Responses to Comments received by the Province on the
Arrow Lakes Reservoir Mid Elevation Scenarios – Scoping Evaluation Report – April 2017.

The following table contains responses to all written comments and feedback received from a variety of organizations, senior government agencies and the public. Where appropriate, similar comments have been combined. The response to each comment is either found below or in the report section noted. In some cases, the response appears below and in the report.

Comment or question	Response	See Report Section
Section 4.2: Vegetation		
What increase in area in the drawdown zone would result from the Scenarios?		3.1, Table 1
Discuss time and limitations to terrestrial ecosystem recovery under the Scenarios.	Under Scenario 2, above 1,430 ft. (435.9 m), the rate of ecosystem succession will vary across the reservoir. Periodic establishment of trees, shrubs and other herbaceous species under existing conditions in low water years, demonstrates that revegetation can begin quickly (likely in 1 to 5 years, depending on species and weather conditions), especially in the fringe adjacent to seed sources (potentially up to 100m+). The rate and trajectories of succession will vary depending on substrate, moisture availability, as well as proximity to seed sources. Moist areas with finer textured soils at the upper elevations will likely revegetate more quickly. In general substrate conditions within the Revelstoke Reach, and areas on fans in the Arrow Lakes portion of the reservoir are more favourable to rapid succession although competition with dense communities of reed canary grass and other sedges may slow initial transition in some areas. Coarse textured soils and exposed bedrock sites will be the slowest to revegetate. Under favourable conditions succession to shrub communities will likely take at least 5 years, while development of full forest structure will likely take at least 30 years. Development on less favourable substrates would potentially benefit from soil enhancement and planting. Un-managed off-road vehicle disturbance may slow revegetation in some areas. The growing season weather of the initial non-flood years will also affect the speed of revegetation by determining seed production and seedling survival. The periodicity of the 1 in 7 flood years will also impact the speed of revegetation, the longer the initial non-flood interval, the faster revegetation will proceed. Effective implementation of Scenario 2 will require an adaptive management strategy complete with on-going monitoring and the potential for responses to identified issues. Where appropriate, the responses may include: planting of trees and shrubs, control of invasive species, re-establishment and stabilization of stream channels on fans, fertilization, management of off-road motorized access to minimize disturbance of establishing vegetation, wildfire management and others.	4.2.2.3

Comment or question	Response	See Report Section
Discuss the implications of the Scenarios on Reed Canary Grass that has established in the Revelstoke Reach. Discuss the risk of fire in reed canary grass sections under the Scenarios.	Reed canary grass (*Phalaris arundinacea*) is a perennial rhizomatous grass native to North America, with widespread occurrences at lower elevations throughout Southern BC (Anonymous 2013). It was first recorded in BC in 1897 and is generally found in wet meadows and along stream banks and lake shores. Introduced cultivars from Europe have likely cross-bred with the native varieties, and these more vigorous hybrids are sometimes classed as invasive (GISD 2017). It prefers fine textured soils and is highly flood tolerant, which likely explains it widespread occurrence in the Revelstoke Reach. It is generally considered of little value for wildlife, and can out-compete other more desirable species, given the right conditions. Given the apparent association of reed canary grass with prolonged annual flooding cycles, it is likely to decrease in cover and vigour as the flooding periodicity changes. To date there are no indications that reed canary grass is major threat to areas outside the reservoir. As conditions become more favourable for native species in the Revelstoke Reach, those species should be in a position to more successfully compete with reed canary grass above 1,430 ft. (435.9 m). It is possible that reed canary grass will become established at lower elevations than presently occurs due to reduced water depths. Under both Scenarios, wildfire risk in the reed canary grass areas will vary with local fire weather conditions, but is expected to be similar to what it is presently in low water years, and should decrease as reed canary grass productivity decreases.	4.2.1 4.2.2.1
Comment on the ecological importance of annual flooding of grasslands in the Revelstoke Reach.		4.2.1 4.2.2.1
Emphasize active adaptive management and monitoring to better understand how vegetation responds to lack of flooding in wet and dry years and on different substrates		4.2.2.3
Discuss need for management of motorized recreation under changes anticipated under the Scenarios.		4.2.3.3

Comment or question	Response	See Report Section
Section 4.2.3: Wildlife and Wildlife Habitats		
Describe how wetlands in the Revelstoke Reach and other locations around the Reservoir be hydrologically sustained under the Scenarios.	There have been some concerns raised that limiting inundation may result in desiccation of some wetlands and ponds. This may be true of some minor wetlands/ponds, such the old Downie gravel pit near Revelstoke or Lower Inonoaklin Road, however it is not a concern in the primary wetlands described above (Airport Marsh, Beaton Beaver Ponds, Montana Slough and Cartier Bay). To varying extents all of the primary wetlands existed prior to inundation (Ketcheson et al. 2005), and continue to be supplied by surface and groundwater sources not associated with reservoir inundation. Further evidence of independent water sources for the wetlands was confirmed by the continued persistence of standing water during field visits in 2015, an extremely low water year where the reservoir failed to inundate most of the wetlands. Physical works, such as those proposed for enhancement of wetland and pond habitats, could multiply the benefits of both Scenarios in those habitat types. If there is a decision to further investigate either of these Scenarios, it could be useful to include consideration of the proposed operating regime in the ongoing effectiveness assessments for those projects, including any potential effects on water sources. Where lack of reservoir-related inundation would limit the effectiveness of the proposed works, development of external water sources should be investigated	4.2.3.3 4.3.2.3
How would Scenarios affect use of Revelstoke Reach as a flyway?		4.2.3.1
How will Scenarios affect insect population? How will Scenarios affect mosquito population?		4.2.3.2 4.2.3.3
List reservoir species that are listed under SARA, Migratory Bird Convention Act, BC Conservation Data Centre, and BC Wildlife Act.		Appendix 2
Indicate that the wildlife studies help to identify elevation bands of relevance for different vegetation and wildlife habitat niches.		4.2.3.1

Comment or question	Response	See Report Section
Further identify species listed under SARA, Migratory Bird Convention and/or BC-CDC. Reservoir elevations that stabilize access to riparian habitat and allow long term development of riparian and forested habitat would likely increase the area of identified habitat conditions for SARA listed species. For Special Concern SARA listed species such as the Western Painted Turtle (Intermountain – Rocky Mountain Population), demonstrating improved habitat access or expanded area of suitable habitat would be a positive conservation outcome helping to prevent the species becoming threatened or endangered.		4.2.3
Analyses and modelling should take into account SARA relevant information such as relevant threats and actions described in posted (legal) federal Recovery Strategies and Identification of Critical Habitat (CH ID) in those recovery strategies.		4.2.3.4
Section 4.4: Fisheries and Aquatic Resources		
Discuss how the return of anadromous salmon will be affected by Scenarios.		4.4.2.8

Comment or question	Response	See Report Section
Discuss how Scenarios reconcile discharge with nutrient retention. Nutrient flushing has more to do with amount and timing of flow passed through the reservoir than it does from elevation.	Agreed that nutrient flushing has more to do with amount and timing of flow passed through the reservoir than it does from elevation. A more stable Arrow Scenario was modeled in the Columbia River Treaty review technical studies process. The modeled (ALT 7 TT) Scenarios have some small differences from Scenarios 1 and 2, but the Technical Study Addendum Report hydrographs (Keenleyside discharge) are possibly instructive. In comparison to current CRT and NTSA operations, the more stable Arrow Scenarios: Have 80 – 180% higher Keenleyside (HLK) discharges during the April – June period; Have steady increases in HLK discharges (90 – 100%) between April and June; and Have smaller decreases (15 – 40%) in July – August discharges. This is suggestive (other conditions being equal) of higher nutrient flushing in the spring (April – June) period and lower nutrient flushing in the summer period. There is less stability in July – August discharges under the ALT 7 TT Scenario in comparison to the current (Treaty Continue) operational regime. Consideration should be given to modeling a Scenario which provides for more stable HLK discharges during the July – September period.	
Discuss how Scenarios will affect nutrient availability given that the riparian areas are projected to revegetate.	There are a wide range of uncertainties about how the proposed 'stable Arrow' Scenarios will affect nutrient availability, particularly in the pelagic area of the lake which is critically important for kokanee production as well as the abundance and size of key piscivores (fish-eating fish including rainbow and bull trout). The revegetation of riparian areas, to the extent that it occurs under Scenarios 1 and 2, will have a wide range of ecosystem benefits, mostly for terrestrial ecosystems but to a lesser extent for aquatic ecosystems. Litter from riparian vegetation will, when it falls or is carried into the water, contribute nutrients to the aquatic ecosystem. The relative contributions of aquatic (mainstem and tributary) inflows, nutrient enhancement and from riparian sources cannot be determined in advance, although aquatic and enhancement (fertilizer) contributions currently likely predominate over riparian sources.	

Comment or question	Response	See Report Section
Clarify nutrient supply, retention, flushing rates under current operations (post 2012) when compared to the Scenarios.	2012 and 2013 were high inflow years with differing effects on Arrow reservoir. Despite high inflows in both years: (i) nutrient levels were very low in 2012 and above average in 2013; (ii) phytoplankton biomass was very low in both years; (iii) zooplankton (Daphnia) biomass was very low in 2012 and relatively high in 2013; and (iv) kokanee average size and biomass was very low in 2012 whereas biomass was low in 2013 but average size was quite high. Thus, it is not really possible to compare the effects of a Scenario 1 or 2 operation with a few years of current operations, particularly when there can be marked differences in parameters related to pelagic productivity even between high inflow years.	
What is the baseline for Scenario analysis of fish and aquatics?		4.4.1
There are studies currently underway to assess the higher flows experienced in 2012 (high inflows in 2012 created a flow regime in the Arrow lakes that closely simulated the prescribed WUP ideal sturgeon flows). Data from the juvenile indexing study on the Lower Columbia River is underway and will be analyzed and help assess the benefits of the higher flow regime. Early results from the studies and data analysis are expected in 2 years and this information will better inform on potential benefits of Scenarios to sturgeon.	White sturgeon spawning and early life stage habitat conditions in the only known spawning location between the Keenleyside and Revelstoke dams, adjacent to the city of Revelstoke, are strongly influenced by Columbia River flows (Revelstoke dam discharges) and Arrow reservoir operations. It is possible that the BC Hydro Water Use Plan white sturgeon juvenile indexing study in the Columbia River downstream of the Arrow reservoir will detect increased juvenile recruitment associated with the 2012 high flow event. This will support the hypothesis that sustained high flows (and associated water velocity) during the sturgeon spawning and incubation period are critically important for early life stage survival. It will then be important to determine if the effect is due to increased water velocity, increased turbidity or improvements in substrate conditions caused by the high flows. If sustained high water velocity is determined to be important for white sturgeon early life stage survival, then Scenario 1 or 2 if combined with sustained higher discharges from the Revelstoke dam during the sturgeon spawning, incubation and early life stage period (late July – early September) will likely be beneficial for white sturgeon.	
Comment on how water quality/clarity (including water temperature profile) will be affected in the Arrow Lakes and the Revelstoke Reach by the Scenarios.	Analysis of the impact of the Scenarios on water quality/clarity is beyond the report's scope and is identified as an information need.	4.4.2.1; 4.4.5

Comment or question	Response	See Report Section
Stable reservoir benefits could be further assessed through multiple analyses, including stranding calculations, effective littoral zone modeling and calculation of rearing habitats from perspectives of juvenile salmonids and other littoral life histories.		4.4.5
The consequence of having slightly different stable levels between the Scenarios could be further reviewed against bathymetric mapping, to determine which provides the most littoral area during the growing period based on light penetration and submerged habitat		4.4.5
Uncertainties need to be resolved relating to juvenile sturgeon survival before specific reservoir conditions can be fully assessed. There are issues with all the sturgeon life stages and the focus shouldn't be larval dispersal. Ultimately there will be no change in Sturgeon spawning if backwatering of ALR to 1,440 ft and above is not occurring during the spawning period. Currently, at highest discharges, the backwater effect is actually positive for sturgeon, by helping to diminish unsuitable water velocities >2.5 m/s over the spawning grounds. Spawning has been documented in a very specific location that is not likely to be influenced at all by either of the Scenarios.	Agreed. There have been seven years of the 'Mid-Columbia River Juvenile White Sturgeon Monitoring' project funded by BC Hydro as a Water Use Plan monitoring requirement. (CLBMON 21). Despite the release of more than 54,000 hatchery-produced juvenile white sturgeon (2007-2016) only a total of 22 have been captured. This suggests either that juvenile white sturgeon have very low susceptibility to the capture gear OR that post-release survival of hatchery-produced juvenile white sturgeon is very low. Also there have been no detections of wild-spawned juvenile sturgeon, despite observations of fertilized eggs and larvae in the Columbia River in the Jordan River confluence – Big Eddy area. Taken together, this suggests that there are at least two early survival bottlenecks: (i) from larvae to free-swimming juveniles (August – October of spawn year); and (ii) from yearling juveniles to year 2 and beyond. Both of these life history periods are affected by habitat conditions in the mid-Columbia River, in turn affected by both reservoir levels and Columbia River flows. Reference: Okanagan Nation Alliance. 2016. CLBMON21: Mid-Columbia River juvenile White Sturgeon Monitoring 2013-2015 Investigations. Report prepared for BC Hydro, Castlegar, BC. 26 p. + 3 app. Concerning backwatering, in the non-flood years the Scenarios will not backwater known sturgeon spawning areas and thus will not attenuate high flows.	

Comment or question	Response	See Report Section
A research and monitoring program to address some of data gaps identified in the report could possibly be funded through a Fish and Wildlife Compensation Program "Directed Study".		4.4.5
Given that invasive mussels are a transboundary issue, this topic could be explored further in the next iterations of this project, given the recent detections in Montana and renewed federal focus on alien invasive species under the Federal-Provincial-Territorial Alien Invasive Species Task Force.		4.4.3; 4.4.5.
Section 4.5: Archaeology		
How will the pictograph sites be affected by the Scenarios?	There are several pictograph sites that are completely inundated by the Reservoir and the Scenarios would not have any further effect. There are also several pictograph sites that are above the high water mark that would also not be affected by the Scenarios. As for pictographs that are within the draw down zone, soil erosion would have little to no effect on these sites. It is unclear at this time what effect prolonged inundation would have, as this has never been studied in the Arrow. It could be postulated that the water would eventually wash all traces of the pictographs away.	
In general all inundated sites will experience greater erosion over time than those above the water- minus those affected by slides etc.	It is likely that the sites within the active wave zone will experience more erosion than those below the active wave zone. Archaeologists are attempting to look at what type of wave/current action occur within the top meter or two of water in reservoirs, to get a sense of whether erosion/disturbance is possible in those depths. The most common cause of erosion known occurs at sites that are in the active erosion zone, or the active wave zone. Those sites that are well above the high water mark would not be impacted by wave erosion, and only mildly by wind erosion.	
Understanding impacts would require more detailed information on the affected sites, size, content, condition, stratigraphy, surficial geology, aspect, and sedimentology. The BC Hydro Reservoir Archaeology Program is collecting some of this information but only as it pertains to current Scenarios – additional inventory work would be required.	Agreed, and it would be ideal if future reservoir archaeology work accounted for potential changes to reservoir operations for management planning.	

Comment or question	Response	See Report Section
Erosion protection for archaeological sites below the Scenario high pool would need to be in the form of physical works (i.e. rip-rap, gabion baskets, articulated concrete blankets etc.). Costs for these treatments are high, success is unproven. Vegetation is unlikely to be successful erosion protection for these sites.	We have seen site erosion protection due to vegetation at the higher elevation bands of the active erosion zone in Kinbasket Reservoir. Protection of archaeological sites within the active erosion zone is something that is being dealt with by BC Hydro in consultation with First Nations as a part of the Archaeological Management Plan (AMP).	
The most likely Scenario would involve a large mitigation effort aimed at removing Heritage site materials from at least a sample of these affected sites – this is of course subject to First Nations agreeing to the removal. Over time there could also be an undercutting effect in some areas that could extend the reach of the erosion zone back into upslope/vegetated areas that would need to be managed.	Removal of heritage site materials that are vulnerable is a part of the current RAP, and will be ongoing through the AMP. Undercutting currently occurs in several places within the Reservoir and is something that would have to be taken into consideration when looking at erosion effects.	
Section 4.6: Recreation		
The most recreational activity often occurs Easter weekend - when the reservoir is below mid-elevation. Burton and Edgewood are swarming with tourists at Easter every year. With the water level up right now (July), only those who can afford a boat and tow it around are here these days and they are confined to boat ramps for non-boating activities because there is no beach.		4.6.3.2
Waterfront landowners have expressed a desire for higher stable water elevations. This comes at increased risk to property damage from high water.		4.6.3.2
Indicate the lack of recreational inputs from non-boating recreationalists – surveys dominated by boaters.		4.6.3.1

Comment or question	Response	See Report Section
Incorporate findings of the Upper Arrow Drawdown Zone Management Plan and Revelstoke Wetlands Conservation Area Feasibility Study reports. These reports detail the importance of the Revelstoke Reach to the community of Revelstoke and the desire to manage recreation to maintain habitat values and prevent destructive activities.	The importance of maintaining recreation and habitat values in the Revelstoke Reach as described in these two reports is acknowledged and discussed in several sections throughout the Report.	Numerous sections.
Section 4.8: Agriculture		
Scenario periodic flooding will limit agriculture to hay cutting and grazing.	This issue is discussed in Section 4.8.2, and conditions necessary for allowing other types of agricultural crops are outlined. Local contradicts information from agricultural practitioners presently working in the drawdown zone	
Section 4.10: Flood Control		
Discuss the increase in flood risk of Scenarios over existing operations (More likely that reservoir will fill to full pool more often than under current operations.)	As described in Section 3.1, both scenarios only peak at full pool once in 5 or 7 years on average. All other years the reservoir elevation is at 1,420 ft. or 1,425 ft. As such the flood risk is considered managed within the Arrow footprint for the purposes of this analysis. In addition, maintaining a constant elevation will not change the maximum permitted full pool elevation of 1,444 ft (or if surcharged to 1,446 ft under exceptional circumstances). System wide modelling of the Scenarios will further delineate frequency of the flood or full pool events in the reservoir, and changes to the flood risk in downstream sections.	
General		
Discuss climate change and impact on Scenarios		4.1
What do the Scenarios mean for low water years	Low water years were not considered in this analysis. However, future iterations of the stable reservoir elevation concept will include low water years in the analysis.	
Discuss the implications of Scenarios on upstream/downstream environments, as well as Duncan and Libby.	The report terms of reference restricted the analysis to the Arrow Lakes Reservoir footprint, and thus did not include upstream and downstream river sections. The authors acknowledge this is a limitation on the report's analysis. Current and future modelling of the constant Arrow concepts will include analysis of upstream and downstream river sections.	

Comment or question	Response	See Report Section
Need to incorporate First Nations Traditional Ecological Knowledge into report.	The BC Ministry of Energy and Mines and Global Affairs Canada will be consulting First Nations on the draft report.	
Development restrictions needed to prohibit building within the floodplain.		4.10.3
Discuss whether the Scenarios would have a positive or negative impact on socio-economic values.	The report did not examine the impact of the Scenarios on socio-economic values, such as tourism, economic and community development, land values, etc. However, a stablised reservoir water level would improve access to the water, visual aesthetics and drive tourism and increased recreational use of the reservoir. Local economies would benefit from increased reservoir use by locals and visitors. Businesses that use the reservoir would also benefit from better access and year round use of the reservoir, and land values in local communities and around the reservoir may increase.	
Keeping Scenario elevations flat without variation does not seem realistic	Agreed. The stabilized reservoir scenarios examined in this report allow for minor fluctuations to occur, but it is more realistic to allow greater fluctuations that mimic natural processes and seasonal variations in runoff. The stable concepts were examined in part to further explore the BC Hydro scenarios 7TT and 8TT (that stabilized the Arrow) and to assess the validity of these concepts. Future iterations of the stabilized theme will include increased variation in water levels (but still be considered ‘stable’).	