Columbia River Treaty 2014/2024 Review: Preliminary Iteration #2 Alternatives and Components

Alternative: An alternative consists of a system of operational, structural and/or non-structural measures formulated to meet the identified study objectives subject to the study constraints.

Component: A component consists of a system of operational, structural and/or non-structural measures formulated to meet only one of the primary driving purposes: Ecosystem-based Function, Flood Risk or Hydropower. Components are not meant to be stand-alone alternatives that could realistically be implemented, but are meant to better understand the operation of the Columbia River system for a single purpose. Based on what is learned during Iteration #2, components may be combined during Iteration #3 to form comprehensive alternatives.

Reference Case CC: 2011 Current Operating Condition	
Reference Case Objective:	To assess the current operation of the Columbia River System following current operating protocols and procedures under the Treaty. This reference case will be used to compare the current operating procedures and the current Flood Control Operating Plan (FCOP) with the post-2024 alternatives.
Operational Assumptions:	▪ Current configuration of the Columbia River System with no major changes in levees, dams, and reservoirs from the current system. ▪ Flood Risk Management based on current Flood Control Operating Plan. ▪ Current operating criteria and objectives. ▪ Loads and resources are projected 2024 levels. ▪ Attempts to manage the flows at The Dalles to below 450 thousand cubic feet per second (kcfs).
What will be evaluated?	▪ Establish pre-2024 base conditions for U.S. in terms of hydropower, ecosystem, flood risk, and other river uses. ▪ Establish pre-2024 base operating conditions for U.S. and Canadian river flows and reservoirs. ▪ Provides a basis from which post-2024 flood risk and operational changes can be evaluated.

Alternative 450 TC (1A-TC): Post 2024 – Treaty Continues, Called Upon, Current SRDs for U.S. Continues	
Alternative Objective:	To assess the Treaty Continues operation with the transition from using assured primary flood storage space in Canada to a Called Upon procedure to access Canadian storage. Coordinated power operations with Canada under the Treaty continue.

Alternative Operational Assumptions:	▪ Current configuration of the Columbia River System with no changes in levees, dams, and reservoirs from the current system. ▪ Flood Risk Management based on current Flood Control Operating Plan EXCEPT: o Effective Use is implemented at U.S. reservoirs prior to calling Canada for additional storage. o Canadian Storage Reservation Diagrams (SRDs) are replaced with the Called Upon procedure. ▪ Current SRDs are used in the U.S. to attempt to manage flows to 450 kcfs or below at The Dalles.
What will be evaluated?	▪ Impacts to the U.S. in terms of hydropower, ecosystem, flood risk, and other river uses. ▪ Impacts to Canada in terms of hydropower and implementation of Called Upon ▪ Changes to U.S. and Canadian river flows and reservoirs.
What are we asking for from Canada?:	Treaty coordinated power operations with implementation of Called Upon flood storage procedures.

Alternative 450 TT (1A-TT): Post 2024 – Treaty Terminates, Called Upon, Current SRDs for U.S.

Alternative Objective:	To assess the Treaty Terminates with the transition from using assured primary flood storage in Canada for flood risk management to a Called Upon procedure to access storage in Canada. Coordinated power operations with Canada do not occur.
Alternative Operational Assumptions:	▪ Current configuration of the Columbia River System with no changes in levees, dams, and reservoirs from the current system. ▪ Flood Risk Management based on current Flood Control Operating Plan EXCEPT: o Effective Use is implemented at U.S. reservoirs prior to calling Canada for additional storage. o Canadian SRDs are replaced with the Called Upon procedure. ▪ Current SRDs are used in the U.S. to attempt to manage flows to 450 kcfs or below at The Dalles. ▪ Knowledge of Canadian operation is uncertain. Flood operations will assume uncertainty in Canadian drafts. Five potential Treaty Terminates Canadian operations will be evaluated.
What will be evaluated?	▪ Impacts to the U.S. in terms of hydropower, ecosystem, flood risk, and other river uses. ▪ Impacts to Canada in terms of hydropower and implementation of Called Upon. ▪ Changes to U.S. and Canadian river flows and reservoirs.
What are we	Implementation of Called Upon flood storage procedures.

asking for from Canada?:	

Alternative Revised 600 TC (2B-TC): Treaty Continues, Modified SRDs at selected U.S. Reservoirs

Alternative Objective:	To assess the impacts and benefits of reducing the amount of system authorized flood storage in the U.S. while implementing Called Upon procedures and a Treaty coordinated power operation.
Alternative Operational Assumptions:	▪ Current system SRDs are used at Libby, and Hungry Horse. Revised SRDs are used at Grand Coulee, Dworshak, and Brownlee resulting in less draft on average for these projects. ▪ Local flood control is maintained. ▪ Revised Called Upon procedures to manage only very large forecasted flow events.
What will be evaluated?	▪ Impacts to the U.S. in terms of hydropower, ecosystem, flood risk, and other river uses. ▪ Impacts to Canada in terms of hydropower and implementation of Called Upon. ▪ Changes to U.S. and Canadian river flows and reservoirs.
What are we asking for from Canada?:	Treaty coordinated power operations with implementation of Called Upon flood storage procedure.

Alternatives Revised 600 TT (2B-TT): Treaty Terminates - Relaxed SRDs at selected U.S. Reservoirs

Alternative Objective:	To assess the impacts and benefits of reducing the amount of system authorized flood storage in the U.S., while implementing Called Upon procedures and no coordinating power operations between the U.S. and Canada.
Alternative Operational Assumptions:	▪ Same as 600 TC with only very large flow events managed through implementation of effective use and Called Upon storage. ▪ Canadian operations and power operations are the same as the 450 TT (1A-TT) alternative. ▪ *Note: Based on results form 450 TT (1A-TT) a decision will be made whether the four additional scenarios for Canadian operation absent the Treaty used in 450TT will also be tested for this alternative.*

What will be evaluated	▪ Impacts to the U.S. in terms of hydropower, ecosystem, flood risk, and other river uses. ▪ Impacts to Canada in terms of hydropower and implementation of Called Upon. ▪ Changes to U.S. and Canadian river flows and reservoirs.
What are we asking for from Canada?:	Implementation of Called Upon flood storage procedures, but only for larger flow events.

Component E1: Normative Hydrograph (based on quintile flow objectives)

Component Objective:	To assess the change in water volume and timing across the Canadian border from Canadian Treaty storage reservoirs and from U.S. storage reservoirs needed to emulate a normative year round at The Dalles that would benefit estuary and mainstem riparian habitats and the species that they support.
Component Operational Assumptions:	▪ Uses the April forecast to determine the quintile flow objective at The Dalles. ▪ To meet the quintile objective at The Dalles, proportionately use the following nine projects: Grand Coulee, Hungry Horse, Libby, Albeni Falls, Dworshak, Brownlee, Mica, Arrow, Duncan. ▪ No system Flood Risk Management operations are used nor are measures provided. ▪ Implement local flood control only below Arrow, Libby, Hungry Horse and Dworshak. ▪ No power operation other than to maintain at least minimum generation required for reliability. ▪ Do not draft the 9 projects during the fall and winter to meet the quintile objective, but store during this period if above the quintile. ▪ No spill restrictions when operating to meet quintile flow target. ▪ Provides voluntary spill to 120% on the Lower Snake, Lower Columbia and Mid-Columbia. ▪ Implements minimum flow requirements for headwater tributaries. ▪ BiOp operations are not included with the exception of the USFWS bull trout operation at Libby and Hungry Horse. ▪ Canadian whitefish and trout operations used below Arrow. ▪ No major structural changes in levees, dams, reservoirs.
What will be evaluated?	▪ Analysis will provide a benchmark for comparison with all other components to inform SRT on the development of alternatives for Iteration 3. ▪ Volume and timing of Canadian storage needed in order to meet year spring and summer quintile flows at The Dalles. ▪ How often the quintile peaking flow targets are met during May and June. ▪ How often other ecosystem flow and reservoir objectives are met throughout the

	year ▪ Impacts to U.S. and Canadian reservoirs ▪ Spill and Total Dissolved Gas ▪ Change in hydropower generation for Canada and U.S. ▪ Compare hydroregulation outputs for Components E1 & E2 and then determine if the following impact assessments will need to be run for both: o Anadromous Fish Productivity Models o Temperature models o Estuary Models o Total Dissolved Gas
What are we asking for from Canada?	A change in reservoir operation to the meet the quintile flow objective at The Dalles year round.

Component E2: Normative Reservoir Levels and River Flows	
Component Objective:	To simulate the most natural condition possible in rivers, and greatest productivity in reservoirs (lake-like conditions), that can be achieved with the existing dams in place to evaluate the difference (maximum contrast) between other components (potential benefits), in order to inform the development of Iteration 3 alternatives. Although this component focuses on the Columbia River headwaters, it was intended to benefit the entire Columbia River Basin Ecosystem – all fish and wildlife species associated with rivers and reservoirs affected by Columbia River Treaty operations.
Component Operational Assumptions:	▪ Minimize reservoir drawdown and make reservoir refill a priority. ▪ No VarQ operations at Libby and Hungry Horse. ▪ No system Flood Risk Management operations are used nor measures provided. ▪ Implement local flood control only below Libby, Hungry Horse, Arrow, and Dworshak. ▪ No power operation other than to maintain at least minimum generation required for reliability. ▪ Provides voluntary spill to 120% on the Lower Snake, Lower Columbia and Mid-Columbia. ▪ Operate to avoid exceeding 110% TDG at Libby, Hungry Horse and Dworshak. ▪ BiOp operations are not included with the exception of the USFWS bull trout and sturgeon BiOp operation. ▪ No Canadian whitefish or trout operations below Arrow. ▪ Draft reservoirs to protect the physical integrity of the dams. ▪ No major structural changes in levees, dams, reservoirs.
What will be evaluated?	▪ Analysis will provide a benchmark for comparison with all other components to inform the development of Iteration 3 alternatives. ▪ What is the minimum level of evacuated storage needed? ▪ How often are the ecosystem flow and reservoir targets met through the year?

	▪ Determine the frequency and volume of spill. ▪ Impacts to U.S. and Canadian reservoirs. ▪ Change in hydropower generation for Canada and U.S. ▪ Compare hydroregulation outputs for Components E1 & E2 and then determine if the following impact assessments will need to be run for both: o Anadromous Fish Productivity Models o Temperature models o Estuary Models o Total Dissolved Gas
What are we asking for from Canada?	Asking Canada to operate their system as an unregulated system except for local flood control below Arrow.

Component E3: Improve Summer Anadromous Fish Migration

Component Objective:	To assess changes to the volume and timing of water across the border to supply summer flows to improve anadromous fish migration. This analysis is being performed to answer the question as to whether the summer flow objective in the NMFS' FCRPS BiOp of 200 kcfs flow at McNary can be met more often with a reasonable change to timing and volume of flow across the Canadian border to supply summer flows and improve water temperatures.
Component Operational Assumptions:	▪ Effective use and Called Upon will not be implemented in this component. ▪ Treaty power operations, Bi-Op operation, and Canadian whitefish and trout spawning operations would be based on the 450 TC (1A-TC) alternative but include the following operations to improve summer flows: o Store as much water as possible during October, November, and December at Mica and/or Arrow so long as: 1) Mica and Arrow meet project minimum flow requirements, and 2) Bonneville meets 100kcfs in October and chum flow requirements in November and December. o Change the timing and volume of flow across the Canadian border to increase flows in July, August, and early September (July 1 - Sept 15) to benefit anadromous fish. o Increase McNary flow from July – September using Canadian storage (no effect on U.S.) without impacting the following spring flow in as many years as possible.
What will be evaluated?	▪ Change in hydropower generation and revenue for Canada and U.S. ▪ Volume and timing of water needed from Canada. ▪ Determine how the frequency of meeting the minimum McNary flow objective changes with volume of flow across the border. ▪ Evaluate any appreciable change in summer mainstem temperature with

	additional flow. This will also help inform the question as to how sensitive mainstem temperatures are to flow. ▪ Evaluate the impacts to the Canadian reservoirs.
What are we asking for from Canada?	To change the timing and volume of water across the border from Canadian Treaty projects to improve flows in July, August, and early September (July 1 - Sept 15).

Component E4: Reconnect Historic Floodplains	
Component Objective:	To assess the value of reconnecting historic floodplains within the U.S. Columbia River Basin to increase Ecosystem based Function benefits, such as anadromous and resident fish habitat, water quality, and wildlife habitat.
Component Operational Assumptions:	▪ Conduct a broad analysis for determination if further modeling is warranted: Initial efforts will utilize GIS to determine the acreage and volume behind the levee systems within the CRT Review area as documented in the report "Columbia River Treaty 2014/2024 Review, Datasets and Models for Flood Risk Assessment Report, Appendix F, Levee Analysis" dated July 2012 and prepared by the US Army Corps of Engineers. (This analysis recognizes that metropolitan areas and/or areas with extensive infrastructure would most likely be excluded from further analysis, and would not be considered feasible for floodplain reconnection). ▪ On Hold: Use currently available information, such as data developed for on-going floodplain restoration efforts by LCREP, Corps, USGS, BPA and others, determine the overall extent of the high priority areas and evaluate how they may aligned with potential reconnected floodplains. ▪ On Hold: Canadian and U.S. operations would initially be based on the revised 600 TC (2B-TC) alternative.
What will be evaluated?	▪ Compare the benefits and costs for this component to the benefits and costs of bringing levees to the authorized levels of flood risk. ▪ Evaluate gross area of potential historic floodplain reconnected for Ecosystem Based Function value for anadromous and resident fish habitat, water quality and quantity. ▪ Determine the gross area of potential floodplain, and anadromous and resident fish habitat gained from reconnecting identified historic floodplain areas. ▪ How often the ecosystem flow and reservoir targets are met through the year.
What are we asking for from Canada?:	The primary justification for this component is to initially explore the extent of Ecosystem based Function benefits from the reconnection of historic floodplains throughout the U.S. Columbia River Basin. There is potential that the U.S. as a secondary benefit, would request less assured or Called Upon storage by increasing

	the amount of floodplain storage.

Component E5: Dry Year Strategy	
Component Objective:	To assess the changes to timing and volume across the border and preserve U.S. Storage that will be needed to improve mainstem Columbia ecosystem based functions: reservoir refill, spring and summer flow objectives for forecasted dry water years (< 72 MAF April – August forecast).
Component Assumptions:	▪ Start with the 600 TC (2B-TC) alternative with BiOp operations and make the following changes in dry water years when the monthly April - August forecast is less than the 20th percentile (72 MAF): o Eliminate chum operations and reduce requirements for Vernita Bar flows allowing Lake Roosevelt and upper basin reservoirs to stay fuller, until forecast increases back above 20th percentile. o Eliminate Canadian whitefish and trout spawning operations. o Change the timing and volume of water across the border to be released Apr 2 – early June. o Refill Canadian fish storage releases in subsequent winter and in subsequent spring based on refill.
What will be evaluated?	▪ Volume and timing of water needed from Canada. ▪ How often minimum spring flow objectives could be met. ▪ Probability of refill for U.S. and Canadian reservoirs. ▪ Effects on summer/fall flows from improved reservoir refill. ▪ Effects of reduced US reservoir drafts in dry water years. ▪ Hydropower generation and revenue for Canada and U.S. ▪ Anadromous Fish Productivity Models. ▪ Temperature models ▪ Estuary Models
What are we asking for from Canada?	To change the timing and volume of water across the border through use of Canadian storage to improve spring flows for forecasted dry water years (20th percentile).

Component F1: Full Use of Authorized Storage	
Component Objective:	To determine the level of flood risk that can be achieved by maximizing use of authorized storage and accounting for forecast uncertainty.
Component Operational	▪ U.S. projects will use standard SRDs and adjustments in reservoir operations to account for forecast uncertainty to determine an operation that maximizes the flood risk management for authorized storage.

Assumptions:	▪ Uses US system authorized flood storage as often as needed. ▪ This would assume 450 TC (1A-TC) for the Canadian operations. ▪ Removes variable flow agreements (i.e. VarQ) ▪ Running through the WAT with FRA compute (Monte Carlo Simulation)
What will be evaluated?	▪ Investigate the level of flood risk reduction the US storage projects can provide post-2024. ▪ Seasonal reservoir elevations and peak flow. ▪ Probability of refill for U.S. and Canadian reservoirs. ▪ Only Flood risk metrics – no other metrics. ▪ How close we can get to the current level of economic consequences ($) through utilization of existing authorization and after the loss of Canadian assured flood storage.
What are we asking for from Canada?	Coordinated power operations with Called Upon flood storage procedures.

Component F2: No Called Upon Flood Storage

Component Objective:	To assess the value of Called Upon in terms of the economic consequence accrued when Canadian storage is not accessed for flood risk management under a treaty continues scenario. To obtain information on future potential negotiations position for an amount of assured storage and how much the US should be willing to pay for Called Upon assistance for just flood risk management purposes.
Component Operational Assumptions:	▪ This component will be based on the 450 TC (1A-TC) alternative but will not call upon Canada for flood risk management assistance. ▪ Effective Use will be implemented. ▪ Running through the Watershed Assessment Tool (WAT) with Flood Risk Assessment (FRA) compute (Monte Carlo Simulation)
What will be evaluated?	▪ Economic flood-based consequence of not requesting Called Upon ▪ Flood risk metrics only
What are we asking for from Canada?	This component is focused on determining the upper end of what the US should be willing to pay for a future amount of assured storage from Canada.

Component F3: Modify US Levees to perform to Authorized Level

Component Objective:	To assess the economic consequences that could be reduced if the U.S. flood risk management levee systems were to perform to an authorized level[1] of protection.
Component Operational Assumptions:	▪ Changed system configuration including modifications to some of the 130 levee systems to perform to authorized level of protection. This would include rehabilitation and repair of deteriorated levees and in some cases increasing the height of levees (i.e. less than a foot) to bring them to their authorized height. ▪ Operations will be based on 450 TC (1A-TC) and 600 TC (2B-TC) alternative
What will be evaluated?	▪ Works within US authorizations to determine the amount of damages avoided when levees perform to authorized levels. ▪ The cost of bringing the levee to the authorized level of protection. ▪ Flood risk metrics only. ▪ Others evaluation metrics will have the same results as 1A-TC and 2B-TC. ▪ Using modeling results, determine if a qualitative analysis is needed to evaluate the implications of levees performing to an authorized level of protection for Ecosystem based Function & other impact assessment areas
What are we asking for from Canada?	Results from this evaluation could be used to develop an alternative for Iteration #3 that would reduce the amount of Called Upon storage requested from Canada.

Component H1: Optimize the Joint Canadian and U.S. Columbia Basin Hydropower System

Component Objective:	To assess whether the joint U.S. and Canadian optimization for power generation as defined under the Treaty in 1961 is a true reflection of the joint system capability based on today's hydropower system and using modern modeling tools and methods.
Component Operational Assumptions:	▪ Canadian and U.S. reservoir operations will be jointly optimized for power generation similar to the current Treaty planning process. ▪ Will include additional consideration for Peace River system coordination and transmission limitations. ▪ Include current forecasts of short-term power markets for optimization. ▪ Optimization will seek to maximize net revenues, e.g. shaping generation into high value period where possible. ▪ Current U.S. biological operational objectives[2] and Canadian fishery objectives are not included in the study. ▪ Canadian and U.S. projects operated to system and local flood risk management objectives. (Initial testing will use FCOP and if results warrant further analysis then run 1A-TC).
What will be Evaluated?:	▪ Change in generation of the Canadian and U.S. Columbia hydropower systems. ▪ Economic value of generation changes in both countries.

[1] Authorized Levels of Flood Protection will be defined and described in a White Paper that is being developed by the Corps.
[2] As described in the Phase 1 Supplemental Report, Appendix

	▪ Does not include re-evaluation of the Canadian Entitlement.
What are we asking for from Canada?:	Optimized and coordinated Canadian reservoir operation that would produce added power benefits for both countries.

Component H2: Optimize the Joint Canadian and U.S. Columbia Basin Hydropower System and the Current Biological Operating Requirements[2]

Component Objective:	To assess the change in hydropower generation when the joint U.S. and Canadian Columbia Basin hydrosystems are optimized for power while constrained by U.S. biological opinion and Canadian fisheries operations.
Component Operational Assumptions:	▪ Canadian and U.S. reservoir operations would be jointly optimized for power benefits, but as constrained by current U.S. biological operational constraints and Canadian fishery operating objectives. ▪ Optimization will seek to maximize net revenues, i.e. shaping generation into high value periods where possible. ▪ Will include additional consideration for Peace River system coordination and transmission limitations. ▪ Include current forecasts of short-term power markets for optimization. ▪ Canadian and U.S. projects operated to system and local flood risk management objectives (initial testing will use FCOP and 1A-TC if results warrant further analysis).
What will be Evaluated?:	▪ Change in generation of the Canadian and U.S. hydro systems. ▪ Economic value of generation changes in both countries. ▪ Does not include re-evaluation of Canadian entitlement
What are we asking for from Canada?:	Optimized and coordinated Canadian reservoir operations that would recognize BiOp and Canadian fisheries constraints.

Component H3: Effect of Renewable Capability and TDG

Component Objective:	Based on numerous comments during the listening session, this component will assess the ability of Federal Columbia River Power System (FCRPS) supply the current level of reserves for integrating renewables while staying below 120% TDG and meeting minimum flows as water is shifted from high-flow to low-flow periods. It will use the current level of generation reserves for wind integration. Incremental reserves entail operating below maximum [hydro] generation so that generation can be increased if renewable generation decreases unexpectedly. Decremental reserves entail operating above minimum hydrogeneration so that generation can be decreased if renewable generation increases unexpectedly.

What will be Evaluated?:	▪ Measure the amount of time the hydro operation stays below 120% TDG during high-flow periods while providing incremental reserves. ▪ Measure the amount of time minimum flows are met while providing decremental reserves. ▪ Assess impact on Canadian reservoirs and power generation. ▪ Assess impact on US flows, TDG, and power generation.
Component Operational Assumptions:	▪ This study will use 450 TC (1A-TC) as the starting point. ▪ Canadian storage will be used to provide additional water during low flow periods and store during high flow periods. ▪ System and local flood control are retained. ▪ Current BiOp and related constraints will be retained (includes April 10 Grand Coulee target and refill). ▪ Meeting load (electricity demand) is secondary to providing reserves for renewable integration.
What are we asking for from Canada?:	Reshaping water releases from Canada to reduce flows in the US during high-flow periods to reduce 120% TDG exceedances while providing incremental reserves and increase flows during low-flow periods to help meet minimum flows while providing decremental reserves.

Additional Analyses	
Primary Driving Purpose	**Description**
Flood Risk Management	• Analyze the amount of available flood risk management storage in the basin.
Ecosystem-based Function	• Determine the amount of readily available floodplain storage below Grand Coulee. • Add metrics that evaluate whether reservoir elevations & flows are adequate to accommodate new fish passage facilities at Chief Joseph, Grand Coulee, Hells Canyon and Dworshak.
Hydropower	• Compare the coordinated Treaty operation with U.S. operations without the Treaty to determine the true power benefits of the Treaty to the U.S.
Impact Assessment Areas	**Description**
Water Supply	• Use output from Component E3 to provide a general assessment of the potential shaping of water from Canada for water supply purposes. This information will be used as the basis for the development of a water supply component as described in the Water Supply Work Plan.