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Memorandum

To	Travis Ritchie, Yukon Energy Corporation	Pages	8
CC			
Subject	Marsh Lake Storage Project - Preliminary Aquatic Effects		
From	Jen Sarchuk and Don Toews		
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Overview

This memorandum and accompanying tables provide an overview of the preliminary results of the aquatics effects assessment. The results are based upon the most recent modelling runs for the Marsh Lake Storage Project. The analysis of changes in lake levels and Yukon River flows on the aquatic VECs has been developed to the point that we are able to provide these results with considerable confidence. In addition to the hydrologic modelling refinements, this preliminary effects assessment also incorporates recent information gathered through field investigations on lake trout spawning. As would be expected with any effects assessment, our understanding of the potential effects on aquatic habitats and fish populations has benefited from the time and effort that has been applied to the refinement of the hydrological modelling as well as the baseline information collected last fall.

This memo outlines the key pathways of effects on the 3 VECs: Chinook salmon; Freshwater Fish (lake trout) and Wetlands. The change in water management under the Project is described, along with the pathway of effect on a particular habitat, life stage of the indicator species, etc. Each pathway of effect and the residual impact rating and determination of significance in summarized in the attached tables. Where there is considerable uncertainty, a monitoring/adaptive management approach has been identified.

Table 1 below shows the Residual Impact Rating Summary for Aquatic VECs.

Effects Rating Criteria

Residual effects criteria are used to identify potentially significant adverse effects. These criteria include direction, extent, duration, frequency, reversibility, magnitude. Confidence and likelihood is a qualifier that may be used in the determination of significance, and can be helpful in identifying those elements where further monitoring to confirm predicted effects may be warranted. The aquatic effects criteria are defined in the tables below.

Table. Residual Effects Rating Criteria – Aquatic

Criteria	Rating Term	Definition
Direction	Positive	Beneficial change.
	Neutral	No change.
	Negative	Adverse change.
Geographic Extent	Local	Effect is limited to the Local Study Area
	Regional	Effect extends to the Regional Study Area.
	Extra-regional	Effect extends beyond the Regional Study Area.
Duration	Short-term	Effect last one season
	Medium-term	Effect lasts for project life = remaining term of water license (2014 to 2025)
	Long-term	Effect lasts beyond term of water license (past 2025)
Frequency	Once	Effect occurs once (e.g. mitigation construction)
	Intermittent	Effect occurs occasionally or periodically during license term.
	Seasonal	Effect occurs seasonally throughout the term of license.
Reversibility	Reversible	Effect is reversed after the activity ceases.
	Non-Reversible	Effect will not be reversed when activity ceases.
Magnitude	Negligible	No measurable impacts.
	Low	A change in habitat function expected to affect <10% of overall available habitat or productivity of available habitat.
	Medium	A change in fish habitat, expected to affect up to 10-25% of overall available habitat or productivity of available habitat
	High	A change in fish habitat expected to affect greater than 25% of available habitat or productivity of available habitat.

Significance Rating Criteria for Residual Effects

Table Significance Rating Criteria for Residual Effects

Magnitude of Effect	Geographic Extent	Duration/Reversibility	Significance
Negligible	Any geographic extent	Any duration	Not Significant
Low	Any geographic extent	Any duration	Not Significant
Moderate	Local Regional	Any duration and reversible	Not significant
	Beyond Regional	Long-term and not reversible	Significant
High	Local	Short-Term Medium-Term Long-Term and reversible	Not Significant
		Long-term and not reversible	Significant

	Regional Beyond Regional	Any duration	Significant
Rating Qualifiers			
Likelihood	Low Medium High	The likelihood (or probability) of the impact occurring.	
Degree of Confidence	Low Medium High	The degree of confidence in data used to assess the impact.	

1. Chinook Salmon

Impact Statement: Potential effects may include effects on adult migration, spawning; incubation success; and rearing habitat productivity.

Pathway CS1: Reduced Yukon River flows during August and September, on average, may affect Yukon River mainstem spawning habitat.

Compared to baseline flows, the Yukon River flows will be reduced, on average, by 12- 13% during August and September under Project conditions. As there is little or no known mainstem spawning above Whitehorse, this potential effect would be limited to the Takhini reach downstream of Whitehorse. The in-stream flow analysis and a habitat suitability analysis showed that the optimal flows for spawning are between 300-400 m^3/s (Thomas R. Payne & Associates 2011; Normandeau 2012a). The reduction in average flows under the Project will have a positive effect for the entire spawning period, averaging a 6% increase in the habitat index, as the reduced flows during August and September more closely approach the optimum range of flows for spawning. For a dry year, there is a negative change in the habitat suitability index, averaging a 5% reduction. Wet years show very little change in habitat suitability index, averaging a 1% increase in the habitat index.

Mitigation:
While the analysis of the average change in available spawning habitat is positive, and showed that even in dry years the 10% reduction threshold in spawning habitat would not be exceeded, mitigation may be considered during multiple years of dry conditions. One potential mitigation measure would be to delay gate closures and thus increase flows during the August - September spawning period when reduced flows could present an issue.

Pathway CS2: Reduced flows in May may affect ability of pike to access wetlands, which in turn may result in increased pike predation on downstream migrating juvenile Chinook in the mainstem.

Compared to baseline flows, there will be a reduction in Yukon River flows in early May as a result of the lower LSL on Marsh Lake. The average reduction in flow is 4%, with flows resuming baseline averages within a couple of weeks. A 4% reduction in average flows under Project conditions falls well within the 10^{th} and 90^{th} percentile of flow variation. During a dry year there will be a 12% change in flows (represented in the change in 10^{th} percentile), and during a wet year there is no change in flows.
If pike are not able to get into wetlands or are delayed significantly, they will remain in the mainstem of the Yukon River and potentially prey on migrating juvenile Chinook salmon. Access to the wetlands

that are connected to the Yukon River mainstem would be delayed, on average, by 4 days. As the migration of juvenile Chinook occurs mainly in June, however, there would be minimal overlap between pike remaining in the river mainstem if access to wetlands is delayed.

Pathway CS3: Increased flows on the Yukon River during November to April may improve Chinook overwintering/incubation success and habitat productivity.

Chinook Incubation occurs from September 1st to May 30th. The Project will increase the average flows of the Yukon River during November to April from 4% to 34%, with the largest increase in flows occurring in February and March. Optimal flows for overwinter incubation ranged from 240-350 m^3/s (*Normandeau, 2012a*) so any increase in flows during the November to April overwintering period (that are typically less than 200 m^3/s) would have a positive impact on overwintering habitat in the Yukon River mainstem. In early May, there will be a slight reduction in flow (due to the reduction in the LSL on Marsh Lake, resulting in a slight reduction in the incubation habitat index of less than 5% for average and wet years, and minimal or positive effect in dry years. The effect on incubation habitat index in May is negligible. Overall, during the incubation period, there will be a net positive change in Chinook incubation of approximately 4% for all year types.

Pathway CS4: Reduced flows in May (as result of a reduction in the LSL on Marsh Lake), and in August/September may affect rearing habitat on the mainstem.

Chinook rearing was assumed to be from May 1st to November 30th during the open water period, on both the Lewes and Takhini reaches (upstream and downstream of the City of Whitehorse). Compared to baseline flows, there will be slight reduction of average flows in early May (due to the reduction in the LSL on Marsh Lake) and a reduction in flow in late August/September under Project conditions. In May, average flows will be reduced by 4% in the early part of May, and reaching historical average flows in the latter part of the month. In the fall, average flows in late August and September will be reduced by 12% to 13%. The effects of flow reductions on rearing habitat were analyzed, using habitat index modelling described in Normandeau's report (Normandeau, 2012).

On the Lewes reach, Chinook juvenile rearing habitat favours historical flows under all water year types, but the difference is small relative to total habitat. In mid-August to late September, Project effects are negative, but do not exceed the threshold of a 10% reduction in rearing habitat index in average years. In October in wet years, there is a negative effect on rearing habitat that results from the loss of higher flow events due to earlier gate closures at the Lewes Dam, , but does not exceed a 10% reduction from baseline.

On the Takhini reach, Project effects over time exhibit fluctuations between positive and negative depending on the time of year. Negative effects tend to occur between May and June for average and wet water years. Both positive and negative changes are observed for the same time period based on dry water years. Beginning in mid-October a positive trend occurs which is attributed to a normal decline in historical flows and increased generation flows during this time, regardless of water year.

In summary, the net percent changes are very minimal; thus, insignificant changes. The rearing habitat index varies depending on water year type. In the Takhini reach there is a tendency toward a reduced habitat index in early summer (May and June) and an increase in the habitat index during the

fall. For the Lewes reach, effects are minimal except for brief period in the fall for average and wet years. In all cases, the change is small.

Pathway CS5: Reduced flows in August and September may affect adult salmon migration.

Adult Chinook salmon are migrating upstream to spawning grounds from July to early September in the Yukon mainstem. An analysis was completed to determine if adult Chinook salmon passage impediments exist for the simulated flows on the Yukon River mainstem, both upstream and downstream of Whitehorse. Depths and velocities were simulated down to a low flow of 50 m^3/s, and no passage issues were detected for flows as low as 50 m^3/s in either the Lewes or Takhini reaches. The Project will not cause flows to drop lower than 50 m^3/s, and will not be detrimental to adult Chinook upstream passage. The minimum flow recorded in August and September was 280m^3/s and 181m^3/s, respectively. Predicted minimum flows under Project conditions are 235 m^3/s and 217m^3/s, respectively; well above the 50m^3/s limit looked at for adult Chinook salmon.

2. Freshwater Fish

Impact Statement 2: Potential effects on freshwater fish are linked to increased winter drawdown; delayed flooding of wetlands connected to Lakes and in the Yukon River due to a lower LSL; and potentially increased turbidity in fall as a result of increased shoreline erosion during the fall.

Pathway FW1: Higher lake levels in late fall may affect lake trout spawning habitat as a result of reduced wave action at depth that clean spawning substrate. Increased winter drawdown on Marsh, Tagish, and Bennett Lakes may affect lake trout incubation success.

Lake trout are fall spawners; therefore, the increased winter drawdown may affect lake trout incubation success. Currently, the drawdown approaches 2.43 m, whereas this will increase up to 2.83 m under Project conditions. Incubation success may be affected with increased winter drawdown due to dewatering and desiccation of eggs. Lake spawning locations are usually in exposed locations associated with wind wave action and water currents, typically at depths typically from 1- 4 m. Lake trout spawning is well documented for Tagish Lake, while there is no documented spawning on Bennett Lake, and little or marginal spawning habitat available on Marsh Lake. Thus the potential effects on lake trout incubation success are not equivalent for all three lakes, given the current understanding of spawning habitat potential.

During spawning (October) lake levels will increase by 0.39, 0.41 and 0.35 meters on Marsh, Tagish and Bennett Lakes, respectively under Project conditions. During lake trout incubation/emergence (April) with lake levels on these lakes are expected to be lower by 0.15 and 0.11 meters on Marsh and Tagish lakes, and negligible change on Bennett Lake.

Based on recent field sampling, little or no spawning on the lakes occurs at water depths less than 2 m, with the majority of spawning documented at 3 to 3.5 m and some spawning as deep as 4.5 m. It is unlikely that the change in winter drawdown from 2.3 to 2.7 m will cause significant impact to lake trout spawning success and recruitment.

Mitigation:

Given the uncertainty around the effect on lake trout spawning under Project conditions, monitoring of spawning depth is likely warranted to confirm if spawning continues to take place below the 2.8m drawdown. If so, then changes in lake trout populations are likely attributable to other factors (over-harvesting). If monitoring shows a decrease in incubation success over time, then an adaptive management approach may be necessary to mitigate this effect.

Pathway FW2: Lower LSL on Marsh Lake may result in delayed access in early spring (insufficient depth of water) to wetlands and tributary streams utilized by freshwater species (spawning Arctic grayling and juvenile fish of most species).

The Project proposes a reduced low supply level (LSL) of 0.10 m; therefore the water levels are predicted to be lower than historical levels for a few weeks in early May. The water levels in May will not change much from baseline conditions, and are well within the historical range of levels in May. The predicted delay in connectivity to the wetlands in the Lewes Marsh will be only one or two days on average. Overall, this potential effect is not significant.

Pathway FW3: Increased lake levels in fall may result in incremental increase in erosion and suspended sediments/turbidity which may affect fish health and fish habitat.

Increased lake levels in the fall may increase shoreline erosion, resulting in increased suspended sediment and turbidity that in term may adversely affect fish health and fish habitat. As described in the Preliminary Effects Assessment for Erosion, AECOM 2012) minor increases in erosion will result in deposition of sediment in existing accretion areas. These areas already experience substantive deposition of sediment naturally; therefore, the nature of the habitat will not change. Areas that are highly erodible currently will continue to erode under Project conditions. Therefore, fish health and fish habitat in erodible areas will remain unchanged. This potential effect is not significant.

3. Wetlands

Potential effects on wetlands are linked to potential decrease in their productivity due to a delay in the spring flooding, and a delay in warming.

Pathway WL1: A lower LSL on the Southern Lakes may result in a delay in spring flooding and warming of the wetlands connected to Southern Lakes. This in turn may result in reduced productivity of the wetlands that support critical life cycle functions of fish.

Wetlands are an important part of an ecosystem as they provide fish habitat in early spring after 6-7 months of ice cover. Wetlands become ice free 3 to 4 weeks before the lakes, and provide food for juveniles of most fish species. Wetlands are particularly important to young of the year juvenile rearing and Northern pike for spawning in the spring time. During baseline studies, three Lewes wetlands were examined in detail to determine the inlet and pool elevations in relation to the lake elevation. By comparing the inlet and pool elevations under baseline conditions to Project conditions, it was possible to estimate the change in timing of wetting up of these wetlands. The change is very minimal, as the 2 days for inlet wetting is expected to be delayed by about 2days, and flooding of the pools by 1 day. This falls well within the natural variation of Southern Lakes wetland wetting that can vary by about one month, and has been as early as May 11 and as late as June 11.

Pathway WL2: Reduced flows in Yukon River in May may result in delayed access for fish (especially Northern pike) and reduced wetted area of wetlands connected to the Yukon River downstream of Lewes Dam.

Initially, six marshes (wetlands) adjacent to the Yukon River were investigated to determine their relationship to the flows in the river. Instream flow studies were conducted along the Yukon River and the stage discharge relationship of the physical habitat transect nearest each marsh site was used to evaluate the relationship between the Yukon River flow and the marsh inundated area (Normandeau 2012b). Bathymetric surveys were conducted on the only four of the six wetlands, as only four of the six are connected to the Yukon River mainstem. The reduction in flows showed that there will be a reduction in the available habitat in four of the six marshes, as follows:

- Marsh B has up to 40% less wetted habitat available in the spring;
- Marsh C has about 11% less wetted habitat available in the spring;
- Marsh D is only connected during really high flows (above 477 m^3/s) and has less than 2% reduction in habitat available in the spring (also only available later in the spring after June 20 when habitat may not be as important); and
- Marsh F has about 5-27% less wetted habitat available in the spring.

All the Marshes (wetlands) display similar trends with the reduced flows in the spring to loss of aquatic habitat; however, the delay is on average only 4 days until the wetlands are wetted which is really the most important factor in determining pike access to wetlands. Under Project conditions, the average flows in May fall within 10^{th} and 90^{th} percentile mean historical flows for May and historical natural variation; thus, this is an insignificant effect as it is already occurring naturally.

Pathway of Effect WL3: Reduced flows in Yukon River from ~mid-August to September may result in reduced fall access to, and the extent of, available wetted habitat of wetlands connected to river downstream of Lewes Control Structure.

In mid-August to September, flows in the Yukon River will be reduced by 13%, on average, under Project conditions. Reduced flows have the potential to limit access and available habitat in the wetlands that are connected to the Yukon River downstream from the Lewes Dam. Cooling water temperatures at this time of year suggest that fish movement is out of the wetlands into the river mainstem.

Similar to the above pathway (**WL2**), the same six marshes were looked at off the Yukon River for the potential to impact access and available habitat of wetlands from mid-August to September.
In conclusion:

- Marsh B wetted habitat will be reduced by up to 15% in mid-August, and in late fall/early winter there is about 5-10% more habitat available;
- Marsh C will experience a sharp decrease in aquatic habitat in mid-August with up to 15% less habitat available in the fall;
- Marsh D is only connected to the river at very high flows (477 m^3/s); reduced flows in August and September will result in less than a 2% reduction in habitat available at this time of year; and
- Marsh F will experience a sharp decrease of about 10% less aquatic habitat available in mid-August.

In summary, the marshes off the Yukon River display similar trends with a decrease in aquatic habitat in mid-August as the Lewes gates are closed in August to reduce the discharge from Marsh Lake.

Wetlands are used intensively by fish species and especially by juvenile fish in spring from June to earlier summer (mid July). Based on temperature data and fish sampling conducted in the wetlands off Marsh Lake in early August; it appears that productivity of wetlands declines in late July and early August due to declining water temperatures. Although there are some decreases in habitat available in these wetlands in the latter part of August and September under Project conditions, the timing of this effect has minimal overlap with the period of highest utilization of these areas by fish.

Mitigation:
A potential mitigation may be to gradually closure the gates at the Lewes control structure to help avoid a sharp decrease in flows during August. This would moderate decreases in aquatic habitat available in wetlands during this time and ensure that fish can migrate out of wetlands in early fall as water temperatures cool.