Keeyask Generation Project

Environmental Impact Statement

Supporting Volume

Physical Environment

KEEYASK

Hydropower Limited Partnership

June 2012

KEEYASK GENERATION PROJECT

PHYSICAL ENVIRONMENT

SUPPORTING VOLUME

SENSITIVITY OF EFFECTS ASSESSMENT TO CLIMATE CHANGE

June 2012

KEEYASK
Hydropower Limited Partnership

This page is intentionally left blank.

TABLE OF CONTENTS

This page is intentionally left blank.

11.0 SENSITIVITY OF EFFECTS ASSESSMENT TO CLIMATE CHANGE

11.1 INTRODUCTION

The preceding sections of the Physical Environment Supporting Volume (PE SV) have described the **effects** of the Keeyask Project on the various components of the physical **environment**. This section will discuss the sensitivity of these assessments to climate change.

11.2 APPROACH AND METHODOLOGY

As discussed in Section 2.0 (Climate), scenarios of projected climate change were described for future 30 year average periods: for the 2020s (average of 2010-2039), the 2050s (2040-2069), and the 2080s (2070-2099). In general, the climate in the region of the **Project** is expected to become warmer, especially in the winter period, and precipitation is expected to increase, again especially in the winter periods. Annual temperatures in the region are projected to increase by about 1.5°C in the 2020s, 2.8°C in the 2050s and 4.1°C in the 2080s. Precipitation is expected to increase by about 6%, 11% and 16% in the 2020s, 2050s and 2080s, respectively. Along with projected changes in temperature and precipitation, annual **evapotranspiration** is expected to increase over time due to climate change; however, the projections for evapotranspiration do not. No quantitative information is available on changes in the frequency or severity of future storm events and high wind conditions but some information suggests the frequency of extreme events will likely increase.

The CEAA document, "General Guidance for Practitioners: Incorporating Climate Change in Environmental Assessments" (CEAA 2010) proposes that the future climate conditions be reviewed to determine if there is a risk to the public or the environment in situations where the Project is the major factor. The physical environment assessments and the conclusions on **residual effects** were reviewed to determine if these conclusions would change as a result of climate change effects.

The examination of the sensitivity to climate change focused on the operations phase as the **construction** period will take place in the near term and climate change is a longer term phenomenon.

As discussed in earlier sections of this supporting volume, the effects of the Project on the physical environment are largely driven by the changes to the surface water and **ice regimes** resulting from this Project. Therefore, the approach to the sensitivity considerations began by reviewing the sensitivity of the future surface water and ice regimes to changes in climate. The examination of the other components of the physical environment built on this understanding.

11.3 SURFACE WATER AND ICE REGIME

The average projections of climate change for the 2020s, 2050s and 2080s indicate increasing temperatures and precipitation for the local region around Gillam. Increased temperatures can affect evapotranspiration, surface runoff and ice regimes, and other characteristics of the physical environment. For this sensitivity analysis, the potential for higher temperatures was considered with respect to ice formation and melting patterns.

Higher precipitation usually results in higher runoff and stream **flows**. Higher local precipitation can increase the flow in the local streams. On a local basis these effects may offset the anticipated higher evapotranspiration rates resulting from increased air temperatures. The local **inflows** are a very small part of the Nelson River **watershed**, which extends into Alberta, Saskatchewan, Manitoba, Ontario, Minnesota and North Dakota.

The overall effect of climate change on the Nelson River flows is currently under review and the information is not available at this time. Due to the absence of information on climate change **impacts** to Nelson River flows, a variability of ±10% has been introduced to the post-Project inflows in order to conduct a sensitivity analysis.

The approach to judging the sensitivity of the water and ice regime to climate change considered the following steps:

1. Consider the climate change scenarios for the future.
2. Assess how local precipitation and temperature changes might affect water and ice regimes.
3. Conduct a sensitivity analysis of changes to water and ice regimes resulting from increased and decreased Nelson River flows.

In the future, it is expected that hydrologic **modelling** will be done by Manitoba Hydro across the entire Nelson River watershed to test how precipitation and temperature scenarios might affect local inflows and how changes to Nelson River inflows might translate to changes in the Split Lake **outflows**.

The assessment of residual effects of the Project on the surface water and ice regimes are relatively unaffected by potential climate changes as described in the following observations:

- Construction is expected to take place within the next decade, therefore, future climate change is not a factor in altering predicted effects in this phase of the Project.
- Upstream **water regime**:
  - Increased river flows will not change effects of Keeyask on Split Lake as the open water **hydraulic zone of influence** remains downstream of the lake. Decreased river flows could result in an increased frequency of very low river flows in winter, which would cause small (about 0.2 m) increases in winter water levels in Split Lake above those which occur without the Project due to the change in ice processes in the reach after the Project is built (see Section 4).

- The **reservoir** operating range of 158 m to 159 m would not change with either an increase or decrease in Nelson River flows. Higher flows would result in a higher frequency of water levels in the upper part of this operating range and reduced daily fluctuations within the operating range. Lower river flows would result in more frequent fluctuation within the 1 m operation range.
- The flooded area of the reservoir would be slightly larger if high flow events were to increase by about 10% and, conversely, if low flows were to decrease by 10%, then the reservoir area would be slightly smaller during these low flow events.
- There will be minimal changes to local stream **backwater effects** from the reservoir for increased or decreased Nelson River flows. The extent of the hydraulic zone of influence in the creeks would be relatively unaffected by changes in creek flows.
- There will be minimal changes to the river **velocity** patterns with either an increased or decreased river flow scenario.

- Downstream water regime:
  - Use of the **spillway** could increase from about 11% to 18% of the time with a 10% increase in river flow, resulting in more frequent wetting of the area downstream of the spillway. Conversely, decreased river flows could result in spillway use decreasing from about 11% to 5% of the time and an associated reduction in the frequency of wetting of the area downstream of the spillway.
- Ice regime:
  - Increased temperatures will result in later formation of an ice cover, potentially delaying it several weeks by the 2080s, and a similar result could be expected in regards to ice breakup which could occur up to several weeks earlier. By the 2050s, the winter ice period may be shorter by 2 to 4 weeks and, by the 2080s, by about 4 weeks.
  - The ice that does develop will likely be somewhat thinner and the location of pressure ridges may change. Increased snowfall could also result in an increase of slush ice on top of the ice cover. These effects are capable of being mitigated with the use of the safe trails program (see Project Description Supporting Volume (PD SV)).

In summary, the residual effects assessment of the surface water and ice regime is not particularly sensitive to likely future changes in climate. This is largely due to the fact the reservoir operating range of 158-159 m remains unchanged, regardless of the Nelson River flows and thus the effects of the Project on the water and ice regimes are relatively unaffected by climate change. There is a low risk of material changes to the water and ice regime assessments due to climate change because the relevant hydraulic and ice models are highly credible and supported by a substantial body of hydrometric data.

The implications of these minor variations in the residual effects of the Project on the water and ice regime resulting from climate change will be used to discuss potential associated changes in the residual effects assessments in the other physical environment sections.

11.4 SHORELINE EROSION PROCESSES

Most of the mineral bank **erosion** and effects on peatlands are expected to occur early in the operating phase (*i.e.,* Years 1 to 5) of the Project when climate conditions are still similar to the assumed conditions at the start of the Project. This observation, coupled with the fact that the operating range of the reservoir will not change, means that the conclusions regarding the residual effects of shoreline erosion are not substantially affected by climate change.

Some observations with respect to **peatland disintegration** and **mineral erosion** include the following:

- Resurfaced **peat**:
  - There will be little incremental response in this process due to climate change because changes in climate are small in the first few years of operation when most of the resurfacing occurs.
- Shoreline peat breakdown:
  - Small changes in climate at the start of the operating period are not expected to substantively change the predictions for the first 5 years of operation when the largest effects of peat shoreline breakdown occur.
  - Changes in climate could increase the rates of breakdown of shoreline peat (rates would be relatively low compared with the first few years of operation) and reservoir expansion could increase somewhat.
  - The overall conclusions with respect to the residual effects of shoreline peat disintegration do not change substantially as a result of climate change.
- Floating peat:
  - There could be a slight increase in the number of mobile peat mats if warmer climate conditions increase peat mat buoyancy, but the Waterways Management Program will mitigate such effects.
- **Organic** sediment:
  - The largest organic sediment loads are predicted to occur within the first 5 years of operation when climate change is small and loading is not expected to substantively change.
  - Additional peatland breakdown beyond Year 5 of operation could result in predicted organic sediment entering the reservoir sooner.
  - Additional expansion would occur primarily in inland areas in **backbays** where the peat would not be mobile.
  - Organic sediment due to potential additional expansion in back bay areas would have negligible effects on the reservoir.

- Mineral shoreline erosion:
  - The range of conditions assumed for mineral erosion studies covers the potential ±10% change in flow and the assessed residual effects of the Project are not changed.
  - Higher flows and more frequent water levels in the upper part of the operating range would result in higher shoreline recession rates closer to the upper end of the predicted range (*i.e.,* predicted effects with base loaded operation) but the overall extent of recession is not expected to change.
  - Additional peatland breakdown in later years could result in mineral shorelines developing sooner in affected locations. Long-term, stable mineral shoreline recession rates could be established sooner at these locations.
  - Higher wave energy caused by increased severity of storms due to climate change would result in higher wave energy during storm events that may occur less frequently. These changes are expected to be most pronounced after long term erosion rates have been established and are not expected to affect long term rates. In localized areas increased storm activity may result in long term rates being established sooner.
- Ice conditions:
  - Longer ice-free conditions could result in more wave-based erosion of mineral shorelines in the reservoir.
  - This potential influence is lowest in the early years of Project operation when erosion rates are highest and changes in climate are smaller.
  - Erosion rates stabilize over time and climate changes are not expected to substantially affect long-term erosion rates.
  - Climate change would not be expected to affect erosion rates in the **riverine reach** upstream of Birthday Rapids owing to the largely **bedrock**-controlled shorelines in this reach.

Overall, the assessment of residual effects of the Project on mineral shoreline erosion and peatland disintegration are not predicted to change as a result of climate change.

11.5 SEDIMENTATION

Shoreline erosion and peatland disintegration are key factors in the **sedimentation** processes as both cause sediment to enter the water. Climate change is not expected to substantially change the residual effects assessment for the Project with respect to shoreline erosion and peatland disintegration, primarily because the largest effects occur in the first few years of operation when changes in climate are smaller. Accordingly, this conclusion applies also to sedimentation.

Organic suspended sediment **concentrations** in the first five years of operation would not substantively change. Although peat shoreline breakdown may be larger than predicted after Year 5 of operation, the overall average concentrations of organic suspended sediment are expected to remain very low within the main reservoir area, as predicted without climate change. Areas of potential additional inland expansion could have increased organic suspended sediment concentrations in those areas where breakdown may occur. Climate change is not expected to substantively change the residual effects assessment because the largest effects occur in the first few years of operation and are very low in later years.

Nelson River flow conditions similar to the +10% scenario have been observed in the open water months of 2005-2007. These data were considered in the assessment of **total suspended solids**. The creeks do not contribute substantially to the total sediment load in the river, so changes in local runoff due to climate change would not be expected to affect turbidity. The highest loads and deposition rates of mineral sediment would still occur in the early years of operation. If additional peat breakdown in later years results in mineral sediment loads from shoreline erosion to stabilize at long-term rates sooner, then lower long-term deposition rates would occur sooner. Changes in future wind conditions have not been predicted but, if climate change results in higher wind speeds it could cause increased frequency of short-term resuspension of **nearshore** sediment.

Overall, the assessment of residual effects for sedimentation and changes to lake/river substrates is not predicted to change as a result of climate change.

11.6 GROUNDWATER

The **groundwater** table will rise as a result of the reservoir. The average groundwater level is predicted to rise 0.3 m or more along the reservoir shoreline and within the new and existing islands within the reservoir. The lateral extent of the affected shoreline area is predicted to be no more than 500 m, depending on the location. The groundwater flow direction will not change due to the Project. Increased temperature and precipitation may result in some melting of **permafrost** in the area. This could increase recharge rates to the **water table** and widen the affected groundwater area but probably no more than about 2%, and this may be offset somewhat by increased evapotranspiration.

Overall, the conclusions on residual effects of the Project on groundwater are not changed by climate change.

11.7 SURFACE WATER TEMPERATURE AND DDISSOLVED OXYGEN

The effects of the Project on **dissolved oxygen** and water temperature were assessed by modelling a range of scenarios of expected conditions and sensitivity analyses using conservative model inputs. Model results showed that Project effects are confined to the new reservoir area upstream of the Project to Birthday Rapids. The temperature of the water entering the reservoir from upstream may increase due to climate changes in the Nelson River **basin** upstream of the Project area. Water temperature changes would likely increase with increased air temperature but at a reduced rate: water temperature increases would likely be no more than about two-thirds to three-quarters of the air temperature increase.

Model predictions showed water temperatures and dissolved oxygen levels in the main stem of the Nelson River were not affected by the Project and this conclusion would not change as a result of climate change.

Water temperatures in the backbays are predicted to be higher than in the main stem and these differentials will likely continue to occur with climate change as warmer climate conditions increase back-bay water temperatures. As with the inflow, the backbay water temperatures would likely reflect changes in average air temperatures but at a reduced rate.

Dissolved oxygen levels in the backbays are predicted to periodically be low in summer periods with hot weather and low wind when high oxygen demands and low reaeration cause DO to be reduced. Increased water temperatures due to climate change could cause low DO concentrations to occur with greater frequency over a larger area. Increased organic suspended solids may also increase the biochemical oxygen demands due to suspended organics, but modeling showed that overall conclusions with respect to dissolved oxygen are not particularly sensitive to even relatively large increases in biochemical oxygen demand. Sediment oxygen demands would still decrease gradually over time. Overall, oxygen demands are still greatest in the early years of operation and decline over time while climate change effects are small initially and increase over time. Wind is a major factor affecting DO concentrations in backbays. Climate change effects on wind were not predicted. However, if average winds increase, the frequency and extent of low DO during low wind periods would decrease, and the opposite would be true if winds decrease. Increasing temperatures in backbay areas and areas of potential additional expansion could cause dissolved oxygen to decrease further over larger areas during infrequent periods of low wind speeds.

Due to the winter ice cover, backbay DO concentrations are expected to decrease over time from initially high levels at the beginning of winter and then stabilize at lower levels through the ice cover period. DO concentrations would recover to high levels in spring when the ice melts. Later ice formation and an earlier melting due to climate change would correspondingly cause a delay in the winter DO decline and earlier DO recovery in spring. While the **duration** of low DO conditions in winter would decrease along with the shorter period of ice cover, the extent and severity of low DO concentrations would not change since a relatively stable low DO condition would still develop each winter.

Overall, the residual effects conclusions with respect to dissolved oxygen and water temperature are not materially changed due to climate change.

11.8 PHYSIOGRAPHY

The **physiography** in the area will be affected by the Project due to the construction of principal structures and supporting infrastructure (roads, quarries, **borrow areas**, etc.). Some of these changes are permanent. In general, climate change will not change these effects. There may be changes in the future regional physiography due to climate change (see Terrestrial Effects Supporting Volume (TE SV)), especially with respect to permafrost, but these changes will not be caused or impacted by the Project. Increased shoreline peatland disintegration due to climate change would correspondingly increase the footprint of the Project. The assessed residual effects of the Project are not materially affected due to climate change.

11.9 AIR QUALITY AND NOISE

The effects of the Project on air quality and noise relate mainly to the construction phase. The change in climate in the relatively near future are not expected to change the effects assessment on air quality and noise. Climate change will not affect the noise conclusion. The larger open-ice intervals in future winter conditions could result in somewhat greater production of ice fog in the Project area.

11.10 DEBRIS

There will be minimal woody **debris** caused by the Project due to the clearing of the reservoir in advance of impoundment. Peat is expected to be mobilized into the reservoir, particularly in the early stages of operation. Climate change will not affect these conclusions and there is a comprehensive Waterways Management Program to manage debris in the operations phase to deal with debris due to reservoir expansion, whether it is greater or less than predicted.

11.11 SUMMARY/CONCLUSIONS

A review of the conclusions of the Project's residual effects on the physical environment indicates that the assessment is not sensitive to climate change. The robustness of the conclusions is largely due to two factors. First, the water regime within the hydraulic zone of influence and the reservoir operating range are not substantially changed when considering climate changes. Second, the largest effects of the Project on the physical environment occur early in the operating period when climate changes are small. Overall, the residual effects of the Project are not substantially affected as a result of projected changes in future climate conditions.

11.12 REFERENCES

Canadian Environmental Assessment Agency (CEAA). 2010. Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners [online]. Available from http://www.ceaa.gc.ca/default.asp?lang=En&n=A41F45C5-1 [accessed February 17, 2012].

This page is intentionally left blank.