

**Scoping Document to Assess the Feasibility, Impacts, and
Benefits (FIBs) of Restoring Anadromous Salmon to the
Canadian Reaches of the Upper Columbia River**

Prepared for:

Upper Columbia Aquatic Management Partnership (UCAMP)

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Executive Summary

This report represents the initial stage in developing a common understanding of the feasibility, impacts, and benefits (FIBs) associated with restoring Pacific salmon to the Canadian reaches of the upper Columbia River, and to deciding whether it is possible to proceed with this proposal. This report grew out of a literature review, interviews with people who have a deep understanding of relevant issues, a compilation of this information into a draft report, a 2-day workshop in Spokane attended by 42 participants (see Appendix B), and a post-workshop synthesis into this final report.. There are five main elements to this report:

- **Steps to reaching a decision.** We describe an adaptive management approach to: progressively scope the breadth of issues; focus on the most critical issues / uncertainties that affect decision making; pursue studies / actions to gather information and help reduce uncertainties; and use that information to inform the next stages of decision making;
- **Issues.** We review the breadth of feasibility, impact and benefit issues;
- **Critical questions, uncertainties and proposed studies / actions.** We identify the outstanding questions, and the studies / actions needed to help answer these questions.
- **Next steps.** We summarize the key studies / actions that we understand as being most important to complete in the near term (i.e., 1–3 years).
- **Framework.** We provide a framework for organizing all pieces of a FIB Assessment report to inform a final decision on whether to restore salmon.

The proposed studies / actions identified in this report represent the beginning of a larger workplan required for a full FIBs assessment. We believe that instead of conducting a single all-encompassing effort at identifying and resolving potential issues, it is better to implement a systematic, phased approach with iterative re-assessments. As funding is obtained for each phase of work, studies / actions should be designed and implemented to help answer the outstanding questions around the next set of FIB issues. Given the complexities of salmon restoration, focusing on a small, manageable sub-set of issues at any one time will be essential.

The FIBs workshop identified a number of primary themes for moving forward in the near-term. These include: 1) establishing the technical engineering and ecological feasibility of restoring fish passage; 2) identifying the potential socio-economic impacts of restored fish passage; 3) developing a clearer understanding of the cultural value of the lost salmon resource to upper Columbia tribes and First Nations; and 4) developing a collaborative strategy for communicating the story of this lost resource, and building the necessary political and legal support for restoring salmon.

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List of Acronyms

BC MOE	BC Ministry of Environment	IJC	International Joint Commission
BCH	BC Hydro	IPNV	Infectious Pancreatic Necrosis Virus
BD	Brilliant Dam	IPPs	Independent Power Producers
BiOP	Biological Opinions	KN	Keenleyside Dam
BPA	Bonneville Power Administration	MC	Mica Dam
CBP	Columbia Basin Project	MOU	Memorandum of Understanding
CCRIFC	Canadian Columbia River Inter-tribal Fisheries Commission	MW	megawatt
CFIA	Canadian Food Inspection Agency	NEPA	National Environmental Policy Act (U.S.)
CEAA	Canadian Environmental Assessment Agency	NFH	National Fish Hatchery
CJ	Chief Joseph Dam	NMFS	National Marine Fisheries Service
CPCN	Certificate of Public Convenience and Necessity	NOAA	National Oceanographic & Atmospheric Administration (U.S.)
CRITFC	Columbia River Inter-Tribal Fish Commission	NWPCC	Northwest Power and Conservation Council
DFO	Fisheries and Oceans Canada	PATH	Plan for Analyzing and Testing Hypotheses
DGAS	dissolved gas abatement study	PUDs	Public Utility Districts
DO	dissolved oxygen	RV	Revelstoke Dam
DPS	Distinct Population Segment	SEPA	State Environmental Policy Act
DREW	Drawdown Regional Economic Workgroup	TDG	Total dissolved gases
EIS	Environmental Impact Statement	TGP	total gas pressure
EPA	United States Environmental Protection Agency	UCAMP	Upper Columbia Aquatic Management Partnership
ESA	Endangered Species Act	USACE	U.S. Army Corps of Engineers
FCRPS	Federal Columbia River Power System	USBR	U.S. Bureau of Reclamation
FERC	Federal Energy Regulatory Commission	USCOE	U.S. Corps of Engineers
FIBs	feasibility, impacts, and benefits	USDOE	U.S. Department of Energy
FPA	Federal Power Act	USDOI	U.S. Department of Interior
GCD	Grand Coulee Dam	USFWS	U.S. Fish and Wildlife Service
GIS	Geographic information systems	WN/SM	Waneta and Seven Mile Dams
		WUP	Water Use Plan

1. Introduction and Background

Grand Coulee Dam, completed in 1941, is a large hydroelectric dam located on the Columbia River in Central Washington. Made from 12 million cubic yards of concrete, Grand Coulee Dam is the largest concrete structure in the United States and the third largest hydroelectric facility in the world. Sharing the river with ten other major U.S. dams, Grand Coulee (Figure 1.1) is the first dam encountered on the Columbia after the river enters the U.S. from Canada. Lake Roosevelt, the reservoir created by the dam, contains 9 million acre-feet of water and stretches over 240 kilometres back to the Canadian border. Construction of Grand Coulee Dam was a huge U.S. government investment in the 1930s when jobs were scarce and such large scale economic development was beyond the means of states, cities and private investors. The benefits of this investment are obvious: thousands of acres of land irrigated for crop production, renewable power generated and distributed throughout the Northwest, and flood control relief of potentially huge property losses as far south as Portland. The construction of Grand Coulee Dam, however, left another legacy. Prior to hydropower development, the upper Columbia River supported a diverse fish assemblage, which included eleven anadromous salmonid stocks and the Pacific lamprey (Scholz et al. 1985). After construction of the dam, escapement of anadromous fish to at least 1100 miles of natal streams / lakes in the upper Columbia (approximately one-third within the U.S., the remainder in Canada) was cut off. The loss of connectivity and free flowing sections of the Columbia River also affected native white sturgeon, bull trout, and burbot. These native fishes are currently well below their historic capacity. This situation was compounded by the later (1958) construction of the Chief Joseph Dam (a further 55 miles downstream) without fish passage facilities. In blocking passage, these dams destroyed the anadromous fishery of the indigenous peoples of the upper Columbia in both the U.S. and Canada who had historically depended upon that fishery for subsistence, livelihood and cultural purposes.

No infrastructure for fish passage was built on the Grand Coulee Dam because in 1934 the Canadian federal government formally responded to inquiry by the U.S. federal government that there were no commercial fisheries on the Columbia River in Canada and thus Canada had no issue with the building of the Grand Coulee Dam without safe fish passage (Ortolano and Cushing 1999; Brugman and Thivierge 2003). At the time of Grand Coulee Dam construction, no consideration was given to the significance of salmon to tribes in either the U.S. or Canada. The state of knowledge of ecosystems at the time was also such that virtually no consideration was given to the maintenance of genetic biodiversity (Ortolano et al. 1999). Fish ladders and safe salmon passage were not provided for or maintained in the later Canadian dams on the mainstem Columbia River (at Keenleyside, Revelstoke and Mica dams) because no passage had been built for the earlier Grand Coulee Dam. However, a growing body of historical, scientific, oral and circumstantial evidence suggests that the upper Columbia once supported an appreciable salmon fishery—and it was only after building of Grand Coulee Dam that anadromous runs were eliminated. Evidence from native and non-native sources indicates that Chinook and sockeye salmon, steelhead and sturgeon flourished throughout the Canadian sections of the Columbia River prior to 1940—albeit their abundances were highly variable both seasonally and on a multi-year basis (NWPPC 1986; Brugman and Thivierge. 2003). Based on aboriginal catch rates, Scholz et al. 1985; Ortolano and Cushing 1999, estimated that between 500,000 and 1.3 million adult salmon escaped above Grand Coulee into the upper Columbia historically. Salmon and steelhead runs did however experience substantial declines prior to construction of Grand Coulee Dam. Reasons included the development of commercial fisheries, over-harvesting, grazing, timber harvesting, mining, dams on the lower mainstem and tributaries, roads, railroads, and destruction of estuarine and freshwater wetlands (Ortolano and Cushing 1999). In 1938, before Grand Coulee Dam cut off the upper Columbia for migrating anadromous fish, the basin-wide run of salmon and steelhead was 2.2 million and the run to the upper Columbia was estimated at 25,000 (Ortolano and Cushing 1999).

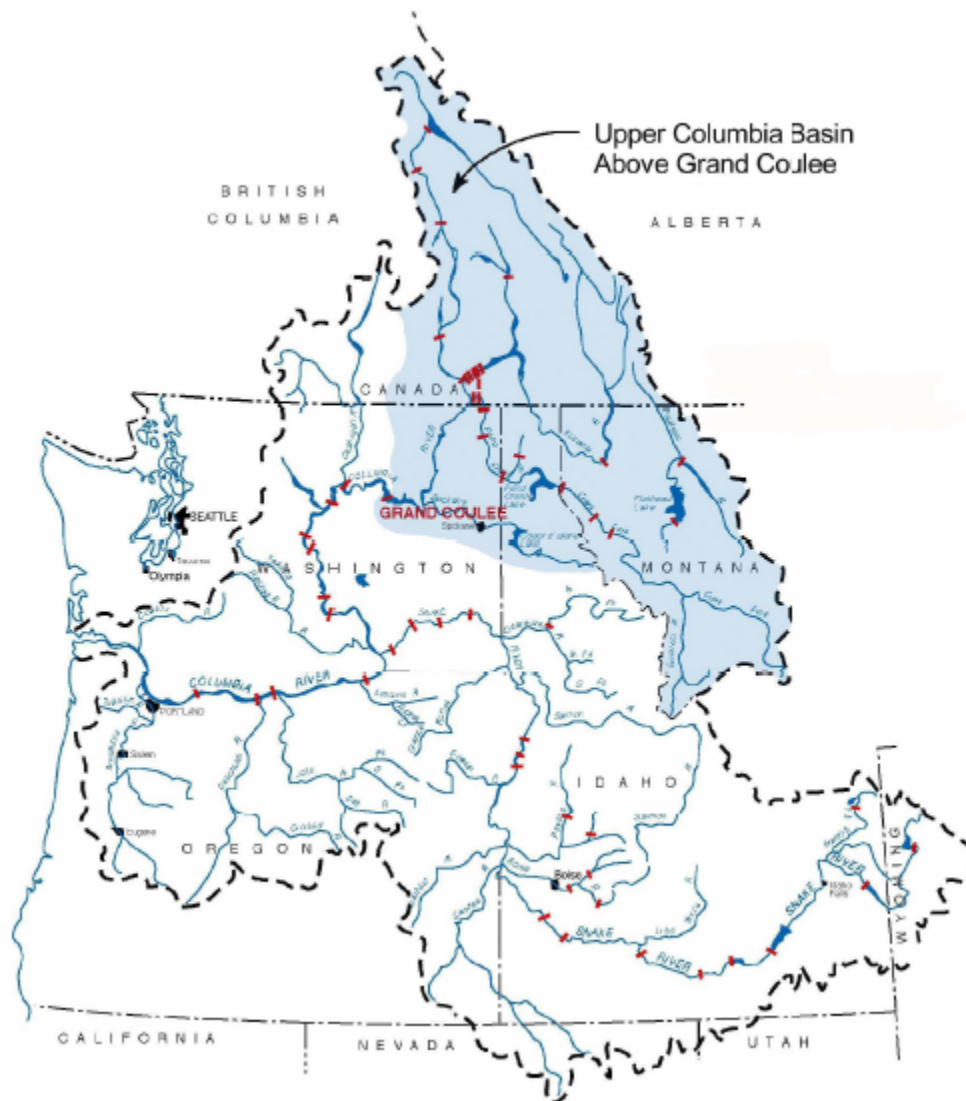


Figure 1.1. Location of major Canadian and U.S. dams and the upper Columbia River basin above Grand Coulee Dam (shaded area) (source: TGG 2000).

The Canadian Columbia River Inter-tribal Fisheries Commission (CCRIFC) was established in 1993 under a Memorandum of Understanding between the Ktunaxa / Kinbasket Tribal Council, the Shuswap Nation Tribal Council and the Okanagan Bands, and represents some of the First Nations communities which have territories within the Columbia River Basin in Canada¹. A primary goal of CCRIFC is to seek redress for the losses experienced as a result of the termination of upper Columbia salmon populations, principally through the restoration of anadromous salmon stocks to the Canadian Columbia River Basin. Key objectives for CCRIFC in achieving this goal are to:

¹ Both the Shuswap Nation Tribal Council and the Okanagan Nation Alliance have withdrawn from CCRIFC. The Shuswap, Ktunaxa and Okanagan Nations are developing the Upper Columbia Aquatic Management Partnership (UCAMP) to continue their working relationship in upper Columbia aquatic ecosystem management. This project is supported by UCAMP.

1. restore salmon stock productivity in the U.S. portion of the Columbia River Basin to allow surplus salmon for seeding areas above Chief Joseph Dam;
2. resolve upstream / downstream passage challenges at Chief Joseph and Grand Coulee Dam; and
3. restore salmon productivity above various Canadian hydroprojects on the Columbia River and its tributaries.

In pursuit of these objectives CCRIFC on April 25, 2003 asked the International Joint Commission (IJC) to enforce the conditions of its Order of Approval for the Grand Coulee Dam and Reservoir (the “1941 Order”). In so doing, CCRIFC asked the IJC to make further Orders necessary to protect and indemnify the fisheries interests of the indigenous communities located along the Columbia River on the Canadian side of the border whose fisheries have been damaged by the construction and operation of the Grand Coulee Dam and Reservoir. Specifically CCRIFC are looking for Orders to restore salmon to upper stretches of the Columbia River. Copies of the IJC’s Order of Approval and of all correspondence with respect to this matter are available on IJC’s weblink at www.ijc.org/rel/boards/ccrifc/request_ccrifc-e.htm). A submittal by West Coast Environmental Law to the IJC supporting the legality of the CCRIFC request is also available at www.wcel.org/wcelpub/2005/14232.pdf. The IJC recently disallowed CCRIFC's application and directed CCRIFC to Foreign Affairs and International Trade Canada.

The overriding goal behind CCRIFC's efforts is to restore viable and harvestable salmon populations in the Canadian Columbia River Basin. Re-establishing and restoring salmon stocks upstream of the Chief Joseph and Grand Coulee dams after such a long period of time will require resolution of a number of additional issues to be resolved beyond the current legal arguments. CCRIFC and UCAMP would like to clearly identify the issues and work towards their eventual resolution.

This report represents the initial stage in developing a common understanding of the feasibility, impacts, and benefits (FIBs) associated with restoring Pacific salmon to the Canadian reaches of the upper Columbia River, and to deciding whether it is possible to proceed with this proposal. There are six main elements to this report. Section **2.0 Steps to reaching a decision**, describes the perceived approach to progressively: (a) scoping the breadth of FIB issues; (b) focusing on the most critical issues / uncertainties that affect decision making; (c) pursuing studies / actions to gather information and help reduce those uncertainties; and (d) using that information to inform next stages of decision making. Section **3.0 Issues around re-establishment of anadromous salmon in the upper Columbia River** summarizes our review of the breadth of FIB issues. These issues have been grouped according to their relevance to (a) environmental / engineering; (b) regulatory / social; and (c) economic / financial concerns. The intent in preparing this list was to be as comprehensive as possible in identifying the potential issues that could affect decision making. As a first step to narrowing this list to ones most critically affect decision making, **4.0 Critical FIBs questions, uncertainties and proposed studies / actions for resolving issues** identifies the outstanding questions, and studies / actions needed to help answer these questions. This summary represents the results of our background research, expert interviews, and comments from participants at a 2-day workshop. Narrowing the focus even further, section **5.0 Next steps** summarizes the key studies / actions that we understand as being most important in completing in the near term (i.e., 1-3 years). **Appendix A – Annotated outline** provides a framework for organizing all pieces of a FIB Assessment report that might be required to inform a final decision on whether to restore salmon. Over time it is expected that this framework would be populated with information gathered through a phased approach to assessing the feasibility, impacts, and benefits of salmon restoration. Finally, **Appendix B – Workshop agenda** provides an overview of the 2-day workshop discussion about issues, uncertainties, and studies / actions needed to understand their significance to decision makers.

2. Steps to Reaching a Decision

Given the breadth and complexity of issues related to understanding this potential undertaking, it is important to be clear as to how this effort fits into subsequent steps of decision making. Figure 2.1 and supporting text proposes a high level overview of the steps we envision as needed to gather information and arrive at a decision about taking courses of action.

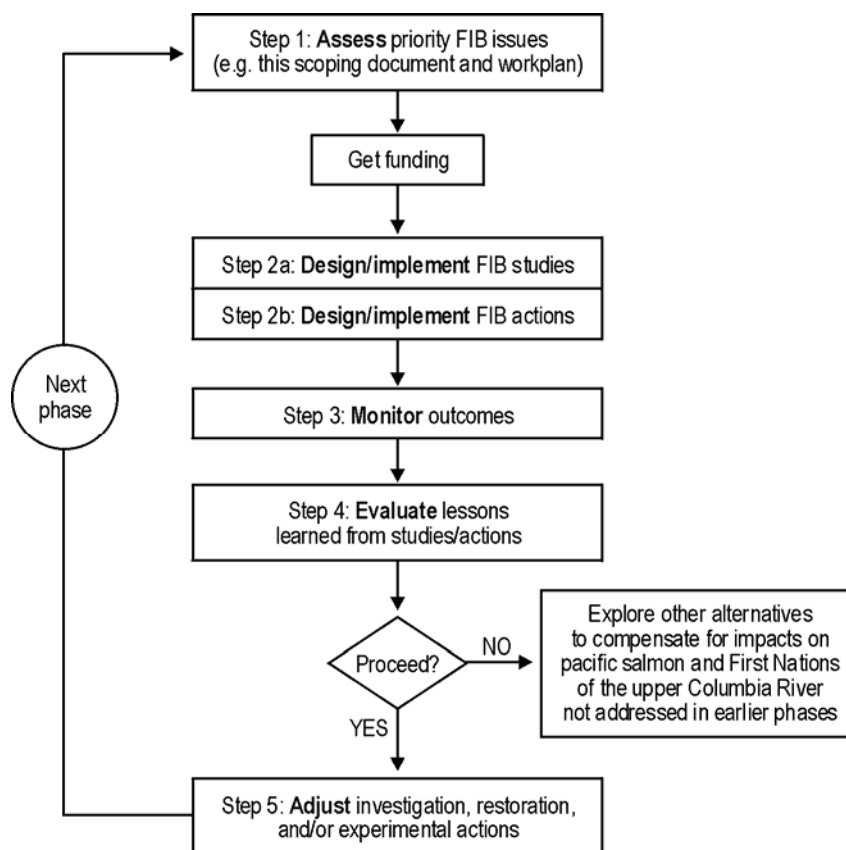


Figure 2.1. Overview of the process to decide whether to restore salmon passage to the upper Columbia River (adapted from Murray and Marmorek 2003). It is expected that this process will be completed using a phased progression of studies / actions over time. For instance, phase 1 studies would provide preliminary information to answer highest priority questions. Following their completion phase 2, 3, etc. studies / actions would be designed, implemented, monitored, and evaluated, building on lessons learned from the previous phases. FIB = feasibility, impacts, benefits.

Step 1. Assess priority FIB issues: Represents the scoping of issues, identification of priorities, and development of a workplan, as demonstrated by this work. Table 2.1 describes the four tasks involved in this project. We envision that a similar, though less comprehensive assessment of issues would be required in future phases to focus on the next priorities, building on information gained from previous stages.

Table 2.1. Summary and description of the tasks completed to develop a scoping document for future assessments / studies.

Task	Description
1 –Literature Review and Interviews of Domain Experts	Our review focused on evaluating: 1) the breadth of ecological, social, or economic issues potentially affecting the decision; and 2) the approaches used in other settings to assess feasibility, impacts, or benefits (e.g., from government approval processes—CEAA or NEPA). We reviewed both the academic and grey literature, and consulted with experts in the relevant subject domains (see Task 4) to gain this understanding.
2 – Summary of Issues	<p>Relevant issues can be described in terms of their feasibility, impacts, and benefits (FIBs). We felt it helpful to consider these issues from the perspective of three subject areas—ecological-scientific, social-governance and economic (see summary of issues in Table 3.1). Consequently, these nine FIB-domains provide the basis from which to describe a more succinct and simplified structure for the assessment and analysis.</p> <p>We provide four elements to our summary of issues. First, we summarize our review of the literature. Second, we identify the potential uncertainties affecting the decision to restore passage. Third, we highlight interdependencies across issues as important considerations for future stages. Finally, we organize resolution of issues into a logical sequence.</p>
3 - Workshop for Technical Committee and Domain Experts	<p>External review and feedback are critical to ensuring that all relevant issues are captured. We held a technical workshop² to review assembled information and to develop a phased workplan for moving forward. Participants at the workshop included the UCAMP Technical Committee, as well as biologists, hydrologists and hydroelectric engineers from Canada and the U.S. representing federal / provincial / state government environmental agencies, Canadian First Nations and U.S. tribes (Appendix B). The specific workshop objectives were to review and elicit feedback on:</p> <ul style="list-style-type: none"> • the framework for gathering information, decision making, and acting to restore salmon passage in the upper Columbia River; • the range of issues identified in draft scoping materials; • the list of uncertainties and series of related questions; and • the workplans for more detailed assessments.
4 - Prepare Final FIB Scoping Document	Discussions and feedback from the workshop (step 3) were integrated into a FIB scoping document (this report). The scoping document will provide the framework for future assessments required to fully evaluate FIB issues.

Step 2. Design and implement FIB studies / actions: As funding is obtained for each phase of work, studies / actions should be designed and implemented to help answer the outstanding questions around FIB issues. Design and implementation of appropriate studies / actions at this stage could include further literature review and elicitation of expert judgements, quantitative models, focused research studies, outreach activities, or field experiments. Thus, this stage would clarify study design requirements (e.g., spatial and temporal scales, variables being measured, etc.) For some actions, regulatory approval may also be required (e.g., Canadian Fish Transplant Permit requirements for transplanting fish above upper Columbia dams; NEPA environmental approvals for each distinct project in the U.S., etc.).

Step 3. Monitor outcomes: Monitoring outcomes from Step 2 restoration actions will be important to evaluate their effectiveness, helping decision makers understand what is working and what is not.

Step 4. Evaluate lessons learned from studies / actions: Once monitoring data are available it will be important to rigorously consider this information in the context of ecological, economic, and social objectives for managing the upper Columbia River. This stage would involve either a formal (e.g., decision analysis) or informal (e.g., discussions about outcomes) exploration of the tradeoffs involved

² Workshop held Feb. 28th – March 1st in Spokane, Washington

with a range of potential restoration alternatives (e.g., maintain no fish passage structures, construct fish passage at Chief Joseph, construct fish passage at Grand Coulee, etc.)

Following this stage, decision makers would need to determine whether to proceed with further phases of salmon restoration (e.g., yes or no decision point in Figure 2.1). Beyond what the data indicate, many other factors could affect this decision including political will, public and/or agency support, financial resources, and/or constraints on water releases during dam and reservoir operations. A decision to proceed from this point acknowledges the need to gather more information and/or evaluate more actions by proceeding to the next phase of FIB assessments. A decision not to proceed at this stage would require exploration of other alternatives to compensate for impacts on Pacific salmon and First Nations of the upper Columbia River that may not have been mitigated for by restoration actions undertaken in earlier phases.

Step 5. Adjust investigation, restoration and/or experimental actions: Given a decision to proceed, appropriate adjustments to the next phase in the workplan would be required. Adjustments could include testing transplantation of different salmon species, changing the number of fish transplanted, increasing the spatial extent of salmon restoration, exploring alternative passage technologies, etc.

We envision this work, and the broader phased approach to taking action proposed in Figure 2.1, as a process of focusing on and reducing uncertainties that will have the greatest effects on a decision to restore salmon to the upper Columbia River. A critical challenge will be to identify and characterize the critical unknowns (questions and uncertainties) that might affect decision makers' abilities to decide and act to restore salmon passage—initially scoped in Sections 3.0 and 4.0 of this report. For example, there are many questions for which we currently don't know the answer:

Can we engineer and construct effective upstream and downstream passage structures at the relevant dams?

What are the expected ecological effects on anadromous and resident fish species?

Would construction of fish passage structures be approved given existing regulatory mechanisms?

How do alternative assumptions of smolt survival during out-migration affect our estimates of anticipated gains in adult escapement?

To frame our understanding of such uncertainties and their effect on a decision, we also need to recognize the multiple agency decision frameworks at play. Different regulatory processes (ESA, FERC, CEAA) may require different forms of assessment, even though there will likely be many common elements. There are also many issues that could have potentially conflicting objectives. For example, an objective to restore spawning salmon in various tributaries upstream of Grand Coulee dam might conflict with an objective of maintaining production of recreational kokanee fisheries in Roosevelt Lake, since juvenile salmon and kokanee compete for zooplankton. It may also be difficult or impossible to assign a dollar value to non-monetary attributes. Thus, we envision this framework as considering multiple ecological, social, and economic objectives and their associated tradeoffs.

3. Issues Around Re-establishment of Anadromous Salmon in the Upper Columbia River

A wide range of issues need to be resolved before re-establishing anadromous salmon in the Canadian reaches of the upper Columbia River. This summary represents the initial stage of gaining a common understanding of the issues needed to better inform decision makers. The following subsections list and describe key issues in this regard as identified through literature review and consultation with leading domain experts. Issues are separated according to three subject areas (1. environmental / engineering, 2. regulatory / social, or 3. economic / financial) and categorized as to whether they relate to the direct feasibility of the undertaking, possible benefits, or possible impacts of restoring salmon. The suite of issues is summarized in Table 3.1.

3.1 Environmental / engineering

3.1.1 Feasibility issues

Dam and reservoir operations

Fish passage engineering (upstream / downstream)

Original engineering assessments for Grand Coulee at time of dam construction indicated that a 350-foot-high fish ladder for the dam was not feasible (given the required length of any proposed ladder and bioenergetic limitations relating to salmon fatigue), and there was no known way at the time to ensure that returning smolts could migrate successfully through the large reservoir proposed or safely pass over such a high spillway. There will be a range of difficulties associated with allowing passage at the different U.S. and Canadian facilities (i.e., some would likely require novel fish passage technologies, others may not). To overcome these concerns new and perhaps technologically novel fish passage structures (e.g., fish ladders, diversions, elevators) or trap and haul infrastructure would need to be built for safe and efficient passage of returning adults and migrating smolts through Chief Joseph, Grand Coulee and some of the Canadian upper Columbia dams and reservoirs (e.g., both Revelstoke and Mica dams in Canada are extremely high: Mica = 244 metres, Revelstoke = 175 metres; others like Keenleyside and Brilliant are considerably lower, Keenleyside = 52 metres, Brilliant = 43 metres). Table 3.2 presents the characteristics of dams and reservoirs in the upper Columbia that could be the focus of passage assessments. Evaluations of possible passage options have already been undertaken at Chief Joseph and some Canadian dams (e.g., Keenleyside, Waneta). However, achieving reasonable survival rates for migrating fish will likely be difficult given continued problems in this regard at existing low head run-of-river dams in the lower Columbia (C. Jordan, K. Hyatt pers. comms.). Successfully achieving passage around such a high head dam as Grand Coulee (hydraulic height of 380 feet) and through such a large reservoir as Grand Coulee (100,390 acres, 10,000,000 acre-ft, with one month average water residence time) would be considered unprecedented. While adult passage over high head dams of greater than 30 meters has been accomplished in other jurisdictions through the use of locks, elevators and trap and haul methods, these have generally been successful only for maintaining small anadromous fish populations upstream of these dams. Past efforts to restore salmon above impassable barriers in the Columbia Basin have not been successful. As an example case study, a trap and haul approach for juveniles was attempted in the much smaller Brownlee Reservoir (14,000 acres, 1,420,000 acre-feet) in the Hells Canyon Complex employing a mesh-barrier system to collect juveniles before they reached the dam, but this eventually proved a failure. Limited ability of the nets to capture sufficient numbers of juvenile salmon and steelhead, combined with elevated water temperature, low dissolved oxygen (DO) levels, and inability of fish to find their way through the Brownlee reservoir were considered as the suite of factors that ultimately led to the failure to re-establish a stock above the Hells Canyon Complex.

Table 3.1. List of Feasibility, Impacts, and Benefits (FIB) issues.

	Environmental / engineering	Regulatory / social	Economic / financial
Feasibility	Evaluation of tradeoffs among ecological, social, and economic impacts / benefits		
	<p>Dam and Reservoir Operations</p> <ul style="list-style-type: none">Fish passage engineering (upstream / downstream)Cumulative impactsDissolved gases (TGP) <p>Ecological</p> <ul style="list-style-type: none">Predation / competitionGenetics and life historyHabitat (access, quality, capacity)Climate warming	<p>Legal (case law, court challenges)</p> <ul style="list-style-type: none">Aboriginal rights and titleResponsible government authority <p>Political</p> <p>Operating agreements and guiding legislation</p> <ul style="list-style-type: none">Columbia River TreatyPacific Northwest Coordination AgreementNon-Treaty Storage AgreementPacific Northwest Electric Power Planning and Conservation ActCanal Plant AgreementEndangered Species ActSpecies at Risk ActColumbia Basin ProjectColumbia River Forum <p>Regulatory framework for project approval (see 3.2.1 for specific regulatory requirements)</p> <ul style="list-style-type: none">Federal approvals (Canada, U.S.)Provincial / state approvals (BC, WA)Local consultation	<p>Financial cost</p> <ul style="list-style-type: none">Capital costs (dam construction works, methods for ensuring fish passage)Operating costs (flow reallocations and foregone revenues)
Impacts	<p>Water Resources</p> <ul style="list-style-type: none">Hydrology (river flows / volumes)Water quality (nutrients, pollutants, sediment, water temperature, TGP) <p>Aquatic Biological Resources</p> <ul style="list-style-type: none">Resident fish (competition, disease, genetics)Non-native fishAnadromous fish (lower river salmon stocks)	<p>Electric power</p> <ul style="list-style-type: none">GenerationReliability <p>Water management</p> <ul style="list-style-type: none">Flood control (storage and flexibility)Agricultural usesNavigation <p>First Nations / tribes</p> <ul style="list-style-type: none">Food, social, and ceremonial (subsistence) fisheries <p>Recreation, tourism, and non-native culture</p> <ul style="list-style-type: none">Commercial and recreational fisheriesRecreational activities (reservoir and downstream uses)	<p>Electric power</p> <ul style="list-style-type: none">GenerationReliability <p>Water management</p> <ul style="list-style-type: none">Flood control (storage and flexibility)Agricultural usesNavigation <p>First Nations / tribes</p> <ul style="list-style-type: none">Food, social, and ceremonial (subsistence) fisheries <p>Recreation, tourism, and non-native culture</p> <ul style="list-style-type: none">Commercial and recreational fisheriesRecreational activities (reservoir and downstream uses)
Benefits	<p>Water Resources</p> <ul style="list-style-type: none">Hydrology (river flows, volumes)Water quality (nutrients, water temperature, sediment, TGP) <p>Aquatic Biological Resources</p> <ul style="list-style-type: none">Habitat quantityHabitat quality (depth, velocity, temperature, substrate)Anadromous salmon (population abundance, life history expression)Other anadromous fish <p>Terrestrial Biological Resources</p> <ul style="list-style-type: none">Nutrient enrichment (vegetation, wildlife)	<p>First Nations / tribes</p> <ul style="list-style-type: none">Food, social, and ceremonial (subsistence) fisheriesCultural significancePolitical (fair and equitable compensation) <p>Recreation, tourism, and non-native culture</p> <ul style="list-style-type: none">Commercial and recreational fisheriesNon-native cultural significance <p>Regulatory environment</p> <ul style="list-style-type: none">ESA status	<p>First Nations / tribes</p> <ul style="list-style-type: none">Food, social, and ceremonial (subsistence) fisheriesCultural significancePolitical (fair and equitable compensation) <p>Recreation, tourism, and non-native culture</p> <ul style="list-style-type: none">Commercial and recreational fisheriesNon-native cultural significance <p>Regulatory environment</p> <ul style="list-style-type: none">ESA status

Table 3.2. Characteristics of upper Columbia River basin dams under possible consideration for restoring passage of anadromous salmon and steelhead.

Dam	Columbia RKM	Structural Height (m)	Reservoir	Length (km)	Area (km ²)
Chief Joseph	874	72	Rufus Woods	82	34
Grand Coulee	956	200.5	Roosevelt	243	406
Keenleyside	1255	52	Arrow	230	520
Revelstoke	1498	175	Revelstoke	129	115
Mica	1638	244	Kinbasket	209	425
Brilliant	(Kootenay R)	43	-	-	-
Waneta	(Pend d'Oreille R.)	67	-	-	-
Seven Mile	(Pend d'Oreille R.)	80	Seven Mile		4.1

A major problem for juvenile passage relates to attracting smolts to dam spillways or passage structures. There are counter-currents at the surface of reservoir dam forebays that will generally confuse smolts and cause them to go in the wrong direction and fail to locate any passage facilities near the dam. To resolve this, operators must either: 1) install structures that can draw water from the surface; 2) draw down the reservoir in the spring to near turbine intake level; or 3) generate heavy spill to create a surface attraction (F. Young – pers. comm.). The use of voluntary spill to improve passage survival is based on data indicating that survival of juvenile salmonids passing dams is greatest at spillways, followed by juvenile bypass systems and then turbines. If attempting to pass smolts directly over spillways it's likely that there would be a need to considerably modify the existing spillway at Grand Coulee (and likely other dams) to improve smolt survival odds. For smolts to even successfully migrate to within attraction range of passage options at the Grand Coulee dam will be difficult, given the vast extent of Lake Roosevelt. Fluctuating water levels in Grand Coulee and other reservoirs will also create difficulties for smolt passage, and as these large storage reservoirs are also used for peaking power this will increase their amount of fluctuation. These fluctuations could become more highly variable given climate change scenarios that could alter priorities for water allocation among different uses and also change the pattern of storage through the linked set of projects on the Columbia River. Variable reservoir operations could also impede access to tributaries required for spawning / rearing.

Establishing successful downstream passage for any migrating smolts from the upper Columbia must account for a number of important factors:

- 1) the optimal window for ocean entry, usually around May;
- 2) the time required to reach the estuary from the point of origin of a given stock;
- 3) the flow required to achieve that travel time to the estuary; and
- 4) the implications of this flow schedule for both other stocks of salmon as well as other fish species including resident fish

Salmon generally need a pulse of flows around April as well as August. Dams are generally drawn down over the winter months, then raised during late spring for the summer months and then more gradually drawn down again in later August period. Any analysis of feasibility would need to look at the overlaps of salmon needs as well as usual storage and drawdown operations. Generally transit time is faster when the reservoir is drawn down. However, summer drawdown affects resident fish. The spring filling of reservoirs relies on snow melt, which could change in the future under climate warming. If flows do need

to be altered to permit migration of these stocks, this would require coordination across multiple hydroelectric projects.

The complete set of passage challenges that would be faced by both adults and juveniles need to be considered when deciding what would be the most appropriate first strategy in establishment of salmon in the upper Columbia River. One could begin by establishing smolts at some of the best habitats in the system (e.g., Arrow Lake), and then if passage through Roosevelt Lake were not feasible, trapping juvenile smolts at Roosevelt Lake and bypassing both Grand Coulee and Chief Joseph. An alternative approach would be to attempt to establish a population above Roosevelt Lake and below Keenleyside Dam, and get that population established before considering establishing populations higher in the system. Adults could, in theory, swim all the way from Grand Coulee to Revelstoke Dam via the navigation locks at Keenleyside Dam, provided that there are enough attraction flows. However, the turbines are currently on the other side of Keenleyside Dam from where the locks are and fish would therefore more likely to be attracted to the turbine outflows than the locks.

Current planned efforts to restore salmon populations above high dams in the Pacific Northwest include projects on the Lewis River in Washington, and the Deschutes River in Oregon. The Federal Energy Regulatory Commission (FERC) relicensing plan for the Lewis River will include an attempt to transport anadromous fish around three dams (Merwin, Yale and Swift) to ultimately reopen access to 117 to 167 miles of potential salmon and bull trout habitat currently blocked to migrating fish. Salmon and steelhead have not had access to these areas since the completion of Merwin Dam in 1931. The plan is for migrating adults to be trapped below Merwin Dam, and then trucked upstream of the dams for release in Swift Reservoir. Surface collectors in the reservoir will be used to guide migrating smolts to Swift Dam for truck transport downstream of Merwin Dam for release. The FERC relicensing plan for the Pelton / Round Butte dams on the Deschutes River below the mouths of the Crooked and Metolius rivers similarly involves trapping adults (of Chinook, sockeye, steelhead, and bull trout) below the dams, selectively screening them for disease and genetic integrity as Deschutes natives, and then trucking them upriver for release. A similar process will be used for processing downstream-migrating juveniles. The original fish-passage facilities that were built at the Pelton / Round Butte dams in 1965 included a three-mile-long fish ladder between the Pelton Regulating Dam and Pelton Dam. A cable tramway system also was constructed to lift large adult fish over the 440-foot-high Round Butte Dam. Many fish refused to use the fish ladder, although some made it upstream to spawn. Unfortunately, the downstream fish-passage system failed, as returning smolts were unable to navigate successfully through Lake Billy Chinook, and ultimately the entire system was abandoned. The current plans for reintroduction of salmon stocks to areas above the Pelton / Round Butte dams include enhanced attraction flows within Lake Billy Chinook to draw smolts towards new passage facilities. This involves construction of a 270-foot selective water withdrawal tower upstream of Round Butte dam that will control reservoir water temperatures and manipulate water currents. A large disc at the top of the tower will draw in most of the surface water, altering the current to attract fish. The tower's draw of warmer water off the surface of Lake Billy Chinook can keep the reservoir cooler in the summer, creating a healthier environment for fish, while an intake near the tower bottom can withdraw cold water at certain times of year, maintaining appropriate downstream temperatures. The water withdrawal tower will also be capped with a intake module that will collect migrating fish and pipe them to a fish handling facility, from which they'll be transported downstream of the project. This experiment is still in the planning stages (slated for 2009) and even if successful it must be noted that Lake Billy Chinook is considerably smaller than Lake Roosevelt (4000 acres vs. 100,390 acres). Undertaking similar trucking, barging or other transportation options for smolts and/or adults will require major infrastructure investment as none of the U.S. upper Columbia dams currently have any transportation facilities in place. Trap and haul approaches in the upper Columbia (for both adults and juveniles) would need to be evaluated through a careful feasibility analysis before committing to any major infrastructure changes in this regard (B. Nordland, pers. comm.).

The possible suite of alternative fish passage options that might need to be considered for migrating spawners and smolts at Chief Joseph, Grand Coulee and Canadian upper Columbia projects is included in Table 3.3.

Table 3.3. Alternative fish passage options.

Spawners	Smolts
<ul style="list-style-type: none"> • Trap and haul past Chief Joseph, or past Chief Joseph and Grand Coulee, or possibly all the way past Lake Roosevelt. For fish to continue upstream migration they will need to be imprinted on the chemical signatures of upstream waters. • Elevators such as have been used in Europe to get adult fish past dams. • A lock, as available at the Keenleyside Dam could permit adult passage • A fish ladder (e.g., several of the mid-Columbia projects could provide models). • A bypass which would link a tributary downstream of Chief Joseph to another tributary which drains into Lake Roosevelt. This crossover link would occur near the upstream end of these two tributaries, such that the adult salmon could swim upstream in one tributary below the dam and then down another above the dam. This type of arrangement has been done in the John Day and Umatilla watersheds. 	<ul style="list-style-type: none"> • Fry outplants in natural streams plus trap and haul to get past some (though not all) reservoirs. • Side channel spillways (e.g., USACE DGAS studies in the mid-1990s, available online in the Walla Walla district office (DGAS = dissolved gas abatement study)). • Stacked near surface collectors, such as are being built for the Howard Hansen Dam in the Green River, WA area, with a downstream lock (GEI and ENSR 2005). • A floating collector or screen far upstream of the dam which would then collect fish for short-haul barging.

The region has a considerable amount of expertise on fish passage (e.g., the Portland and Walla Walla offices of USACE, Batelle Pacific Northwest Labs, Alden Labs, PUDs). Experts from these groups could work together on brainstorming options that could be feasibly implemented at each of the projects for both upstream adult and downstream smolt passage. In addition, there is a need for behavioural studies to track movement and survival of smolts through Lake Roosevelt, to assess if reservoir passage would be feasible. Passage past Grand Coulee Dam will be especially problematic, due to some of its particular attributes. For smolts, the fluctuations in the reservoir create difficulties in structuring a passage facility. The high head of the reservoir means that passing fish down through turbines has an associated high level of mortality due to the pressure changes that fish experience. The fish would need to find an entrance with sufficient attraction flows to carry them to some kind of bypass around the dam. However, power generation occurs right across the axis of the dam which makes establishment of higher attraction flows more difficult. The dam has high spillway mortality and high levels of TDG, which do not dissipate quickly. All of the above factors make establishing smolt passage at Grand Coulee a considerable challenge. For adults, the design of a fish ladder at Grand Coulee also presents considerable challenges. The fish would need to have many resting pools to successfully ascend past the dam. An alternative would be to trap fish at Chief Joseph and transport them varying distances, potentially all the way past Roosevelt Lake 320 km upstream.

A set of detailed studies for assessing fish passage options are described in Section 4.0 But in general, there are three steps required in the process of evaluating passage feasibility:

1. Assess the required travel time for stocks of fish in different locations (with different life histories), and the required flows / reservoir levels necessary to have these fish reach the estuary in the critical window. These alternative stocks and life histories could then be screened in terms of their technical feasibility given the current set of operations at the various projects.

2. A set of studies should be undertaken to determine if fish can survive migration through the reservoirs (both smolts and adults). If they can survive transit through the reservoirs, then it would be worthwhile exploring options for establishing passage at the dam projects. If, on the other hand, fish cannot survive reservoir transit, then there would be a need to examine options for bypassing the reservoirs.
3. Once these options have been filtered down, one should do a collaborative decision analysis of the tradeoffs across various different objectives for the operation of these projects, including:
 - a) salmon passage and production;
 - b) other anadromous fish, both listed and unlisted;
 - c) resident fish;
 - d) power production (both revenue from hydroelectric projects as well as the impacts of replacement power if hydroelectric production is reduced);
 - e) flood control (in both Canada and the U.S.);
 - f) irrigation and other objectives listed in Chapter 4.

Supporting references: Office of Technology and Assessment 1995; Whitney et al. 1997; Heinith and Karr 1997; BC Hydro 2000; Hay & Company Consultants 2001; Larnier 2001; Yuskavitch 2001; Muir 2001; Giorgi et al. 2002; Oldani and Baigun 2002; IDACORP 2002; Idaho Power 2003; Marx 2003; R2 Resource Consultants 2004; PacifiCorp 2004; California Energy Commission 2005; GEI Consultants and ENSR International 2005; Johnson et al. 2005; California Energy Commission 2005; PGE 2006, USACE 2002c; Ferguson et al. 2006.

Dissolved Gases (TGP)

Levels of dissolved gases such as nitrogen and oxygen in the water column at Grand Coulee and Canadian Dams can be very high (historically approaching 120-130% saturation subsequent to passage through upper Columbia Canadian dams – M. Filardo, pers. comm.). Elevated total gas pressure (TGP, or total dissolved gas – TDG) may affect fish by causing gas bubble trauma (GBT), a condition that, in severe stages, may be fatal. Under total dissolved gas conditions of 115% to 120%, signs of GBD are usually minimal or nonexistent, with no apparent GBT-related mortality, whereas levels above 120% that are prolonged can lead to symptoms. A number of factors contribute to the susceptibility of fish to GBT, including TGP concentration (itself affected by temperature), duration of elevated TGP, species and life stage of fish, and depth at which the fish is swimming. Highest TGP levels occur during periods of significant spill, usually associated with the peak of freshet or snowmelt when river flows are highest, or other conditions when flows exceed generating capacity. Because gas levels do not dissipate quickly, TGP tends to increase progressively downstream when there are several dams on a system.

TGP levels in the Columbia River have decreased since the early 1990s as a result of operational changes and upgrades at the dams and construction of the Arrow Lakes Generating Station (ALGS) at Hugh Keenleyside Dam. The BC TGP Water Quality Objective of 110% is met most of the year, and exceeded only on occasion when spill volumes are greatest. A 1999 CRIEMP study reported that since construction of the ALGS power plant there were now fewer days of elevated TGP, although the maximum TGP levels had not decreased. Other studies conducted since the early 1990s by BC Hydro and the Columbia Power Corporation have also shown considerable reductions in TGP and associated risks to fish. Further substantial reductions in TGP are expected in the upper Columbia hydrosystem when the Brilliant Expansion (under construction) and Waneta Expansion (EA review) eventually come into operation (B. Green, pers. comm.).

The Columbia River Transboundary Gas Group (TGG) was formed in April 1998 to help coordinate Columbia Basin dissolved gas planning activities between Canada, the United States, state, provincial, and federal agencies, tribes, first nations, and other organizations. TGG members discuss the latest developments in dissolved gas monitoring, abatement methods, modeling, and biological effects. The TGG can provide recommendations for further improvements, but they have no official capacity to enforce changes.

Supporting references: USACE 2000; NMFS 2005; CRIEMP 2005; TGG 2006; Beeman and Maule 2006

Cumulative Impacts

Migrating and rearing salmon face a gauntlet of potential additive mortality factors within the current lower river extent of the Columbia hydrosystem. Cumulative impacts that are commonly faced by salmon include: drawdown of water for irrigation and power demands which can expose spawning beds and cause entrapment of fry in irrigation channels; altered flow of water (e.g., reduced spring flow) that can increase residence time for fry / smolts, thereby increasing exposure to fish predators and elevated temperatures; mortality in turbines and debris traps; mortality in spillways from supersaturated gases and temperature shock; mortality from exposure to industrial pollution; mortality associated with lower river smolt transport options (e.g., barging); mortality from marine mammal and avian predation; etc. Direct mortality of migrating adults at dams is considered to average around 2% per project. Direct mortality of juveniles at dams is more variable, as juvenile fish migrate past the lower dams by several routes: through the turbines, through juvenile bypass systems, through spillways, or by collection and transport in barges or trucks.

Fish passing through hydraulic turbines are subject to various forms of stress likely to cause high mortality: probability of shocks from moving or stationary parts of the turbine (guide vanes, vanes or blades on the wheel), sudden acceleration or deceleration, very sudden variations in pressure, and cavitation. The mortality rate for juvenile salmonids in turbines can vary greatly, depending on the properties of the wheel (diameter, speed of rotation, etc), their conditions of operation, the head, and the species and size of the fish concerned. Turbine passage for juvenile salmon at lower Columbia dams has a survival rate of 85 to 95% per project.

Bypass and spill survivals can be much better, where survival rates in the order of approximately 95 to 99% per project have been demonstrated in the lower Columbia River. Passage through spillways can, however, be both a direct cause of injury or mortality, and an indirect cause (increased susceptibility of disoriented or shocked fish to predation). Spillway mortality rate varies greatly from one location to another and has some correlation with spillway height: for example mortalities of between 0% and 4% for the Bonneville, McNary and John Day dams (about 30 m high spillways) on the Columbia River, and 8% at the Glines Canyon dam (60 m high spillway) on the Elwha river in Washington. Mortalities at spillways have several causes: shearing effects, abrasion against spillway surfaces, turbulence in pools at the base of the dam, sudden variations in velocity and pressure as the fish hits the water, and physical impact against energy dissipators. The manner in which energy is dissipated in the spillway can have a determinant effect on fish mortality rates. Significant damage occurs (with injuries to gills, eyes and internal organs) when the impact velocity of the fish on the water surface in the downstream pool exceeds 16 m/s, whatever its size. A column of water reaches this critical velocity for fish after a straight drop of 13 m.

Direct mortality at dams and cumulative impacts throughout the migratory corridor can also be highly variable for salmon stocks on an annual basis, depending on climate, hydrosystem operations and cycles of abundance in salmon. However, given the current cumulative mortality impacts already involved with salmon migrations through the lower Columbia River corridor, the persistence of any newly established upper river stocks will likely be highly dependent on minimizing any additional mortality at upper river dams and reservoirs.

Supporting references: NWPPC 1986; Raymond 1988; NWFSC 2000; Larinier 2001; NMFS 2005; Anderson 2006

Ecological

Predation / Competition

Fish stockings and/or ill-advised restoration experiments have allowed a range of exotic species (e.g., walleye, carp, yellow perch, smallmouth bass, pumpkinseed, lake whitefish, brook trout, bullheads and Mysis shrimp) to enter reservoirs and streams of the upper Columbia, any of which could negatively affect the success of salmon reintroductions through predatory or competitive interactions.

Supporting references: Brugman and Thivierge 2003

Genetics and life history

It is uncertain whether potential donor stocks required for transplanting anadromous fish in the upper Columbia represent suitable genetic material for restoration and recovery in Columbia upriver habitats. There are unlikely to be many available stocks in the Mid-Columbia with populations of sufficient size to reseed the Canadian portions of the Basin. Originally there were 12 sockeye stocks in the Columbia Basin (primarily from Arrow and Slocan Lakes); now only the Wenatchee and Okanagan stocks remain (plus conservation hatchery stock for Redfish Lake). It might now be possible to use summer Chinook from the Okanagan or Chief Joseph hatchery, Okanagan sockeye, or Kokanee used as sockeye surrogates. However, donor stocks may have to come from healthy populations outside the Basin, with life history traits presumably conducive to establishing an upper river population.

Obtaining a brood stock that would perform well for upper Columbia reintroductions is likely to be problematic (P. Moran, pers. comm.). Sockeye in particular are notoriously difficult to recolonize (K. Hyatt, pers. comm.). A long term project (initiated in 1949) to re-establish sockeye runs in the Upper Adams River has had mixed success. Early in the twentieth century, due to the slide at Hells Gate in the Fraser River canyon and numerous years of logging splash-dam operation at the outlet of Adams Lake, the Upper Adams sockeye stock was wiped out. In subsequent decades, the International Pacific Salmon Fisheries Commission performed numerous transplants in an attempt to re-establish and rebuild the run. It was not until the mid 1980's that any measurable returns were documented, with presence only one year in four. Renewed recovery efforts by DFO's Salmonid Enhancement Program beginning in 1988 using annual transplants of sockeye raised at the Shuswap River Hatchery resulted in the return of over 70,000 adult spawners to the Upper Adams by the year 2000. This long term restoration effort, however, has been derailed (at least temporarily) by the almost complete collapse of the run in the fall of 2004 resulting from excessively high temperatures in the lower Fraser River that year (D. Lofthouse, pers. comm.). DFO has also had successful outplants of sockeye in the Stikine (although not in the Taku) and are optimistic about eventual success of transplants into Skaha Lake on the Okanagan River system. The situation in the Skaha likely represents the ideal for attempting a sockeye reintroduction i.e., good quality habitats available, a minimal and feasibly passable barrier, an existing fish stock directly below the barrier, and only a limited extension of their distribution required for reestablishment above the current barrier (K. Hyatt, pers. comm.). This ideal situation will not exist for re-introductions above Grand Coulee and sockeye runs would likely have to be maintained through hatchery production with supplementation used to establish natural spawning.

Counter to the difficulties associated with sockeye reintroductions, efforts with Chinook have been more encouraging. A limited release of 520 thousand Lower Shuswap origin juvenile Chinook in to the Upper Adams River over five consecutive brood years (1989 to 1993) has resulted in a now apparently self sustaining run into the river, with an estimated F3 generation return of 165 adults (D. Lofthouse, pers. comm.).

The type of fish production (i.e., natural, hatchery, or some combination) is intimately related to the types of passage options which would need to be considered. A hatchery would offer the potential for outplanting fish to the various locations and establishing some imprinting on those waters. If using hatchery stocks for reseeding it may, however, be difficult to maintain overall population fitness (e.g., genetic and life history diversity). The Colville Tribe's Chief Joseph hatchery will likely be integral for developing an effective supplementation strategy that could support the required diversity of naturally spawning upper river stocks. While it isn't clear what life history types originally existed in the upper Columbia Basin in Canada, some speculation suggests that fish, at least in the Slocan, may have had an 'ocean type' of life history. This is because it gets too warm in the summer for such fish to remain in their natal habitat, and therefore they likely moved downstream to cooler waters fairly early in the summer. On the other hand, some of the Upper Columbia River stocks may have had a stream-type life history similar to stocks in the upper Fraser River. This speculation is based on First Nations reports that there used to be two runs of salmon at different times of the year. As you move upstream in the system, all of the reservoir delays will become increasingly incremental. This suggests that a life history which allowed fish to leave their natal stream fairly early (perhaps like the Slocan) and then move downstream in a staged fashion might offer the best opportunity for survival down to the Columbia River estuary. Supporting the identification of appropriate life history types, there is also a need to determine how many fish are required for a stock to have a sustainable level of production. This could utilize some of the TRT (Technical Recovery Team) abundance vs. productivity curves to determine for candidate stocks the 140 appropriate minimum levels to ensure viability (e.g., 500–1000 fish per stock).

Supporting references: Ricker 1972; Williams 1987; Cramer and Whitty 1998; Mundy and Backman 2000, DFO 2001; Lofthouse 2002; Hume et al. 2003; MacKinlay et al. 2004; Wright and Smith 2004; CTCR 2004; Quinn T. 2005; Hyatt et al. 2005; Beechie et al. 2006; Riffe and Mercer 2006, Narum et al. 2007

Habitat (Access / Quality / Capacity)

The condition (access / quantity / quality) of spawning and rearing habitat may be insufficient and water quality (e.g., nutrients, sediment, pollutants, temperature) too impaired in some tributary streams within the upper Columbia to support large salmon populations. Existing spawning / rearing habitat in Grand Coulee tributaries in particular may be limited. Past contamination of Lake Roosevelt sediments from an upstream lead-zinc smelters and pulp mill may still be a factor impacting habitat quality and fish health, although these pollutant loadings have been reduced in recent years. Reservoir elevations required for hydrosystem operations may limit available salmon shore spawning habitat. There are many existing barriers that will prevent access to tributary habitats, including smaller dams and culverts, once fish have successfully gotten past the big dams. Generally there may be limited amounts of salmon spawning / rearing habitat currently available between Grand Coulee and Canada, although this could change with reservoir fluctuations that might be required for anadromous fish passage. A major problem for sockeye reintroductions is that current lake ecosystems in the upper river are no longer what were there originally for sockeye (K. Hyatt, pers. comm.), as there are now Mysis shrimp and kokanee competing for resources, and the carrying capacity is likely much more limited than historically.

Recent assessments of the river reach between Chief Joseph and Grand Coulee indicate that it contains approximately 48.7 ha of potentially suitable fall Chinook spawning habitat. Spawning habitat here is primarily limited by water that is too deep and secondly by water velocities that are too low, the combination of which results in only 20% (9.6 ha) of the potential spawning habitat being characterized as high quality. Estimates of redd capacity within the potential spawning habitat range from 207–1599 redds, based on proportional use of potential habitat and varying assumptions about the amount of channelbed used by spawning salmon (i.e., redd size plus inter-redd spacing).

Supporting references: Munn 2000; Hanrahan et al. 2001; Wright et al. 2003; Hanrahan et al. 2004; Cox et al. 2004

Climate Warming

Anthropogenic climate change could impede salmon reintroduction efforts in the upper Columbia River, dependent on future greenhouse gas emissions and the response of regional climate. Columbia Basin climate models, although variable quantitatively based on model assumptions, generally suggest a range of environmental impacts that could affect salmon through alterations to the timing of discharge and changes in sedimentation rate, temperature, and flow. Increased summer temperatures could delay spawning and earlier and more frequent floods could scour eggs and alevins before emergence. More frequent and severe droughts could produce lower flows and increased water temperatures during juvenile rearing and outmigration, resulting in poor survival and poor returns in subsequent years. Specific impacts would likely depend on the species or run (e.g., spring-run Chinook salmon might be most affected by a shift in peak discharge impeding smolt migration whereas juvenile steelhead might be most affected by reduced summer flows). All salmon populations would likely be negatively affected by warmer freshwater temperatures, especially during the summer.

Climate change could also affect the success of reintroductions through shifted community interactions. For example, warming may increase the activity and metabolic demand of predators, reducing the survival of juvenile salmonids. In this regard, research undertaken in the lower Columbia River showed that pikeminnow predation on juvenile salmon during the warmest year evaluated was 96% higher than during the coldest. The overall competitive balance between cold water salmonids and warmer water non-salmonids could change (to the detriment of salmon), while incidences and virulence of infectious diseases and parasites would also be expected to increase with increased water temperatures.

Supporting references: Neitzel 1991; Vigg and Burley 1991; Hamlet 1999; Peterson and Kitchell 2001; VOX Communications 2003; Lindley et al. 2007

3.1.2 Impacts

Table 3.4 summarizes impacts and benefits from an ecological / engineering perspective.

Water resources

Hydrology

Adjusting flows to allow passage of upriver salmon species / stocks could affect total amounts of water available in the hydrosystem at other times of year that may be necessary to provide suitable passage, spawning, rearing conditions for lower river species / stocks (e.g., releasing water for spring / summer Chinook passage could affect the amount of water available to provide cooler temperatures for fall Chinook). Conceivably management or upgrades to tributary projects (e.g., Spillimacheen, Walter Hardman, etc.) could perhaps supplement flow deficiencies created within the Columbia River mainstem in this regard (J. Clarricoates, pers. comm.). This would, however, likely require new construction of large storage dams and reservoirs to provide for a measurable cooling effect, as Spillimacheen currently has no storage capacity and Walter Hardman has only very limited capacity (B. Green, pers. comm.). Changes in flow could also affect human users of water (e.g., for hydropower production, irrigation).

Water quality (nutrient loads, pollutants, sediment, temperature, TGP)

Large numbers of decomposing salmon spawners could conceivably increase nutrient loads to eutrophic levels in some areas of upriver reservoirs. Risks of this would depend on the current nutrient status of

upper river reservoirs, and the ultimate number of returning spawners. As upper Columbia reservoirs are known to be strongly oligotrophic it seems unlikely they would become eutrophic. Conversely, it might instead be argued that dispersing salmon across broader areas would reduce any excess nutrient loading in the U.S. Recent evaluations undertaken for a possible re-introduction of sockeye salmon in B.C.'s oligotrophic Coquitlam Reservoir determined risks of nutrient loading on water quality through returning spawners were negligible (albeit for a much smaller potential run than envisioned for the upper Columbia). Conceivably there might be some risk of localized eutrophication, especially if there is poor circulation in some bays that become heavily used for spawning, but the low nutrient levels in most of the Canadian portion of the Columbia suggest, instead, that the upper river would more likely instead benefit from any additional nutrients (C. Beers, pers. comm.). Eutrophication would be a conceivable risk only if no returning fish were being harvested in the lower river and/or hatchery operations were overstocking salmon species (J. Clarricoates, pers. comm.).

Changed flows from upper river reservoirs might increase suspended sediment levels in some areas (which could be an impact or a benefit, depending on the situation) and/or could change managers' ability to manage temperatures as required for down river stocks at different times of the year.

It has been suggested that groups of migrating salmon can act as bulk-transport vectors of persistent industrial pollutants such as polychlorinated biphenyls (PCBs), DDT and mercury which they assimilate from the ocean and then convey back to their natal spawning lakes. After spawning, the fish die delivering toxins to the lake sediment and increasing its PCB content significantly when the density of returning salmon is high. It has been calculated that one million adult salmon could conceivably transport more than 0.16 kg of PCBs to spawning areas, which is comparable to the amount of fugitive PCBs released annually from hazardous waste incinerators. Fat-soluble PCBs could then be transported to freshwaters, where they may enter aquatic and terrestrial foodwebs. Whether these contaminants could have any serious affects on juvenile salmon survival or other ecosystem consequences is as yet unknown. Studies undertaken as part of a recent assessment of sockeye reintroductions to BC's Coquitlam Reservoir showed that the concentration of PCBs and mercury accumulating in the sediments of the reservoir from a sockeye re-introduction even at high stocking densities would be several orders of magnitude less than the levels considered safe for freshwater aquatic sediments.

Supporting references: Fenisten and Van Hecke 2000, RL & L Consultants 2001a, 2001b; Wetzel 2001; Bocking and Gaboury 2003, Perrin et al. 2006

Aquatic Biological Resources

Resident fish (competition / disease / genetics)

Highly productive, high-expense resident fisheries and associated hatcheries are now well established in upper Columbia reservoirs and could be negatively affected by runs of anadromous salmon, through competitive interactions, disease transmission or genetic effects of interbreeding. Lake Roosevelt (for example) currently supports 20 species of resident game fish (rainbow trout, kokanee salmon, and walleye predominant) which could be affected in various ways dependent on their ecology, life history patterns or genetic relatedness. There will undoubtedly be interactions between sockeye and kokanee. Generally in such cases of interaction it has been found that kokanee will tend to persist in interior lakes but not on the coast (likely relating to differences in the nutrient base) (K. Hyatt, pers. comm.). Competitive, disease and genetic interactions between resident fish and reintroduced anadromous salmon would all be of ecological and regulatory (i.e., transplant permit) concern (J. Burrows, pers. comm.). Chief concern will be for transmission of Whirling Disease and Infectious Pancreatic Necrosis Virus (IPN) variants (B. Anderson, C. Cross, pers. comms.).

Supporting references: Bjornn 1978; Ratcliff 1981; Buchanan et al. 1983; Hunter 1989; Wright 1991; McLellan et al. 2003; Parnell et al. 2003; Lake Roosevelt Forum 2006; Pearsons and Temple 2007.

Lower Columbia River salmon populations

Although access into upriver areas of the Columbia River will make new habitats available to anadromous salmon, there is a potential for this to have negative effects on existing down river populations that may migrate further upriver if upstream habitat conditions ultimately prove to be poor and unproductive (i.e., a sink for lower river stocks). Even if upper river areas did become sinks it seems unlikely that this would have serious impacts as current lower river spawning / rearing areas would presumably continue to be used as in the past, so the worst that is likely is that the upper river areas would provide no additional benefits (J. Clarricoates, pers. comm.). There may however be density dependent interactions that are yet unclear in this regard. The key to this issue if it develops may be management of the escapement of up-river migrants.

Non-native fish (exotics)

Providing passage for anadromous salmon may also inadvertently increase the spread of undesirable non-native species (e.g., walleye) and allow entry to previously inaccessible areas (i.e., beyond the current distribution of these exotic species in the upper Columbia).

3.1.3 Benefits

Water resources

Hydrology

Increased river flows / volumes that more closely mimic natural flow patterns that may be required to allow upstream / downstream passage of anadromous fish in the upper Columbia would also likely benefit other salmon stocks in the lower Columbia River (e.g., among other more indirect benefits, increased water velocity generally increases migration speed of smolts, which increases survival). There would also likely be benefits to resident fish species in the upper and lower river, through a variety of mechanisms (e.g., improved habitat conditions, better water quality, improved temperature regimes). White sturgeon, a listed species in Canada, would be another possible beneficiary of increased summer flows.

Supporting references: Bain et al. 1988; Giorgi et al. 2002

Water quality (nutrients, sediment, temperature, TGP)

The return of ocean-going salmon could naturally fertilize the upper watersheds and increase aquatic productivity. It is well documented and widely accepted that marine derived nutrients are critical to aquatic productivity in many coastal systems. Increased nutrient inputs to the upper river from returning salmon spawners could also allow a reduction in current agency lake fertilization programs designed to support resident fish populations. Lakes currently being fertilized are obviously oligotrophic, so any associated risk of eutrophication is low. Returning spawners could also provide a direct seasonal, food source for upper river predators and scavengers (e.g., a current food source for white sturgeon in the upper river are carcasses of spawned-out kokanee (J. Clarricoates), which presumably would be supplemented with salmon carcasses).

Supporting references: Reimchen et al. 2002; Zhang et al. 2003; Hyatt et al. 2004; Nelitz et al. 2006

Aquatic Biological Resources

Resident fish (genetics)

Access to currently inaccessible habitat and consequent greater mixing of resident fish (if anadromous passage designs and operations also assist movement of resident fish) could improve genetic diversity of valuable resident fish populations in the upper Columbia Basin (J. Clarricoates, pers. comm.).

Fish habitat (depth / velocity / temperature / substrate)

Access to a substantial portion of historical habitat was blocked for anadromous fish by Chief Joseph and Grand Coulee Dams. The construction of the Grand Coulee Dam is considered to have removed over 2830 kilometres of spawning and rearing habitat for anadromous salmon. Some portion of this would presumably be made available once again with restored passage at Grand Coulee and other upper river dams. Increased flows and draw downs at dams that would likely be required as part of processes to allow upstream and downstream survival of anadromous fish in the upper Columbia could improve the extent and diversity of fish habitats (e.g., water depth, water velocity, water temperature, cover and substrate composition), benefiting salmon and other fish species.

Supporting references: Fish and Hanavan 1948; Jowett 1990; Harza 1994; Poff et al. 1997; Freeman et al. 2000; BPA 2000

Salmon abundance

Chinook, sockeye and steelhead populations are currently extinct in the Canadian reaches of the upper Columbia. Although quantitative knowledge of historical distribution and abundances of upper Columbia stocks is very poor, there is ample anecdotal evidence from a variety of native and non-native sources that Chinook, sockeye and steelhead flourished throughout the Canadian sections of the Columbia River prior to 1940. Access to new upstream habitats could allow a return of salmon stocks to Canada and increase the abundance of upper Columbia salmon populations in the U.S., particularly if Canadian waters offer better thermal conditions as climate warming continues (provided that salmon can survive warmer waters during their upstream migration). Sockeye currently stray to the Chief Joseph tailrace area as they may be delayed in migrating up the Okanagan River due to high water temperatures at the mouth of the Okanagan. Opportunities for upstream passage at Chief Joseph and Grand Coulee dams could allow these adults to move upstream and potentially recolonize upper basin areas.

The current status of lower Columbia River salmon populations argues strongly for the importance of restoring salmon upstream of Grand Coulee Dam. Upper Columbia spring Chinook are listed as endangered, and upper Columbia steelhead are listed as threatened, and habitat degradation as well as dam passage are key reasons for this status. Habitat in the Wenatchee, Entiat, Methow, and Okanagan rivers is highly degraded in the lower reaches and the Okanagan River is degraded in upper reaches as well. The prospects for the long term survival of these species improve if access to more-intact watersheds upstream of Grand Coulee dam was provided and the fish could thrive in these basins.

Wenatchee and Okanagan sockeye salmon, though not listed under the Endangered Species Act (ESA), may benefit most by the provision of additional habitat upstream of Grand Coulee Dam. Of the over 30 lakes that traditionally maintained Columbia Basin sockeye salmon, there are naturally maintained sockeye salmon populations in only these two rivers. Five of the six largest lakes formerly accessible to Columbia Basin sockeye salmon, making up almost half of the potential lake rearing area, were upstream of Grand Coulee Dam—Whatshan, Kinbasket, Slocan, and Upper and Lower Arrow Lakes. Given the problems faced by Wenatchee River sockeye salmon (small lake size, spawning failures caused by rain-on-snow events washing out redds) and Okanagan sockeye salmon (small lake size, high water temperatures, competition for water and habitat by a rapidly expanding human population), the long term

future of sockeye salmon in the Columbia Basin may well depend on restoring access to former habitat (J. Fryer pers. comm.).

For all salmon, the prospect of global warming may lead to a diminishment of salmon abundance in southern, lower reaches of their habitat. Instead, they may tend to migrate to rivers at higher elevation and further to the north, which are some of the very rivers presently blocked by Grand Coulee Dam (J. Fryer pers. comm.).

Supporting references: NWPPC 1986; Fryer 1995; CRTFIC 2004; Brugman and Thieverage 2003; NMFS 2006

Salmonid Life History Expression

Access to a larger mix of upriver and downriver habitats would present an opportunity for fuller life history expression for salmon and currently landlocked (but potentially anadromous) upper river salmonid populations of kokanee and rainbow trout. Increased intra-river connectivity could also serve non-andromous species that could benefit from increased access to habitats. Uncertainty around this would relate to how suitable salmon passage designs and operations are for passage of other native species (C. Beers, pers. comm.). Establishing passage for bull trout at Grand Coulee and other mainstem dams would likely only be helpful if it was part of a larger strategy to re-establish connectivity at a series of smaller tributary dams as well (e.g., Box Canyon, Albeni Falls, Boundary) (H. Schaller, pers. comm.). Actual population status of bull trout in the U.S. Upper Columbia Conservation Unit is unknown, but existing resident bull trout populations persist farther up in Canadian headwater areas.

Supporting references: Whitesel et al. 2004; Beechie et al. 2006; Narum et al. 2007;

Other Andromous Fish Species

Other anadromous fish species in the Columbia River (e.g., listed populations of Pacific lamprey (*Lampetra tridentata*), white sturgeon (*Acipenser transmontanus*)) could potentially benefit if they could also access habitat and other populations in the upper Columbia as part of restoration actions primarily directed at salmon. Pacific lamprey historically made it to the upper Columbia, with documented evidence of Pacific lamprey migrating past Kettle Falls in the 1930s (pre-Grand Coulee). Currently Pacific lamprey make it through four mainstem dams into the Yakima Subbasin and seven mainstem dams into the Wenatchee subbasin. Relative to salmonids, upstream passage at Columbia River dams is poor for adult Pacific lamprey and white sturgeon.

Supporting references: Moser and Close 2003; Moser et al. 2005; Jager 2005; NMFS 2005; Upper Columbia White Sturgeon Initiative (UCWSI). 2006.

Terrestrial Biological Resources

Nutrient enrichment (riparian / wildlife)

The return of ocean-going salmon could naturally fertilize the upper watersheds and increase general terrestrial productivity. It is well documented and widely accepted that marine derived nutrients are important to ecosystem function (i.e., salmon-riparian-wildlife linkages), particularly where other nutrient sources are scarce. Bears for example are considered highly reliant on salmon to maintain high population densities, larger body sizes, and higher rates of reproduction. Recent research has found that the impact of marine nutrients brought by adult salmon to streams of the Pacific Northwest is historically large and that a diminution of salmon runs has adversely affected overall terrestrial ecosystem health. It may be conceivable that nutrient enrichment through its linkages to terrestrial ecology could also be of benefit to local agriculture, but as yet there is no known evidence to support this linkage.

Supporting references: Cedarholm et al. 2000; Gende et al. 2000; Reimchen et al. 2002; Naiman et al. 2002; Schindler et al. 2003; Zhang et al. 2003; Himmer 2006; Nelitz et al. 2006

Table 3.4. Summary of **environmental-engineering** impacts and benefits of restored passage of salmon to upper Columbia River.

Impacts or Benefits	Mgmt Action		Facility ³							Factors Affecting Significance of Issue	
	Flow ¹	Pass ²	CJ	GC	KN	RV	MC	BD	WAN / SM	Affected User ⁴	Magnitude of Change ⁵
WATER RESOURCES											
Hydrology	X		X	X	X	X	X	X	X		
Impact – adjusted flows to allow upper river migration could affect amounts of water available for lower river stocks at other times of year										NOAA, Tribal Fisheries Programs, recreational fishers, hydropower generators, irrigators, flood control operators	High
Benefit – increased river flows / volumes for upriver passage could improve survival rates for lower river salmon stocks and resident fish											Low
Water Quality (nutrient loads, sediment, temperature)	X	X	X	X	X	X	X	X	X		
Impact - decomposing salmon spawners could cause eutrophic conditions										PUDs, Municipalities, EPA	Low
Impact – decomposing salmon spawners could release accumulated PCBs acquired during ocean residency										NOAA, Tribal Fisheries Programs	Low
Impact - changed flows could increase suspended sediment levels										Hunters, recreational fishers, BC MOF, BC MOE	Moderate
Impact - changed flows could reduce ability to manage lower river water temperatures										Fish and Wildlife Compensation Program (BC Hydro – MoE)	Uncertain
Benefit – salmon spawners could fertilize areas of the upper river watersheds and increase aquatic productivity											Uncertain
Benefit – lake fertilization programs for resident fish populations could be reduced											
AQUATIC BIOLOGICAL RESOURCES											
Resident Fish (competition / disease / genetics)		X		X	X	X	X	X	X		
Impact - resident fisheries may be affected by anadromous salmon through competition, disease or genetics										Fish managers, hatcheries, recreational fishers	Uncertain
Lower River Salmon Populations		X	X	X	X	X	X	X	X		
Impact – new upper river habitats may be unproductive for lower river stocks that migrate higher in the system										NOAA, lower river tribal, commercial and recreational fishers	Uncertain
Non-native Fish		X	X	X	X	X	X	X	X		
Impact - improved salmon passage may also facilitate movement of exotic fish species											High
Fish habitat (depth / velocity / temperature / substrate)	X		X	X	X	X	X	X	X		
Benefit – altered flows and draw downs could improve the extent and diversity of habitats for salmon and other fish species										BC MOE, DFO, NOAA, USFWS, Tribal Fisheries Programs	High
Benefit – access to cooler upper river habitats could allow persistence of salmon stocks that might not be able to otherwise cope with deteriorating downstream conditions under possible climate warming scenarios											
Salmon abundance		X	X	X	X	X	X	X	X		
Benefit – return of salmon stocks to Canada and a potential increase in the abundance of Upper Columbia salmon populations in the U.S.										Tribal Fisheries Programs, Tribal, Commercial and Recreational Fishers	High
Other Anadromous Fish Species	X	X	X	X	X	X	X	X	X		
Benefit – Other anadromous fish species could benefit if allowed access to habitat and other populations in the upper Columbia										NOAA, USFWS, State Fish Agencies, Tribal Fisheries Programs, BC MOE	Uncertain
TERRESTRIAL BIOLOGICAL RESOURCES											
Nutrient Enrichment (riparian / wildlife)		X	X	X	X	X	X	X	X		
Benefit - salmon spawners could fertilize areas of the upper river watersheds and increase terrestrial productivity										BC MOE, BC MOF, Hunters	Uncertain

Table Footnotes:

- 1 – Denotes whether changes in flow operations are applicable to the impact or benefit, especially timing and magnitude of flows (reservoir storage and instream flow) (hydro), or whether there are direct effects from construction of fish passage structure and indirect effects associated with environmental / social changes due to reintroduction of salmon (harvest, hatchery, habitat).
- 2 – Codes for upper Columbia Basin dams under consideration: CJ (Chief Joseph), GC (Grand Coulee), KN (Keenleyside), RV (Revelstoke), MC (Mica), BD (Brilliant), WAN/SM (Waneta and Seven Mile).
- 3 – Affected users are important to understand because different stakeholders will perceive an environmental change from a different perspective. Some will view change as a positive benefit, others will view change as a negative impact.
- 4 – Magnitude of change based on qualitative ranking of high, moderate, low, or highly uncertain.

3.2 Regulatory / social

3.2.1 Feasibility issues

Discussed below are four issues that need to be resolved from a regulatory / social perspective: 1) legal; 2) political; 3) operating agreements and guiding legislation; and 4) regulatory framework for project approval. A proposal to restore salmon passage to the upper Columbia River is obviously unique. Therefore, resolution of the legal requirements of governments to respond and the political appetite for such a proposal given potentially large financial costs are highly uncertain. The other two feasibility issues, however, are more typical considerations for the Columbia River system where precedents are available to which decision makers can look for guidance on how to proceed. Outstanding questions related to understanding these issues have been summarized in Section 4, Table 4.2.

Legal (case law, court challenges)

Aboriginal rights and title (Canadian First Nations and U.S. tribes)

Actions by U.S. and Canadian governments may depend on their legal obligations to respond to First Nations and Tribal concerns. “In 1990, the Supreme Court of Canada released its landmark decision in *R. v. Sparrow* (scc.lexum.umontreal.ca/en/1990/1990rcs1-1075/1990rcs1-1075.html) which held that, after conservation and other ‘valid legislative objectives’, Aboriginal rights to fish for food, social and ceremonial purposes have priority over all other uses of the fishery. The Court also held that infringements of Aboriginal rights must be justified and that part of the justification analysis involves an assessment of whether adequate consultation has occurred” (www.pac.dfo-mpo.gc.ca/tapd/fsc_e.htm). Currently, Canadian First Nations have not been able to sue for damages caused by Grand Coulee Dam (GCD) (from resulting losses of salmon) because they lack legal standing in the U.S. court system. Thus, they do not have a mechanism for making claims for damages against the U.S. government (Ortolano and Cushing 2002). In 2003 CCRIFC asked the IJC to enforce the conditions of its Order of Approval for the Grand Coulee Dam and Reservoir (the “1941 Order”). The recent response by IJC has been to direct CCRIFC’s requests for action to Foreign Affairs. Foreign Affairs is supportive of CCRIFC’s efforts to address their concerns through this work—the FIB assessment (Peter Fawcett, pers. comm.). Recent court decisions in the U.S. have used the Superfund Law to hold Teck Cominco responsible for pollution in Lake Roosevelt. This case may be a relevant transboundary precedent suggesting the U.S. government could be forced to react to First Nations losses of upper Columbia River salmon (www.ecy.wa.gov/news/2006news/2006-157.html).

Various U.S. tribal treaties, statutes, and presidential executive orders identify a trust responsibility between Indian nations and the U.S. government (Center for Columbia River History (www.ccrh.org/comm/river/harvest.htm)). These documents are not explicit about tribal resources, but the courts have implied tribal access to water in association with reserve lands (WSTB & BEST 2004). The trust responsibilities obligate the U.S. government to provide services that protect and enhance Indian lands and resources, which includes the need to maintain harvestable stocks of anadromous fish and claims to water. *United States v. Winans* (198 U.S. 371, 1905) and *U.S. v. Winters* (1908) are seen as foundational legal cases providing the legal basis for tribal rights to fish and water. Under *Winans* case, tribes may also reserve by treaty the right to hunt or fish off-reservation. The *U.S. v. Oregon* (1969) decision established that the tribes have treaty rights to an equitable share of the Columbia Basin fishery resource. In 1951, 1975, and 1991 the Colville and Spokane Tribes took legal action against the U.S. government demanding compensation for the loss of traditional fishing. In 1994, partial agreement was reached with Colville Tribes receiving a lump sum of \$53 million and \$15.25 million annually thereafter (Ortolano and Cushing 1999).

Political

Given the potential implications on power production, water management, and large financial costs, decisions about restoration of upper Columbia Basin salmon will likely be made at political levels of government. For example, changes in water operations resulting from BC Hydro's water use planning process were constrained by a \$50 million cap on costs to BC Hydro. This cap was set by the government which meant that there was little flexibility to consider changes in Peace and Columbia basin operations given their importance to provincial power production. Government decision making will be driven, in part, by the political interest of a wide variety of interest groups in the Columbia Basin. Political feasibility would be affected by the support or opposition of a variety of groups. Such groups include the public, potentially affected user groups, politicians, federal and state / provincial governments (in the U.S. and Canada), U.S. tribes and Canadian First Nations.

A decision about whether to restore salmon must also balance the significant costs involved / government responsibility / obligations to respond to First Nations / tribal concerns. To-date there has been little government interest or action regarding the issue of restoring salmon to the Canadian portion of the upper Columbia River. Provincial and federal government agencies in Canada responsible for preserving fish resources (such as DFO and BC MOE), as well as various sectors of the public have not focused on this issue despite its great importance to First Nations (Brugman and Thivierge 2003). For instance, the IJC requires support from both the U.S. and Canadian governments to respond favourably to CCRIFC's request for action (Peter Fawcett, Foreign Affairs, pers. comm.). Recently, the IJC referred CCRIFC to Canada's Foreign Affairs Department regarding its request to take action on IJC's 1941 Order of Approval for Grand Coulee Dam (letter from Murray Clamen, IJC, to Fred Fortier, CCRIFC, dated October 31, 2006). USACE operators take direction from U.S. Congress; any major changes to operations / dam structure would require congressional approval.

Operating agreements and guiding legislation

Close coordination would be required between U.S. and Canada to ensure fish survival during downstream migration, and to ensure that spawners are able to return to Canada in numbers sufficient to maintain a viable population. Bi-national planning and coordination of Columbia River hydro operations are guided by a series of complex and interrelated laws, treaties, agreements, and guidelines. Priorities for system operations are flood control, power production, fish passage and endangered species protection. The Columbia River Treaty specifies that the parties must agree on an optimum operation for power production and flood control; deviations from this optimum (for example, for fish passage purposes) can be agreed to only through negotiations to achieve mutual benefits. There are a total of 11 dams on the mainstem Columbia in the U.S., which includes 6 federal dams (1 USBR project and 5 USACE projects) and 5 Public Utility District operators (Douglas, Chelan and Grant Counties) in the mid-Columbia. The Federal Columbia River Power Systems (FCRPS, coordinated by the Technical Management Team) and Public Utility Districts (PUD) operate under different regulatory requirements, thus requiring cross-system coordination. USBR operates Grand Coulee dam (GCD) while also providing water for irrigation through the Columbia Basin Project (CBP). USACE operates Chief Joseph dam and is responsible for flood control at all U.S. Columbia reservoirs as well as maintaining navigation channels. The Bonneville Power Administration (BPA) distributes power produced by these federal hydro projects. In Canada, BC Hydro operates three mainstem dams on the Columbia River (Keenleyside, Mica, and Revelstoke), one on the Pend d'Oreille River (Seven Mile), downstream of which is Waneta dam (operated by Teck Cominco), and the Columbia Power Corporation operates Arrow generating station (at Keenleyside dam) and Brilliant dam on the Kootenay River. The Columbia Basin Trust is involved with these operators in the long-term stewardship of the Basin's natural resources in Canada. BC Hydro oversees coordination

and operation of Canadian facilities. Key guiding laws and operating agreements include (BPA et al. 2001; Muckleston 2003; WSTB and BEST 2004):

Columbia River Treaty

...was signed between Canada and the U.S. in 1961. Three upper Columbia basin dams (Duncan–1967, Keenleyside–1968, Mica–1973, and Libby–1973) were constructed and are operated under the Columbia River Treaty, which includes provisions for flood control and power generation. The treaty also allowed the U.S. to construct Libby Dam in 1973, and its operation is coordinated with Canada as part of the Treaty. The reservoirs created by these dams represent almost half the water storage in the Columbia. The Treaty does not have an end date, but either country can terminate the Treaty after 2024 with 10 years' notice.

Pacific Northwest Coordination Agreement

...(1997) is an agreement for planned operation among hydro utilities in the Pacific Northwest (Canadian-U.S. and federal-non federal) to optimize system reliability and power production, after giving priority to non-power objectives. The agreement calls for annual planning which must accommodate all authorized water needs.

Pacific Northwest Electric Power Planning and Conservation Act

...(1980) created the Northwest Power Planning Council which is entrusted with adopting a Fish and Wildlife Program for the Columbia Basin and preparing a Regional Electric Power and Conservation Plan. Council actions have led to changes in system operations. BPA is required to fund certain fish and wildlife mitigation programs.

Canal Plant Agreement

...coordinates Canadian hydro operators (BC Hydro, Columbia Power Corporation, Fortis BC, and Teck Cominco to provide power and flood control. Operations are overseen by BC Hydro.

U.S. Endangered Species Act

...protects threatened and endangered species. Under Section 7 of the ESA, the National Marine Fisheries Service (NMFS) develops and issues Biological Opinions (BiOps) for listed anadromous fish (as well as marine mammal) species, in response to Biological Assessments from agencies proposing federal actions, including hydrosystem operations, which might adversely affect those species. The U.S. Fish and Wildlife Service has similar jurisdiction for resident fish, plants and terrestrial wildlife, and also issues BiOps for federally proposed actions. U.S. District Court Judge James A. Redden has struck down NMFS's Biological Opinions of 2000 and 2004 which were issued to protect the 12 listed Columbia and Snake River salmon and steelhead stocks from Columbia / Snake River hydrosystem operations. Currently, there is a period of uncertainty in managing federal facilities on the Columbia River while a new Biological Assessment and Biological Opinion are prepared. Salmon restored above Chief Joseph and Grand Coulee might initially be listed as threatened or endangered, if the donor stock had this status."

Canadian Species at Risk Act

...in Canada this could also be a consideration for hydrosystem operations, in terms of protecting critical habitats for listed species. Species of concern in the upper Columbia River include the white sturgeon (endangered) and Columbia mottled sculpin (special concern).

Columbia Basin Project (CBP)

...is an authorized use of the Columbia River, drawing water through irrigation infrastructure from Grand Coulee dam to the Columbia Plateau, 125 miles south (www.usbr.gov/dataweb/html/columbia.html). The Columbia Basin Project Act (1943) brought the project under provisions of the Reclamation Project Act. In the 1970s, the courts confirmed that fish and wildlife was also a purpose of this project pursuant to the Fish and Wildlife Coordination Act. There have been recent political initiatives in Washington for agricultural users to gain access to more water withdrawals through this project (Bob Heinith, pers. comm.). Oregon irrigators are likely to put in similar requests for water.

Canadian Columbia River Forum

...is a body whose purpose is to collect and assemble information and involve the public, elected officials and government agencies in discussions on improving watershed management in the entire Columbia River Basin (www.nwcouncil.org/library/releases/2004/0721.htm). A Memorandum of Understanding (MOU) among participating parties (government, operators, First Nations) was signed in February, 2007. This forum may provide an opportunity to discuss structural changes and modifications to flow required for restoring salmon to the upper Columbia River.

A variety of other operating agreements / pieces of guiding legislation were identified at the Feb./March 2007 FIBs workshop and are listed in Table 3.5.

Table 3.5. List of additional and potentially relevant operating agreements / pieces of legislation.

Relevant jurisdiction	Potentially relevant agreement / legislation	Notes
Canada	BC Heritage Conservation Act	Ensures protection of designated heritage sites in BC
	BC Energy Policy	Implication on calls for power (e.g., green power, Independent Power Producers on tributary streams)
	Power purchase agreements	E.g., between BC Hydro and Columbia Power Corporation
	Legal orders for hydro operations	Order for allowable daily water changes at border (non-BC Hydro facilities) International Joint Commission order for Kootenay Lake
	BC Hydro and Power Authority Act	
United States	Clean Water Act	As applicable to dissolved gas and water temperatures
	Columbia River Initiative / Columbia River Water Management Program	Affecting Lake Roosevelt elevations
	Columbia River Compact / U.S. v Oregon	Court ruling resulted in allocation of harvest and levels of hatchery production to 4 treaty tribes Zone 6 compact establishes lower river commercial fishing season in coordination with U.S. v Oregon
	U.S. Fish and Wildlife Coordination Act	Assists government agencies in conserving fish and wildlife
	Northwest Power Act	Created the Northwest Power Planning Council whose objectives are, in part, to help address the impacts of hydro operations on fish and wildlife
	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund Law)	Establishes requirements for management of sources of hazardous wastes
	Antiquities Act and National Historic Preservation Act	Ensures preservation of National historic sites
	Vernita Bar Agreement	Establishes flow requirements among three mid-Columbia Public Utility Districts (Grant, Chelan and Douglas County)
Trans-boundary	Pacific Northwest Power Agreement	Coordinates power production amongst various producers
	Boundary Waters Treaty	Provides principles and mechanisms for resolving transboundary water quality and quantity issues between Canada and the U.S.
	Greenhouse gas agreements (e.g., Kyoto)	Effects on energy policy and demands for low emissions energy sources such as hydro
	<i>Pacific Salmon Treaty</i>	Commits both U.S. and Canada to work together towards conservation and allocation of harvest of salmon between countries for fish intercepted in each other fisheries.

Regulatory framework for project approval

Project completion would depend on approvals and permitting from various levels of government.

Federal approvals (Canada and U.S.)

Although unlikely, changes to Canadian facilities, or a reintroduction of salmon due to changes in the U.S. might trigger the Canadian Environmental Assessment (CEAA) process if it were deemed that a Harmful, Alteration, Disruption, or Destruction of Habitat (HADD) authorization was required under the Fisheries Act. As restoration of salmon passage would improve access to habitats, a regulatory review

might be required only if construction activities at dam facilities led to adverse effects. If changes to operations on Canadian reservoirs affected ferry operations on the Arrow reservoir or Keenleyside navigation lock, the Navigable Waters Protection Act (NWPA) may apply, additionally triggering the Canadian Environmental Assessment process (www.ceaa-acee.gc.ca/013/act_e.htm). A joint federal-provincial Introductions and Transfers Committee (ITC) has been formed by a Memorandum of Understanding between DFO and MOE to advise on issues related to fish introductions and transfers (Stephen 1998; DFO and BC Government 2002). The regulatory process for evaluating the biological risks associated with fish transplants is guided by the Canadian Fish Health Protection Guidelines and subject to the Pacific salmon import policy. In 2008 it is likely that the federal Health of Animals Act (under jurisdiction of the Canadian Food Inspection Agency – CFIA) will also apply to fish and disease issues (Brian Anderson, pers. comm.).

The 1969 U.S. National Environmental Policy Act (NEPA) requires environmental scrutiny of actions proposed by any Federal agency, which requires preparation of an Environmental Impact Statement (EIS) for actions deemed significant in their effect on the human environment (which would include salmon reintroduction). For instance, in the 1990s, federal agencies (BPA, USACE, USBR) used NEPA to consider changes to operations of the Federal Columbia River Power System, though this process was criticized by U.S. tribes for not being transparent and engaging (BPA et al. 1995). A programmatic EIS might be prepared and individual project document (EISs or Environmental Assessments (EAs)) with Findings of No Significant Impact (FoNSIs) might follow under NEPA.

Other U.S. agencies which could become involved in a regulatory capacity for Columbia projects include the U.S. Department of State (for Treaty matters), NOAA-Fisheries, USFWS, U.S. EPA and state water resource agencies. The Lower Snake River Juvenile Salmon Migration Feasibility Report (which examined breaching of four dams on the Lower Snake River) provides guidance on what might be required in preparing an EIS with the upper Columbia River proposal (USACE 2002b). Irrigation districts and public utilities also operate and maintain water resource facilities in the mid-Columbia Basin. Therefore, changes to upstream dam and reservoir operations affecting mid-Columbia non-federal dams might involve the Federal Energy Regulatory Commission (FERC) (pursuant to the Federal Power Act (FPA) and the U.S. Department of Energy Organization Act. Currently, a number of PUDs are in different stages of long-term (50 year) re-licensing reviews (Douglas submitting in 2010, Grant under review in 2006, and Chelan County approved in 2006) which might constrain any upstream operational changes.

Placement of dredged or fill material in waters of the U.S., including certain wetlands, requires a Corps of Engineers permit under Sec. 404 of the Clean Water Act, though there are several Nationwide Permits in existence that cover certain circumstances. Construction in navigable waters of the U.S. requires a permit under Sec. 10 of the Rivers and Harbors Act. It will be necessary for proponents of any project in the U.S. that requires construction to be sure of their requirements under these regulations. (www.nws.usace.army.mil – Regulatory).

Changes in dam and reservoir operations on the U.S. Columbia River are coordinated by various inter-agency groups, including the Regional Implementation Forum and the Technical Management Team (TMT). The TMT is involved only in week-to-week operational decisions, however, and not strategic initiatives like the one proposed.

Provincial / state approvals (BC and Washington)

Changes to Canadian facilities would not likely be reviewable under the BC Environmental Assessment Act because under the Reviewable Project Regulation, Part 5 Water Management Project “The following are not reviewable under subsection (1) (b) a dam or reservoir that is associated with a hydroelectric power plant” (www.qp.gov.bc.ca/statreg/reg/E/EnvAssess/370_2002.htm#part5). The provincial-federal

Fish Transplant Committee would require a permit for reintroduction of salmon. This permitting process requires a technical review of disease issues and assessment of potential impacts on existing fish communities. As well, the BC Ministry of Environment's Water Stewardship Division would need to consider changes to Water Licenses for any Canadian facilities under the BC Water Act. The Division recently issued an order to BC Hydro to implement results from a multi-year and multi-stakeholder water use planning process (WUP) on the Columbia River. Any changes to operations in the Columbia basin would need to be reviewed by a similar planning process. If deemed acceptable to relevant parties, a revised water license would order that a revised WUP be implemented by BC Hydro. Finally, if changes in operations of BC Hydro facilities resulted in a potential cost to British Columbia ratepayers, a Certificate of Public Necessity and Convenience (CPCN) would likely be required. A CPCN is issued by the BC Utilities Commission given that "a person must not begin the construction or operation of a public utility plant or system, or an extension of either, without first obtaining from the commission a certificate that public convenience and necessity" (www.bcuc.com/Documents/Guidelines/2004/DOC_4726_L18_CPCN.pdf).

Washington Department of Ecology permitting would be required under Section 401 of the U.S. Clean Water Act, which concerns actions (including federal) that affect water quality. There may be requirements to consider implications of Washington state's Water Permit System, though this is unlikely, given that reintroduction of salmon to the upper Columbia would not require issuance of a new water permit. Washington's Instream Flow Protection Program outline rules for minimum instantaneous instream flow at five locations on the mainstem for 17 different time periods during the year (WSTB and BEST 2004). Upstream changes to operations would need to consider effects on flows at these locations and time periods.

Local consultation

As demonstrated during recent modification to the Arrow Lakes Generating Station Project, (McDaniels Research Ltd. And Eberle Planning & Research 2002), local consultation would likely be required in both Canada and the U.S. In Canada, consultation would likely be framed around a water use planning process. Such discussions would be essential to understanding the effects of changes to the system, and the trade-offs among environmental, social, and economic objectives, as well as ensuring broader support for any anticipated changes to the freshwater ecosystem system and hydro operations. If changes to the flow regimes led to impacts on municipal and/or industrial water supplies or intakes, these local resource users may also need to be consulted to ascertain the magnitude of effect and whether mitigation strategies are possible.

Although not directly relevant to this proposal, the provincial government's recently announced Bill 30 – Miscellaneous Statutes Amendment Act, 2006 proposed amendments to the Utilities Commission Act (www2.news.gov.bc.ca/news_releases_2005-2009/2006AG0022-000503.htm) suggest a trend towards less control of local governments over regional power activities. In particular, Bill 30 has been criticized for eliminating local government involvement and engagement in review and approval processes of Independent Power Producers (IPPs) and removing jurisdiction of local government over IPPs on Crown Land.

3.2.2 Impacts

Impacts of restoring salmon to the upper Columbia River would likely be directed towards those who received the majority of benefits from original construction of Grand Coulee dam (Ortolano and Cushing 2002); including: (1) electric power producers and users; (2) water users, both industrial and agriculture; (3) recreationalists; and (4) tribal groups in the U.S. adversely affected by impacts on residential fisheries (though such impacts may be partially or completely offset by the benefits of having salmon restored).

Table 3.6 summarizes the list of regulatory / social impacts and benefits. Table 4.4 in Section 4 lists the outstanding questions associated with determining the significance of these issues.

Electric power (generation and system reliability)

There are eight dams under consideration in this assessment with a combined capacity of up to 14,018 MW (BPA et al. 2001; BC Hydro 2005a): Chief Joseph (2,069 MW), Grand Coulee (6,494 MW), Keeleyside (Arrow generating station 185 MW), Mica (1,805 MW), Revelstoke (1,980 MW), Seven Mile (790 MW), Waneta (450 MW), and Brilliant (125 MW currently with another 120 MW upgrade in 2007). Reductions or alterations in streamflow may have significant implications to power production, revenues, and system reliability. Changes in flow at upstream reservoirs also have the potential to affect nine other dams on the mainstem Columbia in the U.S. (four USACE dams and five Public Utility District operators). Clearly, there is the potential for large impacts on power production (John Harrison and John Shurts, Northwest Power and Conservation Council, pers. comm.).

Other factors affecting magnitude of impacts on power generation and reliability include:

- changes in voluntary spill and load shaping (or peaking) at Revelstoke, Waneta, Grand Coulee, and Chief Joseph (to meet power demands and increase power revenues) could affect fish passage;
- dam maintenance could change if flow releases and storage patterns affect timing and extent of drawdown; and
- changes to power supply options in the future (e.g., wind power) could affect timing of electricity demands on hydroelectric facilities.

Water management

Flood control

Loss of storage capacity in Canadian reservoirs (Mica, Arrow, or Duncan) for flood control and other purposes may be required to enhance flows for upstream / downstream passage. Such changes in hydrosystem operations may impact USACE flood control strategies (BPA et al. 2001; USACE 1991; USACE 2001; USACE 2002a; Ortolano and Cushing 2002). However, optimum flood control operations are required under the current Columbia River Treaty and are considered non-negotiable. Thus, impacts on flood control may be unlikely and at a minimum would pose hard constraints on designing flow alternatives for fish passage. Strategies to determine and achieve flood control “optima” may however be negotiable, as recently demonstrated by the U.S. with the inception of the VarQ flood control strategy (B. Green, pers. comm.; USACE 2006). Recent increases in development in flood plains would also need to be considered when evaluating the significance of any changes in upstream storage. Proper compensation to flood plain landowners could conceivably allow the USACE to revise flood control objectives and constraints (J. Clarricoates, pers. comm.), although how this would be accomplished and who would provide this compensation are uncertain, and would need to be part of any feasibility analysis.

Agricultural uses

Grand Coulee dam (GCD) is associated with large irrigation works. The Columbia Basin Project (CBP) benefits 267,000 hectares of agricultural land in eastern Washington (Ortolano and Cushing 2002). Resulting agricultural productivity in the region is significant (USBR 1992; 1994). The State of Washington is working with the Bureau of Reclamation to deliver Columbia River water to lands currently served by groundwater in the Columbia Basin Project (with Oregon likely to follow). There have been commitments to maintain late summer flows for fish passage in low water years through these agreements (Bob Heinith, pers. comm.). Agricultural uses in the Canadian system are relatively minor.

Table 3.6. Summary of **regulatory-social** impacts and benefits of restored salmon passage to the upper Columbia River.

Impacts or Benefits	Mgmt Action ¹		Facility ²							Factors Affecting Significance of Issue	
	Flow	Pass	CJ	GC	KN	RV	MC	BD	WN / SM	Affected User ³	Magnitude of Change ⁴
ELECTRIC POWER											
Generation and System Reliability	X	X	X	X	X	X	X	X	X		
Impact – Reductions or alterations in streamflow will likely have significant implications to power production, revenues, and system reliability										Canadian operators, federal and non-federal operators in U.S.	High
WATER MANAGEMENT											
Flood Control	X	X		X	X	X	X				
Impact – Changes to flood storage capacity in Canada to accommodate fish migration would impact USACE flood control strategies.										All hydro operators and potentially affected downstream residents	High
Agricultural Uses	X			X							
Impact – Grand Coulee dam is associated with large irrigation works. Operational changes affecting agriculture might require compensation.										Irrigators / agricultural users in Washington state	Potentially High
Navigation	X			X	X						
Impact – No anticipated effect on downstream Columbia River navigation but changes in operations of Hugh Keenleyside Dam navigational lock and Arrow Lakes reservoir elevation might affect ferry / boat traffic.										Navigation on Arrow Lakes Hugh Keenleyside Navigational Lock	Low
RECREATION, TOURISM, AND NON-NATIVE CULTURE											
Commercial and Recreational Fisheries		X	X	X	X	X	X	X	X		
Impact – Restored upper river salmon could introduce weak stock into salmon management which might affect commercial fishing opportunities. Commercial losses might result from initial protection of restored salmon.										U.S. and Canadian commercial sockeye harvesters	Uncertain
Benefit – There may be opportunities for increased and more flexible marine harvest allocations if upper Columbia salmon stocks were restored to commercially harvestable levels.										U.S. and Canadian commercial sockeye harvesters	High
Recreation (reservoir and downstream uses)	X			X	X	??	??				
Impact – Drawdowns for power and fish passage could adversely affect some recreational activities (e.g., boating, picnicking, etc.) at reservoirs if water access is too low or reduces aesthetics / shoreline access.										Recreational users on Lake Roosevelt and affected Canadian reservoirs (Arrow)	Uncertain
Non-native cultural significance	X	X	X	X	X	X	X	X	X		
Benefit – Individuals who value ecosystems in their natural state will perceive benefits with restoration of salmon.										Individuals in region who assigns value to environment restoration	Uncertain
FIRST NATIONS / TRIBES											
Food, social, and ceremonial (subsistence) fishery		X	X	X	X	X	X	X	X		
Impact – Potential losses to resident fishery opportunities for tribes. Magnitude of effect on Tribal harvest depend on whether switch from resident to anadromous harvesting is viewed as an impact.										U.S. tribes	Uncertain
Benefit – Restored salmon harvest could recover what once was a vital part of First Nations / Tribal economies.										U.S. tribes and Canadian First Nations	High
Cultural significance	X	X	X	X	X	X	X	X	X		
Benefit – Salmon was historically central to cultural, religious, and social activities of First Nations / tribes.										Canadian First Nation and upper Columbia U.S. tribes	High
Political (fair and equitable compensation)	X	X	X	X	X	X	X	X	X		
Benefit – Restoration could help resolve longstanding grievances between those bearing costs of dam construction (i.e., the loss of salmon) and government agencies managing the project.										Canadian First Nation and upper Columbia U.S. tribes	High
REGULATORY ENVIRONMENT											
Endangered Species Act (ESA) status		X	X								
Benefit – Recovery or downlisting of U.S. Upper Columbia salmon stocks would ease restrictions related to their conservation.										NOAA, BPA, PUDs, USBR, USACE	High

Table Footnotes:

- 1 – Denotes whether changes in flow operations are applicable to the impact or benefit, especially timing and magnitude of flows (reservoir storage and instream flow) (hydro), or whether there are direct effects from construction of fish passage structure and indirect effects associated with environmental / social changes due to reintroduction of salmon (harvest, hatchery, habitat)
- 2 – Codes for upper Columbia Basin dams under consideration: CJ (Chief Joseph), GC (Grand Coulee), KN (Keenleyside), RV (Revelstoke), MC (Mica), BD (Brilliant), WN/SM (Waneta and Seven Mile)
- 3 – Affected users are important to understand because different stakeholders will perceive an environmental change from a different perspective. Some will view change as a positive benefit, others will view change as a negative impact.
- 4 – Magnitude of change based on qualitative ranking of high, moderate, low, or highly uncertain

Navigation

Grand Coulee dam regulates flow of the Columbia River which supports year-round navigation on the lower Columbia River (only the four lower mainstem dams have navigation locks—Bonneville, The Dalles, John Day, and McNary). It is also the only large capacity storage reservoir on the U.S. Columbia, suggesting that changing operations could affect downstream navigation. Changes in operations of Hugh Keenleyside Dam navigational lock and Arrow Lakes reservoir elevation might affect ferry and boat traffic.

Recreation, tourism, and non-native culture

Commercial and recreational fisheries

The Pacific Salmon Treaty (1999) commits both the U.S. and Canada to work together to manage salmon runs where they intersect the other country's commercial fleet. In the near-term it is likely that restored salmon would introduce another weak stock into salmon management under the Treaty. Co-migration of weak and strong / harvestable stocks may reduce fishing opportunities of strong stocks in the marine environment (although once stocks have recovered harvest opportunities may instead increase, as discussed later in the benefits section). Although not formally listed under the Canadian Species at Risk Act, the weak Cultus and Sakinaw Lake sockeye salmon stocks have had an effect on harvesting opportunities of more abundant populations (GS Gislason & Associates Ltd. 2004).

Losses to non-native recreational fisheries may be significant. These impacts need to be considered in the context of increasing abundance of salmon, allowing for a potential switch in angling opportunities. Recreational impacts may not be perceived as high if fishing opportunities for anadromous salmon are viewed as a reasonable substitute or better alternative. However, there will be differences in the length of fishing season: opportunities to fish resident species will span a greater portion of the year, while opportunities to fish salmon will be limited to a narrower window.

Recreational activities (reservoir and downstream uses)

The best conditions for recreational use at GCD are at full reservoir levels—aesthetically pleasing shoreline, and access at all shoreline facilities. High season for recreational use is in the summer. Drawdowns for power and fish passage adversely affect some activities (e.g., boating) when water access is too low or reduces aesthetics. Reservoir elevation at 1288 feet is ideal, negative effects start at 1287 feet, while at 1285 feet all recreational uses are impaired, and many facilities are unusable at 1280 feet. Typical dam operations ensure lake levels between 1285–1290 by July 31 each year (USDOI and USBR 1993). Recreational uses include fishing (dealt with here as a separate issue), picnicking, sightseeing, hunting, as well as camping, water-skiing, boating, canoeing, kayaking, hiking, swimming, jet-skiing, wildlife observation, horseback riding, rock hounding (users who might actually perceive a benefit to more exposed substrate), scuba diving, photography, and bird watching (Ortolano and Cushing 1999; 2002). There are also increasing pressures to maintain stable summer reservoir levels in Canada (Arrow Lakes) for recreational boating (Kindy Gosal, pers. comm.).

First Nations / tribes

Food, social, and ceremonial (subsistence) fisheries

Current fishery opportunities for First Nations may be depressed if restored salmon caused a decrease in abundances of resident fish populations. This could affect the availability of fish for food and social / ceremonial purposes. The magnitude and duration of this effect on Tribal harvest would depend on how

severely resident fish populations were affected and how quickly a switch could be made from resident to anadromous fish harvesting. Presumably once a switch had been made First Nations would achieve even greater benefits from the direct fishing of salmon, and the related activities / jobs associated with the processing (drying, etc.) and distributing of salmon (Gregory and Harstone 2007, draft).

3.2.3 Benefits

In contrast to impacts being focused on those parties who benefited from dam construction, the benefits of restoring fish passage would be focused on those who bore the greatest costs of original dam construction. These parties include: 1) First Nations / tribes; and 2) recreation, tourism, non-native culture. There may also be benefits from 3) a regulatory perspective. These benefits are summarized in Table 3.6.

First Nations / tribes

Food, social, and ceremonial (subsistence) fisheries

Restored salmon harvest could recover what once was a vital part of First Nations / Tribal economies. U.S. court decisions have specifically established that the tribes have treaty rights to an equitable share of the Columbia Basin fishery resource (1969 landmark U.S. v. Oregon decision). As with Okanagan sockeye, there would be a need to negotiate harvest agreements between Canadian First Nations and U.S. tribes. Anadromous salmon species traditionally harvested by natives in the upper Columbia included Chinook salmon (spring and summer), steelhead (fall, late winter, and spring), coho salmon (fall), and sockeye. With the loss of all or most of their anadromous fish with the construction of Grand Coulee, the upper river tribes lost the centerpiece of their economy and livelihoods (CRITFC 1995; Allen 2003; USACE 1999). Upper Columbia River hydroelectric facilities in Canada are within the claimed territories of the Ktunaxa Nation Council, Shuswap Nation Tribal Council, Little Shuswap Indian Band, the Okanagan Nation Alliance, and the Spallumacheen Indian Band (BC Hydro 2005b).

Cultural significance

Construction of GCD eliminated salmon and steelhead upstream of the dam, which has led to significant adverse effects on U.S. tribes (Colville, Spokane) and Canadian First Nations (Shuswap, Okanagan, and Ktunaxa) where salmon has been central to cultural, religious, and social activities—e.g., cultural and ritual ceremonies, language, crafts, and diets (Watkins 2000; CRITFC 1995; USACE 1999). These groups have borne the majority of project non-financial costs. Traditional fishing activities either stopped or were forced to move elsewhere. The project also forced relocation of 2000 members of the Colville Tribe (Colville Confederated Tribes 1975), and 100–250 members of the Spokane Tribe (Ortolano and Cushing 2002). A report on GCD by the World Commission on Dams recognized that an important outstanding issue to be addressed in understanding the impacts and benefits of construction of GCD is to characterize the cultural significance of salmon to Native American tribes and people of the Pacific Northwest (Ortolano and Cushing 1999).

Political (fair and equitable compensation)

Lack of fair and equitable compensation over construction of GCD has led to longstanding bitterness between those bearing large costs of dam construction (e.g., U.S. tribes and Canadian First Nations who have been denied access to salmon) and government agencies managing the project (e.g., USBR, USACE, BPA). As well, Canadian First Nations have not been able to benefit from fish mitigation / compensation programmes in the U.S. Columbia River. Lack of consultation during initial project development has led to a situation that is widely viewed as inequitable (i.e., tribes / First Nations paid an enormous price while receiving few benefits). In the U.S., benefits received to-date have been the result of court actions by U.S. tribes, not through willing compensation (Ortolano and Cushing 2002). It will be difficult to

quantitatively measure the political capital gained by resolving long-standing disputes between U.S. / Canadian governments and First Nations / tribes, but this is likely to be appreciable. Restoration of salmon to the upper Columbia could help resolve some of this bitterness. Resolution of this issue could provide a template for re-development of power generation in other countries that are facing their own issues with native claims.

Recreation, tourism, and non-native culture

Commercial and recreational fisheries

The Pacific Salmon Treaty (1999) commits both the U.S. and Canada to work together to increase salmon runs and coordinate commercial harvest. In the longer-term there may be opportunities to sustain marine harvest if upper Columbia salmon stocks were restored to sufficient levels. Greater salmon abundance might allow greater flexibility under the Pacific Salmon Treaty, potentially affecting harvesting allocations between Canada-U.S. and alleviating harvesting pressures on Fraser River and other stocks (but see earlier impacts discussion: until stocks are recovered harvest flexibility may instead be reduced).

Recovery of recreational fisheries for salmon and steelhead in the upper Columbia to harvestable levels could provide substantial economic benefit through increased long-term jobs in ecotourism, hunting and sport fishery and help businesses such as motels, restaurants, tackle shops, and guide services (Reading 2005; IEAB 2005a; 2005b).

A report on GCD by the World Commission on Dams recognized that the effect of construction of GCD (and thus benefits of restoring salmon) on commercial and sport fishing is an important outstanding issue (Ortolano and Cushing 1999).

Non-native cultural significance

Other individuals who value ecosystems in their natural state will perceive benefits with restoration of salmon beyond Chief Joseph / Grand Coulee . These individuals have also been identified as bearing the cost of GCD construction (Ortolano and Cushing 1999). Social significance and scientific understanding of maintaining / restoring anadromous fish have changed since the construction of GCD. Changes in perception now recognize the ecological and social value of these species, which has been represented by general improvements in fish passage flows over many years (Ortolano and Cushing 2002). Northwest Power and Conservation Council (NWPPCC) Fish and Wildlife Program states that they support restoring salmon passage above Chief Joseph / Grand Coulee, “where feasible” (John Harrison, pers. comm.). The impact on non-native cultural significance will depend on how the change in fish production (from resident to anadromous) is valued by local communities. Some community members will likely value existing resident fish production more than anadromous production (Kindy Gosal, pers. comm.).

Regulatory environment

Endangered Species Act (ESA) status

Upper Columbia Spring Chinook and steelhead are both ESA listed in the U.S. (NMFS 2006).

The Upper Columbia Spring Chinook ESU was listed as endangered on March 24, 1999; this endangered status was reaffirmed on June 28, 2005. The ESU includes all naturally spawned populations of Chinook salmon in all river reaches accessible to Chinook salmon in Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam in Washington (excluding the Okanogan River), the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to Chief Joseph Dam

in Washington, as well as six artificial propagation programs: the Twisp River, Chewuch River, Methow Composite, Winthrop NFH, Chiwawa River, and White River spring-run Chinook hatchery programs.

The Upper Columbia steelhead ESU was listed as endangered on August 18, 1997; this status was upgraded to threatened on January 5, 2006, and the population unit was reclassified as a Distinct Population Segment (DPS). The DPS includes all naturally spawned anadromous *O. mykiss* (steelhead) populations below natural and manmade impassable barriers in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the U.S.-Canada border, as well six artificial propagation programs: the Wenatchee River, Wells Hatchery (in the Methow and Okanogan Rivers), Winthrop NFH, Omak Creek, and the Ringold steelhead hatchery programs. Maps defining the boundaries of these ESUs and DPSs can be downloaded NOAA Fisheries ESA Salmon Listing website (www.nwr.noaa.gov/ESA-Salmon-Listings/).

The prospects for the long term recovery of these stocks may improve if access to more-intact watersheds upstream of Grand Coulee dam was provided and the fish could thrive in these basins. Recovery or downlisting of U.S. Columbia salmon and steelhead stocks would ease restrictions related to their conservation.

3.3 Economic / financial

3.3.1 Feasibility issues

A significant issue in determining the feasibility of restoring salmon passage is the capital and operating costs of such a proposal. These costs will likely be significant and affect the political feasibility of the effort. Costs are driven by the engineering and ecological requirements discussed elsewhere.

Financial

Capital cost (dam construction works, methods for ensuring fish passage)

The direct capital cost of required re-engineering to allow upstream and downstream passage is uncertain (and will depend on the site-specific passage issues at each dam that is re-engineered) but will undoubtedly be high. For instance, new fish passage facilities at the Waneta Expansion Project have been calculated at \$30–40 million U.S. (R2 Resource Consultants 2004). Capital costs reported in a preliminary evaluation of passage options at Chief Joseph dam ranged from \$7-71 million (USACE 2002c). Costs would also include conducting the necessary biological and engineering studies to support a proposed design option. Estimates of study costs associated with passage options at Chief Joseph ranged from \$4–9 million. Bypass facilities at Rocky Reach Dam cost approximately \$107 million in capital costs (Chelan County PUD www.chelanpud.org/fast-facts.html), though these costs are being paid back through reduced spill requirements.

Operating costs (flow reallocations and foregone revenues)

Longer term maintenance costs, foregone power revenues, and reporting / monitoring costs could be appreciable and will be dependent on the number and type of passage options at each facility (e.g., IEAB 2004). Maintenance of the fish passage facilities and/or trap and haul programs at the different dams in the upper river would be a continuing long term cost required to ensure successful establishment of salmon populations (Hay & Company Consultants 2001). Annual operating costs (i.e., annual operating costs and generation losses) associated with fish passage options at Chief Joseph have been estimated to range from \$1.1 to \$4.0 million (USACE 2002c). Reallocations of flows and water volumes to benefit

passage of upper river salmon may also have significant financial implications to other water user groups (e.g., irrigation, hydro power, municipal users).

3.3.2 Impacts

Table 3.7 summarizes the list of impacts and benefits associated with economic / financial issues. This list mirrors those issues described under Table 3.6 because the economic / financial characterize the significance of social-regulatory concerns. This characterization would be important to understanding the distribution of costs and benefits following restoration of salmon passage, and for comparing to the situation pre- and post-construction of Grand Coulee dam. An economic evaluation needs to recognize the limitations / difficulties of assigning market value to non-market goods and services (e.g., existence values, ecosystem services). As well, there are challenges when evaluating impacts and benefits in the context of intergenerational equity. Economic analyses with a high discount rate tend to favour decisions that benefit current generations, leading to the question: “How equitable are current benefits when considering impacts on past / future generations?”

Electric power (generation and system reliability)

Marginal value of water for hydropower has been estimated at \$4–62/per acre-foot (WSTB and BEST 2004). This value depends on location / elevation of water within the Columbia system. Larger benefits are drawn from water stored higher up because it passes through the largest number of generating facilities. Foregone revenues need to be considered (mentioned as a feasibility issue) and potential for replacement of hydro power with other supply / conservation alternatives. For instance, as regulations change in the future and carbon emissions become more stringently regulated, impacts on power production from hydroelectric generation (a power source with relatively few carbon emissions) may be valued much higher than today. This is particularly important given U.S. CRITFC’s commitment to implement this project over the next seven generations.

Water management

Flood control (storage and flexibility)

Economic estimates would be based on data of damage averted due to flood protection. USBR (1999) study estimated annual flood control benefits associated with Grand Coulee Dam at \$20 million (1998 dollars), though data provided by Ortolano and Cushing (1999, Appendix D) suggest benefits range from \$0 to \$252 million depending on the annual flows. However, it is difficult to attribute all of these benefits solely to Lake Roosevelt because flood control in the Columbia is managed as a system (i.e., other storage contributes to these estimates). For example, storage in Mica Reservoir B.C. prevents flooding in Portland, Oregon. Significance of these impacts is also questionable given that changes to flood control measures in Canada would be non-negotiable under the Columbia River Treaty. From 1950–2005 estimated accumulated flood control benefits of Bureau of Reclamation dams were \$183 million, or \$3.27 million annually (Brawley 2006).

Agricultural uses

Any operational changes leading to adverse effects on agricultural interests might lead to requirements for compensation given the long-term agreements under which irrigators currently operate. This would require calculating the difference between crop yields from the current situation and those under reduced water for irrigation. Depending on the crop and location of agricultural activities, the marginal value of water for agricultural purposes has been estimated to range from \$3 to \$200 per acre-foot (WSTB and BEST 2004). Specific agricultural impacts could relate to the possibly increased pumping costs from

Lake Roosevelt (if maintained at a lower level) to Banks Lake which supplies the Columbia Basin Project lands. These costs are currently highly subsidized (B. Green, pers. comm.).

Navigation

As discussed above, impacts on navigation of the lower Columbia River could occur. The marginal value of water for navigational purposes on Columbia River has been estimated at \$5.60/acre-foot (WSTB and BEST 2004). There could also be quantifiable economic impacts if changes to the operation of Hugh Keenleyside Navigation Lock are necessary. No known data are available to quantify these effects in Canada. The value in Canada would likely be less given less traffic and less reliance on Canadian reservoirs for navigation.

First Nations / tribes

Food, social, and ceremonial(subsistence) fisheries

Resident fishery opportunities for First Nations may be depressed if restored salmon were to affect these opportunities. The magnitude of effect on Tribal harvest may depend on whether a switch from resident to anadromous harvesting is viewed as an impact.

Recreation, tourism, and non-native culture

Commercial and recreational fisheries

Economic impacts might apply to recreational and commercial fisheries. Recreational losses relate to evaluating costs associated with change from a freshwater fish community to one with anadromous populations. Commercial losses might result from restrictions imposed to protect restored salmon co-migrating with harvestable stocks. In Canada, GS Gislason & Associates Ltd. (2004) estimated the magnitude of commercial and recreational fisheries on the Fraser River to evaluate the impacts of listing Cultus and Sakinaw Lake sockeye salmon under SARA. Under the current management system the commercial value of the fishery was estimated at \$6.6 million or \$19 per fish, while the recreational fishery was estimated at \$6.3 million or \$110 per fish. The difference between the base case and a worst case scenario of listing was a 94% reduction in the value of both the commercial and recreational fisheries, thus providing a measure of the potential magnitude of these impacts.

Recreational activities (reservoir and downstream uses)

Grand Coulee Dam (GCD) related activities generate 3 million visitor days per year (1/2 related to angling). Ortolano and Cushing (1999) highlight the lack of information related to understanding the economic recreational benefits (and thus potential impacts) of GCD, how operation of GCD and CBP affect recreational activities, and the nature and extent of recreational users at GCD recreational facilities. Few studies have looked at recreational benefits (which might provide insights into potential impacts) at GCD (Ortolano and Cushing 1999). However, Olsen (1996) estimated direct (between \$21-70 million) and indirect benefits (\$22 million) of activities at Roosevelt Lake. The recreational value of water in the Columbia Basin has been estimated at \$7.7 to \$130 per acre-foot (WSTB and BEST 2004).

Table 3.7. Summary of **economic / financial** impacts and benefits of restored salmon passage to the upper Columbia River.

Impacts or Benefits	Mgmt Action ¹		Facility ²							Factors Affecting Significance of Issue	
	Flow	Pass	CJ	GC	KN	RV	MC	BD	WN / SM	Affected User ³	Magnitude of Change ⁴
ELECTRIC POWER											
Generation and System Reliability	X	X	X	X	X	X	X	X	X		
Impact – Marginal value of water depends on location / elevation of water within the Columbia system										Canadian operators, federal and non-federal operators in U.S.	High
WATER MANAGEMENT											
Flood Control	X	X		X	X	X	X				
Impact – Potential economic costs based on damage previously averted due to greater flood protection.										All hydro operators and potentially affected downstream residents	High
Agricultural Uses	X			X							
Impact – Compensation would be based on difference between current crop yields and yields with reduced water for irrigation.										Irrigators / agricultural producers in Washington state	Potentially High
Benefit – Removal of market distortions and subsidies to agricultural producers benefiting from irrigation works associated with Grand Coulee Dam										Agricultural producers in Pacific Northwest	Uncertain
Navigation	X			X	X						
Impact – Water is considered of marginal value for navigational purposes on Columbia in the U.S. and Canada										Navigation on Arrow Lakes Hugh Keenleyside Navigational Lock	Low
RECREATION, TOURISM, AND NON-NATIVE CULTURE											
Commercial and Recreational Fisheries		X	X	X	X	X	X	X	X		
Impact – Losses to non-native recreational fisheries may be significant affecting guiding and business over a large portion of the year. Recreational losses relate to costs associated with change from fishing for resident fish to salmon.										Recreational anglers in Canada and U.S.	Uncertain
Benefit – Harvest of restored salmon and steelhead in the upper Columbia to harvestable levels would provide economic benefits through increased jobs in ecotourism, hunting, and sport fishery within a narrow time of year.										U.S. and Canadian commercial sockeye harvesters, Recreational anglers in Canada and U.S.	High
Recreation (reservoir and downstream uses)	X			X	X	??	??				
Impact – Few studies have looked at recreational benefits directly that could provide insights into potential impacts at Roosevelt Lake and other reservoirs										Recreational users on Lake Roosevelt and affected Canadian reservoirs (Arrow)	Uncertain
Non-native cultural significance	X	X	X	X	X	X	X	X	X		
Benefit – Individuals who value ecosystems in their natural state will perceive non-market benefits with restoration of salmon.										Individuals in region who assigns value to environment restoration	Uncertain
FIRST NATIONS / TRIBES											
Food, social, and ceremonial (subsistence) fishery		X	X	X	X	X	X	X	X		
Impact – Potential losses to resident fishery opportunities for tribes. Magnitude of effect on Tribal harvest may depend on whether switch from resident to anadromous harvesting is viewed as an impact.										U.S. tribes	Uncertain
Benefit – Restored salmon harvest could recover what once was a vital part of First Nations / Tribal economies.										U.S. tribes and Canadian First Nations	High
Cultural significance	X	X	X	X	X	X	X	X	X		
Benefit – Salmon was historically central to cultural, religious, and social activities of First Nations / tribes.										Canadian First Nation and upper Columbia U.S. tribes	High
Political (fair and equitable compensation)	X	X	X	X	X	X	X	X	X		
Benefit – Restoration could help resolve longstanding grievances between those bearing costs of dam construction (i.e., the loss of access to salmon) and government agencies managing the project. Difficult to quantitatively measure the political capital gained by resolving long-standing disputes.										Canadian First Nation and upper Columbia U.S. tribes	High
REGULATORY ENVIRONMENT											
Endangered Species Act (ESA) status		X	X								
Benefit – Recovery or downlisting of U.S. Upper Columbia salmon stocks would ease restrictions related to their conservation, potentially allowing for greater economic opportunities.										NOAA, BPA, PUDs	High

Table Footnotes:
1 – Denotes whether changes in flow operations are applicable to the impact or benefit, especially timing and magnitude of flows (reservoir storage and instream flow) (hydro), or whether there are direct effects from construction of fish passage structure and indirect effects associated with environmental / social changes due to reintroduction of salmon (harvest, hatchery, habitat)
2 – Codes for upper Columbia Basin dams under consideration: CJ (Chief Joseph), GC (Grand Coulee), KN (Keenleyside), RV (Revelstoke), MC (Mica), BD (Brilliant), WN/SM (Waneta and Seven Mile)
3 – Affected users are important to understand because different stakeholders will perceive an environmental change from a different perspective. Some will view change as a positive benefit, others will view change as a negative impact.
4 – Magnitude of change based on qualitative ranking of high, moderate, low, or highly uncertain

3.3.3 Benefits

It is expected that potential economic benefits would be targeted towards: 1) First Nations / tribes; 2) recreation, tourism, and non-native culture; and 3) regulatory environment. Table 3.7 summarizes the list of impacts and benefits associated with economic / financial issues, which again mirrors those issues described under Table 3.6.

Water management

Agricultural uses

Construction of GCD has also resulted in market distortions and agricultural subsidies. Agricultural users in eastern Washington have benefited from the CBP irrigation works, resulting in a large subsidy to their industry (paid for by U.S. Treasury and Columbia Basin ratepayers). Initially, CBP was developed with the intention of encouraging small scale farmers within the region. However, water subsidies have led to reduced costs and a competitive advantage over growers in BC and elsewhere in Washington (Ortolano and Cushing 2002). Restoration of salmon might improve economic imbalances, potentially removing market distortions and resulting in measurable benefits

First Nations / tribes

Food, social, and ceremonial (subsistence) fisheries

Restoration of anadromous salmon to the upper Columbia River could allow a return of the native cultural, social and economic relations that historically were based on the salmon resource. Fishing and processing of salmon traditionally encompassed a broad set of activities that typically would involve the full community, as well as bartering with and trading with other First Nations (Gregory and Harstone 2007, draft). Primary fishing activities would take place in the summer and fall, coinciding with the timing of salmon runs into the upper Columbia. Many examples of subsequent lifestyle losses were noted in the recent Gregory and Harstone report (2007, draft), particularly in terms of loss of valued activities associated with fishing. As quoted therein by one elder, “We had a gathering community, we had socializing there, we had celebrations, we had ceremonies there, we had a lifestyle, we had our food gathering.”

Salmon was historically an important part of the diet for many upper Columbia First Nations; the loss of which has caused a significant change in diet. Since the construction of the GCD there has been a shift away from locally caught and produced food towards more expensive store-bought food of generally lower quality, with concomitant greater health risks (Gregory and Harstone 2007, draft). Omega-3 fatty acids such as those obtained from salmon have been shown to help protect against heart disease, periodontitis, arthritis, and other inflammatory conditions (U.S. National Institutes of Health). Impacts on health can also be more indirect. In the case of the Ktunaxa, one of the important secondary uses of salmon was as a trade item to obtain other food sources. Traditionally the Ktunaxa would travel to the eastern foothills of the Rockies to trade salmon for meat harvested by plains Indians (Gregory and Harstone 2007, draft). The direct salmon resource losses associated with construction of GCD and other upper Columbia River dams includes the consumptive, ecological and ceremonial values they provided to First Nations in the upper river. In addition there have been losses of other fish (e.g., cod, sturgeon) and reductions in the abundance of culturally important wildlife such as eagles and bears that would feed off the salmon (Gregory and Harstone 2007, draft).

Cultural significance

Construction of upper Columbia dams and the loss of anadromous salmon runs has had dramatic emotional, physical and psychological impacts on the native communities in the upper Columbia; impacts that could be alleviated by a return of salmon to these waters. Currently, many of the traditional ceremonies and practices relating to the fishing and processing of salmon have been lost. Although salmon is still consumed by upper Columbia First Nations communities the only sources for “fresh” salmon are from the Fraser River. Many families have tried to continue their salmon practices, but this is costly and requires travelling long distances. Without the salmon and the ceremonies associated with their return to the upper Columbia, the native youth of these communities have lost their interest in and connection to what was a defining feature of their cultural way of life. One of the greatest impacts has been in the change in traditional ceremonial practices and spiritual sites, as the loss of anadromous salmon runs has prevented their use for ceremonial purposes. As quoted by a native elder in the recent Gregory and Harstone (2007, draft) report, “We don’t have anything to share with our children or grandchildren in ceremonies... Like trading back and forth with our spiritual side. There’s nothing there. That’s the real sad part.” Sites that were sacred because of the associated resource uses have now been lost. With the loss of the salmon runs has come a loss of purpose for many First Nations individuals, a loss of connection to each other and to the land.

Traditional ecological knowledge (TEK) of indigenous peoples, as described in Gregory and Harstone (2007, draft), is composed of many components: learning and teaching traditional skills, maintaining a cultural heritage, protecting traditional sites, and nurturing spiritual values. TEK is both inherited and developed anew with each generation. It is generally transmitted orally and through cultural processes, including observation, demonstration, participation, stories, ceremonies, and teachings at special times of one’s life or during special occasions such as feasts or potlatches (Turner 2005 as quoted in Gregory and Harstone (2007, draft)). With the disappearance of the salmon resource, so too have many of the TEK practices in the upper Columbia. As quoted by a younger native in Gregory and Harstone (2007, draft), “That is a real sad thing because we listen to the elders that are older than us talk about how they used to go out and fish from the banks and that kind of stuff. It’s really sad that we’ve lost that part of our culture.”

Political (fair and equitable compensation)

In response to claims by the Colville Tribes in 1978 and 1990, they received revenues sharing with BPA (\$15–25 million / year) as well as fish and wildlife compensation funds (\$3 million lump sum in 1978, \$8 million annually) to offset impacts on culture and losses to fishing since 1940 (Joe Peone, Colville Tribe, pers. comm.; Watkins 2000; U.S. Claims Court 1990). Such compensation is still not viewed as fair and equitable for the impacts and losses to tribal / First Nations traditional ways of life due to the construction of Grand Coulee dam (Ortolano and Cushing 2002).

Recreation, tourism, and non-native culture

Commercial and recreational fisheries

Characterizing the economic benefits of commercial and recreational salmon fisheries has been somewhat contentious in the Columbia Basin. Annual recreational losses due to Grand Coulee Dam have been estimated between \$250,000 and \$300,000 (\$2.8–3.4 million U.S. in 1998 dollars) (Calkins et al. 1939), thus indicating the potential magnitude of benefits in restoring this fishery. A more recent study indicated that fully restored salmon and steelhead fisheries in Idaho could produce \$544 million in economic activity a year (Reading 2005). In contrast, the Independent Economic Analysis Board reported that recreational and commercial fishing in the entire Columbia Basin generated \$140 million U.S. in income benefits throughout the western U.S. and Canada (IEAB 2005a), while also arguing that Reading’s

estimates were overstated (IEAB 2005b). In Canada, the direct commercial value of the Fraser River sockeye fishery has been estimated at \$6.4 million for First Nations, \$6.6 million for the commercial fleet, and \$6.3 for recreational harvesters (total of \$19.3 million annually) (GS Gislason & Associates Ltd. 2004). Gislason (2006) provides a framework for estimating the economic value of commercial and recreational fisheries based on the consumer, business, and worker surpluses, as well as adjusting for government revenues.

Non-native cultural significance

Economic benefits could include estimates of the value of ecosystem services provided by returning salmon—enhancement of freshwater ecosystems, terrestrial environment, and wildlife populations due to marine derived nutrients. There may also be financial gains in the reduction of costs associated with nutrient enhancement programs. Existence values are defined as the benefit received from individuals simply knowing the resource exists even if no use is made of it. Loomis (1999) estimated the non-use value of restoring salmon to the Lower Snake River at \$420 million annually.

Regulatory environment

Endangered Species Act (ESA) status

The economic benefits of restoration actions to enhance recovery of salmon could be measured by the revenues associated with flow management changes that enhance power production without affecting salmon survival (IEAB's criteria for evaluating cost-effectiveness of recovery programs). The magnitude of these benefits could be large, since in 1998 the region spent approximately \$200 million annually on restoration efforts (Morlan 1998). Such benefits may also be desirable given a more competitive power market than historically, and the reported difficulty in recovering costs associated with fish and wildlife programs (Morlan 1998). However, restoring salmon passage past GCD would likely decrease, not increase, power production.

3.4 Cross-domain considerations

There are two main components to considering interactions across the issues discussed in Sections 3.1–3.3. The first consideration is to provide clarity around a unique and potentially complex decision making process. A decision process will be complex because feasibility issues may be resolved by any one of a variety of decision pathways: they may be linked such that resolution of one issue requires resolving a sequence of other issues (sequential approach to decision making); and/or they may require parallel processing (resolving multiple issues at a time). Figure 3.1 illustrates some of the analyses and interconnectedness of issues when determining the feasibility of restoring passage. A clearly articulated map of the decision process should identify critical decisions, the parties involved in making a decision, the criteria used to make a decision, the level / source of evidence needed to move beyond a decision point, and the critical uncertainties affecting decision making. We also recognize the limitations in trying to anticipate and resolve too many issues early on. Trying to answer too many questions would likely be of overwhelming complexity, and paralyze efforts to move forward to reducing uncertainties. Thus, the phased approach outlined in 2.0 Steps to reaching a decision, is recommended as a general framework for gathering information about restoration feasibility.

The second cross-domain consideration is that a decision about whether to restore salmon will depend on results of a trade-off evaluation of impact and benefit issues discussed in Sections 3.1–3.3. A rigorous way of structuring an evaluation of the alternatives is by decision analysis, which allows analysts to explicitly consider the effect of uncertainties and decision makers to view the alternatives in terms of their rank order (Clemen 1996; Morgan and Henrion 1990; Hammond et al. 1999). Each restoration alternative

will be associated with different levels of feasibility, including different impacts and benefits in terms of cost and fish / habitat responses (e.g., Figure 3.2). As well, a trade-off evaluation needs to consider hard constraints on decision making. For example, there will be constraints on flow alternatives at upstream dams due to legal obligations to maintain flow / storage at other places and points in time for either ESA purposes or other licensing requirements as part of the Columbia Basin Project, Columbia River Treaty, or FERC regimenting. Finally, if it were determined that the U.S. or Canadian governments had an obligation to restore salmon to Canadian First Nations / U.S. tribes, a “no action” alternative may not be acceptable. A trade-off evaluation should consider economic, social, and ecological objectives, distribution of costs and benefits across various parties, and a “no action” alternative.

There are four relevant examples from the region about how dam-related activities could be assessed. First, in 1995, the National Marine Fisheries Service (NMFS) created the Plan for Analyzing and Testing Hypotheses (PATH), a collaborative interagency analytical process to help reduce uncertainties in NMFS's hydrosystem decisions on the Lower Snake River. PATH involved about 30 fisheries scientists from a dozen agencies, as well as independent participating scientists and a technical facilitation team (Marmorek and Peters 2001). Alternatives were assessed using a quantitative decision analysis framework. Second, a group of regional economists, was convened to evaluate the economic effects of four alternatives to improve juvenile salmon passage on the Lower Snake River (USACE 2002b). Third, the Northwest Power and Conservation Council uses three panels of independent experts to review and advise on fish, wildlife and power issues. One is a panel of economists—the Independent Economic Analysis Board (www.nwcouncil.org/fw/ieab/). Ortolano and Cushing (1999) suggest that, in general, the most sophisticated estimates of monetary benefits associated with dam projects would be those associated with the benefit-cost analysis (sometimes referred to as an “economic justification”) that has been required of many federal water resources projects in the U.S. since the passage of the Flood Control Act of 1936. Documents prepared for project authorisation before 1936 are not likely to contain the types of rigorous benefit and cost computations that would be expected in projects authorised later. However, this framework may also be useful for assessing the impacts and benefits of restoring salmon to the upper Columbia River. Finally, over the last decade, BC Hydro has been involved in a Water Use Planning process to review water management decisions, not structural alternatives, at the majority of their facilities. In some cases, these Water Use Plans evaluated decision alternatives using a structured decision making process (e.g., Marmorek and Parnell 2002).

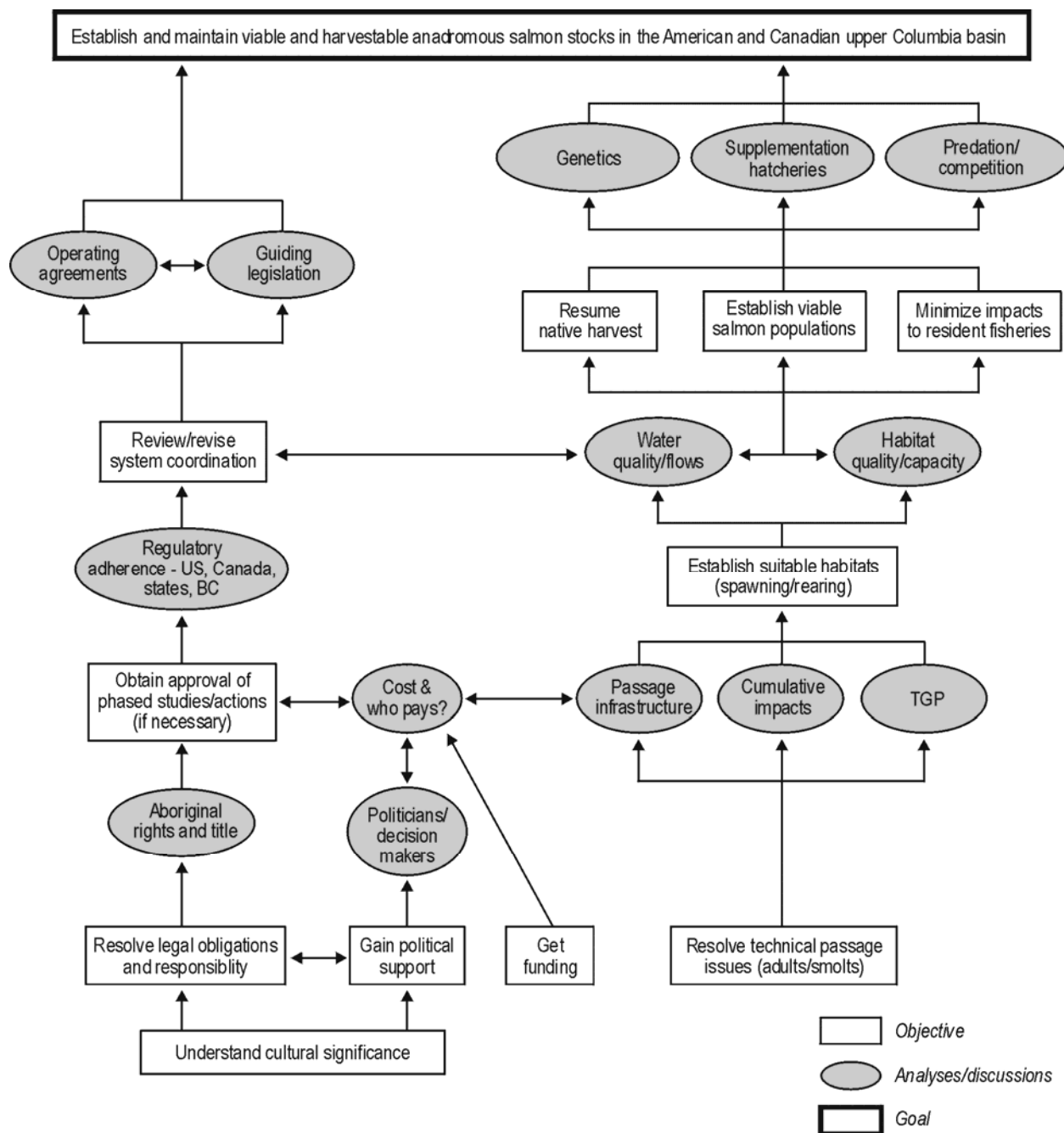


Figure 3.1. Flowchart of interconnected objectives and associated studies / actions required to assess whether it is feasible to restore viable and harvestable anadromous salmon stocks in the upper reaches of the Columbia River. Note that this figure does not represent the interconnectedness involved in resolving impact and benefit issues.

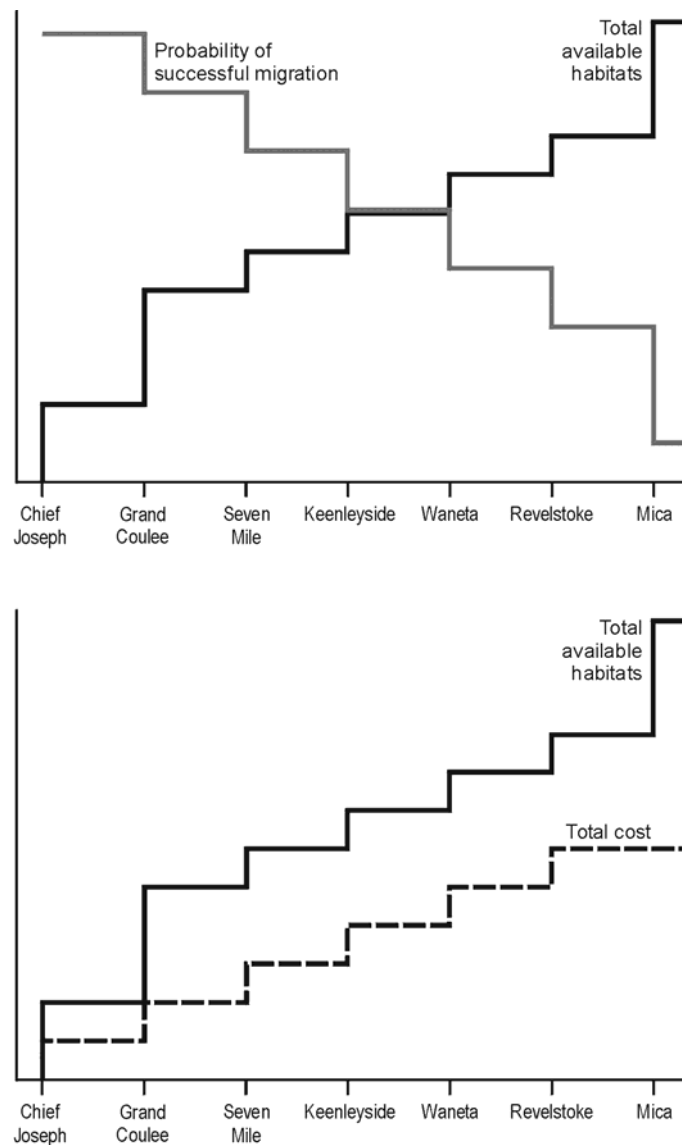


Figure 3.2. Conceptual illustration of the tradeoffs between increased habitat availability, decreased probability of successful migration, and increased costs. The hypothetical example in the upper panel shows how passage by additional dams should open up more habitat for fish (darker line), but the probability of successful passage past these additional dams may go down concomitantly (lighter line). Some balance of the two may represent an optional strategy for restoration. The lower panel shows how there will be an increasing total cost (dashed line) with the total available habitat opened up (solid line) by additional dam passage. At some point in the process it may be concluded that the additional habitat that could be accessed does not warrant the additional cost required. These relationships are not supported by any data; they are intended to illustrate a general concept about potential tradeoffs.

4. Critical FIBs Questions, Uncertainties and Proposed Studies / Actions for Resolving Issues

Tables 4.1 to 4.4 present critical FIB questions and uncertainties as determined from literature review, consultation with domain experts, and facilitated discussions with participants at the FIBs workshop. Subgroups at the workshop focused on identifying specific studies or actions that could ultimately help address many of these uncertainties. These studies / actions are provided in Tables 4.1 to 4.4 and related to the specific issues they are designed to help address. For some issues, a large suite of potential studies / actions are identified. Conversely, for other issues no specific studies / actions have yet been identified. Participants at the FIBs workshop focused primarily on identifying the priority issues that should be resolved in the near-term for a project of this scale to move forward. The expectation is that further relevant studies / actions to address additional issues will be identified as UCAMP progresses through a phased workplan (see 2.0 Steps to reaching a decision).

Table 4.1. Summary of outstanding questions, uncertainties related to understanding key **feasibility** issues and recommended studies / actions to address these issues.

Feasibility Issue	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
LEGAL		
<p>Aboriginal rights and title</p> <p>Government responsibility</p>	<p>Can Canadian First Nations gain legal standing to their position (either in U.S. or Canada)?</p> <p>Are there any legal precedents where cross-boundary cases supported / did not support legal standing for First Nations, or precedents where Canada has / has not respond to transboundary requests for action?</p> <p>Would compensation open up the door to other similar cross-border requirements for compensation (might affect political feasibility)?</p> <p>Could Canadian FN treaty negotiations affect action to restore salmon?</p> <p>Could undefined treaty rights for Columbia First Nations be used to help restore salmon?</p> <p>What are the transboundary obligation for respecting neighbour country treaties?</p> <p>Could Colville / Spokane / CRITFC Tribes make a claim to U.S. government with Canadian First Nations to restore salmon?</p> <p>Could Canadian Aboriginal case law change to support restoration (trend towards more rulings in favour of FNs)?</p> <p>Could Canadian Minister of Fisheries impose action on hydro operators in Canada?</p> <p>Is agreement within Pacific Salmon Treaty and Columbia River Treaty necessary to resolve legal feasibility?</p>	<p>1) Form coalition among Canadian First Nations – U.S. tribes. Needs a lead entity. Should integrate / consider legal standing of different tribes.</p> <p>2) Form coalition among other groups with legal standing. (e.g., Northwest Indian Fisheries Commission, agencies representing ESA)</p> <p>3) Develop a communications strategy (coordinate legal-political strategies)</p>
POLITICAL		
	<p>Who are the relevant political decision makers in Canada and the U.S.?</p> <p>Who are the political allies of restoring salmon to the upper Columbia River?</p> <p>What is the political will for restoring salmon to the upper Columbia River?</p> <p>What is the specific project (flow and passage alternatives)?</p> <p>What is the timing for implementing project (7 years vs. 7 generations)?</p> <p>Willingness to bear cost?</p> <p>What is the cost to society and willingness to pay?</p> <p>How do you place value on intangibles that help inform political decision</p>	<p>1) Develop a short and detailed menu of desirable technical studies that need to be resolved to inform decision making.</p> <p>2) Clarify upper Columbia River restoration goals.</p> <p>3) Convene a series of meetings to gauge political support for the project (Congressional staff, Lake Roosevelt Forum, public support, etc.)</p> <p>4) Work with federal politicians to develop budget earmark</p> <p>5) Develop a communications strategy (coordinate legal-political strategies)</p>

Feasibility Issue	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
	<p>making?</p> <p>What are the FIB (feasibility, impact, benefit) issues and associated trade-offs?</p> <p>What is the process for public consultation?</p> <p>Can political motivation for restoration start in U.S.?</p>	
DAM and RESERVOIR OPERATIONS		
Fish Passage	<p>Would adult salmon be able to successfully migrate through Lake Roosevelt?</p> <p>Could smolts survive passage over Grand Coulee's 350 ft. spillway (or is height irrelevant once terminal velocity has been reached)?</p> <p>Would migrating smolts be able to successfully navigate through the expanse of Lake Roosevelt (150 miles with no current) to the spillway or a potential passage structure at Grand Coulee?</p> <p>Would it be necessary to artificially move salmon smolts through upper river reservoirs? If so, could techniques be developed to trap and haul juveniles at tributary streams that would not unduly damage the fish?</p> <p>Trap/haul techniques have been developed and used successfully in several areas, including the Corps' Willamette Valley projects such as Foster / Green Peter dams on Santiam River; trap / haul approaches alternatively were unsuccessful at Brownlee Reservoir.</p> <p>Would newer fish passage technologies for adult fish will be sufficient to allow ascent of Grand Coulee and other high head dams in the upper Columbia?</p> <p>Will increased population growth in the Basin lead to increased municipal / domestic water consumption, making provision of migration flows more difficult?</p>	<ol style="list-style-type: none"> 1) Evaluate possible alternative approaches, technologies for guiding, transporting smolts through Lake Roosevelt to or around Grand Coulee Dam. Develop pilot studies on different options. 2) Do studies of possible passage options for adults at Chief Joseph and Grand Coulee, building on expertise gained at other projects. 3) Assess ability to get adults 320 km past Lake Roosevelt, either swimming or in a truck, using Chinook returning to CJ hatchery. 4) Track radio tagged salmon adults released in Lake Roosevelt as pilot to assess utilization of any available potential spawning habitat, and to determine fish movement within the lake. 5) Do tracking, behavioural and survival studies of smolts through Roosevelt Lake, using hatchery Chinook from CJ hatchery to get enough fish. Need to repeat these over several years at different smolt outplant sites. 6) Assess required travel time for hypothetical fish stocks in different locations (and different life histories) to reach estuary in critical window 7) Simulate ability of different stocks to reach estuary under: a) current operations (fish fit the system); b) modified flows and reservoir levels (system fits the fish); c) hybrids. Simulate travel time, survival and TDG. Could system be operated to meet conditions? 8) Undertake gaming of these presumed flow needs for migrations of hypothetical upper river stocks, and assess how this would affect needs of downriver stocks (possibly utilizing existing Columbia River flow management models). 9) Undertake experiments to evaluate methods to enhance directional flow at lake inflows e.g., piping systems, rock weirs, etc. (intent is to improve effectiveness of possible smolt trapping at tributaries)
Cumulative impacts	Given current high cumulative mortality in the present lower river migration through the hydrosystem, could re-introduced salmon stocks ultimately persist	See #7 under Fish Passage Section immediately above.

Feasibility Issue	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
	<p>in the face of additional mortality imposed by passage at two or more upper river dams?</p> <p>The extent of turbine mortality of smolts at Grande Coulee and Grand Joseph (and Canadian Dams) are unknown but are likely to be considerable as they were not originally designed to be fish-friendly.</p> <p>Survival benefits of possibly barging adults and juveniles around Grand Coulee and other dams is uncertain (generally survival for juveniles is considered better passing over spillways in lower Columbia dams)</p> <p>If transportation was not provided, could sufficient survival rates be maintained, both through the reservoirs and at dams as the fish pass through turbines, bypasses or spill?</p>	
Dissolved gases (TGP)	<p>What would be the impact of gas bubble trauma on migrating smolts?</p> <p>Is there a need for operators to further reduce TGP levels at Grand Coulee and at upstream Canadian dams to levels that would allow safe passage for anadromous salmon?</p>	See #7 under Fish Passage Section immediately above.
OPERATING AGREEMENTS AND GUIDING LEGISLATION		
<p>Columbia River Treaty</p> <p>Pacific Northwest Coordination Agreement</p> <p>Non-Treaty Storage Agreement</p> <p>Pacific Northwest Electric Power Planning and Conservation Act</p> <p>Canal Plant Agreement</p> <p>Endangered Species Act</p> <p>Species at Risk Act</p> <p>Columbia Basin Project</p> <p>Columbia River</p>	<p>What is the specific project (flow and passage alternatives)? E.g., magnitude of changes in timing, location, of flows in reservoirs and in downstream?</p> <p>What is the timing for implementing project (7 years vs. 7 generations)?</p> <p>How would ESA / SARA affect restoration? Would objectives for salmon conflict with other fish objectives?</p> <p>Can you make necessary operational changes within CRT?</p> <p>What happens to existing Water Use Plans (in Canada) and FERC re-licensing (in U.S.)?</p> <p>What is the order of operations for evaluating project across these operating agreements?</p> <p>Which are the most constraining / stringent agreements? Priorities? Show stoppers? Which apply?</p> <p>Will the Columbia River Forum provide a venue to propose / consider changes in system coordination?</p> <p>Can existing regulatory frameworks be adjusted within appropriate timing windows (e.g., WUP, CRT, FERC re-licensing)?</p> <p>How does timing of restoration coincide with re-negotiations of existing agreements?</p>	<p>1) Define the "project". In other words, clarify design requirements for the restoration project (e.g., which facilities, which passage options, what is the spatial extent of re-introduction, what are the anticipated changes in flow regimes). This information must be available to determine the implications of regulatory requirements on the specific project.</p> <p>2) Conduct an assessment to determine which agreements would apply, which are the most stringent, identify show stoppers, describe implications on relevant ones, etc.</p>

Feasibility Issue	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
Forum	What kind of mechanism could be used to resolve conflicts among agreements?	
ECOLOGICAL		
Predation / competition	Would potential ecological interaction with resident and/or invasive fish species in the upper river limit success of anadromous salmon reintroductions?	<ol style="list-style-type: none"> 1) Inventory predatory fish abundance (particularly walleye) in Lake Roosevelt (and later expand to Canadian reservoirs). Model expected impact on salmon (based on lower Columbia River assessments / models of predator effects). 2) Evaluate possible control methods for invasive fish predators (especially walleye) in Roosevelt Lake
Genetics and life history	<p>Could suitable donor stock be identified and obtained that would perform well in these reintroductions?</p> <p>Would the most obvious suitable donor stock for fall Chinook reintroductions (Hanford Reach Upriver Brights) be sufficiently healthy to cope with brood stock removals?</p> <p>How closely related are the large rainbow trout in Lake Roosevelt to anadromous steelhead? Could they represent a potential donor stock for steelhead restoration?</p> <p>Would it be necessary to maintain the stocks through a supplementation hatchery program that could help establish natural runs and maintain genetic diversity?</p>	<ol style="list-style-type: none"> 1) Identify potential donor stocks a) inbasin (preferred)—as genetically similar as possible to historical stocks and/or suitable life history traits (including existing kokanee and rainbow in L. Roosevelt); and b) out-of-basin with suitable life-history types (not preferred, and presenting potential transplant policy issues). 2) Determine characteristics of disease prevalence in potential donor stocks. 3) Determine how many natural spawners would theoretically be required to maintain genetically viable populations of different stocks in the Canadian upper Columbia. 4) Undertake paleolimnological study (e.g., past midden sites, pre-Grand Coulee scale samples) of past genetic structure of Chinook, sockeye and coho in Canadian parts of upper Columbia. 5) Determine and evaluate implementation strategies for establishing salmon populations through use of supplementation hatcheries (i.e., life stage of release, numbers released, acclimation site locations, etc.). Establish precedents from the literature. Alternatively evaluate likelihood of being able to successfully implement restoration program without use of supplementation hatchery (i.e., natural production only).
Habitat (quality / capacity)	<p>Would dam operators have the flexibility to maintain upper river reservoirs at elevation levels conducive to sockeye shore spawning?</p> <p>How good is the habitat upstream of Grand Coulee for salmon and what measures would be necessary to improve it and/or access to it?</p> <p>What would be the impact to migrating / rearing juvenile salmon exposed to contaminated sediments and associated food resources in Lake Roosevelt?</p>	<ol style="list-style-type: none"> 1) Undertake detailed baseline field assessments of lake and tributary habitat quantity, quality and capacity for various life stages of salmon above Grand Coulee in Lake Roosevelt and its tributaries. 2) Undertake broad scale (i.e., remote sensed, GIS) assessments of the amount of spawning and rearing habitat available in different parts of Columbia Basin to identify potential stock locations (explore tapping into provincial habitat capacity models that are currently

Feasibility Issue	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
		being developed by BC MOE). 3) Utilize the above analysis to undertake a stepped assessment of habitat availability (as illustrated in Figure 3.2 of this report) to scope out "reasonable" restoration alternatives for further more detailed analysis.
Climate warming	<p>Composition of earth's atmosphere is partly under human control and we cannot predict how it might be managed in the future to alleviate climate warming problems</p> <p>Different climate models present significantly different quantitative climate forecasts and it is uncertain which scenarios might ultimately occur.</p> <p>Very uncertain how salmon habitats would change as a result of climate warming and how salmon populations might respond to these changes.</p> <p>Uncertain if potentially reduced water volumes would be preferentially allocated to recreation, power, irrigation or urban water supply demands over fish needs</p>	1) Model the predicted water temperatures and available future water volumes / flows in the upper Columbia under varied climate change scenarios. Use this for evaluating the probability that conditions will remain suitable for restored upper river salmon.
FINANCIAL		
Capital cost (dam construction works, methods for ensuring fish passage)	<p>Options for reengineering approaches to allowing passage have been explored from Chief Joseph and some of the Canadian dams but considerable work still needs to be done in this regard</p> <p>Stocking salmon juveniles in upstream areas might be useful large scale experiment to see how well the fish survive in the available habitats and if they can make successfully navigate to the dams; before investing in costly permanent fish passage engineering.</p> <p>The Corps Willamette Valley existing trap / haul projects might provide a foundation for estimating potential costs in this regard</p> <p>What can the various tribes (U.S. and Canada) offer in the way of financial assistance?</p> <p>What are other potential funding sources for restoration? BPA (i.e., ratepayers)? At the same time BPA is seeking to reduce costs, BoR, USACE, Anadromous Fish Evaluation Program.</p>	1) Get crude estimates of costs of alternative fish passage options - are they in "reasonable" range of what people are willing to spend? Determine what fraction of total ecosystem capital goes to fish. Only proceed onto more detailed costing assessments for alternatives that have some finite chance of being financed.
Operating costs (flow reallocations and foregone revenues)	<p>Costs will be difficult to evaluate without detailed description of the alternatives (which passage structures) and what flow regime. Other technical feasibility issues need to be resolved before this question can be answered.</p> <p>The extent to which society will be willing to accept considerable annual foregone revenue and limitations on overall water allocations for the sake of restored upper river salmon stocks will be a continuing uncertainty (e.g., would</p>	

Feasibility Issue	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
	<p>the general population be open to exploring greater use of alternative technologies for generating power)</p> <p>Can governments indemnify operators; ensure they will not be held liable for additional costs (foregone revenues included)?</p>	
REGULATORY FRAMEWORK FOR PROJECT APPROVAL		
Federal approvals (Canada and U.S.)	<p>What are the alternative projects (flow and passage considerations) being evaluated?</p> <p>What kind of constraints would FERC re-licensing place on upstream operations?</p> <p>What is the specific project (flow and passage alternatives)?</p> <p>What is the timing for implementing project (7 years vs. 7 generations)?</p> <p>Who is the lead permitting agency?</p> <p>How does timing of permitting requirements fit with other regulatory aspects (operating agreements)?</p> <p>What are the permitting requirements to conduct studies?</p>	1) Define the "project". See #1 above under Operating Agreements and Guiding Legislation.
Provincial / state approvals (BC and Washington)	<p>What are the alternative projects (flow and passage considerations) being evaluated?</p> <p>Would state regulations / permitting be required to see changes to the infrastructure or operations of Chief Joseph or Grand Coulee dam?</p> <p>What is the specific project (flow and passage alternatives)?</p> <p>What is the timing for implementing project (7 years vs. 7 generations)?</p> <p>Who is the lead permitting agency?</p> <p>How does timing of permitting requirements fit with other regulatory aspects (operating agreements)?</p> <p>What are the permitting requirements to conduct studies?</p>	1) Define the "project". See #1 above under Operating Agreements and Guiding Legislation.
Local consultation	<p>What are the consultation requirements with local communities / regions?</p> <p>How do objectives for salmon restoration affect other environmental, social, and economic objectives?</p>	1) Define the "project". In other words, clarify design requirements for the restoration project (e.g., which facilities, which passage options, what is the spatial extent of re-introduction, what are the anticipated changes in flow regimes). This information must be available to determine the implications of regulatory requirements on the specific project.
TRADE-OFF EVALUATION		
	What are the measurable objectives and performance measures that need to	1) Look at impacts of alternative scenarios on various objectives and

Feasibility Issue	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
	<p>be considered in a trade-off evaluation?</p> <p>What are the hard constraints on a trade-off evaluation? Areas for which compromises are not possible?</p>	<p>tradeoffs among these objectives in an integrated, multi-project decision analysis with stakeholder participation (super - Water Use Plan or System Operating Review). Would logically be considered as part of possible changes to Columbia River Treaty.</p>

Table 4.2. Summary of outstanding questions, uncertainties related to understanding potential **environmental / engineering** impacts and benefit issues and recommended studies / actions to address these issues.

Impacts or Benefits	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
WATER RESOURCES		
Hydrology		
<p>Impact – adjusted flows to allow migration (upstream or downstream) of upper river stocks could affect amounts of water available for lower river stocks at other times of year</p> <p>Benefit – increased river flows / volumes for upriver passage could improve survival rates for lower river salmon stocks and resident fish</p>	What sort of flow (volumes / timing) adjustments would be required to allow both upstream and downstream passage of different salmon stocks?	
Water Quality (nutrient loads, sediment, temperature)		
<p>Impact - decomposing salmon spawners could cause eutrophic conditions</p> <p>Impact – decomposing salmon spawners release PCBs accumulated during ocean residency</p> <p>Impact - changed flows could increase suspended sediment levels</p> <p>Impact - changed flows could reduce ability to manage lower river water temperatures</p>	<p>Nutrient loads (and potential localized eutrophication) would depend on both the numbers of returning spawners and the base nutrient condition of receiving waters. Extent of concern in regards to eutrophication would also depend on intended consumptive uses for this water.</p> <p>Extent of this accumulation and the impacts of their potential release to aquatic and/or terrestrial ecosystems are unknown?</p> <p>Concerns in regards to suspended sediment would be dependent on timing and magnitude of flows</p> <p>Concerns in regards to temperature would be dependent on timing and magnitude of flows</p>	1) Identify potential hotspots for possible localized eutrophication effects. Assess nutrient levels here as baseline for future monitoring of post-salmon restoration impacts.
<p>Benefit – salmon spawners could fertilize areas of the upper river watersheds and increase aquatic productivity</p>	<p>Could enough salmon return upstream of Grand Coulee to make a difference ecologically in terms of nutrient enrichment? The general benefits of marine derived nutrients would depend on both the numbers of returning spawners and the base nutrient condition of receiving waters.</p>	<p>1) Model which watersheds / streams / lakes are currently likely to be nutrient limited in the upper Columbia and would most likely benefit from marine derived nutrients. Develop remote sensed analyses using physiographic features as model inputs at broad scale, with supporting baseline field data where available.</p> <p>2) Identify indicator streams (representative of a range of different stream types) and then initiate long-term monitoring (baseline vs. post-andromous salmon restoration) of population changes in key freshwater biota (plankton, fish, etc.).</p>

Impacts or Benefits	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
Benefit – lake fertilization programs for resident fish populations could be reduced	Even if spawners brought back equivalent nutrient levels, would their spatial distribution be appropriate / sufficient to replace or supplement ongoing programs?	1) Determine what number of spawners would be required to change base productivity in selected areas of upper Columbia (evaluate how this relates to current agency fertilization levels in Arrow Lake, recognizing additional micronutrient elements of carcasses vs. agency phosphorus / nitrogen inputs).
AQUATIC BIOLOGICAL RESOURCES		
Resident Fish (competition / disease / genetics)		
Impact - resident fisheries may be affected by anadromous salmon through competition, disease or genetics	What is the extent of the potential for competitive and genetic interactions between resident fish and reintroduced anadromous species? What is the risk to resident fish from pathogens (e.g., Whirling Disease, IPN variants) that could be introduced with migrating salmon? Would Canadians be prepared to potentially sacrifice resident trout production areas to rear anadromous fish from which they may not greatly benefit?	1) Assess the baseline stock status and genetics of resident fish populations in Lake Roosevelt (and later expand to Canadian reservoirs). Use baseline data for any monitoring of post-salmon restoration impacts on resident fish. 2) Develop models of the predicted impacts of sockeye on resident kokanee (for Roosevelt, Arrow and Kinbasket lakes). Explore adapting existing models developed for Skaha, other areas.
Lower River Salmon Populations		
Impact – new upper river habitats may be unproductive for lower river stocks that migrate higher in the system Impact – adjusted flows to allow upper river migration could affect amounts of water available for lower river stocks at other times of year	Current potential of upriver habitats for salmon production has only been evaluated for some areas (e.g., upstream of Chief Joseph Dam) Uncertain of the extent of re-regulation that would be required to achieve upstream passage needs while maintaining mandated flows for lower river species / life stages	
Non-native Fish		
Impact - improved salmon passage may also inadvertently allow for movement of exotic fish species	What exotic species could be introduced into the upper river with salmon and would these pose a threat to resident fish or re-establishing salmon populations? It will not be possible to fully evaluate the risk of increased spread of non-native fish until fish passage designs / options for anadromous fish are determined. The Okanagan Band's Skaha sockeye reintroduction project may provide guidance on methods to prevent passage of exotics.	

Impacts or Benefits	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
Fish habitat (depth / velocity / temperature / substrate)		
<p>Benefit – altered flows and draw downs could improve the extent and diversity of habitats for salmon and other fish species</p> <p>Benefit – access to cooler upper river habitats could allow persistence of salmon stocks that might not be able to otherwise cope with deteriorating downstream conditions under possible climate warming scenarios</p>	The extent of flow changes that might be required to allow successful upstream and downstream passage is currently unknown, so the potential of these flows to alter / improve habitats is also unknown	1) Model the predicted water temperatures available future water volumes / flows throughout Columbia Basin under varied climate change scenarios. Use for evaluation of possible long-term benefit of improved access to cooler water refuges in upper Columbia.
Salmon abundance		
Benefit – return of salmon stocks to Canada and a potential increase in the abundance of Upper Columbia salmon populations in the U.S.	The regulatory framework (ESA, U.S. v. Oregon) seems ill-prepared to deal with increased salmon abundance. Unclear how this increased abundance, if it materializes, would be allocated e.g., Catch / escapement, Tribal / Non-Tribal harvest, or Treaty / Non-Treaty harvest?	
Salmonid Life History Expression		
Benefit – Access to fuller extent of upriver habitats could allow for full life history expression for presently constrained upper river salmonid populations	The ability of these upper river salmonid populations (e.g., kokonee, rainbow, possibly bull trout) to resume anadromy is unknown. It is thought, however, that some returning sockeye captured recently in the lower Columbia may be of Lake Roosevelt origin.	
Other Anadromous Fish Species		
Benefit – Other anadromous fish species could benefit if allowed access to habitat and other populations in the upper Columbia	Extent to which passage / flow measures to benefit salmon could indirectly assist these other species is unknown	
TERRESTRIAL BIOLOGICAL RESOURCES		
Nutrient Enrichment (riparian / wildlife)		
Benefit - salmon spawners could fertilize areas of the upper river watersheds and increase terrestrial productivity	Could enough salmon return upstream of Grand Coulee to make a difference ecologically in terms of nutrient enrichment? The extent of this would depend on the number of spawners that return, the current base productivity of the terrestrial system, and the ecological pathways that could occur given present vegetation and wildlife communities existing in the upper Columbia Basin.	1) Develop a cost-effective monitoring design for key indicator species of terrestrial ecosystem response (e.g., birds, amphibians, riparian vegetation). Select indicator areas for baseline assessments and long term monitoring of potential changes post-salmon restoration.

Table 4.3. Summary of outstanding questions related to understanding potential **regulatory / social** impacts and benefits issues and recommended studies / actions to address these issues.

Impacts or Benefits	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
ELECTRIC POWER		
Generation and System Reliability		
Impact – Reductions or alterations in streamflow and storage will likely have significant implications to power production, revenues, and system reliability	<p>What is the anticipated effect on power generation (particularly in the months April, May and June when the provincial energy plan gives clean hydro energy a high priority)? Impact will be a function of timing and magnitude of changes in flow or storage, which are driven by needs for fish passage options.</p> <p>What are the flow scenarios required to support upper Columbia salmon upstream and downstream migrations? Evaluation of this should include 1) minimal and optimal scenarios; and 2) for salmon produced in Arrow Lakes, transboundary reach and Roosevelt reservoir / tributaries.</p> <p>What are the increments of required flow beyond current downstream salmon recovery needs (based on likely donor stocks / life history strategies for upper river populations)?</p>	1) Develop socio-economic impact assessment of alternative hydrograph scenarios. Additional considerations would include: potential climate change, comparison to BiOPs, impacts on flood control.
WATER MANAGEMENT		
Flood Control		
Impact – Changes to flood storage capacity in Canada to accommodate fish migration would impact USACE flood control strategies.	<p>What are the most likely juvenile passage options at U.S. and CDN facilities and how would these affect Canadian storage facilities?</p> <p>Could (former) NTSA storage be used for flow augmentation?</p>	
Agricultural Uses		
Impact – Grand Coulee dam is associated with large irrigation works (about 3% of the river's total flow goes to the Columbia Basin Project). Operational changes affecting agriculture might require compensation	<p>Will irrigation demands for water conflict with water demands for upstream or downstream fish passage?</p> <p>What would be the affect of the possible expansion (doubling) of the Columbia Basin project?</p> <p>Would operational changes affect Roosevelt Lake levels resulting in increased pumping costs?</p>	1) Assess impacts of human population growth on water use in the basin on water availability for fish production (Canada and the U.S.)

Impacts or Benefits	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
Navigation		
<p>Impact – No anticipated effect on downstream Columbia River navigation but changes in operations of Hugh Keenleyside Dam navigational lock and Arrow Lakes reservoir elevation might affect ferry / boat traffic.</p>	<p>How significant would changes in reservoir levels / lock operations need to be to affect navigation on Canadian reservoirs?</p> <p>Issues here are very site specific (e.g., the Faquier / Needles ferry may suffer more adverse impacts on navigation than Shelter Bay / Galena).</p>	
RECREATION, TOURISM, AND NON-NATIVE CULTURE		
Commercial and Recreational Fisheries		
<p>Impact – Restored upper river salmon could introduce weak stock into salmon management which might affect commercial fishing opportunities. Commercial losses might result from initial protection of restored salmon.</p> <p>Benefit – There may be opportunities for increased and more flexible marine harvest allocations if upper Columbia salmon stocks were restored to recreationally and commercially harvestable levels.</p>	<p>These effects would depend on migration timing and migration routes of donor stock for restored salmon.</p> <p>How long until upper Columbia River salmon are strong enough to provide recreational harvesting opportunities? Will they ever be strong enough?</p> <p>Would seasonal fishery closures (during salmon migration season) affect resident rainbow trout fisheries in the transboundary reach?</p> <p>Would there be impacts to resident fish management / mitigation programs (e.g., U.S. tribal, CBFWCP)?</p> <p>What would be the impact on weak stock management of lower river fisheries?</p> <p>What is the likelihood of recovering populations to the level they could be harvested?</p>	<p>1) Need to understand downstream and upstream survival scenarios for upper Columbia salmon. Use and modify population modelling tools to assess the probability of, and timelines for development of viable, harvestable upstream salmon populations.</p>

Impacts or Benefits	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
Recreational Activities (reservoir and downstream uses)		
<p>Impact – Draw downs for power and fish passage could adversely affect some recreational activities (e.g., boating, picnicking, etc.) at reservoirs if water access is too low or reduces aesthetics / shoreline access.</p>	<p>Is there a conflict in operating Lake Roosevelt near full pool during summer recreation, and maintaining adult passage in the late summer / fall?</p> <p>What is the extent of recreational opportunities on Canadian reservoirs?</p> <p>Will changes in flow operations for downstream fish passage require changes in reservoir elevations during summer months?</p> <p>Could any recreational revenue lost be recovered through the sale of fishing permits and other side-benefits (i.e., economic spin-offs)?</p> <p>What would BiOp flows / storage operations look like if considering migration needs for upper Columbia salmon?</p>	
Non-native Cultural Significance		
<p>Benefit – Individuals who value ecosystems in their natural state will perceive benefits with restoration of salmon.</p>		
FIRST NATIONS / TRIBES		
Food, Social, and Ceremonial (Subsistence) Fishery		
<p>Impact – Potential losses to resident fishery opportunities for tribes. Magnitude of effect on Tribal harvest may depend on whether switch from resident to anadromous harvesting is viewed as an impact.</p> <p>Benefit – Restored salmon harvest could recover what once was a vital part of First Nations / Tribal economies.</p> <p>Improved health of First Nations / tribes with restored consumption of salmon</p>	<p>Do all tribes support reintroduction of anadromous salmon to the upper Columbia?</p> <p>Key uncertainties for all harvest elements relate to lack of knowledge of marine fisheries impacts. Some of these uncertainties might be resolved by managing upper river stocks as terminal fisheries.</p>	<p>1) Develop a comprehensive and systematic understanding and assessment of the losses experienced by First Nations and tribes from extirpation of salmon: understand magnitude of losses (flip side - potential gains) and engage in education of general public about these losses.</p>

Impacts or Benefits	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
Cultural Significance		
<p>Benefit – Salmon was historically central to cultural, religious, and social activities of First Nations / tribes.</p> <p>Impact – Drawdowns could potentially expose archaeological sites</p>	<p>Would other tribes known to barter with local First Nations / tribes consider restoration of salmon as a benefit? There is a need for clear and systematic understanding and assessment of affected First Nations / tribal values.</p>	<p>1) Develop a comprehensive and systematic understanding and assessment of the losses experienced by First Nations and tribes from extirpation of salmon: understand magnitude of losses (flip side - potential gains) and engage in education of general public about these losses.</p>
Political (fair and equitable compensation)		
<p>Benefit – Restoration could help resolve longstanding bitterness between those bearing costs of dam construction (i.e., loss of access to salmon) and government agencies managing the project.</p> <p>Impact – Electrical power costs could be increased for Colville tribal members and GCD / BPA revenues for Colville tribe could be affected</p>	<p>Does this perception exist for other U.S. / Canadian dams?</p> <p>How measurable / tangible are these benefits? There is a need for clear and systematic understanding and assessment of affected First Nations / tribal values.</p>	<p>See #1 above (Cultural Significance)</p>
REGULATORY ENVIRONMENT		
Endangered Species Act (ESA) Status		
<p>Benefit – Recovery or downlisting of U.S. Upper Columbia salmon stocks would ease restrictions related to their conservation.</p>	<p>The extent and rate at which efforts to re-establish upriver passage would benefit endangered lower river stocks is unknown. Given that NOAA has included the area upstream of Grand Coulee in its ESUs for both ESA-listed spring Chinook and steelhead, would reintroduced fish become ESA listed?</p>	

Table 4.4. Summary of outstanding questions, uncertainties related to understanding potential **economic / financial** impacts and benefits issues and recommended studies / actions to address these issues.

Impacts or Benefits	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
ELECTRIC POWER		
Generation and System Reliability		
Impact – Marginal value of water depends on location / elevation of water within the Columbia system Benefit – Potentially increased hydro costs to rate payers could encourage increased energy conservation. May encourage adaptive changes in power system: conservation, wind power, flow management, etc.	What would be the detailed flow management changes needed to accommodate fish passage? How much would these changes affect foregone power generation? What would be the impacts to users from potentially increased power prices?	See #1 under Trade-Off Evaluation in Table 4.1
WATER MANAGEMENT		
Flood Control		
Impact – Potential economic costs based on damage previously averted due to greater flood protection.	What is the value of flood control from Canadian reservoirs? How likely is it that changes in flow operations will / can affect flood control?	See #1 under Trade-Off Evaluation in Table 4.1
Agricultural Uses		
Impact – Compensation would be based on difference between current crop yields and yields with reduced water for irrigation.	What is the extent of the conflict between fish passage and agricultural water uses? Driven by timing of these water uses. How much would fish passage water use take from agricultural users and how much water is available for fish passage through existing spill? What is the likely change in crop yields and/or intensity due to reduced irrigation access?	See #1 under Trade-Off Evaluation in Table 4.1
Navigation		
Impact – Water is considered of marginal value for navigational purposes on Columbia in the U.S. and Canada.	What is the magnitude of impacts on navigational uses in Canada?	See #1 under Trade-Off Evaluation in Table 4.1

Impacts or Benefits	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
RECREATION, TOURISM, AND NON-NATIVE CULTURE		
Commercial and Recreational Fisheries		
<p>Impact – Losses to non-native recreational fisheries may be significant affecting guiding and business over a large portion of the year. Recreational losses relate to costs associated with change from fishing for resident fish to salmon.</p> <p>Benefit – Harvest of restored salmon and steelhead in the upper Columbia to harvestable levels would provide economic benefits through increased jobs in ecotourism, hunting, and sport fishery within a narrow time of year.</p>	<p>Are salmon a reasonable / better substitute for resident fish species? (trading multiple season fishery for one across a single season)</p> <p>Will populations ever be able to support recreational fishery? How long until recovery?</p> <p>Would short-term harvest management problems (weak stocks) result in short term harvest restrictions?</p> <p>Depends on perceived benefits in substituting resident fish for salmon.</p> <p>Depends also on the extent to which resident fish would be replaced by anadromous fish. There are examples – such as Shuswap Lake, Seton Lake – where anadromous and resident fishes co-exist (e.g., are conditions in this system different from those where species co-exist?)</p>	<p>See #1 under Trade-Off Evaluation in Table 4.1</p> <p>See #1 under Trade-Off Evaluation in Table 4.1</p>
Recreational Activities (reservoir and downstream uses)		
<p>Impact – Few studies have looked at recreational benefits directly that could provide insights into potential impacts at Roosevelt Lake and other reservoirs</p>	<p>Considerable economic impact assessment information related to affects on tourism and recreation from varying reservoir levels is available from BC Hydro Water Use Planning.</p>	<p>See #1 under Trade-Off Evaluation in Table 4.1</p>
Non-native Cultural Significance		
<p>Benefit – Individuals who value ecosystems in their natural state will perceive benefits with restoration of salmon.</p>	<p>These benefits are difficult to quantify. How accurate / variable are these estimates?</p>	<p>See #1 under Trade-Off Evaluation in Table 4.1</p>
FIRST NATIONS / TRIBES		
Food, Social, and Ceremonial (Subsistence) Fishery		
<p>Impact – Potential losses to resident fishery opportunities for tribes. Magnitude of effect on Tribal harvest may depend on whether switch from resident to anadromous harvesting is viewed as an impact.</p>	<p>Do all tribes support reintroduction of anadromous salmon to the upper Columbia?</p> <p>Are there potential impacts to adfluvial rainbow trout fisheries on the Colville Reservation if salmon restoration efforts affect productivity of these populations?</p>	

Impacts or Benefits	Key uncertainties / outstanding questions	Studies / actions recommended by workshop participants
<p>Benefit – Restored salmon harvest could recover what once was a vital part of First Nations / Tribal economies and reduce the cost for First Nation / tribal members to access high quality fish protein.</p> <p>Reduced health care costs for First Nations / tribes with increased availability of salmon.</p>	<p>What is the likelihood and timeframe for restoring harvestable anadromous populations? Population modelling could assist with this assessment.</p>	
Cultural Significance		
<p>Benefit – Salmon was historically central to cultural, religious, and social activities of First Nations / tribes.</p>	<p>Could there be some corollary impact related to increased costs for protection of archaeological or cultural sites with increased reservoir drawdowns (if required)?</p>	
Political (fair and equitable compensation)		
<p>Benefit – Restoration could help resolve longstanding bitterness between those bearing costs of dam construction and government agencies managing the project. Difficult to quantitatively measure the political capital gained by resolving long-standing disputes.</p>	<p>Does this perception exist for other U.S. / Canadian dams? How measurable / tangible are these benefits?</p>	
REGULATORY ENVIRONMENT		
Endangered Species Act (ESA) Status		
<p>Benefit – Recovery or downlisting of U.S. Upper Columbia salmon stocks would ease restrictions related to their conservation, potentially allowing for greater economic opportunities.</p>	<p>The extent and rate at which efforts to re-establish upriver passage would benefit endangered lower river stocks is unknown.</p> <p>Given that NOAA has included the area upstream of Grand Coulee in its ESUs for both ESA-listed spring Chinook and steelhead, would reintroduced fish become ESA listed?</p> <p>Would the 'water cost' of flow changes to support salmon recovery (downstream) and restoration (upstream) be reduced on a 'per fish' basis with upper river restoration?</p>	

5. Next Steps

The summaries of proposed studies / actions in Tables 4.1 to 4.4 represent the beginning of a larger workplan required for producing a full FIBs assessment report. A proposed annotated outline for a full FIBs report is presented in Appendix A. We believe, however, that instead of conducting a single all-encompassing effort at identifying and resolving potential issues, it is better to implement a systematic, phased approach with iterative re-assessments (see 2.0 Steps to reaching a decision). As funding is obtained for each phase of work, studies / actions should be designed and implemented to help answer the outstanding questions around the next set of FIB issues. In this manner the sections / sub-sections of the full FIBs report outlined in Appendix A will be populated incrementally over time.

The feasibility, impacts and benefits of salmon restoration are complex. Thus, focusing on a small, manageable sub-set of issues at any one time will be essential. The FIBs workshop identified a number of primary themes for moving forward in the near-term. These included: 1) establishing the technical engineering and ecological feasibility of restoring fish passage, 2) identifying the potential socio-economic impacts of restored fish passage, 3) developing a clearer understanding of the cultural value of the lost salmon resource to upper Columbia tribes and First Nations, and 4) developing a collaborative strategy for communicating the story of this lost resource, and building the necessary political and legal support for restoring salmon. Derived from these larger themes and based on our research and discussions at the 2-day workshop, we believe that the following specific recommendations are the highest immediate priority issues to resolve in the first phase (i.e., 1–3 years) to both make progress towards restoring salmon to the upper Columbia River, and understanding the implications of such an endeavour.

Investigate options for permitting upstream and downstream passage of salmon past upper Columbia River dams and reservoirs.

- Complete studies of possible passage options for adults at Chief Joseph and Grand Coulee, building on expertise gained at other projects.
- Evaluate possible alternative approaches, technologies for guiding, transporting smolts through Lake Roosevelt to or around Grand Coulee Dam. Develop pilot studies on different options.
- Undertake tracking, behavioural and survival studies of smolts through Roosevelt Lake, using hatchery Chinook from CJ hatchery to get enough fish. Repeat these over several years at different smolt outplant sites.
- Track radio tagged salmon adults released in Lake Roosevelt as pilot to assess utilization of any available potential spawning habitat, and to determine fish movement within the lake.

Investigate potential donor stocks that could be used for re-establishment of upper Columbia River salmon / steelhead populations

- Identify potential donor stocks (a) inbasin (preferred) - as genetically similar as possible to historical stocks and/or suitable life history traits for successful downstream and upstream passage (including existing kokanee and rainbow in L. Roosevelt); and (b) out-of-basin with suitable life-history types (not preferred, and presenting potential transplant policy issues).
- Determine characteristics of disease prevalence in potential donor stocks.
- Determine and evaluate implementation strategies for establishing salmon populations through use of supplementation hatcheries (i.e., life stage of release, numbers released, acclimation site locations, etc.). Establish precedents from the literature. Alternatively evaluate likelihood of

being able to successfully implement restoration program without use of supplementation hatchery (i.e., natural production only).

Evaluate existing quantity, quality and capacity of salmon habitat in the upper Columbia River.

- Undertake detailed baseline field assessments of lake and tributary habitat quantity, quality and capacity for various life stages of salmon above Grand Coulee in Lake Roosevelt and its tributaries.
- Undertake broad scale (i.e., remote sensed, GIS) assessments of the amount of spawning and rearing habitat available in different parts of Canadian Columbia Basin to identify potential stock locations (explore tapping into provincial habitat capacity models that are currently being developed by BC MOE).

Develop or apply existing simulation models to explore hydrosystem operating changes possibly required for successful upstream / downstream migrations of upper Columbia river stocks and the effects of these changes on management of lower Columbia river stocks.

- Assess required travel time for hypothetical fish stocks in different locations (and different life histories) to reach estuary in critical window.
- Simulate ability of different stocks to reach estuary under: (a) current operations (fish fit the system); (b) modified flows and reservoir levels (system fits the fish); (c) hybrids. Evaluate how the system could be operated to meet these conditions?
- Undertaken gaming of these presumed flow needs for migrations of hypothetical upper river stocks, and assess how this would affect needs of downriver stocks (possibly utilizing existing Columbia River flow management models).

Assess socio-economic implications of alternative hydrograph scenarios.

- Depending on the findings of technical studies (e.g., life history characteristics of donor stock), select a set of reasonable hydrograph scenarios required for fish passage.
- Estimate cost of fish passage technologies associated with these flows.
- Select passage options in "reasonable" range of what people are willing to spend and use these to inform socio-economic assessment.
- Specify socio-economic objectives and performance measures for most relevant attributes of the upper Columbia River (e.g., recreational fisheries, flood control, power generation, downstream ESA listed species – BiOps).
- Assess implications of restoration options on operating agreements / guiding legislation (e.g., Columbia River Treaty, BiOps, water licenses, etc.).
- Identify sequence in which agreements need to be resolved and those which could / could not be adjusted to meet flow requirements.

Develop a comprehensive understanding of First Nations and Tribal cultural losses resulting from extirpation of salmon.

- Understand magnitude of losses (and thus potential gains).
- Educate public / political decision makers about those losses.

Formulate support among entities with legal standing.

- Form coalition among Canadian First Nations and U.S. tribes to coordinate support for restoration.
- Identify lead entity pursuing restoration in Canada and U.S.
- Consider legal standing of different tribes in U.S.
- Form coalition among other groups with legal standing (e.g., Northwest Indian Fisheries Coalition and agencies representing ESA)

Develop a communications plan.

- Meet with other First Nations / tribes to clarify desired future condition around restoration and expectations if restoration is not possible.
- Integrate information from above technical studies into a story that can be clearly articulated to technical and non-technical audiences (e.g., what were the historic losses, what are some feasible technology options for restoring salmon, what are the costs, what are the social implications of restoring salmon)
- Plan activities to communicate this story and build political support by engaging Canadian / U.S. politicians, other First Nations, the public, irrigators, recreational users, etc. For example:
 - Convene a series of meetings to build political / financial support for restoration (e.g., Congressional staff, Lake Roosevelt Forum, public meetings, etc.).
 - Hold events among First Nations / tribes who have experienced losses, to recognize timing of historical returns of salmon.
- Coordinate legal-political strategies to minimize conflicts during communication.

6. References

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Appendix A – Annotated Outline of FIBs Assessment Report

Section I – Introduction

This section should provide:

1. an overview of historical conditions (pre-Grand Coulee) in the U.S. and Canadian sections of the upper Columbia including:
 - anadromous fish populations (distribution and abundances)
 - spawning / rearing habitats for anadromous fish
 - resident fish populations
 - native harvest of anadromous fish
 - non-native fishing activities
2. an overview of current conditions (post-Grand Coulee) in the U.S. and Canadian sections of the upper Columbia including:
 - role of Grand Coulee Dam and other upper Columbia dams in the operation of the Columbia River hydrosystem
 - resident fish populations (species, distribution, abundances)
 - current programs in place for production and enhancement of resident fish
 - other human related problems
 - fish and wildlife planning agencies / groups and activities in the upper Columbia Basin
3. Background
 - legal precedents
 - Biological Opinions etc.
4. Purpose and scope of this undertaking
 - geographic and jurisdictional
 - public involvement
5. Feasibility study process

Section II – Project Alternatives

Feasibility of restoring passage is highly dependent on the facilities and habitats made available by passage improvements. This section should clearly describe the passage alternatives that were considered during the different phases of FIB assessments. Regardless of which alternative is pursued as a desired end-point, each alternative requires would require a phased assessment to understand the feasibility and incremental costs / benefits and associated tradeoffs (see 2.0 Steps to reaching a decision). Each project alternative should describe:

- affected facilities;
- upstream and downstream engineering options;
- anticipated financial cost;
- related improvement in habitat availability / capacity; and

- potential for increase in salmon abundance or biomass (i.e., relative likelihood of successful upstream and downstream migration).

Geographic representations of a **hypothetical** set of alternatives and improvements in access to habitats are illustrated in Figures A1 to A4.

Alternative 1 – No passage enhancements

This option would offer no change to passage at any upper Columbia River dams. Discussion of non-passage compensation options would likely depend on legal responsibility / political will of U.S. and Canadian government to compensate for losses of salmon to Canadian First Nations in the upper Columbia River.

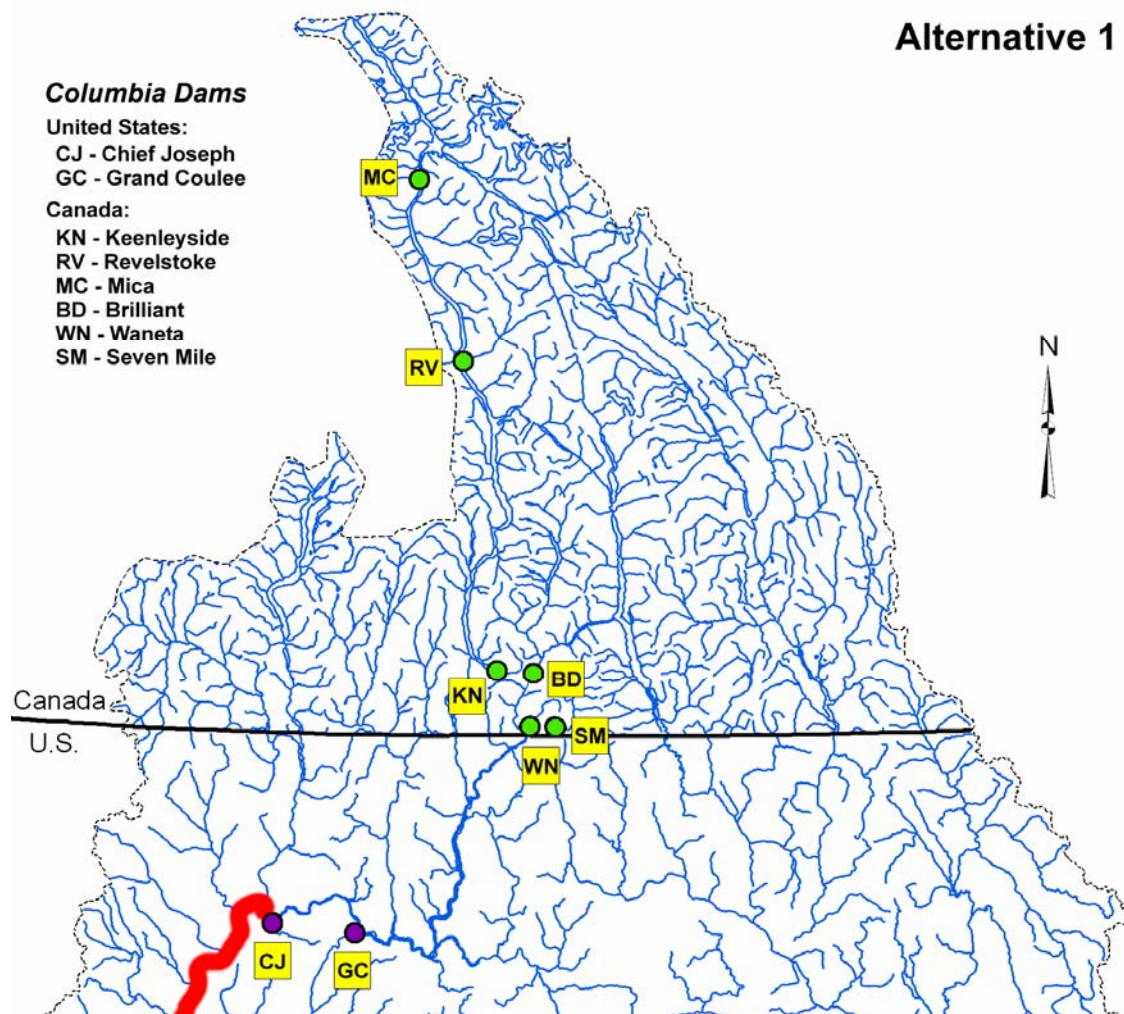


Figure A1. Map of alternative 1.

Alternative 2 – Minimum passage enhancements

This alternative would provide a lower bookend on the number of salmon, costs, and feasibility of restoring salmon to Canadian waters. Upstream and downstream passage would only be proposed at Chief Joseph and Grand Coulee facilities.

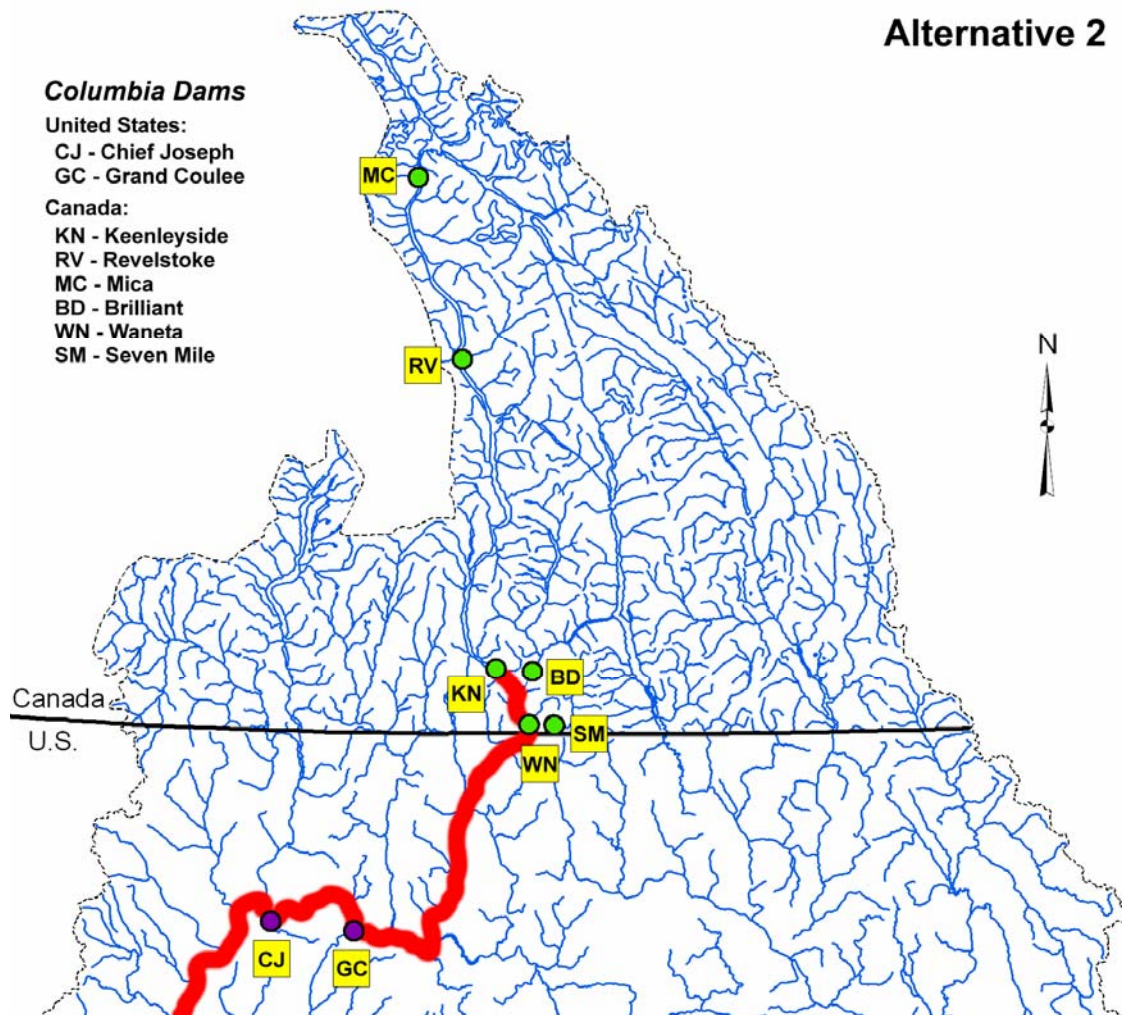


Figure A2. Map of alternative 2.

Alternative 3 – Fish-focused passage enhancements

This specific passage design (i.e., which combination of dams / technologies) would be selected following an analysis of the tradeoff between maximizing access to habitats and maximizing the likelihood of successful upstream and downstream migration (i.e., maximize expected salmon productivity—escapement multiplied by the anticipated likelihood of reaching that target escapement, see Table 3.1). The challenge in selecting an appropriate passage design is that as access to upstream habitats is increased (with increased costs), upstream migration becomes more difficult due to constraints in finding an appropriate long-distance migrant donor stock and successful downstream migration becomes more difficult due to cumulative smolt mortality of the dams.

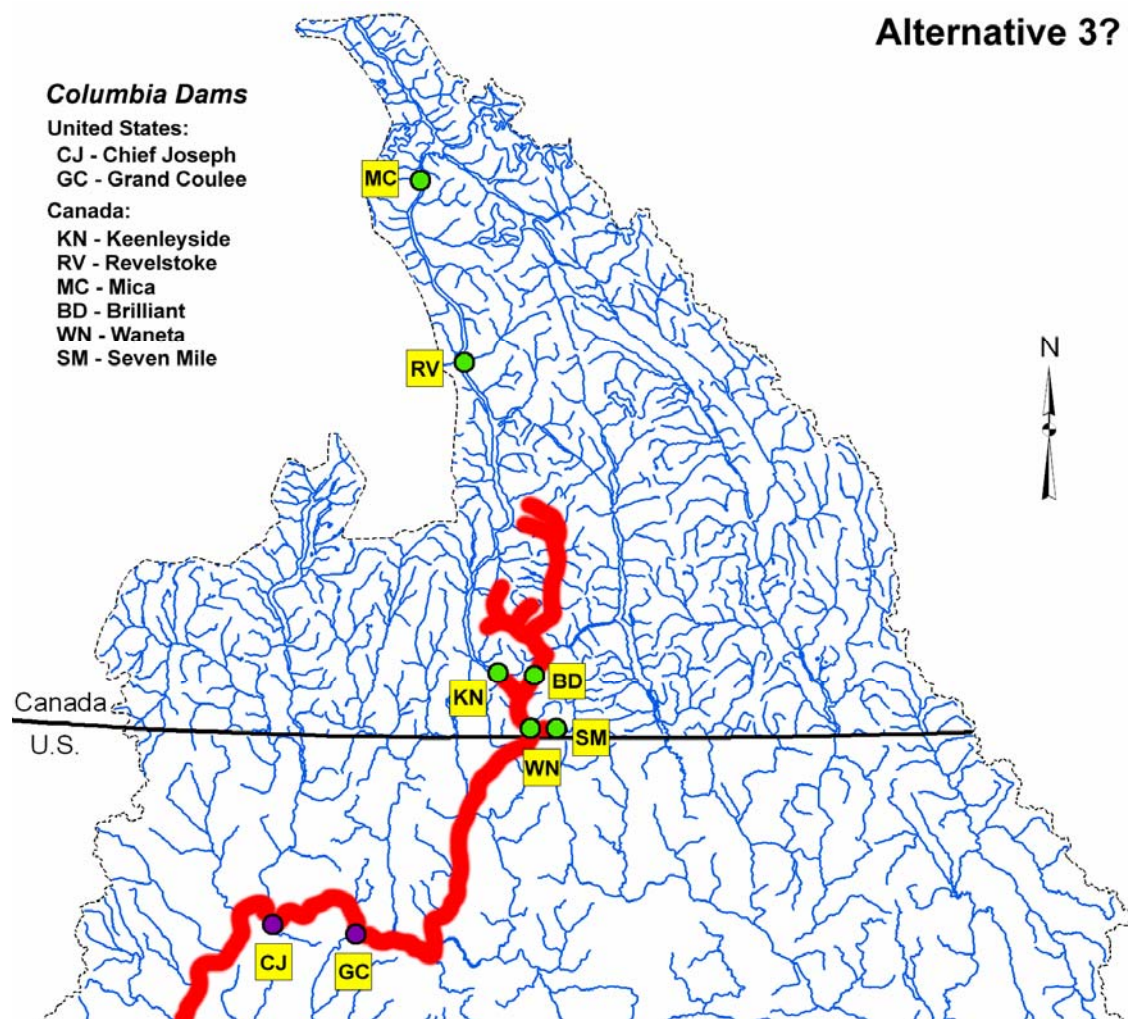


Figure A3. Map of alternative 3.

Alternative 4 – Maximum passage enhancements

This alternative would provide an upper bookend describing the engineering options, financial costs, and regulatory considerations of restoring passage beyond all potential dams in the upper Columbia River (e.g., Chief Joseph, Grand Coulee, Keenleyside, Revelstoke, Mica, Brilliant, Seven Mile, and Waneta). This alternative would be based on the assumption that it is biologically feasible to restore salmon to the fullest extent of accessible range.

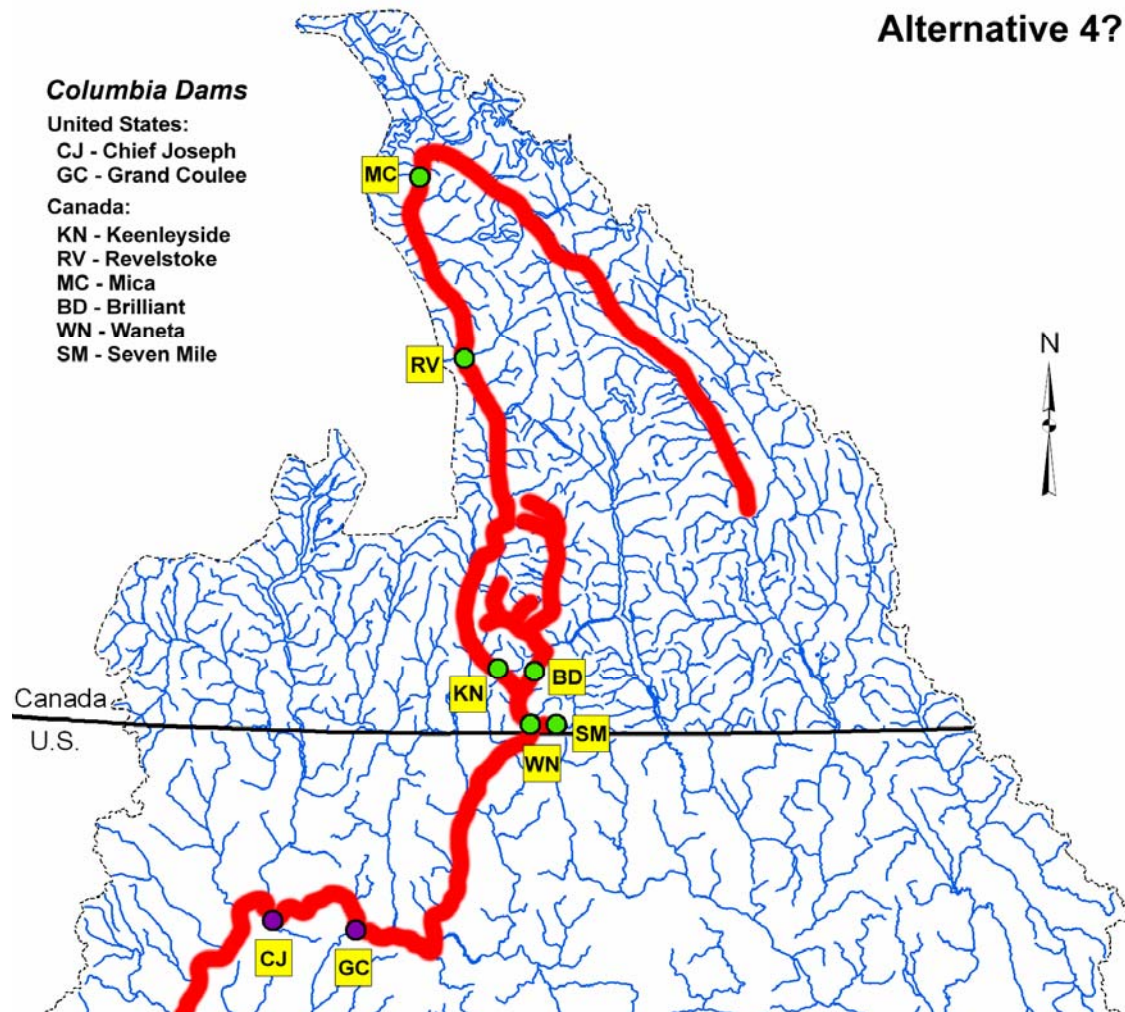


Figure A4. Map of alternative 4.

Section III – Historic, Current, and Future Conditions

This section would describe pre-Coulee, the current baseline, and anticipated future conditions under the alternative restoration scenarios from a social, economic, and environmental perspective (e.g., Figure A6). Definition of the critical issues in the sections below will be driven, in part, by those impacts and benefits identified at the scoping stages. These issues are listed in Table A1.

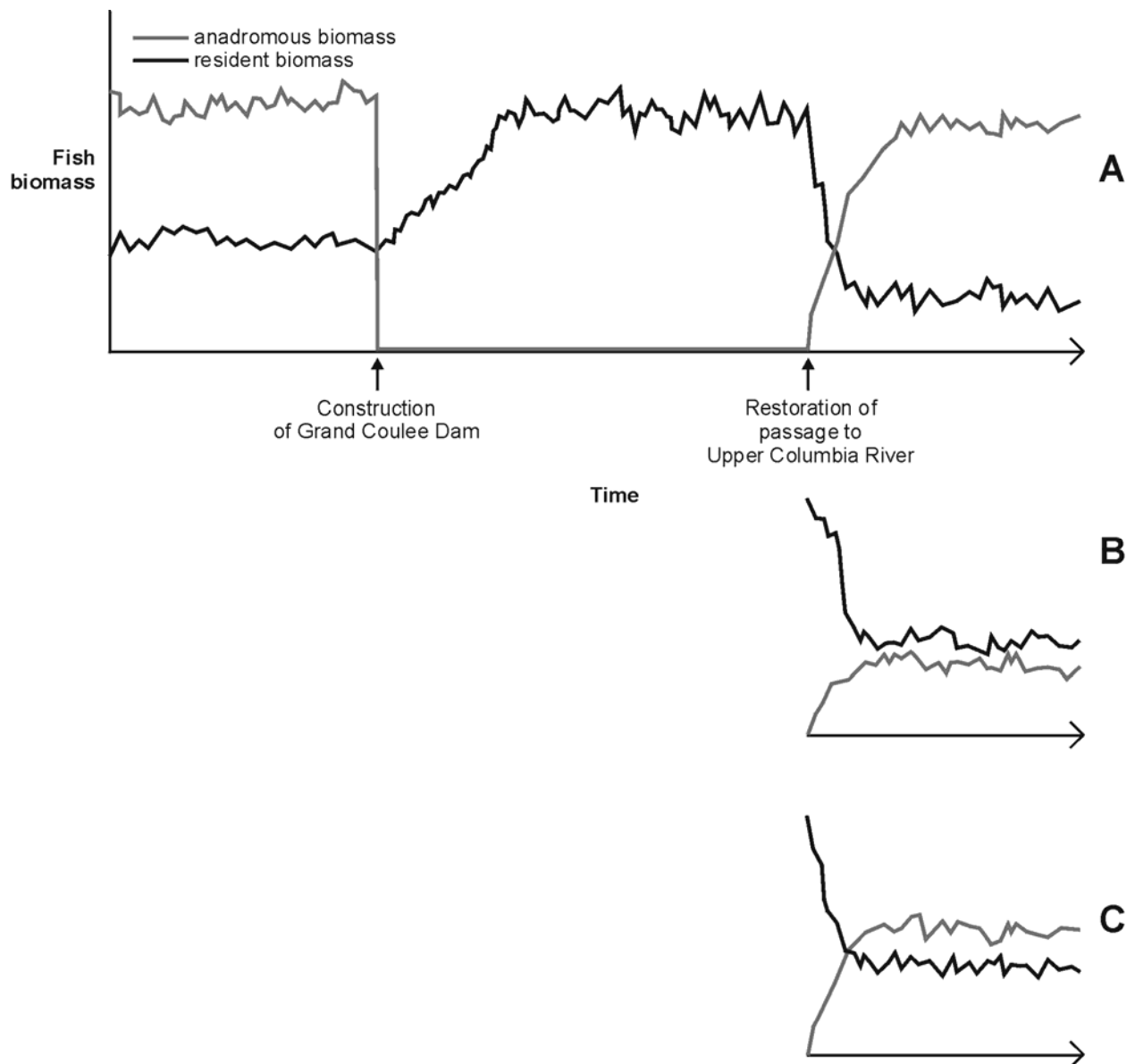


Figure A6. Conceptual illustration of the historic biomass of anadromous salmon and resident fish species in the upper Columbia over three time periods: (1) pre-construction of Grand Coulee dam; (2) post-construction of Grand Coulee dam; and (3) three hypothetical restoration scenarios in the future (A, B, and C).

Table A1. List of the issues for which historic, current, and future conditions would ultimately be discussed in a complete FIB assessment report. Information for these sections would be populated over time as different phased assessments are completed.

1. Water Resources	6. Recreation, Tourism, and Non-Native Culture
1. Hydrology	1. Fisheries
i. River flow / volumes	i. Commercial
2. Water quality	ii. Recreational
i. Nutrients	2. Recreational activity
ii. Sediment	i. Downstream uses
iii. Water temperature	ii. Upstream uses
2. Aquatic Biological Resources	iii. Non-native cultural significance
1. Anadromous fish	7. First Nations / tribes
i. Population abundance	1. Food, social, and ceremonial (subsistence) fisheries
ii. Habitat quality (depth / velocity / temperature)	2. Cultural significance
iii. Habitat quantity	3. Political (fair and equitable compensation)
iv. Life history expression	8. Economic Implications
v. Non-salmonid species	1. Electric Power
2. Resident fish	i. Power generation
i. Competition	ii. System reliability
ii. Disease	2. Water Management
iii. Genetics	i. Flood control
3. Non-native fish	1. Storage capacity
3. Terrestrial Biological Resources	2. Flexibility
1. Riparian Vegetation	ii. Agricultural uses
2. Wildlife	iii. Navigation
3. Agriculture	3. Recreation, tourism, and non-native culture
4. Electric Power	i. Fisheries
1. Power generation	1. Commercial
2. System reliability	2. Recreational
5. Water Management	ii. Recreational activity
1. Flood control	1. Downstream users
i. Storage capacity	2. Upstream users
ii. Flexibility	iii. Non-native cultural significance
2. Agricultural uses	4. First Nations / tribes
3. Navigation	i. Food, social, and ceremonial (subsistence) fisheries
	ii. Cultural significance
	iii. Political (fair and equitable compensation)
	5. Regulatory environment
	i. ESA / SARA listing

III.1 Pre-construction conditions

To the extent possible, this section will describe the above issues prior to construction of Grand Coulee dam. It is expected that published information describing conditions prior to Grand Coulee will be limited. Aboriginal and non-aboriginal traditional use information will be essential to describing pre-construction conditions. Historic information is important to set the context for defining desired future conditions.

III.2 Existing conditions

Recent or new studies will provide the basis for informing decision makers about the existing social, economic, and environmental conditions (issues listed above) prior to any potential future changes to the Columbia River system.

III.3 Future conditions

This section will provide predictions of the effects of the alternatives on existing conditions, relative to historic conditions. Anticipated effects will be described in terms of the level of evidence supporting a prediction (i.e., state of knowledge), the anticipated magnitude of effect, the geographic extent, the duration, and outstanding uncertainties (e.g., assumptions, caveats) affecting predictions. Such evaluations could include modeling to predict how future lower river climate / river conditions might affect migration (e.g., could elevated lower river temperatures increase mortality beyond what is sustainable for fish to make it upstream to Canada).

Section IV – Selecting a Preferred Alternative

IV.1 Feasibility issues

Discussion about the feasibility issues described below and a description about whether these issues can be overcome for each alternative. A completed assessment may not provide answers / resolve all of these issues. Resolution of some issues is likely dependent on responses to others. Hence, a final decision on whether to proceed requires resolution of a series of linked decisions (see 2.0 Steps to reaching a decision).

IV.1.1 Legal

- aboriginal rights and title
- transboundary responsibility

IV.1.2 Political

- U.S. Congress, Canadian Foreign Affairs, International Joint Commission, local governments, lobby groups
- political will might be superseded by legal responsibility

IV.1.3 Dam and reservoir operations

- fish passage engineering
- cumulative effects
- dissolved gas

IV.1.4 Operating agreements and guiding legislation

- Columbia River Treaty
- Pacific Northwest Coordination Agreement
- Non-Treaty Storage Agreement
- Pacific Northwest Electric Power Planning and Conservation Act
- Canal Plant Agreement
- Endangered Species Act
- Species at Risk Act
- Columbia Basin Project
- Columbia River Forum

IV.1.5 Ecology

- predation / competition
- genetics and life history
- habitat access / quality / capacity

IV.1.6 Financial cost

- Responsibility (who pays?)
- Capital costs (dam construction works, methods for ensuring fish passage)
- Operating costs (flow reallocations and foregone revenues)

IV.1.7 Regulatory framework for project approval

- Federal approvals (Canada, U.S.)
- Provincial / state approvals (BC, WA)
- Local consultation

IV.2 Trade-off evaluation

IV.2.1 Restoration goal

Discussion about the “desired future condition” for restoration and rationale for selecting this goal:

- viable population
- historic abundance
- food, social, and ceremonial (subsistence) fishery
- commercial / recreational fishery

This section will also include discussion about the desired condition of other ecological, social, or economic components of the upper Columbia. This discussion will set the context for evaluating the alternatives in a trade-off evaluation.

IV.2.2 Management objectives

Discussion about selection and development of management objectives given the potential impacts and benefits described in Section IV. Objectives are statements reflecting the desired condition or state of the system that decision makers want to achieve, or describe the most important considerations in a decision. Without clear objectives, it would not be possible to tell which management alternative is the best choice. Challenges lie in balancing multiple and conflicting objectives. Thus, the first step is to understand and describe the individual objectives associated with a decision problem. The focus *should* be on fundamental objectives — What would you like to achieve? The focus *should not* be on means objectives — How do you hope to achieve it?

IV.2.3 Performance measures

Discussion about selection and development of performance measures as well as sources of data that are reflective of above objectives that inform decision making. Performance measures (PMs) qualitatively or quantitatively describe outcomes that inform comparisons among the alternatives. PMs link to fundamental management objectives because they relate the performance of a decision to the level of success in achieving the stated objectives. Such measures are often found by considering things in the system that are: 1) culturally important, 2) have regional, national, or international significance, or 3) if altered from their existing status, would be important in focusing management or regulatory policy (e.g., endangered species).

IV.2.4 Recommended alternative

A discussion of the recommended alternative and rationale for selection based on a consideration of the social, economic, and environmental tradeoffs associated with each alternative and whether an alternative is likely to achieve the desired future condition. It may not be possible to reach a determination of the best alternative following completion of the first round of FIB studies. A final decision on whether to proceed may require progress in a phased approach, where each phase builds on the information base of the last until a decision about whether to proceed or not, or how far to proceed is reached.

Appendix B – Workshop Agenda

Developing a scoping document to assess the feasibility, impacts, and benefits (FIBs) of restoring anadromous salmon into the Canadian reaches of the upper Columbia River

Date February 28, 2007 – March 1, 2007
Time 9:00-5:00 (28th); 8:00-4:00 (1st)
Location Spokane, Washington
Venue Double Tree Hotel, 322 North Spokane Falls Court

Workshop objectives

1. Review / refine the feasibility, impact, and benefit issues identified in the scoping document.
2. Clarify the critical uncertainties / outstanding issues related to making a decision about restoring salmon passage.
3. Discuss the studies necessary to resolve critical uncertainties required to support a decision regarding restoration of upper Columbia River salmon populations.
4. Propose a framework for gathering information and making decisions about restoring salmon passage to the upper Columbia River.

Day 1 – Wednesday, February 28, 2007

9:00 **Opening prayer**

9:05 **Welcome, introductions, historical context, and overview of the project**
[Bill Green, Canadian Columbia River Intertribal Fisheries Commission (CCRIFC)]

9:40 **Summary of feasibility, impact, and benefit issues (FIBs), regulatory processes, and identified uncertainties**
[Marc Nelitz and Marc Porter, ESSA Technologies Ltd.]

10:40 **BREAK**

11:00 **Plenary discussion** [Dave Marmorek, ESSA Technologies Ltd.]

1. *What is the general perspective of agencies within the Columbia Basin on a process to decide whether to restore anadromous salmon to the upper Columbia?*
2. *What would be the desired future condition for restoring anadromous salmon to the Canadian upper Columbia: viable populations; food, social, and ceremonial (subsistence) fisheries; commercially harvestable; historic abundance?*

Task: Explore these broad issues as they relate to defining ultimate restoration strategies, objectives / goal

Task Process: Agency perspectives and open discussion

Considerations:

- historical aspects
- realistic expectations
- critical uncertainties
- affected parties

12:00 LUNCH

1:00 **Charge to 4 sub-groups** [*all facilitators*]

- (A) Biological-ecological sub-group [*Marc Porter, ESSA Technologies Ltd.*]
- (B) Engineering-flow management sub-group [*Dave Marmorek, ESSA Technologies Ltd.*]
- (C) Social sub-group [*Bill Green, CCRIFC*]

Task: Review FIB issues as described in draft scoping document

Task Process: Open discussion using Scoping Document as backgrounder

Considerations:

- missing issues / inaccuracies
- critical uncertainties / outstanding questions
- affected parties / dams

Task: Identify studies needed to resolve issues

Task Process: Develop gannt charts using post-it notes with studies coded by sub-group

Considerations:

- relevant regulatory processes / drivers
- types of studies
- priority of individual studies within a sub-group based on regulatory importance / significance of effect / state of knowledge

(D) Legal-policy-regulatory sub-group [*Marc Nelitz, ESSA Technologies Ltd.*]

Task: Map decision process(es) for legal-policy-regulatory approval

Task Process: Develop a decision tree identifying decision points, decision criteria, and key uncertainties

Considerations:

- who needs to be involved in decision-making?
- what is the sequence of steps (i.e., decision points)?
- what are the decision criteria at each step?
- what is the level / source of evidence needed to move beyond a decision point?

3:30 BREAK

4:00 **Continue sub-groups discussions**

5:00 ADJOURN

Day 2 – Thursday, March 1, 2007

8:00 **Continue sub-groups discussions from Day 1** (as necessary)

9:00 **Sub-groups A, B, and C report on first day discussion**
[Marc Porter, Dave Marmorek, and Bill Green]

10:00 BREAK

10:15 **Report back from sub-group D on possible decision process(es)** [Marc Nelitz]

10:30 **Plenary discussion** [all facilitators]

Question: What are the interdependencies among issues?

Task Process: List of issues aligned with relevant regulatory requirements.

Question: Given decision process / interdependencies, what is the logical order of operations in conducting studies on FIB issues for each sub-group?

Task Process: Integrate gantt charts with post-it notes based on cross-group discussions.

Question: Given order of operations, what are priorities for integration of studies among sub-groups at each stage in the decision process?

Task Process: Revise gantt chart based on cross-group discussions and priorities discussed on Day 1.

Question: Are there phased end points for potential restoration alternatives that could / should be evaluated as part of FIB assessments: e.g., no change in passage; minimal passage; full tribal access; maximum passage; passage based on optimal productivity?

Task Process: Determine the elements that would define these possible end points, and the type of assessments that could help determine them (e.g., habitat models, tribal use boundaries, etc.)

12:00 LUNCH

1:00 **Continue plenary discussion**

2:00 **Revisit sub-group priorities based on plenary discussion**

2:30 BREAK

2:45 **Plenary discussion based on sub-group revisions** [Dave Marmorek]

3:00 **Plenary summary** [all facilitators]

- Workshop results
- Next steps

4:00 ADJOURN

Alignment of workshop participants with sub-groups

Sub-group	Participants	
A – Biological-ecological	Colin Spence	Chris Carlson
	Fred Fortier	Jeff Fryer
	Gerry Marco	Jim Clarricoates
	Chris Beers	Brian Ferguson
	Paul Moran	Marc Porter (facilitator)
B – Engineering-flow management	Dan Katz	Dan Feil
	Llewellyn Matthews	Howie Wright
	Bill Towey	Jeffrey Lauffle
	Margaret J. Filardo	Kelvin Ketchum
	Mark Thomas	Jim Barton
	Bruce MacDonald	Bob Hallock
	Craig Sprankle	Dave Marmorek (facilitator)
C – Socio-economic	Joe Peone	Bill Duncan
	Sheri Sears	Mary Verner
	Deanne Pavik	Tim Peone
	Chase Davis	Deanna Machin
	John Harrison	Bob Moody Bill Green (facilitator)
D – Legal-policy-regulatory	Deana Machin	Sunny Lebourdais
	Gary Birch	Ray Warden
	Patrick McGrane	Bob Heinith
	Rick Pendergrass	Barry Rosenberger
	Patrick Higgins	John Whalen Marc Nelitz (facilitator)