; however, such operation would be at odds with juvenile benefits of deep slow moving water (at a high reservoir).
	Entrainment	Minimize fish entrainment.	Entrainment assessment conducted. At Revelstoke Facility Kokanee and bull Trout were assessed at a high and moderate risk of entrainment respectively.

Hugh Keenleyside Dam and Arrow Lakes Reservoir

Category	Sub-Category	Specific Interests	Mitigation
Ecosystem Integrity	Primary Productivity	Dams have reduced the inflow of nutrients and primary productivity has decreased. Maximize the primary production of carbon to enhance higher trophic level production.	<p>Arrow Lakes Reservoir Nutrient Restoration Program was initiated in 1999 and is collaboratively implemented based on several project partner contributions including, the Fish and Wildlife Compensation Program – Columbia (FWCP-Columbia), the BC Ministry of Forests, Lands, and Natural Resource Operations (FLNRO) , the BC Ministry of Environment (MOE) and the Arrow Lakes Power Corporation (ALPC) which owns the Arrow Lakes Generating Station. ALPC is jointly owned by Columbia Power Corporation and Columbia Basin Trust.</p> <p>Columbia Power Corporation manages the operations of the ALPC on behalf of the joint venture. The funding is being provided as a compensatory benefit for the operations of the Arrow Lakes Generating Station on the Lower Arrow Lake. The day to day operations are implemented by FLNRO and administered through FWCP-Columbia. The FWCP program contributes \$ 750K a year and CPC contributes \$250K per year.</p> <p>The liquid fertilizer is introduced into the lake from a tank truck loaded on the ferry and dispersed in measured amounts as the ferry crosses the lake.</p>
Fish	General Productivity of various species - pelagic and littoral	<p>Maximize pelagic and littoral productivity in Arrow Lakes reservoirs</p> <p>Generally, an earlier filled reservoir that is kept higher and maintained during summer months is better for pelagic productivity.</p> <p>Most promising way to boost littoral productivity was thought to be through increasing the minimum water surface elevation in winter.</p> <p>Water Use Plan determined that fertilization was more efficient than operational changes to increase carbon production and thus fish productivity.</p>	<p>Stabilization of the reservoir at 1438.7 ft (438.5 m) during the growing season is estimated to increase the carbon production by about 10% (from 10,400 tC/yr to 11,000 tC/yr). In contrast additional fertilization to Arrow lakes Reservoir has increased production by 4000 tC/yr.</p> <p>Burbot life history assessment being conducted under the Arrow Lakes Reservoir Operations Management Plan.</p>
	White Sturgeon	<p>Build a self-sustaining population of white sturgeon.</p> <p>Maximize the probability of successful juvenile recruitment of white sturgeon in the mid-Columbia (see above with Revelstoke). 5k cfs min flow from Revelstoke was in part to benefit juvenile sturgeon and other fish in the Mid-Columbia.</p>	<p>Risk assessment of sturgeon entrainment has been assessed as a moderate risk and is under further review.</p>

Hugh Keenleyside Dam and Arrow Lakes Reservoir

Category	Sub-Category	Specific Interests	Mitigation
	Kokanee and Bull trout tributary spawning	Maximize tributary access during kokanee and Bull trout spawning period (late Aug to early Nov). Seasonal changes in the Arrow lakes Reservoir elevation has have the potential to adversely affect tributary access to critical spawning grounds during the autumn. Preliminary studies indicate that there are barriers ranging from 1418-1438ft in seven tributaries, with most occurring below 1430ft.	Soft constraints were developed for Arrow Lakes operations – need to study, but recommended minimum elevations of 434m (1424ft) from August 25 – November 15. (Col Water Use Plan). Now measuring # days when reservoir elevation is above 1430ft between August 25 and November 15 (NTSA). Multi-year study of tributary fish migration under Arrow lakes reservoir management plan continues under WLR monitoring program.
	Total Dissolved Gas	Minimise the impact of TDG. Readings of over 140% have been measured at Hugh Keenleyside.	BC Hydro preferentially discharges water through the north bank, then south bank and then the spillway to minimize TDG levels during normal operations. The Arrow Lakes generating station can divert up to 1115m ³ /s (40 Kcfs) away from Hugh Keenleyside dam where TDG is produced.
Wildlife and vegetation	Vegetation (riparian habitat)	The depth, timing and duration of flooding on the Revelstoke Reach affect the species composition, spatial extent and diversity of vegetation in the drawdown zone. The measurement of what is ‘good’ for vegetation is complex: During the Water Use Plan there was a general consensus to maintain current levels of vegetation at and above 434m (1424ft) elevation. Minimize inundation of vegetation during the growing season.	Soft constraint (in 2004) – Apr to Oct minimize water levels at or above 434m (1224ft) where preservation of of 2004 levels of vegetation above 1424ft in the drawdown zone would be a priority. The NTSA consultation looked at weeks of flooding (7 consecutive days) at different elevation bands. Implementation of the Arrow Reservoir Wildlife Management Plan.
	Birds – spring nesting and fall migratory birds	Maximize capacity of wetlands to provide habitat for spring nesting and fall migratory birds. Minimizing inundation of nesting bird habitat by rising reservoir water levels.	Soft constraint – try and keep early summer elevations (Apr 30-Jun 16) at or below 434m (1424ft) which are historical levels (1984-1999). Soft constraint – ensure that availability of fall migratory bird habitat is no worse than recent averages targeting reservoir levels (draft the reservoir after full pool) target level of 438m (1438ft) or lower by Aug 7 – Oct 31. These constraints were reviewed during Rev5 and Mica 5/6 consultations.
	(Revelstoke Wetlands)	Maximizing migratory bird habitat in the fall.	
	Shorebirds	Maximize capacity of wetlands to provide habitat for shorebirds (fall migration mid-July to mid Sept). Optimal water levels were assessed to be at 435m for retaining maximum available habitat for shorebirds during the late summer early fall. Reach at Drimmie creek starts to flood at El 430m and becomes fully flooded at 440m.	Arrow Lake Soft Constraints (Table 2).

Lower Columbia (<i>Below Hugh Keenleyside Dam</i>)			
Category	Sub-Category	Specific Interests	Mitigation
Ecosystem Integrity	Flushing flows	Flushing flows can be beneficial to help maintain fish habitat if they are of a significant magnitude to move and flush the substrate.	There has been no attempt to accommodate flushing flows as the level needed would exceed 165kcfs which is the level at which flood damage occurs.
Fish	Flow stability	Avoid sudden and significant flow fluctuations <u>Winter</u> Mean monthly flow changes between Jan 1 and March 31. <u>Summer</u> Mean monthly flow changes at Birchbank during June & July.	Mean monthly flow changes are set for the winter and summer.
	Mountain Whitefish	Mountain whitefish spawn in the lower Columbia River between November and March. Priority of maintaining smooth transition of winter flows for whitefish to minimize the number of dewatered MWF eggs. The Water Use Plan explored flow changes that could be negotiated with the U.S. each year to addresses fisheries interests in the lower Columbia.	Soft Constraint – winter flow restrictions (low as possible) below Keenleyside dam (identified as a high priority) during incubation (Dec – March) and emergence (March to May) periods. Modelling and monitoring of whitefish egg loss was used during the NTSA consultations. The Whitefish Operating Agreement, which allows storage at Kinbasket and Arrow Lakes reservoirs during the 1–15 January period to reduce Arrow outflow by 20 kcfs for enhancement of Whitefish spawning. Lower Columbia whitefish spawning ground, egg monitoring and life history surveys under the Lower Columbia River Fish Management Plan. DFO and BC Hydro have developed agreed upon criteria for acceptable whitefish egg loss in the Lower Columbia Region. Modelled outcomes for Non-Treaty Storage operations suggest that early spring operations of Non-Treaty Storage are potentially adversely impacting whitefish. As such, modification to actual operations of Non-Treaty may be required to meet the agreed upon criteria. The Fall Provisional Storage Agreement and March Whitefish Flow Agreement, which allows for a provisional draft of Arrow Lakes Reservoir during the September–October period in compensation to the U.S. for lost energy benefits associated with maintaining stable minimum flows to minimize the dewatering of whitefish eggs until 31 March.
	Indigenous Fish	Improve the response of indigenous rainbow trout, burbot, whitefish and other populations to the hydrograph in the lower Columbia River.	

Lower Columbia (Below Hugh Keenleyside Dam)

Category	Sub-Category	Specific Interests	Mitigation
	Rainbow Trout	<p>Priority under the Water Use Plan was to maintain stable or increasing flows for rainbow trout between April 1 to June 30. The Water Use Plan explored flow changes that could be negotiated with the U.S. each year to address fisheries interests in the lower Columbia.</p> <p>Rainbow trout seasonal flows have a negative impact on Arrow Reservoir vegetation and nesting habitat in the spring, but benefit fall migratory birds.</p>	<p>Soft Constraint – maintain spawning habitat flows (i.e. do not drop) at Norns (Pass) Creek from April 1 to June 30. Over many years this has been defined by flows around 425cms (15kcf). Flow reductions outside of this period require management of fish stranding impacts and mitigation of dewatered redds under agreement with DFO.</p> <p>The Rainbow trout seasonal flows were found to outweigh negative aspects of reservoir littoral productivity. Physical works were undertaken to mitigate the negative effects to nesting birds.</p>
	White Sturgeon	<p>High flows are thought to be important to help to facilitate recruitment. Initiate white sturgeon experimental plan to facilitate recruitment. Seasonal high flows of 200 kcsf at the border was discussed in the Water Use Plan to improve sturgeon recruitment.</p> <p>Opportunistically provide high flows.</p>	<p>Water Use Plan to improve sturgeon recruitment. Providing the flow would be costly (\$15-20M), may not be agreeable to the U.S., and may damage infrastructure around Genelle/Trail. The high flow option was dropped and instead, the committee recommended opportunistic assessment of high flow events when they occur naturally (2 in 10 years) and turbidity augmentation. Subsequent to the Water Use Plan the turbidity augmentation was found to be not feasible.</p>
	Stranding Juvenile Fish	<p>Flow ramping rates may be responsible for stranding of juvenile fish. Minimize stranding of juvenile fish.</p>	<p>The subcommittee agreed that the best way to manage fish stranding was through a flow reduction protocol and standard practices. WUP studies were conducted and protocols and standard practices are now in place.</p>
	Total Dissolved Gas (TDG)	<p>Minimize TDG effects on fish. Historically TGP has been an issue at Keenleyside, but this has been partially mitigated with Arrow Lakes Generating Station (which can divert up to 40kcf). Flows which lead to TGP levels above 115% are undesirable.</p>	<p>Flows of 40 kcf can be diverted from Keenleyside and run through the Arrow Lakes Generating Station reducing the TGP below Keenleyside Dam. BC Hydro also has an operating protocol to reduce TGP below Keenleyside Dam. Under the Water Use Plan a performance measure for TGP based on head and flow was calculated; however, the risk is much reduced with ALGS and the performance measure was dropped.</p>
	Water temperature	<p>Water temperature released from Keenleyside is cooler than normal water during the March to August period and this may have adverse effects on stream productivity.</p>	<p>In the Water Use Plan it was recognized that any operational changes considered could not significantly influence temperatures below Hugh Keenleyside Dam. Further it was acknowledged that the Columbia River Integrated Environmental Monitoring Program (CRIEMP) is interested in long term monitoring of temperature in the Lower Columbia with respect to global warming and ecosystem health.</p>

Lower Columbia (*Below Hugh Keenleyside Dam*)

Category	Sub-Category	Specific Interests	Mitigation
Wildlife and Vegetation	Riparian Habitat	Minimize impacts to riparian habitat. Riparian vegetation may be affected by large flows. There are gravel bars in the area of Genelle which are susceptible to higher flows, however these were found not to be adversely affected by flows of 160 kcfs.	Flood control operations keep flows below 165 kcfs.
	Great Blue Heron – Waldie Island	<p>Waldie Island provides important winter refuge and foraging habitat for heron.</p> <p>Maximize winter refuge habitat (and foraging habitat) at Waldie Island</p> <p>Important winter forage habitat at Waldie Island and Breakwater Island, especially from Nov 15 to Dec 21 - there is a desire to keep water levels at or below 1381ft (421m) (this requires discharges of < 60kcfs from Keenleyside Dam).</p> <p>Another objective was to minimize access to the island during the spring/summer period with higher water levels above 1373ft.</p> <p>Concern in high flow years with large pulse of flows from Keenleyside Dam to enhance whitefish spawning in November. Incubation of whitefish is Dec-Mar where lower flows are required.</p> <p>In low flow years it was recommended to maintain elevations at or above 418.7m from April 1 to Aug 31 to limit public access.</p>	Waldie Island is being studied through the WRL monitoring program.

Duncan Dam and Reservoir and Lower Duncan River			
Category	Sub-Category	Specific Interests	Mitigation
Ecosystem Integrity	Riparian flooding flows for Cottonwoods	<p>Inundation period during the growing season (Apr 1 to Oct 30). Decrease elevations to 573.7m or less after reaching full pool and maintain.</p> <p>For cottonwood recruitment in the lower river, generally want to follow a more natural hydrograph once every 5 yrs. Which includes: peak flows in July (basically defined above 250cms), recession flows by late Aug and lower base flows till next freshet.</p>	<p>Riparian and wetland habitat in the Lower Duncan River were considered of high value. Cottonwood forests were chosen as an indicator of riparian success since cottonwood establishment is highly sensitive to flow. The 'cottonwood hydrograph' sought was natural reductions in flows during ramp downs, maximum flows of 250 cms over the fall and early winter, and peak flows in early to mid summer. The cottonwood hydrograph alternative was treated independently from the other alternatives in the Water Use Plan as it was to be required on an infrequent basis (about every fifth year on average) to achieve the recruitment benefits. Analysis indicated that there were only four years in the 33 year record where inflows were high enough to achieve the cottonwood flows and avoid negative impacts on other performance measures. The average cost of implementing the cottonwood flows was \$10M/yr. The committee dropped the cottonwood alternative as it would negatively impact recreation and financial revenue, and the preferred alternative performed relatively well for the cottonwood interests. The cost includes impacts at Arrow Lakes Generating Station and on the Kootenay system (approximately \$2 million). The cost at Arrow Lakes under Treaty termination potentially could be less.</p>
Fish	General reservoir species	<p>Maximize littoral productivity</p> <p>Maximize pelagic productivity</p> <p>Minimize fish stranding</p> <p>Minimize egg mortality associated with tributary backwatering</p> <p>Minimize entrainment risk</p> <p>Maximize white sturgeon populations</p> <p>Maximize bull trout populations</p> <p>Maximize nutrient loading in the North Arm of Kootenay.</p>	Implementation of Water Use Plan recommendations.
	White Sturgeon (reservoir)	White sturgeon are found in the reservoir. As a SARA listed species it is important to examine how they can be conserved.	The Water Use Plan fish technical committee assumed the position of MOE that the Duncan reservoir population is part of the Kootenay Lake population and the Duncan system cannot sustain a sturgeon population under any operational regime.

Duncan Dam and Reservoir and Lower Duncan River			
Category	Sub-Category	Specific Interests	Mitigation
	Burbot (reservoir)	<p>Maximize burbot spawning success</p> <p>There is a hypothesis that burbot spawn in the Duncan reservoir at the interface between the reservoir and the tributaries. Thus stable reservoir levels (+/- 0.25m) are believed to be beneficial during incubation (Feb 15- Apr 15) to reduce egg loss through dewatering or suffocation from bank erosion. This is at odds with flows that would benefit fish in the lower Duncan River at the same time (see below). There is a lack of understanding on the specifics of burbot spawning.</p>	<p>Burbot spawning was not included in the Water Use Plan deliberations and a 10 year WLR monitoring study has been developed to help address uncertainties. The study is in year 4 of its term.</p>
	Kokanee and Bull trout tributary spawning (reservoir)	<p>Maximize tributary access to spawning tributaries.</p> <p>When reservoir levels are too low certain species, such as kokanee and bull trout, cannot access spawning areas.</p>	<p>A study was conducted and concluded that the operating alternatives for Duncan did not hinder tributary access for Bull trout and further studies are being done to focus on spawning of Kokanee.</p>
	River species (kokanee, bull trout, rainbow trout etc.	<p>Water is stored in the reservoir to augment natural flows up to the minimum flow levels in the spring. There is a direct trade-off between what benefits fish in the lower river and power benefits to the system. Duncan does not generate power, but there is less water to generate power in the Lower Kootenay and there is a need to increase flows from Hugh Keenleyside (no power) to meet Treaty requirements.</p> <p><u>Lower Duncan River</u></p> <ul style="list-style-type: none"> Minimize fish stranding risk – related to the stability of side channel flows. Minimize temperature effects Maximize tributary access Maximize habitat suitability Maximize food availability Minimize any fish passage issues in the main stem <p>Setting a min flow of 73cms year round was considered beneficial for the productive capacity of main stem and side channel habitats, especially for Kokanee (as there is a distinct population of Kokanee).</p>	<p>The alternative decided by the Water Use Plan targeted level flows in the lower Duncan river of 73cms (below confluence with Lardeau River) from Sep 15 to Nov 15. Alternatives considered had impacts to power of \$300k to \$500k/year.</p> <p>Maintaining the maximum flow targets in the lower Duncan River 250m³/s between 22 December and 9 April.</p> <p>Stranding protocol has been developed.</p> <p>Temperature effects were shown not to be significant in a 2003 report.</p> <p>Fish passage - Duncan dam is operated to allow bull trout in and out of the reservoir.</p> <p>In lower Duncan autumn flows have been protected for spawning and incubation of whitefish and kokanee.</p>
	Total Dissolved Gas	<p>Monitoring has shown that spill events greater than 114 m³/s result Total Gas Pressure levels of 115 %.</p>	<p>Monitoring of spill events.</p>
Wildlife	Reservoir	<p>Bear Trap Creek Flats and the low gradient portions of creek fans in the</p>	<p>The recommended alternative from the Water Use Plan has the reservoir</p>

Duncan Dam and Reservoir and Lower Duncan River			
Category	Sub-Category	Specific Interests	Mitigation
and vegetation	species	drawdown zone were viewed as good areas to focus on for improving the reservoir riparian area. A performance measure was developed. There was a trade-off between recreation and riparian productivity in the reservoir. Generally, higher reservoir levels (after reaching full pool in the summer that benefited recreation interests, July 15-Sept 1) were worse for riparian communities in the reservoir.	reaching full pool between Aug 1-10 and drafts 1-1.5m (3-5ft) by the end of labour day.
	Various species	Maximize the quality and quantity of available habitat area for wildlife. 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. Inundation period during the growing season (Apr 1 to Oct 30). Decrease elevations to 573.7m or less after reaching full pool and maintain. For cottonwood recruitment in the lower river, generally want to follow a more natural hydrograph once every 5 yrs. which includes: peak flows in July (basically defined above 250cms), recession flows by late Aug and lower base flows till next freshet.	Riparian and wetland habitat in the Lower Duncan River were considered of high value. Cottonwood forests were chosen as an indicator of riparian success since cottonwood establishment is highly sensitive to flow. See the above discussion.

Kootenay Lake and lower Kootenay River			
Category	Sub-Category	Specific Interests	Mitigation
Ecosystem Integrity	Primary Productivity	Duncan and Libby dams have reduced the inflow of nutrients and primary productivity has decreased. Maximize the primary production of carbon to enhance higher trophic level production.	<p>Kootenay Lake Nutrient Restoration Program was initiated in the North Arm in 1992 and the South Arm in 2003. The operations at Libby dam, Duncan dam, and outlet Corra Linn and Kootenay Canal can influence pelagic productivity. There was a nutrient retention performance measure that was used to determine compensation of nutrient loss associated with Duncan Dam operations.</p> <p>The Kootenay Lake Nutrient Restoration Program is collaboratively implemented based on several project partner contributions including Bonneville Power Administration, Northwest Power and Conservation Council's Columbia Basin Fish and Wildlife Program, Kootenai Tribe of Idaho (KTOI), the Fish and Wildlife Compensation Program - Columbia (FWCP - Columbia), the BC Ministry of Forests, Lands, and Natural Resource Operations (FLNRO) and the BC Ministry of Environment (MOE). The day to day operations are implemented by FLNRO and administered through FWCP-Columbia, KTOI and British Columbia Conservation Foundation (BCCF). FWCP-Columbia contributes approximately 750K/year. The Kootenai Tribe of Idaho receives funding from the Bonneville Power Administration through the Northwest Power and Conservation Council's Columbia Basin Fish and Wildlife Program of approximately \$740K US/year.</p>
Fish	General Productivity of various species - pelagic and littoral	<p>Minimize fish strandings by Duncan Delta.</p> <p>Minimize Total Dissolved Gas effects below Brilliant, Lower Bonnington, and Keenleyside dams.</p> <p>Minimize stranding effects below Brilliant dam</p> <p>Avoid impacts to Columbia River white fish and rainbow trout flows.</p> <p>Avoid unintended negative impacts to fish associated with VarQ flows from Libby dam.</p> <p>Minimise impacts to Mountain Whitefish spawning in Lower Kootenay River between November and March.</p>	<p>During the Water Use Plan these issues were hypothesized and while a preliminary review did not identify any measurable effects of significance from potential operational changes at Duncan, they did not consider changes as a result of different Treaty conditions nor as a result of flow changes from Libby dam.</p> <p>Gerrard- Rainbow Trout monitoring and studies in spawning channels.</p> <p>Rainbow trout are known to spawn in the headpond of Upper Bonnington below Corra Linn. Studies with Fortis are being done to assess fish stranding.</p>

Kootenay Lake and lower Kootenay River

Category	Sub-Category	Specific Interests	Mitigation
			Assessment of Kootenay Lake West Arm shoal spawning and incubation success for recommendations for Kootenay Lake operating regime.
			Burbot Conservation Strategy for Kootenay Lake and Kootenai River is being developed and some hypothesis tested regarding washing out of redds in Idaho. Operations at Libby dam and Kootenay Lake levels will influence redds. Note burbot are Red Listed in the Kootenays and are of particular interest to First Nations.
	White Sturgeon		Development of draft Sturgeon Management Plan for the Columbia.
Wildlife and vegetation	Riparian Habitat	Minimize losses of riparian habitat in drawdown zone (and corresponding increase in sand dune areas around Kootenay Lake).	Maintain water levels to the upper portions of the drawdown zone.
	Wetland Areas	Minimize losses of marsh wetland areas around Kootenay Lake	Maintain water levels to the upper portions of the drawdown zone

Koocanusa Region and Kootenay River

Category	Sub-Category	Specific Interests	Mitigation
Ecosystem Integrity	Backwatering	When reservoir levels drop below about 2400ft there is no backwatering effect on the Canadian side of the border.	
Fish	Bull Trout (threatened)	Maximize the abundance, diversity and condition priority species Minimize possible negative effects on other resident fish and their habitats on the Canadian side of the border.	
	Cutthroat Trout		
	White Sturgeon	Enhance the recruitment of the white Sturgeon population in the Kootenay River below Libby dam.	The VarQ flood control strategy is currently being implemented by the US Army Corps of Engineers. The strategy involves a spring pulse flow to assist sturgeon migration followed by a summer and fall flow regime to promote improved sturgeon spawning and rearing requirements as a result of

Koocanusa Region and Kootenay River			
Category	Sub-Category	Specific Interests	Mitigation
			increased volume and a more appropriate temperature regime. Bulltrout and cutthroat trout also benefit from the flow increases.
Wildlife and vegetation	Riparian Habitat and Littoral Productivity	Opportunity to initiate greater restoration activities.	Operating Koocanusa Reservoir to a lower annual maximum elevation, with infrequent exceedances, could provide for increased riparian, wetland and floodplain habitats.
	Grassland	Loss of grassland at Northern end of reservoir due to higher water levels in the spring time during VarQ flows.	No specific mitigation.
	Floodplain ecology	Improvements to ecological functioning of the flood plain (Creston Valley).	There are higher and more natural flows for certain periods under VarQ.
	Protected Areas Nesting Habitat	Flooding impacts of protected areas (e.g. Wildlife Management Areas) or other important habitats (Northern Leopard Frog breeding grounds) <u>Kootenay River Region (Duck Lake)</u> Preferred elevation range 1744' – 1746' (Spring) Detrimental elevation(s) >1749', <1744' (May 15 – Aug 31)	No specific mitigation but there is collaboration with US Army Corps.

Next Steps

The Columbia River Treaty Review team welcomes feedback on these first two chapters of the Environmental Discussion Paper. Please send your feedback to columbiarivertreaty@gov.bc.ca, and include "ENV Discussion Paper" in your subject.

Hydrological modelling studies to evaluate the potential impacts and benefits to environmental values based on alternative water management operating scenarios are being completed. Results will be presented at the upcoming community consultation sessions in November 2012. The next chapters of this discussion paper will describe these results in further detail and include relevant input and feedback from Basin residents, stakeholders, First Nations and government agencies.

