Fisheries and Oceans Canada / Pêches et Océans Canada
Ecosystems and Oceans Science / Sciences des écosystèmes et des océans

Central and Arctic Region

Canadian Science Advisory Secretariat
Science Response 2020/035

SCIENCE REVIEW OF THE CHANGE IN TIMING OF IMPOUNDMENT FOR THE KEEYASK GENERATION PROJECT

1.0 Context

The Keeyask Generation Project is a new hydropower development on the lower Nelson River in northern Manitoba. The project includes a powerhouse with seven turbine generators situated on the north side and a spillway located on the south side of Gull (Keeyask) Rapids. An Environmental Impact Statement (EIS) was prepared by the Proponent, Manitoba Hydro, and reviewed under the Canadian Environmental Assessment Agency (CEAA) in 2012–2014. The Project was approved on June 27, 2014 and construction commenced in 2016.

Within the 2012 EIS, environmental effects were assessed and approved for reservoir impoundment from an elevation of 155 m ASL (above sea level) to an elevation of 159 m ASL to commence in August 2019 and be completed by October 2019 (EIS, Section 4.6.15–Reservoir Impoundment). Since this time, construction delays have put the project behind schedule. Subsequently Manitoba Hydro has requested an amendment to change the timing of water-up to late February 2020 and timing of impoundment to late March/early April 2020, rather than the originally proposed late summer/fall schedule for both activities (August 2019–October 2019). Consequently, the under ice conditions should be considered in the assessments of water-up and impoundment in the winter rather than the original open-water environmental assessment.

The evaluation and authorization of the proposed amendment has been divided by Fisheries and Oceans Canada (DFO) Fish and Fish Habitat Protection Program (FFHPP) into two phases. The first phase is the water-up of the Keeyask Generating Station (including removal of the coffer dams and rock groyne) up to the prevailing level outside of the cofferdams (current water level ~156 m ASL). The second phase is the impoundment of the reservoir to the full supply level (FSL), at an elevation of 159 m ASL.

Based on Manitoba Hydro's modelled prediction, the open water hydraulic zone of influence of the Keeyask reservoir at FSL of 159 m might extend upstream ~42 km from the Generating Station to about 3 km downstream of the outlet of Clark Lake, with a flooded area of approximately 45 km^2 (Figure 1).

This Science Response Report results from the Science Response Process on the Science Review of the Change in Timing of Impoundment for the Keeyask Generation Project held on February 27, 2020, in Winnipeg, MB.

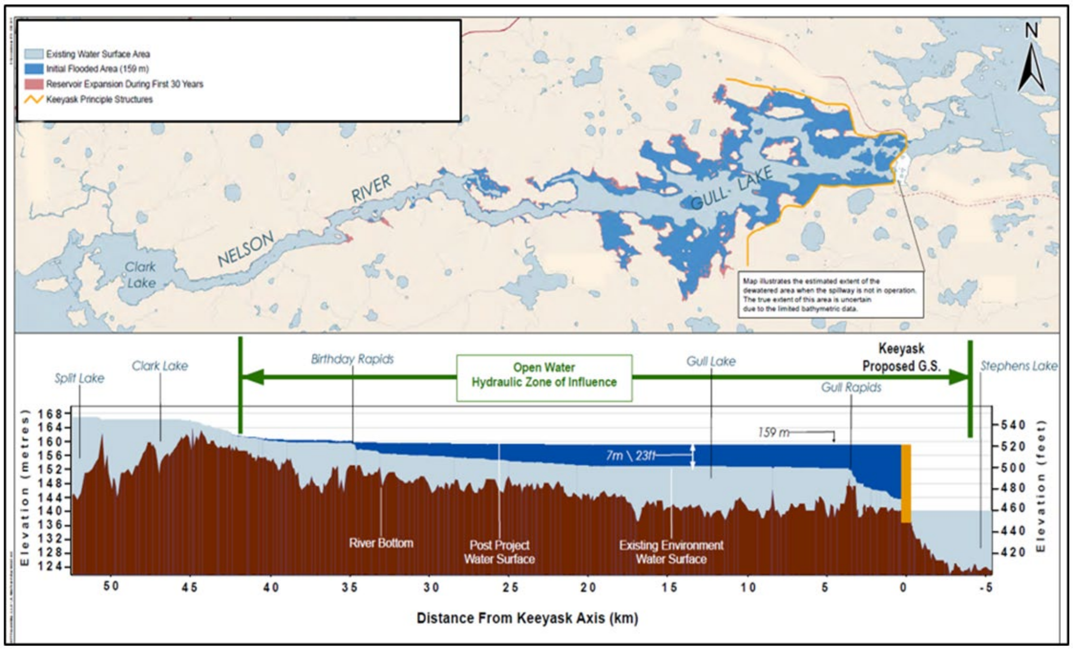

Figure 1. Anticipated water surface profiles and flooded areas in the Keeyask Reservoir (modified from Keeyask Generating Project Environmental Review – Change of Timing of Water-up and Impoundment, 2020).

The amendment is currently under review by DFO's FFHPP for decision. FFHPP has requested that DFO Science review the proposed amendment. In particular, the objectives of this review are to:

1. review the outputs of the hydrodynamic model presented in the amendment and identify uncertainties and data gaps;
2. identify other potential impacts that may occur with winter impoundment;
3. determine the appropriateness and adequacy of the proposed mitigation and monitoring measures, and;
4. if necessary, recommend additional information, studies, data collection that are required for DFO Science to complete its assessment.

This Science Response Report resulted from the Science Response Process of February 27, 2020 which included a review of several documents and/or presentations received from FFHPP.

2.0 Background

The Nelson River in Northern Manitoba, Canada, drains Lake Winnipeg and flows 644 km through several lakes including Sipiwesk Lake, Split Lake, and Stephens Lake into Hudson Bay. It has mean annual discharge of 2,370 $m^3 \cdot s^{-1}$ and a drainage basin of 1,072,300 km^2 including the Winnipeg, Red, and Saskatchewan rivers watersheds. Historically, the Nelson River had relatively low flows from summer to the following spring and a spring freshet driven by snowmelt that extended to early summer. Given its large discharge and change in elevation, the Nelson River is a valuable water course for generating hydroelectricity.

The first dam on the Nelson River was Manitoba Hydro's Kelsey Generating Station that was constructed in the late 1950s. Since then, four additional generating stations have been built on the lower Nelson River (Keeyask, Kettle, Long Spruce, and Limestone) and the Jenpeg Generating Station regulates the inflowing water and transforms Lake Winnipeg into a hydroelectric reservoir (Figure 2). In addition, the Missi Falls Control Structure situated on the mouth of South Indian Lake reduces the flow in the lower Churchill River directing the majority of water from the upper Churchill River into the Nelson River (Figure 2).

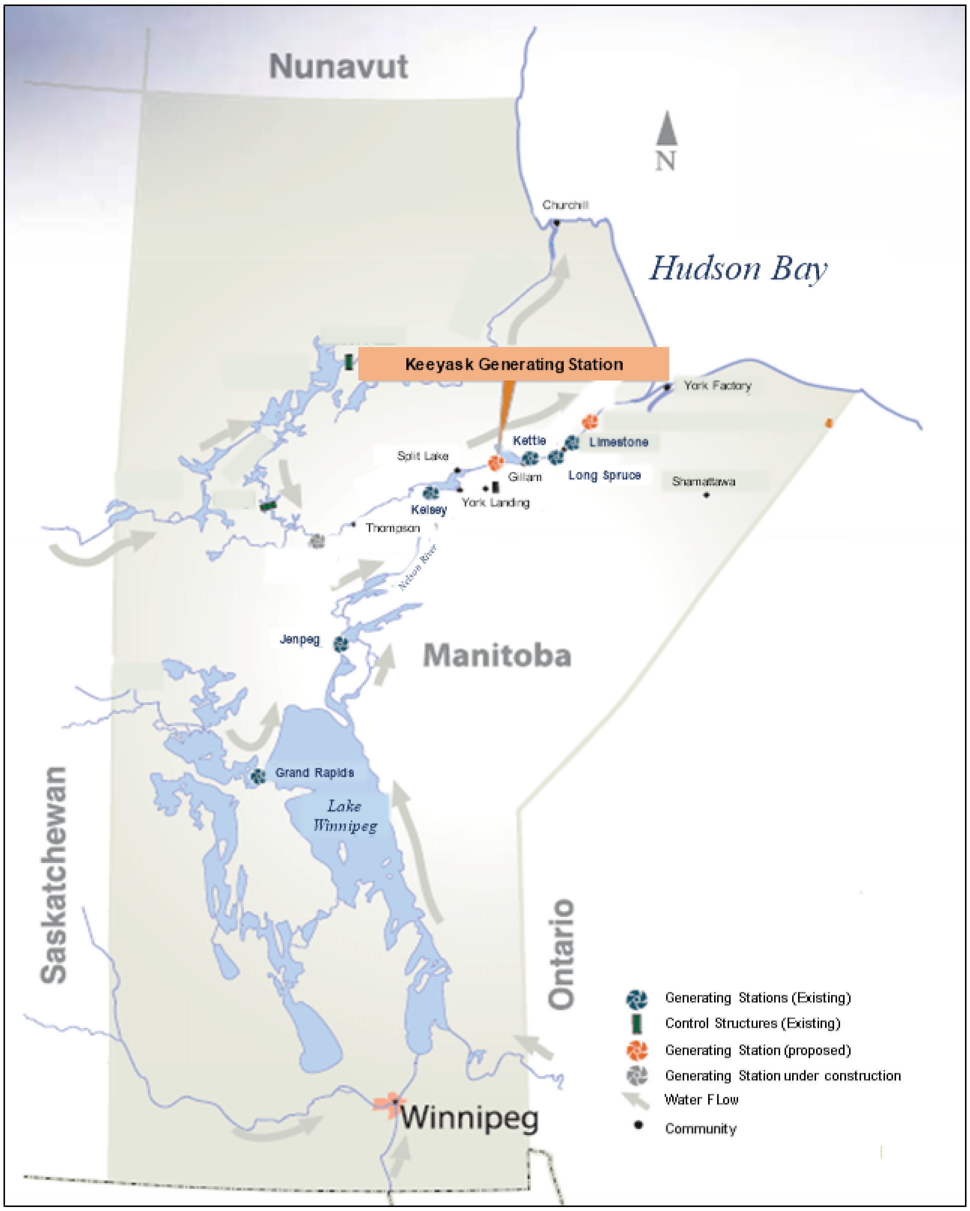

Figure 2. Map from the 2012 Keeyask Environmental Impact Statement (EIS) showing Manitoba Hydro Generating Stations (existing and proposed) and control structures in Manitoba (taken from the Executive Summary of the EIS Part 1).

Situated in the Boreal Plains Ecozone, it is known that ice processes play a dominant role in the hydrologic regime of the Nelson River and are intimately related to the life cycle of many aquatic, terrestrial, and avian species. The most serious impacts of river ice occur during ice-jam flooding, but also the occurrence of frazil and anchor ice can affect aquatic species. Due to the socio-economic and environmental importance of river ice processes, numerous river ice models have been developed to anticipate the consequences of different discharges and water levels on river ice (e.g., CRISSP2D, Liu et al. 2006; ICESIM and ICEDYN, Groeneveld et al. 2017; RIVICE, Lindenschmidt 2017). The accuracy of hydrodynamic model predictions is an inherent concern, particularly in regards to the simulation of dynamic river ice processes. Consequently, calibration and model validation with field data are essential (Zare et al. 2013). Carsen et al. (2011) demonstrated in a comparative study that river ice models performed well when necessary calibration data describing ice characteristics was available, but varied considerably without such collected calibration data.

Environmental modelling requires a model to be calibrated, verified or validated, and ideally have a sensitivity analysis performed to have more confidence in accuracy of predictions. Model calibration is a process that requires the adjustment of certain model parameters to achieve the best performance of the model for specific applications. Model calibration should express the level of agreement achieved, how realistic the representation of the applications is, and define the criteria by which it has been judged as being fit for the application. The quantitative assessment of data error, accuracy, and uncertainty in models could then define criteria against which model performance can be judged. Notably, the accuracy of the model outputs cannot be proved to be greater than the accuracy of the original calibration data (Williams and Esteves 2017).

Validation requires an independent dataset (separate from calibration data) to confirm that the calibrated model is accurately predicting observed data. Sensitivity analysis can be performed to observe the change in the predicted result when significant changes are made in the input data, and to clarify where potentially inaccurate input will lead to minor or major errors in predictions (i.e., which outputs are particularly sensitive to model input changes). This step is important for the interpretation of confidence in the model's ability to accurately predict scenarios, and where it is critical to have accurate input data (Williams and Esteves 2017).

Aquatic ecosystems have adapted over time to the prevailing ice regimes of Canadian rivers. At the onset of the cold water conditions, freeze-up, and during the winter period, fish chose suitable overwintering habitat to avoid high water velocities and contact with ice (Bergeron and Enders 2013). Changes to the ice regime can have serious ecological impacts. As a result, when significant changes of the river environments occur, the natural adaptation of fish to overwintering conditions may become disturbed. Consequently, dramatically changing the environmental conditions (e.g., reservoir impoundment) during winter may have detrimental effects on the fitness and/or survival of fish. Immobile life stages (i.e., fertilized eggs of fall spawners) may be particularly affected.

3.0 Analysis and Response

Documents for review were submitted to DFO Science between January 28, 2020 and March 2, 2020 by FFHPP. The comments in this Science Response are related to those supporting and supplementary materials received by DFO Science, which are listed in Table 1.

Due to the jurisdiction of DFO and the expertise of the review team, DFO Science focused its review on the hydrodynamic modelling and the impacts of the change in impoundment timing on fish and fish habitat. Effects on the terrestrial environment as well as on benthic invertebrates, erosion, sedimentation, debris, birds, and mammals were not reviewed.

Table 1. List of documents in support of the proposed amendment provided to DFO Science for review.

Supporting and Supplementary Document	Science Response Section(s)
Manitoba Hydro PowerPoint presented at the Technical Review meeting on January 28, 2020	3.1
Amendment Submission entitled: *"Keeyask Generation Project Environmental Review: Change of Timing of Water-up and Impoundment"* dated January 10, 2020	3.1
Keeyask Generation Project Technical Memorandum regarding "*Assessment of the effects of fall vs Late Winter Impoundment on Lake Whitefish Spawn*" dated February 17, 2020	3.2
Manitoba Hydro PowerPoint presented on February 11, 2020 entitled: "*Keeyask Generation Project: Change in Timing of Water-up and Impoundment*"	3.1
Manitoba Hydro Correspondence Letter "*RE: Keeyask Project – Change in Timing of Water-up & Impoundment*" dated January 28, 2020.	3.1
Manitoba Hydro Interoffice Memorandum Subject Title "*Keeyask Generation Project – Water Level Monitoring & Response Plan During Water-up & Final Impoundment to Reservoir Full Supply Level (159 m ASL)*" drafted February 19, 2020.	3.1
Keeyask Generation Project – Application for *Fisheries Act* Amendment to Change Timing of Water up and Impoundment and associated work entitled: "*Summary of Incremental Environmental Effects and Additional Mitigation, Monitoring, and Contingencies for Water Up and Impoundment*" dated February 19, 2020.	3.1, 3.2
Keeyask Generation Project Technical Memorandum regarding "*Assessment of the effects of fall vs Late Winter Impoundment on Lake Whitefish Spawn*" dated February 19, 2020	3.2

DFO Science notes that there were gaps in the information provided and inconsistencies in the material presented in support of the proposed amendment. It was consequently difficult to fully assess Manitoba Hydro's analyses and therefore, some of their conclusions.

3.1 Hydrodynamic Model Review

Manitoba Hydro used the ICEDYN model to simulate surface water elevations for a 2020 winter impoundment scenario. The ICEDYN model is an in-house model developed by Acres Manitoba Ltd. (now Hatch). Originally, Acres Manitoba Ltd. developed ICESIM in the early 1970s, which is a one-dimensional steady state model. This model was improved over two decades to account for, or simulate ice accumulation under non-steady flow conditions and subsequently named ICEDYN. The intent of both models was to assist in the design calculations for river management schemes during construction of hydroelectric plants, mainly in Canadian Rivers (e.g., Athabasca and Saskatchewan rivers).

The ice dynamics in the Nelson River are complex (Newbury 1969), rendering it more challenging to accurately model relative to other river systems. The amendment proposal submitted by Manitoba Hydro contains no information regarding the limitations, assumptions, applicability, or the validity of the ICEDYN model to simulate ice processes in the Nelson River.

One of the primary data sets used to calibrate the ICEDYN model was surface water elevations collected at gauge stations within the hydraulic zone of influence (Figure 3). DFO Science recognizes that a limited amount of winter data, dating back to the early 1990's and 2000's, was used to calibrate the water surface profile for the model. However, DFO Science is concerned that the model could have been calibrated to an open water scenario rather than the proposed under ice or winter season condition, due to a lack of winter data. There was also no calibration against the ice characteristics, including the extent of ice cover, ice thickness, ice type, and the elevation of the top and bottom of the ice surfaces, necessary to verify the accuracy of the model predictions. In addition, calibration against flow velocities or water depths appears to have been overlooked in their analysis.

Furthermore, in the amendment, there are no model simulations presented to provide information on changes and/or the impact of anchor ice, frazil ice, or ice jams (e.g., accumulating, eroding, moving) and their potential impact(s) on the winter water surface profile. This may be relevant to the prediction of the spatial extent of flooding in the hydraulic zone of influence (Figure 3). It is unclear if during the model simulation process, the ice volume was conserved (Figure 4). This may result in different winter water surface elevations than currently predicted, particularly in the vicinity of the steep bed slope upstream of Birthday Rapids, downstream to Gull Lake (Figure 5). As a result, DFO Science is concerned with the calibration of the model and therefore the accuracy of the model predictions.

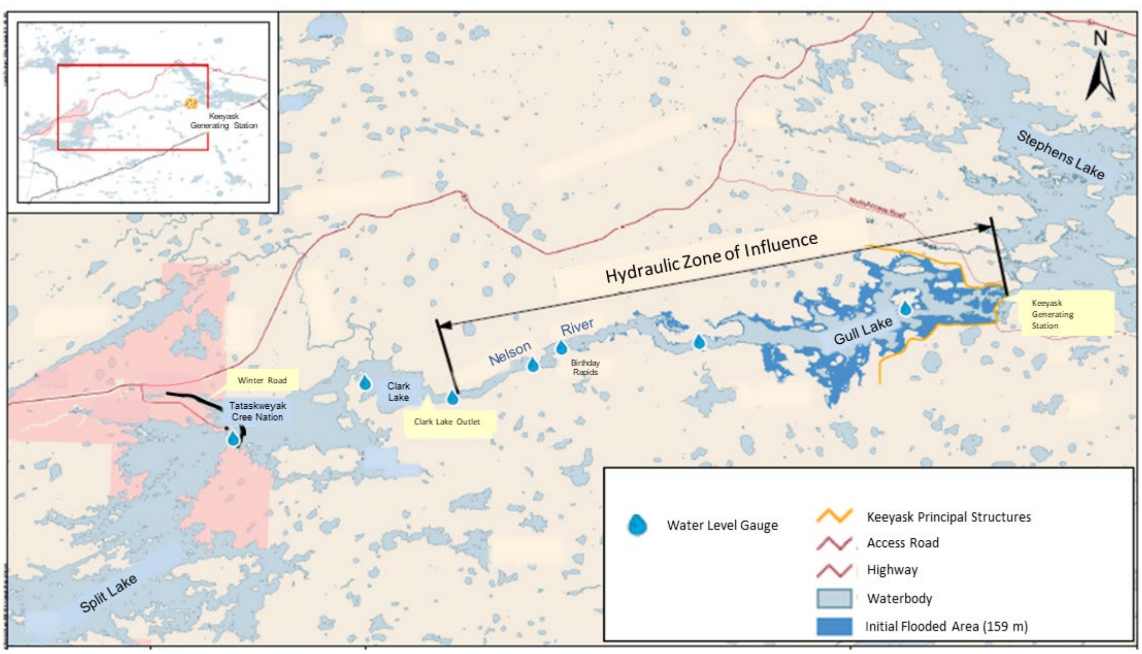

*Figure 3. Water level gauges and hydraulic zone of influence on the Nelson River (modified from Manitoba Hydro Correspondence Letter "*RE: Keeyask Project – Change in Timing of Water-up & Impoundment*" dated January 28, 2020).*

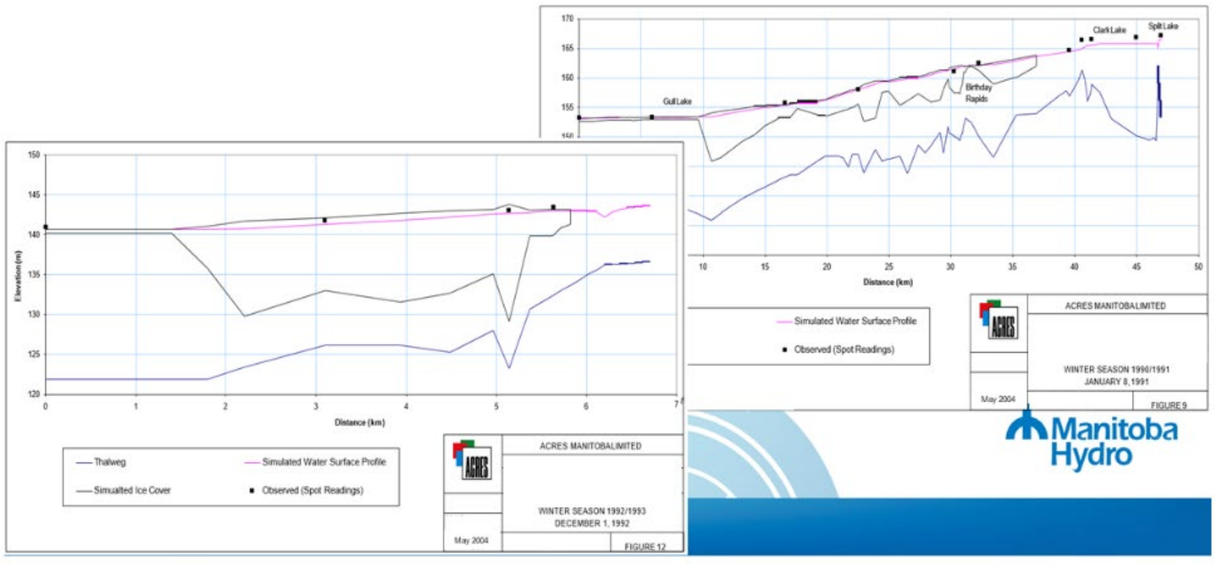

*Figure 4. Model calibration of the ICEDYN model using water surface data from the 1990s and 2000s (taken from Manitoba Hydro PowerPoint presented at the Technical Review meeting on January 28, 2020 entitled: "*Keeyask Generation Project: Change in Timing of Water-up and Impoundment*").*

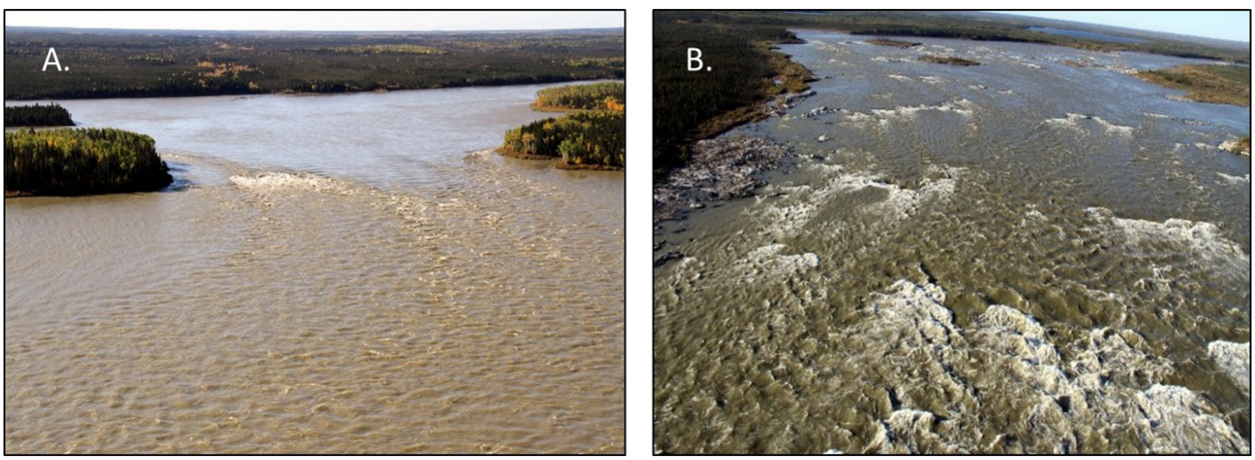

Figure 5. Images of a) Birthday Rapids and b) Gull Rapids, two areas of fast water that will be affected by the impoundment (photos courtesy of D. Watkinson, DFO, Winnipeg, MB).

In calibrating and validating the model simulations, the Proponent did not provide any comparative statistics, including percentage of error between the calibrated modeling predictions and the monitored or observed data to assess the accuracy of the calibration process and therefore the model predictions. For example, DFO Science concerns regarding model accuracy appears in Figure 4, where at Clark Lake and Split Lake, the observed water surface elevations are higher than the simulated water surface profile. In addition, to our knowledge, no sensitivity analyses were conducted. Given that there were no additional winter simulations specifically considering ice dynamics, there is uncertainty with respect to the extent of the hydraulic zone of influence, which is currently shown as being no different with or without the project in the winter starting at about ~42 km upstream and thus including Clark and Split lakes (Figure 6).

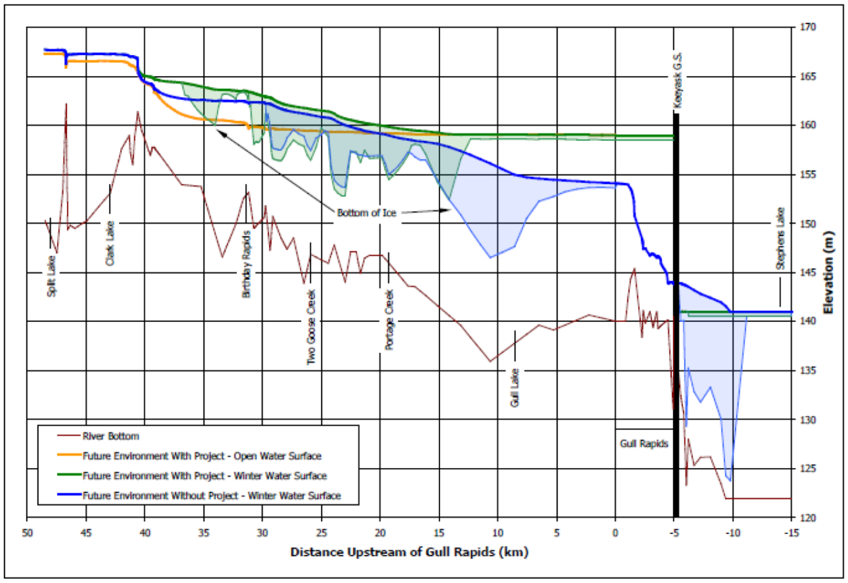

Figure 4.4-29: Modelled Winter Water Surface Profiles, 95th Percentile Flow, Average Temperature Conditions

*Figure 6. Simulated water surface profile upstream of the Keeyask Generating Station (taken from Manitoba Hydro PowerPoint presented at the Technical Review meeting on January 28, 2020 entitled: "*Keeyask Generation Project: Change in Timing of Water-up and Impoundment"*).*

Recommendation

DFO Science suggests the following recommendations in order to assess and potentially increase confidence in the model predictions, including:

- presentation of the percentage of error between predicted and observed data to ensure that the calibrated model reasonably and accurately matches observations, and sensitivity analysis on model parameters to ensure that small variations in some of the model input data would not impact the results to a greater extent. This should help in increasing the confidence in the accuracy of the winter model predictions;
- time-dependent simulations of each step of the impoundment would assist when monitoring the change of conditions during the winter impoundment, as the accuracy of model predictions can then be independently assessed at each stage, potentially allowing for an improved response time should large deviations be observed;
- real-time monitoring during the impoundment would inform and provide verification that the modelling simulations were correct (e.g., predicted water levels along the entire length of the hydraulic zone of influence), including new knowledge on the advancement, progression or stabilization of the ice cover and the observed water surface elevations at the confluence of tributaries;
- in the absence of a suitable model, real-time monitoring would also effectively allow for adaptive management and improved response time; and,
- monitoring water surface gauges within the Two-Goose Creek and Portage Creek sub-basins (Figure 7) during impoundment to document water level changes and the flooded area into the creeks as no additional modeling results were provided beyond those along the Nelson River.

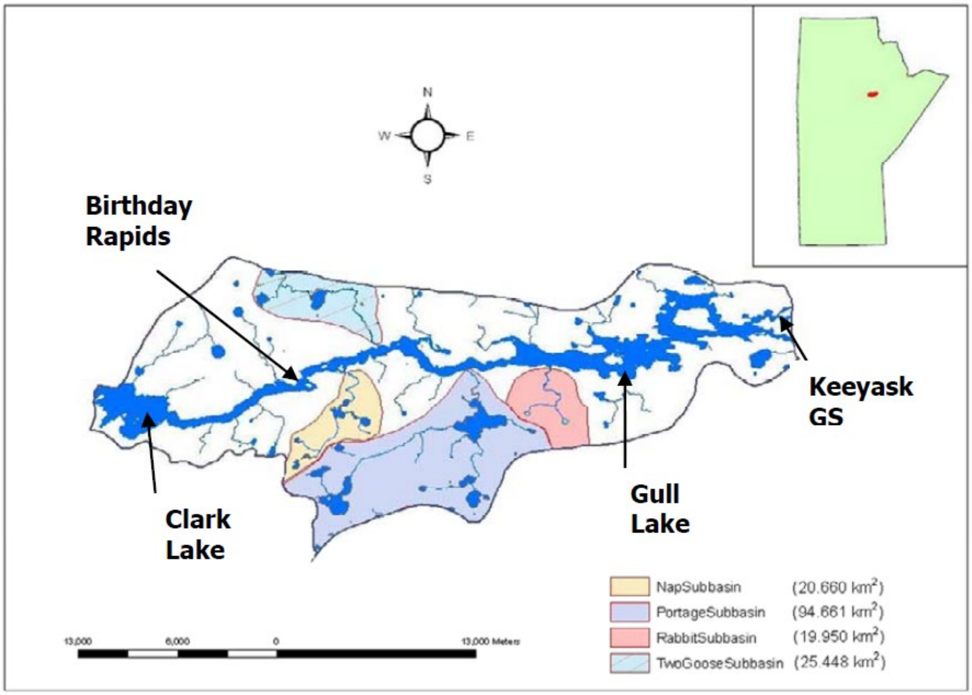

*Figure 7. Map of the sub-basins in the Keeyask Generating Station study region (modified from "*Keeyask Generation Project: Surface Water and Ice Regimes*" – DRAFT submitted September 2010)*

3.2 Predicted effects on fish and fish habitat in regards to changes in water-up and impoundment timing

The construction of the Keeyask Generating Station and Spillway will lead to major impacts on fish and fish habitat, these have been addressed in the Environmental Impact Statement and have been authorized by DFO. The focus of this review is to determine if additional impacts on fish and fish habitat will occur due to the change of the timing in water-up and impoundment from the planned open water condition in an August-October period to an under ice conditions in a March-April winter period.

We agree with the statement in the EIS, and copied in the Keeyask Generation Project Technical Memorandum entitled "Assessment of the Effects of Fall vs Late Winter Impoundment on Lake Whitefish Spawn" dated February 19, 2020 that: "*Changes in aquatic habitat in the Keeyask reservoir could result in increased fish movements out of the reach. In particular, there could be a mass emigration of fish out of the reach in the first year of impoundment as fish move away from disturbed habitat (Section 5.4.2.2.5)".* Fish were predicted to move upon impoundment and this will be the case regardless of the timing.

The concern about changing the environmental conditions for fish during the winter period lies in the fact that fish are poikilothermic, meaning that they do not produce heat to maintain a constant body temperature but rather see their body temperature fluctuate with the ambient water temperature. Consequently, as they are very lethargic with reduced swimming capacity in cold waters during the cold winter months, northern fish generally chose appropriate overwintering areas. Often riverine fish gather in groups in deeper pools near the bottom trying to avoid anchor and frazil ice, and search for areas with reduced water velocities. Given that feeding during winter is greatly reduced, fish have depleted energy reserves towards the end of winter, when impoundment is now proposed to occur. Limited telemetry data suggests that most of the tagged Walleye (*Sander vitreus*), Northern Pike (*Esox lucius*), and Lake Whitefish (*Coregonus clupeaformis*) overwinter in sheltered bays on the north side of Gull Lake, and it was suggested that the water velocity, sediment, and dissolved oxygen dynamics in these sheltered bays would not change substantially during or after impoundment. Yet, this does not mean that fish will not move during impoundment since at least the water depth will change. However, tagged Lake Sturgeon (*Acipenser fulvescens*) were observed overwintering in deep areas of the middle basin of Gull Lake (~10 km upstream of Gull Rapids), and only a subgroup of individuals of the limited number of other tagged fish species were located in the sheltered bays on the north side of the lake. Thus, during impoundment it is our concern that many overwintering habitats will be changing rapidly, potentially requiring fish to continually relocate to find suitable habitat at a time when energy reserves are low, reducing fitness, and potentially affecting survival. Also during a winter impoundment, the movement, cracking and adjustment of ice will create an extremely noisy environment for overwintering fish, subjecting all fish to disturbance from noise that could induce movement. In addition, different life stages are likely to be affected differently by environmental stressors based on ability to move. Likely the fertilised eggs of fall spawners will be most vulnerable, followed by juveniles, small bodied fish species, and large bodied adult fish.

The impounding under ice conditions is likely to increase the water pressure (e.g., additional water volume) on the aquatic organisms, which may particularly negatively affect the viability of the egg life stage. Flow dynamics will also be changing at the 2019 fall spawning sites, affecting sediment accumulation and oxygen dynamics, potentially further affecting egg viability. The EIS assumed that the reduction in velocity and increase in water depth at existing spawning locations would affect fish in August-September 2019 when fish would have had the ability to find alternate spawning locations if conditions were no longer suitable at historical existing sites. It was recognized that the potential existed for fish to fail to find suitable sites under impoundment conditions, particularly in the initial years when the new habitat is debris and sediment laden and potentially less suitable, which may have affected the 2019 year class strength. This potential impact was previously authorized.

With the current plan of winter impoundment in March-April 2020, the fall spawners have already deposited their eggs in appropriate spawning habitat and the eggs will most likely be negatively affected by the environmental changes. In the EIS, only Lake Whitefish is considered as a fall spawner. Lake Whitefish eggs remain on the substrate until the following spring. During the winter, eggs are susceptible to water level fluctuations, oxygen depletion, and sediment deposition. In addition, the fall 2020 spawners will now be confronted with finding alternate spawning locations if conditions are no longer suitable at originally existing sites as laid out in the EIS for the 2019 fall spawners. Consequently, two year classes of the fall spawners upstream of Gull Rapids may be affected, and thus the impacts on Lake Whitefish is likely to be greater than predicted in the EIS. Furthermore, Lake Whitefish from Stephens Lake are thought to spawn in or downstream of Gull Rapids and they may also spawn along the Powerhouse Tailrace Cofferdam. Consequently, the anticipated removal of Tailrace Cofferdam in winter 2020 will likely lead to a high mortality of the Lake Whitefish eggs laid downstream in the fall 2019, another impact over and above those predicted in the EIS.

In addition to Lake Whitefish, Burbot (*Lota lota*) and Cisco (*Coregonus artedi*), that are important for the biodiversity in the fish community, are fall (Cisco) or winter (Burbot) spawners and therefore likely to be affected as well. The fish community monitoring in the Keeyask Generation Project Aquatic Effects Monitoring Plan only monitors the population status of Walleye, Northern Pike, and Lake Whitefish. Consequently, any impacts to Burbot and Cisco will likely remain undetected.

The Powerhouse Tailrace Cofferdam was built to allow for the construction of the tailrace channel and the offset Lake Sturgeon spawning habitat in the dry (p. 2, S.2.1 of the EnvR-Environmental Review Change in Timing Water-Up and Impoundment). To permit for commissioning of one or more turbines at a given time, the Tailrace Cofferdam will be removed in stages, likely beginning near the south-east corner of the cofferdam and progress north along the north-south leg of the cofferdam towards the north shoreline. With the new changes in timing, only 100 m would be removed before mid-May (May 15, 2020), allowing Lake Sturgeon very reduced access to the offset spawning habitat. Based on water velocities, there is potential that Lake Sturgeon spawn along the south-east portion of the Tailrace Cofferdam, when water temperature reaches ~10 °C at the end of May or early June in the Nelson River (p. 6, S.4.2 of the EnvR-Environmental Review Change in Timing Water up and Impoundment). Spawning habitat on the south-east corner of the Tailrace Cofferdam will be destroyed for the 2020 Lake Sturgeon spawners. Given that the offset spawning habitat may not be fully available in 2020, the success of spawning may be impacted.

Due to the high uncertainty in the hydrodynamic modeling under ice conditions, the subsequent extent of the physical environment changes (i.e., scouring, frazil and anchor ice, debris and sediment load, changes in turbidity) caused by the change of the impoundment date and the poor understanding of the winter ecology of northern fishes and invertebrates, it is impossible to assert that there won't be additional effects due to the timing change on fish and fish habitat. It is likely this major environmental shift to a time period where fish are potentially more vulnerable will have impacts on spawning success, sub-lethal fitness effects, and increased mortality risks for eggs, juvenile, and adult fish.

Recommendations

- Conduct an analysis of Burbot and Cisco samples obtained during the fish community monitoring in the Keeyask Generation Project Aquatic Effects Monitoring Plan.
- Maximize access to the created offset spawning habitat for Lake Sturgeon.

3.3 Monitoring

The proposed monitoring plan and additional measures are generally well laid out. The water surface loggers are located at specific key sites deemed necessary to monitor the changes in water surface elevations. The proposed timing, frequency, and duration of the monitoring of the winter water levels during water-up and impoundment are generally adequate to monitor any expected changes in the water levels. However, there are still additional locations that are suggested for monitoring, specifically the confluences of the tributaries, Two-Goose Creek and Portage Creek (Figure 7), during impoundment to document water level changes and the flooded area into the creeks as no additional modeling results were provided beyond those along the Nelson River.

Thresholds to determine pausing/stopping of water-up and/or impoundment, should upstream water levels exceed predictions, need to be more specifically identified. The mechanism(s) and response measures on how quickly the water-up and/or the impoundment processes can be paused/stopped need to be added to the monitoring plan. Monitoring parameters including discharge and water surface elevation are recommended to be checked against the modeling predictions during and after impoundment.

The proposed amendment monitoring plan was focused entirely on water levels and will thus not determine effects due the change in timing of the impoundment on fish and fish habitat. It is not clear in the original aquatic effects monitoring plan what information is being collected on

Burbot and Cisco. All fish captured in the gill netting method should be documented during monitoring. Given the additional uncertainty of the 2019 and 2020 year class survival, it is recommended to monitor at least three years post impoundment and maximize number of sample sites to allow the detection of changes in fish abundance.

Recommendations

- The current Keeyask Generation Project Aquatic Effects Monitoring Plan is sufficient to monitor the impact of the 2019 and 2020 year class survival, However DFO Science recommends that all fish captured in the gill netting method should be documented during monitoring. It is also recommended to monitor at least three years post impoundment and maximize number of sample sites to detect changes in fish abundance.

Sources of uncertainty

Several sources of uncertainty were highlighted in section 3.1. with respect to the review of the hydrodynamic model.

Concerns that back flooding into tributaries at higher water levels, and over longer stream reaches that were not prepared for flooding, were not anticipated in the available review material. Consequently, uncertainty persists about the spatial extent of flooding and its associated risk of increasing mercury levels in fish in Gull Lake, and to a lesser extent in Stephens Lake, to a higher level than predicted in the EIS. In addition, DFO Science is uncertain that if water levels exceed predictions, particularly above cleared zones, what the extent and impact of additional debris and sediment loads would bring to the river system.

The current amendment discussed the timing of commissioning the first and second turbines. However, it is unclear when turbine units 3–7 will be commissioned, how this will affect water levels and discharges, and how timing relates to biologically significant periods (e.g., Lake Sturgeon spawning).

4.0 Conclusions

DFO Science recognizes the amount of baseline work that the Proponent has conducted to describe the impacts of change in timing of the water-up and impoundment. The objectives of this review were to evaluate the Proponent's predicted hydrodynamic model outputs, identify other potential impacts that may occur with winter impoundment, review the proposed mitigation and monitoring measures, and lastly, if necessary, recommend additional information needed to complete the assessment. More specifically, the review detailed in this Science Response concluded the following:

- The major concern is that hydrodynamic modeling was performed for open-water conditions but applied to under ice scenario to identify the changes in water levels at different impoundment stages and the approximate extent of areas that would be affected.
- Due to the uncertainty in the accuracy of the model calibration and simulation results, as discussed in detail above, there is low confidence in the accuracy of the predicted water surface elevations, particularly in the vicinity of the steep bed slope upstream of Birthday Rapids downstream to Gull Lake. In the absence of a suitable model, real-time monitoring would also effectively allow for adaptive management and improved response time.
- Concerns of impounding in late March/early April are centered around ice conditions, water levels, and their impacts on fish and fish habitat. In particular, the potential for negative impacts to two year classes of fall/winter spawning fishes (i.e., the existing overwintering

eggs, and the 2020 fall spawning activity) is beyond the original impacts predicted in the EIS. Effects of inducing extensive fish movement on fitness and potential survival during the end of their overwintering periods, when fish are lethargic and have minimal energy reserves, are also of concern.

- The Proponent has negated any concerns about the impact of the timing of impoundment on increased ice scouring, erosion, debris, and sediment loads and its potential impact on fish and fish habitat, due to weak ice and frozen ground at the time of impoundment. DFO Science is uncertain of this assertion and recommends that sediment/debris loading should be monitored during impoundment and a mitigation plan be identified should these factors become of concern.

5.0 Contributors

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(March 10, 2020)

7.0 Sources of information

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