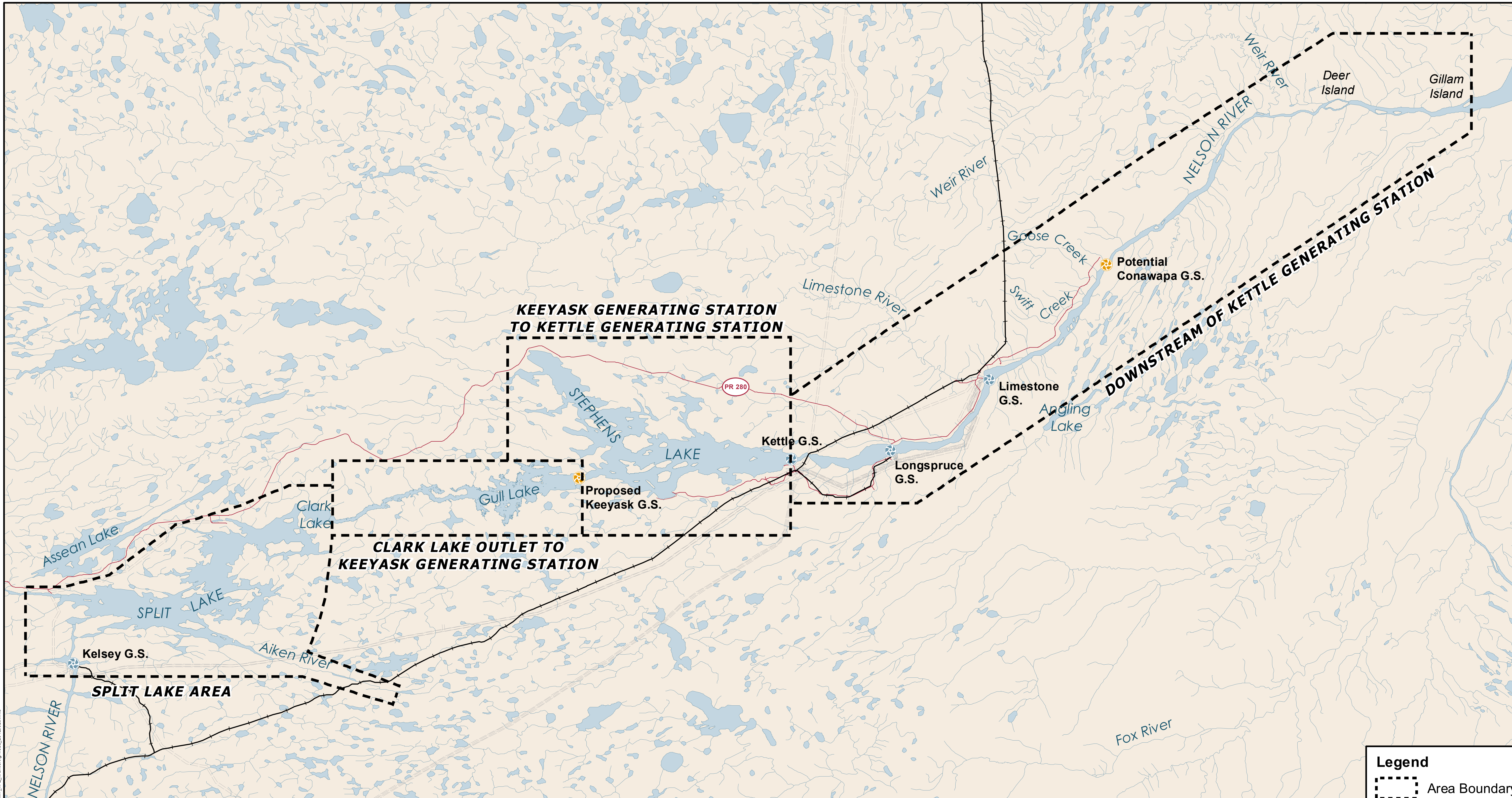


KEEYASK Hydropower Limited Partnership

0 25 50 Kilometres

0 10 20 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:500 000

Water Quality Monitoring Areas

capture the extent of effects. Sampling locations along the gradient should represent different exposure levels (e.g., within the mixing zone vs. fully mixed river condition). The hybrid design allows for statistical testing for effects in the area immediately downstream of construction activities and also provides an estimate of the spatial extent of effects.

Effects will be evaluated through statistical comparisons of key parameters between reference and exposure locations during each sampling event and to pre-Project baseline data. Water quality data will also be compared to MWQSOGs and CCME guidelines for the protection of aquatic life (PAL), Health Canada guidelines for drinking water, and any regulatory requirements specified in environmental approvals for the Project. As previously noted, water quality data collected under CAMP at locations in the region will be considered to provide context for observed changes.

An *a priori* power analysis (Environment Canada 2011) will be completed for key water quality parameters (selected based on predictions described in the EIS) to determine the appropriate level of sampling effort (i.e., the number of sites per area) required for the conduct of a reasonably statistically robust sampling design. Results from this assessment will be used to further refine the sampling prior to implementation.

2.1.2.3 Parameters

Surface water samples will be collected and submitted to a Canadian Association for Laboratory Accreditation Inc. (CALA) accredited analytical laboratory for analysis for the parameters indicated in Table 3. *In situ* measurements of pH, temperature, specific conductance/conductivity, turbidity, DO, and water depth will be collected from each site.

2.1.2.4 Sampling Sites

Sampling sites will be located along the Nelson River, starting at sites upstream of construction activities (i.e., Aiken River, Split Lake, Clark Lake and the Nelson River and continue through Stephens Lake. Sampling in Split and Stephens lakes will generally occur at sites established during baseline studies. Water quality will also be sampled at baseline sites along the Nelson River mainstem, and in the vicinity of construction activities, as close as feasible considering safety and logistics, as well as downstream in the fully mixed zone. The precise location of sites in the vicinity of construction activities will be determined during the initial monitoring.

During the initial one or two rounds of intensive instream construction, water quality sampling will extend downstream to the estuary, but may be scaled back in subsequent rounds if effects are not detected.

Specific locations will be chosen to minimize physical variation among sites to the extent possible. The number of replicates collected at each sampling location will be determined based on the results of the power analysis described in the sampling design.

Table 3. Laboratory water quality parameters that will be monitored during Project construction.

Parameter	Units	Parameter	Units
Total Kjeldahl nitrogen	mg/L	Total mercury	mg/L
Ammonia	mg/L	Dissolved mercury	mg/L
Nitrate/nitrite	mg/L	Total methylmercury	mg/L
Total phosphorus	mg/L	Dissolved methylmercury	mg/L
Total dissolved phosphorus	mg/L	Aluminum (Al)-Total	mg/L
Orthophosphate-Dissolved	mg/L	Antimony (Sb)-Total	mg/L
Total organic carbon	mg/L	Arsenic (As)-Total	mg/L
Dissolved organic carbon	mg/L	Barium (Ba)-Total	mg/L
Total suspended solids	mg/L	Beryllium (Be)-Total	mg/L
Turbidity	NTU	Bismuth (Bi)-Total	mg/L
True Colour	TCU	Boron (B)-Total	mg/L
Conductivity	µmhos/cm	Cadmium (Cd)-Total	mg/L
Total dissolved solids	mg/L	Calcium (Ca)-Total	mg/L
Hardness	mg/L	Chromium (Cr)-Total	mg/L
pH	-	Cobalt (Co)-Total	mg/L
Alkalinity, Total (as $CaCO_3$)	mg/L	Copper (Cu)-Total	mg/L
Bicarbonate (HCO_3)	mg/L	Iron (Fe)-Total	mg/L
Carbonate (CO_3)	mg/L	Lead (Pb)-Total	mg/L
Hydroxide (OH)	mg/L	Magnesium (Mg)-Total	mg/L
Chloride	mg/L	Manganese (Mn)-Total	mg/L
Sulphate	mg/L	Molybdenum (Mo)-Total	mg/L
Chlorophyll *a*/pheophytin *a*	µg/L	Nickel (Ni)-Total	mg/L
		Potassium (K)-Total	mg/L
Benzene	mg/L	Selenium (Se)-Total	mg/L
Toluene	mg/L	Silicon (Si)-Total	mg/L
Ethyl benzene	mg/L	Silver (Ag)-Total	mg/L
Xylene	mg/L	Sodium (Na)-Total	mg/L
F1 Hydrocarbons (C6-C10)	mg/L	Strontium (Sr)-Total	mg/L
F2 Hydrocarbons (C10-C16)	mg/L	Thallium (Tl)-Total	mg/L

Table 3. Laboratory water quality parameters that will be monitored during Project construction.

Parameter	Units	Parameter	Units
F3 Hydrocarbons (C16-C34)	mg/L	Thorium (Th)-Total	mg/L
F4 Hydrocarbons (C34-C50)	mg/L	Tin (Sn)-Total	mg/L
		Titanium (Ti)-Total	mg/L
		Tungsten (W)-Total	mg/L
		Uranium (U)-Total	mg/L
		Vanadium (V)-Total	mg/L
		Zinc (Zn)-Total	mg/L
		Zirconium (Zr)-Total	mg/L

2.1.2.5 Sampling Frequency and Schedule

Core water quality monitoring will be conducted prior to, during, and following major instream construction activities, most notably those that are predicted to result in measureable changes in TSS at the end of the mixing zone. As the construction schedule will not be finalized until after the selection of contractors, the precise timing and frequency of monitoring cannot be identified at this time. Additional monitoring, at a minimum once in winter and once in the open-water season of each year of construction, will be conducted in years without intensive instream construction, to monitor for unforeseen effects. This sampling will occur at similar times each year to allow for between-year comparisons .

2.1.2.6 Methods

In situ measurements will be collected using calibrated field meters. Samples of water will be collected by directly filling sample bottles (provided by the analytical laboratory) at approximately 30 cm below the surface at all sites. Depending on plume mixing and whether sampling within a plume can be conducted safely, samples will also be collected at depth (i.e., approximately 1 m from the sediments)..

2.1.2.7 Quality Assurance and Quality Control

A Quality Assurance/Quality Control (QA/QC) plan will be developed prior to program implementation and will outline the planning, implementation, and assessment procedures to be used in order to apply specific QA/QC activities and criteria to the AEMP. As indicated, water quality samples will be submitted to an analytical laboratory that is accredited under CALA.

2.1.3 Specific Effects Monitoring

Additional water quality monitoring will be conducted, as required, in association with activities that may have more localized effects, such as discharge of point sources (e.g., concrete batch plant discharge) and construction of water intakes, boat and barge landings, haul road crossings, and stream crossings along the south access road. Monitoring of wastewater treatment plant discharge and settling pond effluent prior to release is addressed in the Keeyask GS EnvPP.

Information is currently not available to identify the locations of all point sources, but in general, monitoring will involve sample collection upstream and downstream of the input and/or before, during and after the release of effluents. In general, monitoring will be conducted along a gradient (i.e., increasing distance from the construction site or point source) and in relation to an upstream reference point, where feasible. Detailed plans cannot be provided at this time as specific construction plans for these small works have not been developed. Targeted monitoring using a similar approach (i.e., transect or gradient design) would also be conducted in association with small instream construction activities (e.g., water intake construction).

2.2 MONITORING DURING OPERATION

The following presents the design, rationale, and methods for surface water quality monitoring during the operation phase of the Project.

2.2.1 Pathways of Effect and Key Questions

Predicted effects of Project operation are expected to be greatest in flooded, isolated backbays in the reservoir, with small changes expected along the main flow of the Nelson River (upstream in the reservoir and downstream of the GS). In brief, flooded backbays are expected to experience reduced DO concentrations (notably in winter under ice cover), lower pH, reduced water clarity, and increased concentrations of nutrients, colour, TSS/turbidity, total dissolved solids (TDS)/conductivity, organic carbon, and metals. These effects will be greatest during the initial years after impoundment of the reservoir to the FSL and will decline notably thereafter. Water quality conditions in these backbays are expected to stabilize within 10–15 years.

Small and few changes in water quality are expected along the main flow of the Nelson River, either upstream of the GS in the reservoir or downstream of the GS. The primary effect on water quality along the main flow of the river is predicted to be reductions in TSS concentrations in the reservoir and downstream in Stephens Lake. Some variables that are correlated to TSS, such as total phosphorus (TP) and some metals, may also slightly decrease in these areas in association with deposition of suspended solids.

Key questions that will be addressed through water quality monitoring during the operation phase are:

- Does Project operation result in exceedances of water quality objectives or guidelines for the protection of aquatic life?
- Will the Project result in exceedances of drinking water quality guidelines?
- What are the magnitude and spatial extent of effects of operation on water quality?
- Are there seasonal differences in effects on water quality?

2.2.2 Core Monitoring

2.2.2.1 Monitoring Area

Core sampling for the operation phase includes the Keeyask reservoir and Stephens Lake, as these areas capture the predicted spatial extent of effects on water quality during operation. However, monitoring will also be conducted upstream of the Keeyask reservoir in an area that, based on technical assessments, is not predicted to be affected by water level and flow changes attributed to the Project (the Aiken River to address YFFN concerns and Split Lake) and sites along the Nelson River downstream of Stephens Lake. Similarly, the north basin of Stephens Lake is relatively isolated from the main flow of the Nelson River that runs along the southern area of the lake and will be monitored to confirm the predictions that this area will not be affected and to provide additional reference area monitoring information. Periodic monitoring downstream of Stephens Lake is included to confirm the impact assessment predictions that water quality in this area will not be affected.

2.2.2.2 Sampling Design

Section 2.1.2 provides a description of sampling design, the approach for evaluation of potential Project-related effects, and the assessment of water quality data to characterize existing variability in measured parameters.

2.2.2.3 Parameters

The monitoring program will include collection of samples for laboratory analysis and measurement of *in situ* water quality conditions. Laboratory variables will include pH/alkalinity, nutrients, TSS/turbidity, true colour, organic carbon, metals, and conductivity/TDS (see Table 4 for details). Samples for the analysis of chlorophyll *a* and phytoplankton community composition will also be collected during the water quality monitoring programs. *In situ* monitoring will include measurement of temperature, specific conductance, pH, turbidity, and total water depth. In addition, turbidity and TSS will be monitored using *in situ* data loggers deployed upstream and downstream of the GS, as described in the PEMP.

Table 4. Laboratory water quality parameters that will be monitored during Project operation.

Parameter	Units	Parameter	Units
Total Kjeldahl nitrogen	mg/L	Total mercury	mg/L
Ammonia	mg/L	Dissolved mercury	mg/L
Nitrate/nitrite	mg/L	Total methylmercury	mg/L
Total phosphorus	mg/L	Dissolved methylmercury	mg/L
Total dissolved phosphorus	mg/L	Aluminum (Al)-Total	mg/L
Orthophosphate-Dissolved	mg/L	Antimony (Sb)-Total	mg/L
Total organic carbon	mg/L	Arsenic (As)-Total	mg/L
Dissolved organic carbon	mg/L	Barium (Ba)-Total	mg/L
Total suspended solids	mg/L	Beryllium (Be)-Total	mg/L
Turbidity	NTU	Bismuth (Bi)-Total	mg/L
True Colour	TCU	Boron (B)-Total	mg/L
Conductivity	µmhos/cm	Cadmium (Cd)-Total	mg/L
Total dissolved solids	mg/L	Calcium (Ca)-Total	mg/L
Hardness	mg/L	Chromium (Cr)-Total	mg/L
pH	-	Cobalt (Co)-Total	mg/L
Alkalinity, Total (as $CaCO_3$)	mg/L	Copper (Cu)-Total	mg/L
Bicarbonate (HCO_3)	mg/L	Iron (Fe)-Total	mg/L
Carbonate (CO_3)	mg/L	Lead (Pb)-Total	mg/L
Hydroxide (OH)	mg/L	Magnesium (Mg)-Total	mg/L
Chloride	mg/L	Manganese (Mn)-Total	mg/L
Sulphate	mg/L	Molybdenum (Mo)-Total	mg/L
Chlorophyll *a*/pheophytin *a*	µg/L	Nickel (Ni)-Total	mg/L
		Potassium (K)-Total	mg/L
		Selenium (Se)-Total	mg/L
		Silicon (Si)-Total	mg/L
		Silver (Ag)-Total	mg/L
		Sodium (Na)-Total	mg/L
		Strontium (Sr)-Total	mg/L
		Thallium (Tl)-Total	mg/L

Table 4. Laboratory water quality parameters that will be monitored during Project operation.

Parameter	Units	Parameter	Units
		Thorium (Th)-Total	mg/L
		Tin (Sn)-Total	mg/L
		Titanium (Ti)-Total	mg/L
		Tungsten (W)-Total	mg/L
		Uranium (U)-Total	mg/L
		Vanadium (V)-Total	mg/L
		Zinc (Zn)-Total	mg/L
		Zirconium (Zr)-Total	mg/L

2.2.2.4 Sample Sites

Sampling areas will include areas on the main flow of the river and representative backbays in the reservoir, areas in Stephens Lake (including the southern and northern areas of the lake), and areas upstream of the reservoir (i.e., the Aiken River and Split Lake). During the first year of operation monitoring, water quality sampling on the Nelson River will extend downstream to the estuary; if no effects are observed, this sampling will be scaled back in future years.

Where feasible, monitoring will be conducted at sites monitored during construction, with the addition of new sites in flooded areas. The number of replicate sites within each of these areas will be determined through the conduct of a power analysis. Sites representative of the flooded backbays and mainstem areas in the reservoir will be monitored across multiple AEMP components (water quality, aquatic habitat, lower trophic levels, and fish community) to allow for an integrated analysis of observed changes.

2.2.2.5 Sampling Frequency and Schedule

Water quality will be monitored annually for the first ten years of Project operation; the frequency and nature of the monitoring program after ten years will be determined based on results at that time (see Section 1.2). Sampling frequency would include multiple sampling periods in the open-water season (over the period of June-October) and one sampling period in late winter (i.e., February/March) during the initial three years of operation. As Project operation is predicted to cause notable decreases in DO in isolated flooded backbays in winter, a second winter sampling event would be conducted in early winter the first year after full impoundment; results of this winter DO monitoring would be reviewed and considered in terms of modification to the monitoring program in subsequent years.

2.2.2.6 Methods

In situ measurements will be collected using a calibrated field meter; incremental depth profiles of *in situ* parameters will be obtained in low velocity areas, including but not limited to lentic areas of the reservoir and lakes. Samples of water would be collected by directly filling sample bottles (provided by the analytical laboratory) at approximately 30 cm below the surface at all sites. Samples will also be collected at approximately 1 m above the sediments using a van Dorn or Kemmerer water sampler at sites located in flooded backbays and from the north arm of Stephens Lake.

2.2.2.7 Quality Assurance / Quality Control

See Section 2.1.2.7.

2.2.3 Specific Effects Monitoring

In addition to the monitoring described in Section 2.2.2, a specific effects monitoring program will be conducted to assess effects of Project operation on DO in the Keeyask reservoir to provide supporting information for biological monitoring. As the effects of the Project on DO and other attributes of the aquatic environment are predicted to be greatest during the initial years of operation, this program is proposed for the first three years of operation, with the frequency of subsequent DO-focused monitoring to be determined based on results collected in the initial three years of operation.

The program will involve collection of measurements of DO and temperature across the water column at a more extensive number of sites in representative flooded backbays in late winter to provide a detailed description of conditions during this season. Sites will be selected to include various water depths and substrates, including flooded organic materials. Measurements will be collected with a calibrated field meter.

3.0 AQUATIC HABITAT

Aquatic habitat provides the environment in which aquatic biota live, as defined by water depth, velocity and substratum, as well as structure, including non-living and living (rooted plants) components. Monitoring will record the development of existing aquatic habitat that is altered by the Project (e.g., increased water levels), the evolution of flooded terrestrial habitat into productive aquatic areas, and assess conditions on mitigation and compensation structures.

Information related to aquatic habitat will also be collected as part of the Physical Environment Monitoring Program (PEMP), including water depth, water velocity, and water level fluctuation. Other activities in the PEMP, such as monitoring ice regime, erosion of mineral and peat shorelines, and rate of mineral and organic sediment deposition, will be used to complement the aquatic habitat monitoring program.

3.1 MONITORING DURING CONSTRUCTION

No monitoring of aquatic habitat prior to impoundment of the reservoir to the full supply level is proposed. Potential effects on substrate composition related to the deposition of sediments released during instream construction will be assessed during the initial round of monitoring after the reservoir is impounded and instream construction is complete. Likewise, habitat changes due to water level changes that begin in the reservoir during construction will be monitored after impoundment is complete.

3.2 MONITORING DURING OPERATION

The core aquatic habitat monitoring program consists of monitoring to:

- Describe the development of nearshore habitat, including areas that would be suitable for the growth of aquatic macrophytes in the Keeyask reservoir; and
- Document changes in substrate composition upstream and downstream of the GS.

A specific effects monitoring program will monitor potential deposition of sediment over constructed and sensitive habitats. A specific effects program will also assess potential blockage of fish access to tributaries.

3.2.1 Pathways of Effect and Key Questions

Upstream of the GS, the development of nearshore habitat and areas suitable for aquatic macrophytes depends primarily on changes in water level, exposure, the type of pre-flood soils, and the processes of erosion, transport, and deposition of sediments. The evolution of substrate composition in deep water within the newly formed reservoir depends mostly on the pattern of water velocities that develop within the reservoir, and how the processes of erosion, transport, and deposition of sediments in the river channel maintain or alter the existing substrate.

Potential effects on aquatic habitat downstream of the GS include the deposition of fine sediments over existing cobble and gravel substrate in the channel area and the existing sand lens in upper Stephens Lake.

The key questions for monitoring during operation are:

- How will nearshore habitat develop in the Keeyask reservoir?
- How will aquatic macrophyte habitat develop in the Keeyask reservoir?
- How will substrate composition change over time in the Keeyask reservoir and downstream of the GS?
- Is substrate composition on constructed habitats suitable for spawning by lake sturgeon and other species or will it change over time due to the deposition of sediments?
- Will the substrate composition in sensitive habitats (e.g., areas where young lake sturgeon presently occur in Gull Lake and Stephens Lake) and in areas that may become sensitive habitats (based on changes in velocity) remain suitable or will they change over time due to the deposition of sediments?

3.2.2 Core Monitoring

3.2.2.1 Development of Nearshore and Aquatic Macrophyte Habitat

3.2.2.1.1 Monitoring Area

The monitoring area will extend from Birthday Rapids to the upper portion of Stephens Lake (Map 5).

3.2.2.1.2 Sampling Design and Methods

Changes in the characteristics of nearshore areas will be assessed using boat-based reconnaissance of randomly selected sites using a stratified sampling design within areas of mineral soil, thin peat over mineral soil, and deep peat. The sites visited during the first survey will be large enough to allow transect replication, and sampling will be repeated at these sites as the Keeyask reservoir ages to describe the evolution of reservoir nearshore habitat. Transects will be perpendicular to the shoreline and will extend below the maximum recorded photic zone (relative to the minimum operating level of 158 m) to document any changes in topographic profile and bed composition. Substrate composition, water velocity, water surface elevation, and bed elevation along each transect will be sampled using GPS and hydroacoustic technologies. A Ponar and/or Ekman dredge will be used to validate the sonar data. The entire set of replicate transects will be mapped at high detail using acoustic and geographic information systems software.

When the first signs of rooted plant growth are present in the reservoir, aquatic macrophyte sampling will be conducted along the substrate transects. Later, possibly fifteen years after impoundment to FSL, remote sensing and validation with a helicopter (methods consistent with those used during environmental assessment studies; see AE SV Appendix 3C) may be used to determine the areas occupied by plants relative to the potential habitat that is available. As a reference for the development of aquatic macrophyte habitat in the Keeyask reservoir, aquatic macrophyte habitat in Stephens Lake will

KEEYASK
Hydropower Limited Partnership

0 2.5 5 7.5 10 Kilometres
0 1.25 2.5 3.75 5 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000
Nelson River Shoreline modelled by Manitoba Hydro.
Extents of dewatered area are estimated based on the existing environment 95th percentile flow.

Aquatic Habitat Monitoring Area

continue to be monitored at a small number of sites. When the Keeyask reservoir attains a similar ratio of occupied to potential aquatic macrophyte habitat to that of Stephens Lake, or within system changes subside (i.e., no appreciable change in the area occupied by plants over time), the monitoring program will be discontinued.

The change in the location, shape, and area of aquatic macrophyte beds and the associated nearshore area will be documented using remote sensing approaches (see Larter 2010 and AE SV, Appendix 3B). Aerial reconnaissance will be used to determine agreement between the patterns observed at nearshore field sites and those evident around the reservoir as it ages, as well as to validate the remote sensing imagery.

3.2.2.1.3 Parameters

Parameters will include bed elevation, water surface elevation, substrate type (organic vs. mineral), substrate composition (percent grain size fraction), aquatic macrophyte species composition and abundance, and percent occupied to potential aquatic macrophyte habitat.

3.2.2.1.4 Sampling Sites

Representative locations along the shoreline of the Keeyask reservoir between Birthday Rapids and the GS will be sampled to monitor the evolution of the nearshore environment and the development of aquatic macrophyte habitat over both mineral and organic substrates. Sites in a representative backbay will be the same as monitored across multiple AEMP components (water quality, lower trophic levels, and fish community) to allow for an integrated analysis of observed changes. Downstream of the GS, the evolution of aquatic macrophyte habitat will be monitored at three to five sites in Stephens Lake.

3.2.2.1.5 Sampling Frequency and Schedule

Monitoring studies will begin when the reservoir attains the FSL for the first time in Year 5–6 of Project construction.

Nearshore habitat sampling will be conducted in each of the first three years after the FSL is first reached, and then at least once every three years until ten years post-impoundment. Monitoring may continue at a reduced frequency until 30 years post-impoundment, depending on results. Aquatic macrophyte surveys will be conducted in association with the nearshore habitat sampling, although it is expected that aquatic macrophyte habitat will take 5–15 years to develop. Aquatic macrophyte surveys will be undertaken at the same time as nearshore habitat sampling, in mid-to-late summer, when plant growth is most evident.

Sampling of aquatic macrophyte habitat in Stephens Lake will be conducted concurrently with sampling in the reservoir, although it will likely occur at a lower frequency.

3.2.2.2 Substrate Composition

Substrate composition will be monitored because of its importance as habitat to aquatic biota and its potential to change over time in the Keeyask reservoir and downstream of the GS.

3.2.2.2.1 Monitoring Area

The monitoring area will extend from the outlet of Clark Lake to approximately 7 km downstream of the GS.

3.2.2.2.2 Sampling Design and Methods

A systematic sampling design will be used to sample substrate composition in the Keeyask reservoir during the operation phase. A subset of the sites previously sampled to describe the existing environment (see AE SV Appendix 3A maps for channel sampling distribution) will be revisited, but sampling will also include new areas where change is expected to occur. New sampling sites will generally be selected based on substrate composition distribution predictions for 30 years post-impoundment. The results of water velocity sampling conducted as part of the PEMP will also be used to help select substrate composition sampling sites. Some new areas will be sampled at a greater density to record development of potential substrate boundaries that change from hard to soft.

Substrate composition downstream of the Keeyask GS and into Stephens Lake will also be monitored because of its importance to aquatic biota (e.g., YOY and sub-adult lake sturgeon). The sampling distribution will capture the material size gradient that transitions from coarse boulder and cobble to gravel and sand, then to silt, to a depth of about 20 m. The local heterogeneity of substrate material size in each area of the material size gradient will also be assessed.

Acoustic imaging methods (side scan and/or Didson) will be deployed at sites and/or along cross-sections of the reservoir and Nelson River channel between the Keeyask GS and Stephens Lake. Ponar grab samples will be used to validate the acoustic sampling in soft substrates. For sites that are hard bottomed and do not yield Ponar samples, the acoustic sampling will be validated using a weighted sounding line along transects to detect any fines in areas of coarse material. The primary metric used to assess substrate composition of Ponar samples collected at a given location will be material size, reported as percent grain size fraction. Sites selected for sonar and validation in the main channel and thalweg within Stephens Lake will be consistent with those presented in the AE SV (Appendix 3A).

3.2.2.2.3 Parameters

The parameters documented in the substrate composition monitoring program will include bed elevation, water surface elevation, and substrate composition (percent grain size fraction).

3.2.2.2.4 Sampling Sites

Within the Keeyask reservoir, the majority of the effort will be focussed on the reach between the entrance of present-day Gull Lake and the GS. Sampling will be conducted in areas that are presently aquatic habitat and in flooded terrestrial habitat. Downstream of the GS, substrate composition will be monitored at cross sections.

3.2.2.2.5 Sampling Frequency and Schedule

Monitoring studies that focus on the operation phase will begin when the reservoir attains the FSL for the first time in Year 5–6 of Project construction.

Annual substrate composition surveys will be conducted along the original mainstem of the Nelson River in the Keeyask reservoir during the first three years of operation. Six years post-impoundment, the monitoring program will be extended to include spatial sampling of all flooded habitat in the reservoir, less that already considered by the nearshore surveys described in Section 3.2.2. This spatial survey will sample substrate composition at least once every three years until review of the overall program ten years post-impoundment. The frequency of monitoring after this time will be determined based on the results of the substrate composition surveys and PEMP studies.

Sampling substrate composition below the Keeyask GS will be conducted in late summer in the first three years after impoundment. If substrate composition at that time is different from what was present in the existing environment, the next sampling period will be scheduled to follow a relatively high magnitude flow event. If, even after exposure to a high flow event, the substrate composition forms a pattern unlike that observed in the existing environment, and it no longer provides the same habitat function and use to aquatic biota, then measures to provide alternate habitat will be developed.

3.2.3 Specific Effects Monitoring

In addition to the monitoring described above, specific effects programs have been developed to address effects to small scale areas of habitat of particular importance, including sensitive sites for young-of-the-year (YOY) lake sturgeon and sites where mitigation/compensation (constructed habitats) has been applied.

3.2.3.1 Monitoring Area

The monitoring area will extend from the outlet of Clark Lake to approximately 7 km downstream of the Keeyask GS.

3.2.3.2 Sampling Design and Methods

Habitats constructed upstream and downstream of the GS will be assessed using acoustic imaging methods (e.g., QTC single-beam sonar system, side-scan sonar system), and photography (e.g., DIDSON camera, underwater video camera), to confirm the material size, composition, and area characteristics of the original design. Water surface elevation, water velocity, sediment deposition, and periphyton biomass will be measured at the constructed habitats; this information, together with results from the PEMP, will be used to assess spawning habitat suitability. Substrate composition in sensitive habitats (e.g., areas where YOY lake sturgeon presently occur in Gull Lake and Stephens Lake), and in areas that may become suitable for YOY lake sturgeon (based on changes in velocity), will be monitored to assess whether they remain/become suitable habitat.

Regular surveys will be conducted to ensure that fish access to tributary streams in the reservoir is not prevented by the accumulation of debris. These surveys will be conducted in coordination with the Waterways Management Program.

3.2.3.3 Parameters

Monitoring of constructed and sensitive habitats will require the collection of information on the following parameters: bed elevation; water surface elevation; water velocity; substrate composition (percent grain size fraction); and periphyton biomass. Monitoring of stream mouths will include a relative assessment of the amount of debris that could block fish access.

3.2.3.4 Sampling Sites

Sampling will be undertaken at constructed habitats upstream and downstream of the Keeyask GS. This will include deep and shallow spawning shoals constructed upstream of the Keeyask GS, the lake sturgeon spawning structure constructed in the Keeyask GS tailrace, and the lake whitefish spawning shoal downstream of the GS. Monitoring of substrate composition will also occur at sensitive habitats (e.g., areas where YOY lake sturgeon presently occur in Gull Lake and Stephens Lake), and in areas that may become sensitive habitats (based on changes in velocity).

Aquatic habitat will be monitored at all tributary confluences known to support large-bodied fish species.

3.2.3.5 Sampling Frequency and Schedule

Monitoring studies that focus on the operation phase will begin when the reservoir attains the FSL for the first time in Year 5–6 of Project construction.

Constructed and sensitive habitats will be monitored annually for the first three years after the reservoir is impounded and/or the constructed habitats are built. Monitoring after Year 3 would occur at least once every three years until ten years post-impoundment. Monitoring may continue at a reduced frequency until Year 30 post-impoundment, depending upon results of the monitoring. If unforeseen changes occur to constructed aquatic habitat, the frequency of that specific aspect of monitoring will increase. The monitoring program will first reaffirm/or not reaffirm the initial predictions and then identify if the unanticipated change is considered to be a positive or negative habitat attribute for the short or long term. If results demonstrate a long-term negative change and options at the site of habitat loss suggest the habitat could not be effectively regained, other sites will be identified. These site(s) would offset the loss in area, demonstrate the same or better habitat function, and will be selected based on a lower potential to develop the same undesirable characteristic.

4.0 AQUATIC MACROINVERTEBRATES

Benthic macroinvertebrates will be monitored during construction, and both benthic and drifting macroinvertebrates will be monitored during operation. In general, sampling locations will remain as consistent as possible throughout the construction and operation phases to facilitate comparisons with data collected during both phases of monitoring.

Aquatic macroinvertebrates are standard indicators of ecological integrity used in bio-monitoring programs worldwide. Similar to most biological indicators, macroinvertebrate community metrics (i.e., indices) are particularly valuable as they integrate environmental conditions over time. Aquatic macroinvertebrates are also an important food source for fish and integral in describing the quality of fish habitat available for key life stages. Sampling of drifting macroinvertebrates provides a replicable approach to sampling one aspect of the overall macroinvertebrate component during Project operation when other sampling techniques are not feasible due to safety and logistical considerations. It is recognized however, that drift samples in large rivers may not reflect local conditions. The species composition of drift is often different from that of the benthos and, as such, drift may not be a density-dependent function of the bottom fauna.

The monitoring program for aquatic macroinvertebrates relies upon a combination of statistical comparisons and professional judgement. Effects will be determined through comparison of data to upstream reference sampling sites (e.g., upstream-downstream comparisons in relation to relatively site-specific construction activities) and to pre-Project data (i.e., baseline data).

4.1 MONITORING DURING CONSTRUCTION

Construction monitoring will specifically address the biological effects of predicted increases in TSS on the benthic community due to in-stream work on the Nelson River, and will complement the water quality (Section 2.0) and aquatic habitat (Section 3.0) programs.

4.1.1 Pathways of Effect and Key Question

As discussed in the AE SV, construction-related activities have the potential to affect benthic macroinvertebrates through effects to water quality, dewatering of habitat in Gull Rapids, and the deposition of sediments in Stephens Lake.

Benthic monitoring programs will assess the biological effects of predicted increases in TSS due to instream work on the Nelson River (intended to complement the water quality monitoring described in Section 2.0) and sediment deposition in Stephens Lake. The key question that monitoring during construction will address is:

- To what degree does benthic invertebrate density and/or community composition change during construction activities in comparison to either upstream or pre-Project conditions?

4.1.2 Core Monitoring

The core monitoring program for aquatic macroinvertebrates during construction is composed of benthic invertebrate monitoring only.

4.1.2.1 Monitoring Area

Monitoring of benthic macroinvertebrates will occur immediately downstream of instream construction activities related to the Keeyask GS where effects, should they be measureable, would be greatest. Benthic macroinvertebrates will also be assessed upstream of instream activities (between Birthday and Gull rapids) and in Split Lake.

4.1.2.2 Sampling Design

The sampling design is a hybrid that incorporates elements of both the before-after-control-impact (BACI) and gradient designs. A BACI design consists of one or more control (or reference) locations to which an exposure (or reference) area is compared, both before and after an impact is deemed to have occurred. A gradient design refers to a series of sampling locations extending away from a potential source of effect (e.g., increase in TSS due to instream work), to a sufficient distance downstream that allows use of the farthest location as a reference (i.e., where an effect is no longer detected). Sampling locations along the gradient should represent different exposure levels (e.g., within the mixing zone vs. fully mixed river condition). The hybrid design allows for the statistical testing for effects in the area immediately downstream of construction activities and also provides an estimate of the spatial extent of potential effects. Potential Project-related effects will be evaluated through statistical comparisons of benthic macroinvertebrate community descriptors (i.e., metrics) between reference and exposure locations during each sampling event and to pre-Project baseline data.

To improve the understanding of the range and magnitude of the metrics calculated, specifically in relation to potential effects from the Project, an assessment of benthic macroinvertebrate data will be conducted to characterize the spatial and temporal (i.e., among years) variability of calculated metrics in the existing environment, both upstream and downstream of the Project. As part of this assessment, an *a priori* power analysis will be carried out using calculated metrics to determine the appropriate level of sampling effort at the station scale (i.e., the number of stations per area) required for a reasonably statistically robust sampling design. Results from this assessment will be used to further refine the sampling design for the monitoring program prior to implementation.

4.1.2.3 Parameters

Benthic macroinvertebrate community descriptors calculated for each sample and utilized in the statistical analysis will include the following:

- Total invertebrate abundance or density;
- Abundance or density of major groups (i.e., Amphipoda, Oligochaeta, Chironomidae, Ephemeroptera, Trichoptera, Plecoptera, Bivalvia, Pisidiidae, and Gastropoda);

- Percent Ephemeroptera, Plecoptera, and Trichoptera taxa (EPT Index);
- Ratio of EPT taxa to Chironomidae abundance or density;
- Percentage of samples with only Oligochaeta and Chironmidae;
- Percentage of samples with no aquatic macroinvertebrates;
- Taxa richness (Family-level);
- Simpson's Diversity Index (Environment Canada 2011); and
- Bray-Curtis Index (Environment Canada 2011).

4.1.2.4 Sampling Sites

To the extent possible, sampling locations will be selected such that sampling conducted pre-Project and during construction will be comparable, with monitoring conducted near established baseline sampling sites when feasible. Benthos will be assessed in Split Lake and upstream of Gull Rapids, and in a gradient downstream of Gull Rapids and through Stephens Lake (exposure areas). If water quality effects are detected downstream of the Kettle GS, additional sampling of benthic macroinvertebrates in this area may be proposed to determine the extent of potential downstream effects on this community due to instream construction activities.

An assessment of the spatial variability in baseline data upstream and downstream of the Project will be used to determine the number and placement of stations required to estimate macroinvertebrate parameters during construction monitoring.

4.1.2.5 Sampling Frequency and Schedule

Benthic monitoring will be conducted annually in the fall during instream construction. If large increases in TSS concentrations do not occur during construction, the spatial extent or frequency of benthic sampling may be reduced.

4.1.2.6 Methods

Benthic macroinvertebrates will be sampled with a petit Ponar dredge (0.023 m^2 opening; used in flowing water environments with typically firmer, mixed/heterogeneous sediments) or an Ekman dredge (0.023 m^2 opening; used in standing water environments with typically softer, homogeneous sediments) in predominantly wetted shallow and deep-water habitats and sieved through a 500 µm sieve bucket. A sample will also be collected at each benthic sampling location to characterize the general type of sediments in terms of organic content and particle size composition.

A QA/QC plan will be developed prior to program implementation and will outline the planning, implementation, and assessment procedures to be used to apply specific QA/QC activities and criteria to the AEMP.

4.2 MONITORING DURING OPERATION

Monitoring activities for the operation phase will focus on evaluating specific Project-related effects identified in the AE SV at selected representative sites to verify predictions made in the AE SV.

4.2.1 Pathways of Effect and Key Questions

4.2.1.1 Outlet of Clark Lake to the Keeyask GS

Operation-related pathways that may affect aquatic macroinvertebrates between the outlet of Clark Lake to the Keeyask GS include:

- The loss of existing habitat and the creation of new habitat due to flooding;
- A reduction in medium and high water velocity habitat upstream of the GS due to reservoir creation;
- A conversion of existing hard gravel, cobble, and boulder substrates to softer silt/clay substrates due to sedimentation in the reservoir;
- An increase in the frequency of water level fluctuations due to GS operations; and
- A conversion of tributary habitat to bays due to flooding; and changes in surface water quality in off-current areas, particularly bays.

Benthic sampling will be designed to assess the biological effects of predicted flooding, sedimentation, increased frequency of water level fluctuations, and changes in surface water quality in bays. Drift net sampling will be used to assess the effects of the reduction in higher water velocity habitat at rapids and the conversion of tributary habitat to bays.

The key questions that will be addressed through aquatic macroinvertebrate monitoring upstream of the GS during operation are:

- Has an area-wide, large increase in benthic macroinvertebrate abundance, and a change in community composition, occurred in the long term in response to the increased availability of aquatic habitat and changes in substrates?
- Are benthic macroinvertebrate abundance and/or distribution in littoral habitat negatively affected by the increased frequency of water level fluctuations?
- Do low DO concentrations in areas of flooding and peat disintegration result in initially low levels of benthic abundance and richness? Do these areas ultimately support higher mean abundances of benthos in the long term if DO depletion continues to occur during the winter months?
- Has drifting invertebrate production within Birthday Rapids and from affected tributaries declined due to reduced water velocity as a result of flooding?
- Are there any unexpected effects on benthic or drifting macroinvertebrates that may be related to GS operation?

4.2.1.2 Downstream of the Keeyask GS

Operation-related pathways that may affect macroinvertebrates downstream of the GS include:

- An alteration of flow patterns, water velocities, and depths;
- A reduction in the extent and severity of ice scour in the portion of the Nelson River from the GS to the inlet of Stephens Lake; and
- The direct loss of aquatic habitat due to dewatering of Gull Rapids and the footprint of the GS structure.

Benthic sampling will be designed to assess the biological effects of predicted alteration of flow, as well as water velocities and depths (where sampling is feasible), and a reduction in ice scour. Drift net sampling is intended to assess the effects of the predicted alteration of flow, and water velocities and depths (where sampling is feasible), and the loss of rapids.

The key questions that will be addressed through aquatic macroinvertebrate monitoring downstream of the GS during operation are:

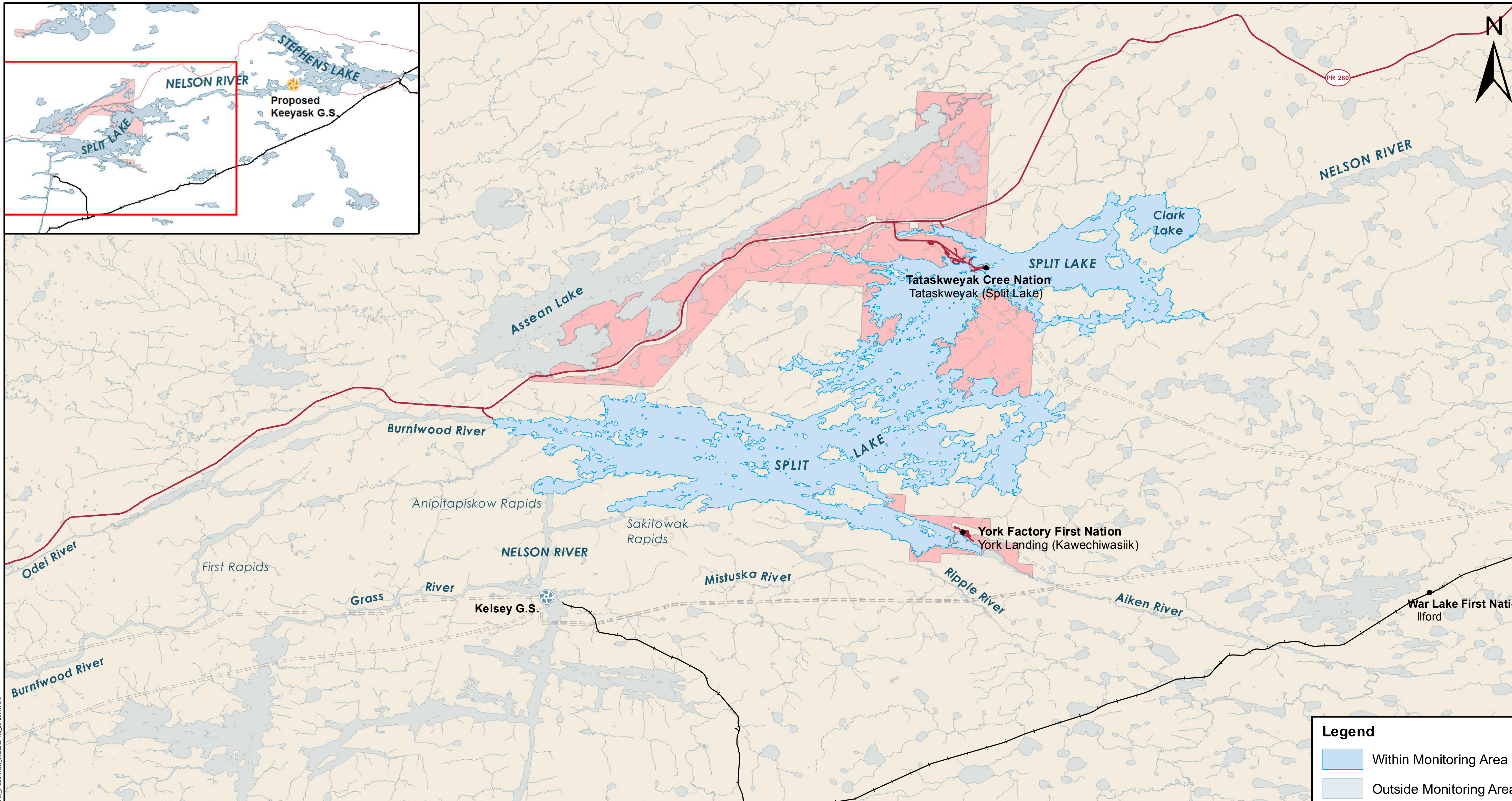
- Have irregular flow patterns reduced macroinvertebrate taxa richness?
- Has reduced ice scour in littoral habitat resulted in any change to the abundance and/or distribution of benthos?
- Has downstream invertebrate drift density and community composition changed during operation in comparison to either upstream or pre-Project conditions?
- How is the newly constructed lake sturgeon spawning structure downstream of the GS affecting drifting invertebrate production?
- Are there any unexpected effects on benthic or drifting macroinvertebrates that may be related to GS operation?

4.2.2 Core Monitoring

During operation, the core monitoring program for macroinvertebrates includes both benthic and drifting components.

4.2.2.1 Monitoring Area

Aquatic macroinvertebrate monitoring during operation includes the area from the GS upstream to the base of Long Rapids and to immediately downstream of the Kettle GS. The benthic community will also be sampled in Split Lake (maps 6, 7 and 8).



KEEYASK Hydropower Limited Partnership

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Split Lake Area
Aquatic Macroinvertebrates Monitoring

KEEYASK
Hydropower Limited Partnership

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000
Nelson River Shoreline modelled by Manitoba Hydro.
Extents of dewatered area are estimated based on the existing environment 95th percentile flow.

Outlet of Clark Lake to Keeyask Generating Station

Aquatic Macroinvertebrates Monitoring

Map 8. Keeyask Generating Station to Kettle Generating Station – Aquatic macroinvertebrate monitoring.

4.2.2.2 Sampling Design

The sampling design for benthic macroinvertebrate monitoring will follow that described in Section 4.1. The sampling design for the drifting macroinvertebrate community will be based on a BACI design, as described in Section 4.1.2.2.

4.2.2.3 Parameters

Parameters are described in Section 4.1.2.3.

4.2.2.4 Sampling Sites

Benthic macroinvertebrates will be assessed in Split Lake, between the outlet of Clark Lake and the Keeyask GS, and in Stephens Lake. Where feasible, sampling stations utilized during construction monitoring will also be sampled during operation, with the addition of stations in newly created habitat (selected so as to be representative of the predominant habitat types within the reservoir) or to address specific Project-related effects (e.g., bays within shallow, flooded areas that experience DO depletion). Sites representative of the flooded backbays and mainstem areas in the reservoir will be monitored across multiple AEMP components (water quality, aquatic habitat, lower trophic levels, and fish community) to allow for an integrated analysis of observed changes. Drifting macroinvertebrates will be assessed upstream and downstream of Birthday Rapids, the Keeyask GS (including the newly constructed lake sturgeon spawning structure) and the Kettle GS. Drift will also be assessed in selected flooded tributaries and suitable tributary habitat that has not been flooded. Positioning of drift traps in riverine habitats will be determined by safety and logistical considerations.

An assessment of the spatial variability in baseline aquatic macroinvertebrate data upstream and downstream of the GS will be used to determine the number and placement of stations required to estimate macroinvertebrate parameters during operation monitoring.

4.2.2.5 Sampling Frequency and Schedule

Benthic monitoring will be conducted annually in the fall, and drifting macroinvertebrate monitoring will be conducted in May, June, August, and October, each year for the first three years following impoundment. Both types of monitoring will then occur at least once every three years until ten years post-impoundment, and may continue at a reduced frequency until thirty years post-impoundment, depending on results.

4.2.2.6 Methods

Benthos will be sampled in the intermittently exposed portion of the littoral zone with a travelling kick/sweep net (≤ 500 µm mesh net bag and a 305 x 254 mm frame opening). Each replicate station would consist of a timed 3-minute zig-zag travelling kick/sweep in a perpendicular direction from the water's edge to a maximum of 1 m water depth (width of zig-zag would be approximately 1 m). In predominantly wetted shallow- and deep-water habitats, benthos will be sampled with either a petit Ponar dredge (0.023 m^2 opening) or an Ekman dredge (0.023 m^2 opening), depending on water velocity and bottom sediment composition; samples will be sieved through a 500 µm sieve bucket.

Drifting macroinvertebrates at riverine stations will be sampled using both floating and bottom-set drift nets (opening of 43 x 85 cm, with an attached 300 cm long, 950 µm Nitex® screen bag, tapered to a 9 cm diameter removable ABS pipe 'cod-end'), where feasible. Drift in tributaries would be assessed using smaller drift traps (opening of 15 cm x 15 cm, with an attached 100 cm long, 250 µm Nitex® screen bag, tapered to a removable, modified Nalgene® bottle) anchored to the creek bottom with metal 't-bars'. Drift nets would be set for approximately 24 hours in riverine sections; however, shorter drift sets may be considered for smaller tributaries to avoid clogging of nets.

A QA/QC plan will be developed prior to program implementation as described in Section 4.1.2.6.

5.0 FISH COMMUNITY

The following section addresses monitoring for the fish community, with an emphasis on walleye, northern pike, and lake whitefish, which were selected as VECs for the Project. Lake sturgeon may be recorded in the studies described in this section but targeted monitoring for lake sturgeon is described in Section 6.0. Monitoring will begin during the construction phase and continue at various levels of effort, depending on results, through the first 20 - 30 years following impoundment.

5.1 MONITORING DURING CONSTRUCTION

As discussed in the AE SV, construction-related activities have the potential to result in the loss/alteration of spawning and foraging habitat. In addition, GS construction may affect macro-scale fish movements both upstream and downstream of the construction site.

Fish community monitoring during construction is composed of two components: a) monitoring will be conducted to address potential fish mortalities due to some blasting events; and b) movements of walleye, northern pike, and lake whitefish will be monitored both upstream and downstream of the construction site to assess the potential for increased emigration, identify record use of habitat near instream construction, and determine macro-scale habitat use.

Potential effects such as entrainment and impingement of fish at screened water intakes (e.g., water intake for concrete plant) are not being monitored because mitigation measures (i.e., fish screens) have been designed according to federal guidelines (DFO 1995). Activities related to the management of construction effects (e.g., the conduct of a salvage fishery during dewatering of the cofferdams) are not discussed in this document.

5.1.1 Pathways of Effect and Key Questions

Construction of the Project will affect fish movements in the main flow of the Nelson River near the construction site by blocking fish movements with placement of cofferdams, altering flow patterns, and causing disturbances that may increase emigration from the construction area. The placement of instream structures and alterations of flows will also affect the use of habitat in Gull Rapids..

Blasting will be required to construct the GS. Blasting has the potential to cause fish mortalities by increasing pressures in the water column and, therefore, monitoring will be required if blasting guidelines cannot be met

Key questions that will be addressed through monitoring of the fish community during construction include:

- Are fish continuing to use habitat in Gull Rapids and immediately downstream of the construction site, particularly during the spawning season?
- If fish are avoiding the construction site, do they remain between the outlet of Clark Lake and the Kettle GS or do they leave the area?

- What is the level of fish mortality during blasting events that are unable to meet the criteria set out in the DFO blasting guidelines?

5.1.2 Core Monitoring

Core monitoring during the construction phase of the Project will focus on fish movements and habitat use. This program will continue into the operation phase of the Project.

5.1.2.1 Monitoring Area

The monitoring area includes the reach of the Nelson River between the outlet of Clark Lake and the Long Spruce GS, with particular emphasis on Gull Rapids and the area immediately downstream of the construction site. Acoustic receivers will be placed and manual tracking will occur at strategic locations upstream and downstream of the construction site.

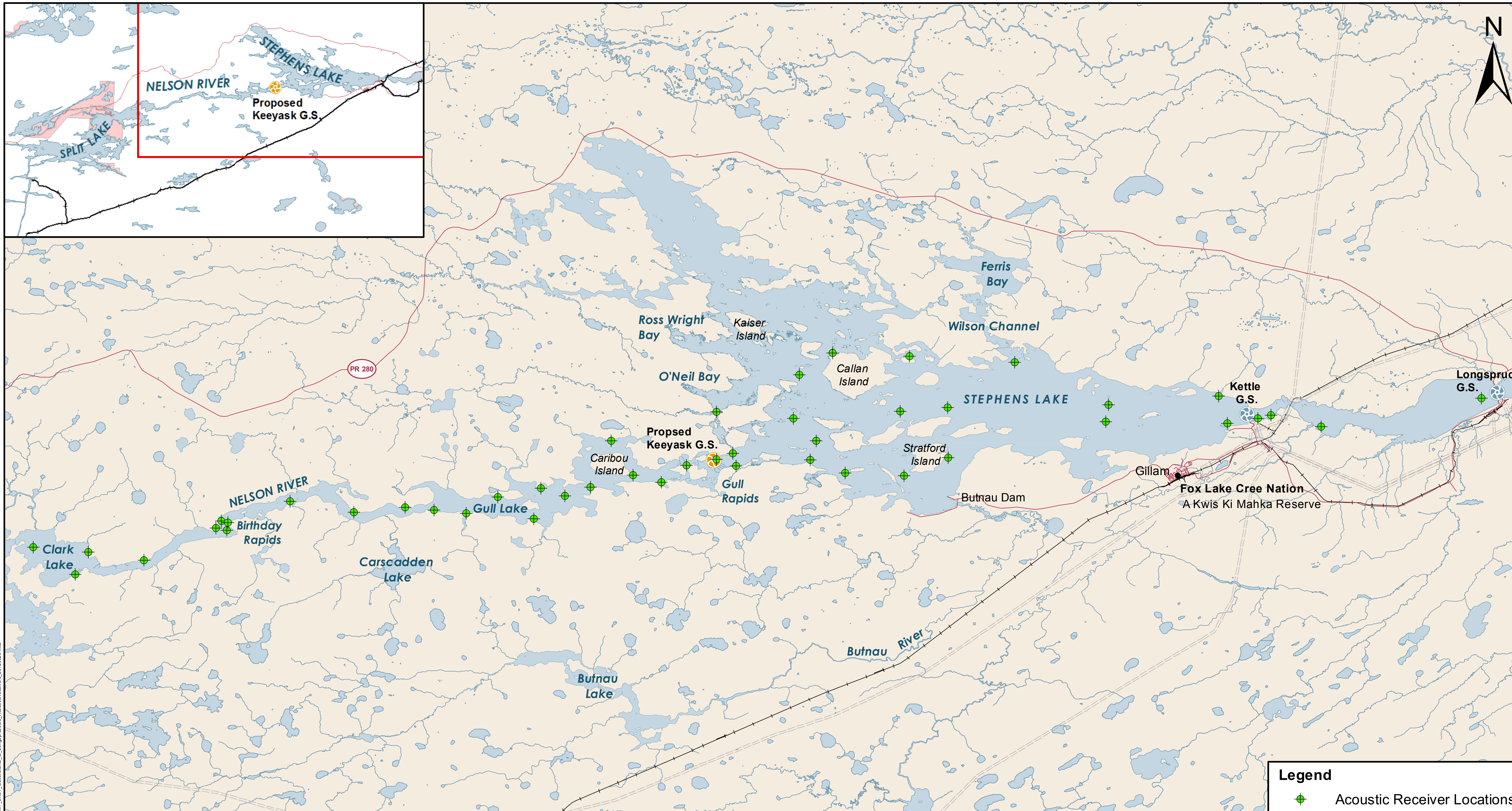
5.1.2.2 Sampling Design

Macro-scale fish movements will be monitored by acoustic telemetry in the Clark Lake to Long Spruce GS reach of the Nelson River. Acoustic telemetry is a proven technology used to document fish movements. Reliable instrumentation is available and this methodology is currently being used as part of Keeyask environmental studies to monitor lake sturgeon movements. The array of acoustic receivers already in place to monitor lake sturgeon movements will be used to monitor movements of tagged walleye, northern pike and lake whitefish. Receivers have been set to maximize the detection distance of each receiver and optimize spatial coverage of the study area, accounting for the potential for long distance upstream or downstream movements. Presently, receivers are set in low current areas in Clark Lake, below sets of rapid (Long Rapids and Birthday Rapids), in off-current areas of the Nelson River, in Gull Lake, in off-current areas within Gull Rapids, in Stephens Lake ,immediately downstream of the Kettle GS and approximately 2 km upstream of the Long Spruce GS (Map 9). Depending on how construction of the GS alters flow patterns upstream and downstream of the GS, additional receivers may be set near the construction site to provide additional data.

5.1.2.3 Parameters

The main parameters that will be used to monitor fish movements in response to construction activities are the number and proportion of walleye, northern pike, and lake whitefish implanted with transmitters that:

- Remain upstream of the construction site;
- Use habitat in the immediate vicinity of construction activities (e.g., foraging in/near Gull Rapids);
- Move downstream over Gull Rapids into Stephens Lake or beyond;
- Move upstream through Gull Rapids; or
- Move upstream into the Split Lake area or beyond.



0 5 10 15 Kilometres

0 2 4 6 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000,
Stephens Lake Shoreline-Quickbird@Digitalglobe, 2006
Nelson River Shoreline modelled by Manitoba Hydro

2011 Acoustic Receiver Locations

5.1.2.4 Sampling Sites

Acoustic receivers are already in place throughout the study area as part of the long-term lake sturgeon monitoring program (Section 6.1.2.2). Additional receivers may be installed to monitor fish movements in the vicinity of the construction site.

5.1.2.5 Sampling Frequency and Schedule

Because the lifespan of the transmitters that are of appropriate size for the fish species of interest generally ranges from two to three years, transmitters will be applied just prior to the start of instream construction and just prior to impoundment to FSL. Stationary receivers will monitor transmitters continuously; a subset of the receivers deployed during the open-water season will remain in Clark Lake, Stephens Lake and the Long Spruce reservoir during winter. Receivers in riverine portions of the Nelson River between Clark Lake and Gull Rapids will be removed prior to the onset of winter.

5.1.2.6 Methods

Acoustic transmitters will be applied to 80 walleye, 80 northern pike, and 80 lake whitefish (or as many as can be captured), with approximately half applied to fish captured upstream and half applied to fish captured downstream of the construction site. Transmitters will be applied to lake whitefish during September to ensure that they are in the best condition possible prior to tag implantation. Other species may be tagged during spring after spawning has been completed. Prior to tag implantation, fish will be captured by angling or in gill nets. Gill nets will be checked every 1 or 2 hours; fish will be removed from the net as soon as possible after capture, with minimal handling (e.g., cutting of the net, if necessary). All walleye, northern pike, and lake whitefish will be measured for fork length (± 1 mm) and weight (± 25 g). Fish in good physical condition and a minimum weight of 400 g will be chosen for tagging. To the extent possible, fish of various sizes and sexes will be selected.

Fish will be anaesthetized in clove oil, and a V13 acoustic transmitter (manufactured by VEMCO) will be surgically implanted into the body cavity through a small mid-ventral incision. The incision will be stitched closed, and the fish held until equilibrium and locomotory function have returned. Fish will be released at the site of capture. Fish will be tagged at various locations upstream and downstream of the construction site to provide adequate spatial representation.

Tagged fish will be monitored using stationary acoustic receivers (VEMCO model VR2W) and manual tracking with a portable receiver (VEMCO, model VR100). Each stationary VR2W receiver consists of a lithium ion battery, an omni-directional hydrophone and internal data logger. The omni-directional hydrophone detects the pulse train transmitted from active transmitters within its range of detection. The transmitter code number, as well as the date and time of each detection are stored in the data logger until downloaded by a computer. Stationary receivers will be anchored to the bottom using ~ 25 kg cement bases, which have two re-bar handles and a vertical central re-bar rod. Receivers will be attached to the vertical rod using cable ties and hose clamps. Floats will be attached to the re-bar handles using heavy rope. Manual tracking will be conducted from a boat using a battery powered portable (VR100) receiver. During tracking, the boat will be anchored, and the hydrophone will be lowered approximately 1 m under the water's surface and was held there for 5 minutes. The date, time, and location associated with each transmitter detection will be recorded.

Monitoring is intended to continue through the construction phase and into the operation phase to provide a continuous dataset on fish movements and habitat use during GS construction, to assess how fish respond to impoundment and the creation of a barrier in the river.

5.1.3 Specific Effects Monitoring

Monitoring of the effect of blasting on the fish community is the only component of the specific effects monitoring program during Project construction.

Blasting will generally be conducted in accordance with DFO guidelines for the use of explosives in or near Canadian fisheries waters (Wright and Hopky 1998) to comply with the fish and fish habitat protection provisions of the *Fisheries Act* (including provisions to protect against overpressure in fish swim bladders and to protect spawning beds during egg incubation). The exception to this will be some blasts conducted in the powerhouse tailrace channel and spillway discharge channel that are proximal to potential lake whitefish spawning habitat, where spawning habitat setback distances cannot be met. To mitigate this potential impact to lake whitefish, where practicable, blasting in these areas will be conducted outside of the lake whitefish spawning and egg incubation period.

In the event that the contractor identifies blasts that cannot meet guidelines for the protection of adult fish, monitoring will be conducted.

5.1.3.1 Monitoring Area

Monitoring will be conducted in the vicinity of the construction site.

5.1.3.2 Sampling Design

Observational monitoring of fish mortalities will be conducted during and after blasts that are not expected to meet the criteria within the DFO guidelines. Due to safety considerations, observers would need to move into the area after blasting is complete.

5.1.3.3 Parameters

Observed dead fish will be collected, enumerated by species and measured for length and weight.

5.1.3.4 Sampling Sites

Monitoring will occur immediately adjacent to and downstream of blasting sites.

5.1.3.5 Sampling Frequency and Schedule

The above stated monitoring will be conducted during construction for any blasting events that are not expected to meet the criteria within the DFO guidelines.

5.1.3.6 Methods

Monitoring will include direct observation of the blast site and the area immediately downstream for period of approximately 30 minutes following the blast. Dead fish will be collected from a boat using a dip net.

5.2 MONITORING DURING OPERATION

The primary objective of monitoring fish populations during operation of the Keeyask GS is to detect Project-related effects to the fish community. These changes could arise due to direct and indirect effects of the Project on fish and fish habitat. Over the long term, the fish community could also change due to factors unrelated to the Project, such as climate change.

Monitoring during operation includes a core monitoring program for fish community composition and abundance in the reservoir, Stephens Lake and Split Lake, and a core monitoring program for fish movements. Specific effects monitoring programs will be conducted to examine: gas bubble trauma in fish; the utilization and success of created spawning habitats and other mitigation/compensation measures; turbine mortality; potential fish stranding following spill events; and, experimental trap and transport of fish upstream over the Keeyask GS. Specific effects programs would also be developed to monitor the effectiveness of additional compensation/mitigation measures that may be identified during review of the environmental assessment by DFO and MCWS.

5.2.1 Pathways of Effect and Key Questions

Effects on the fish community in the Keeyask reservoir during operation are expected due to changes in the water regime (flooding, reduction in water velocity, increased water level fluctuation, and loss of tributary habitat) and associated effects due to alterations in aquatic habitat, water quality, and lower trophic levels. The loss of Gull Rapids within the footprint of the Project will affect spawning habitat use by the three VEC fish species. Movement of fish from Stephens Lake upstream into the Keeyask reservoir will be provided by an experimental catch and transport program. Fish will be able to move from the Keeyask reservoir downstream into Stephens Lake through the turbines or over the spillway. The turbines have been designed to minimize injury and mortality, but a low level of fish injury or mortality is still expected. The reduction of water velocity at Birthday Rapids could facilitate fish movements upstream into Split and Clark lakes.

The impoundment of the Nelson River at Gull Rapids and the installation of turbines and a spillway will produce large changes in the physical habitat, some of which have the potential to result in total dissolved gas supersaturation (TDGS). Changes to habitat in the reservoir and alteration of rapids habitat at Birthday Rapids due to impoundment, and loss of rapids habitat at Gull Rapids in the footprint of the GS, have the potential to affect spawning by fish (in particular walleye and lake whitefish). Constructed spawning habitats are expected to be used by walleye and lake whitefish.

Key questions that will be addressed through monitoring the fish community upstream and downstream of the GS during operation include:

- Has fish community composition and catch-per-unit-of-effort (CPUE) changed in the Keeyask reservoir, its tributaries, and Stephens Lake in comparison to pre-Project conditions?
- Are there any unexpected effects on CPUE and community composition in the reservoir and downstream of the Project that may be related to operation?
- On a broad scale, what types of habitat are VEC fish species utilizing most frequently in the study area (i.e., are fish using the upper, middle or lower end of the reservoir)?
- Are the escape channels at the former location of Little Gull Lake effective in preventing winterkill in this portion of the reservoir?
- Is there evidence for GBT (gas bubble trauma) in fish downstream of the Keeyask GS and if so, what species (and life stages) are most affected?
- Do walleye and lake whitefish use spawning habitat created upstream and downstream of the Keeyask GS?
- Do fish use the newly created/altered channels extending between the Nelson River and Stephens Lake?
- Is fish stranding occurring following use of the spillway?
- What proportion of the fish population moves from the Keeyask reservoir upstream past Birthday and/or Long rapids?
- How prevalent are downstream movements of fish through the Keeyask GS, which species/size classes are moving downstream, and when are the movements occurring?
- For fish moving downstream through the Keeyask GS, do they move over the spillway or past the turbines?
- What is the rate of injury and mortality of fish moving downstream through the Keeyask GS turbines?
- Where and what types/sizes of fish congregate in the fast water environment immediately below the Keeyask GS, and does the species composition/size classes of fish vary by season?
- Are fish that are congregating below the GS cuing in to habitats that are fulfilling a specific life history function at that location (e.g., use of high velocity habitat for spawning)?
- How do fish transported upstream over the Keeyask GS during the experimental catch and transport program respond to the reservoir environment?
- Does capture and transport negatively affect fish (e.g., evidence of stress, mortality)? and
- What proportion of the transported fish remain in the reservoir post-release (does it vary by species and life-stage)?

5.2.2 Core Monitoring

5.2.2.1 Fish Community Composition and Abundance in the Keeyask Reservoir

5.2.2.1.1 Monitoring Area

Monitoring of the fish community will be conducted in the Keeyask reservoir (including selected tributaries upstream to the outlet of Clark Lake), Stephens Lake, and Split Lake (maps 10, 11, and 12). Fish community sampling will assess fish abundance (CPUE) and fish community composition. The core program will indicate whether there has been a change from pre-Project conditions.

As discussed in Section 1.3.2, there are no waterbodies that meet all the requirements for a reference location, in terms of a similar fish community, habitat, and external stressors (e.g., fisheries). Split Lake is being used as a reference waterbody, although it is recognized that there may be a small amount of interchange with the Keeyask reservoir. Any changes to the fish community of Split Lake due to changes in the immigration rate of fish from the Keeyask reservoir are expected to be minimal and will be monitored as part of fish movement studies. In addition, fish community data from lakes sampled under CAMP will be available to provide context for changes observed at Keeyask.

5.2.2.1.2 Sampling Design

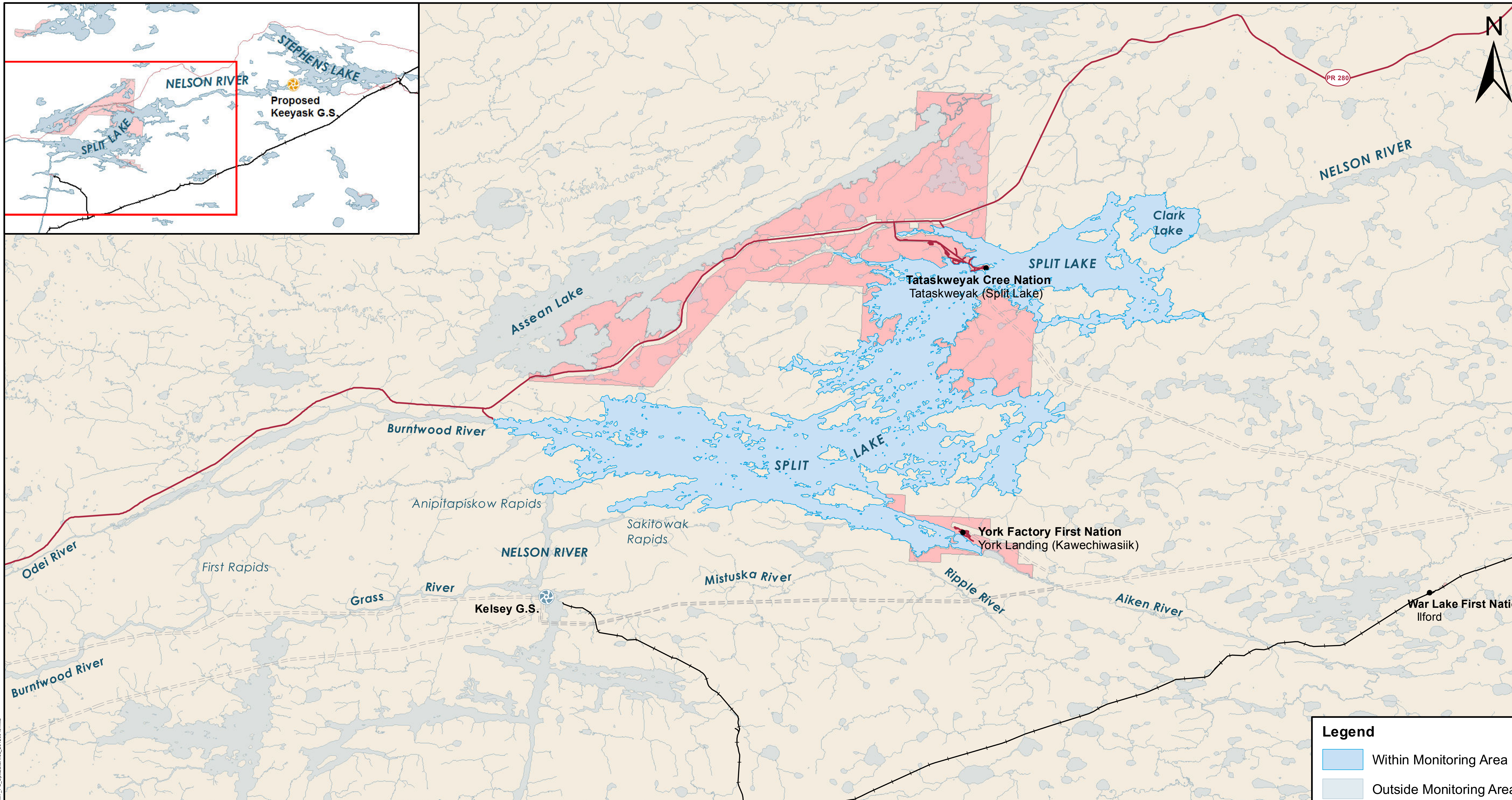
A standard index gillnetting program will be conducted in summer during the operation phase to generate relative abundance and CPUE data.

The inherent variability in gillnet catches and composition require several levels of assessment. Comparisons are restricted to nonparametric statistics as the existing count data do not conform to a normal distribution. The probability of CPUE values can be determined using the fitted distribution both individually to determine the likelihood of observed values, and in combination to test deviations from baseline expectation. Additional tests of reliability can be determined *post hoc* by iteration to approximate the nonparametric equivalent of statistical power. All of the analyses will be run using random deviates from built-in Microsoft Excel distribution functions. All iteration-based analyses will be built using Excel macros written in Visual Basic for Applications.

Changes in relative abundance and fish species composition in reservoir tributaries will be monitored at sites upstream of the reservoir FSL by way of a backpack electrofishing program conducted in the spring and fall to generate relative abundance and CPUE data.

Community composition will be compared to existing baseline data to determine whether the monitoring data fall within the expected variation. Incidence-abundance curves of existing baseline data will be used to assess the incidence and abundance of fish species during the monitoring period. Annual frequency of occurrence of fish species in the baseline line data will be used to assess annual variation in composition and allow appropriate assessment of the composition during the monitoring period.

Condition factor and length-at-age relationships will also be calculated for fish from each waterbody using metrics (length, weight, age) collected during the index gillnetting programs. Data will be compared to pre-Project information to identify if changes are occurring.

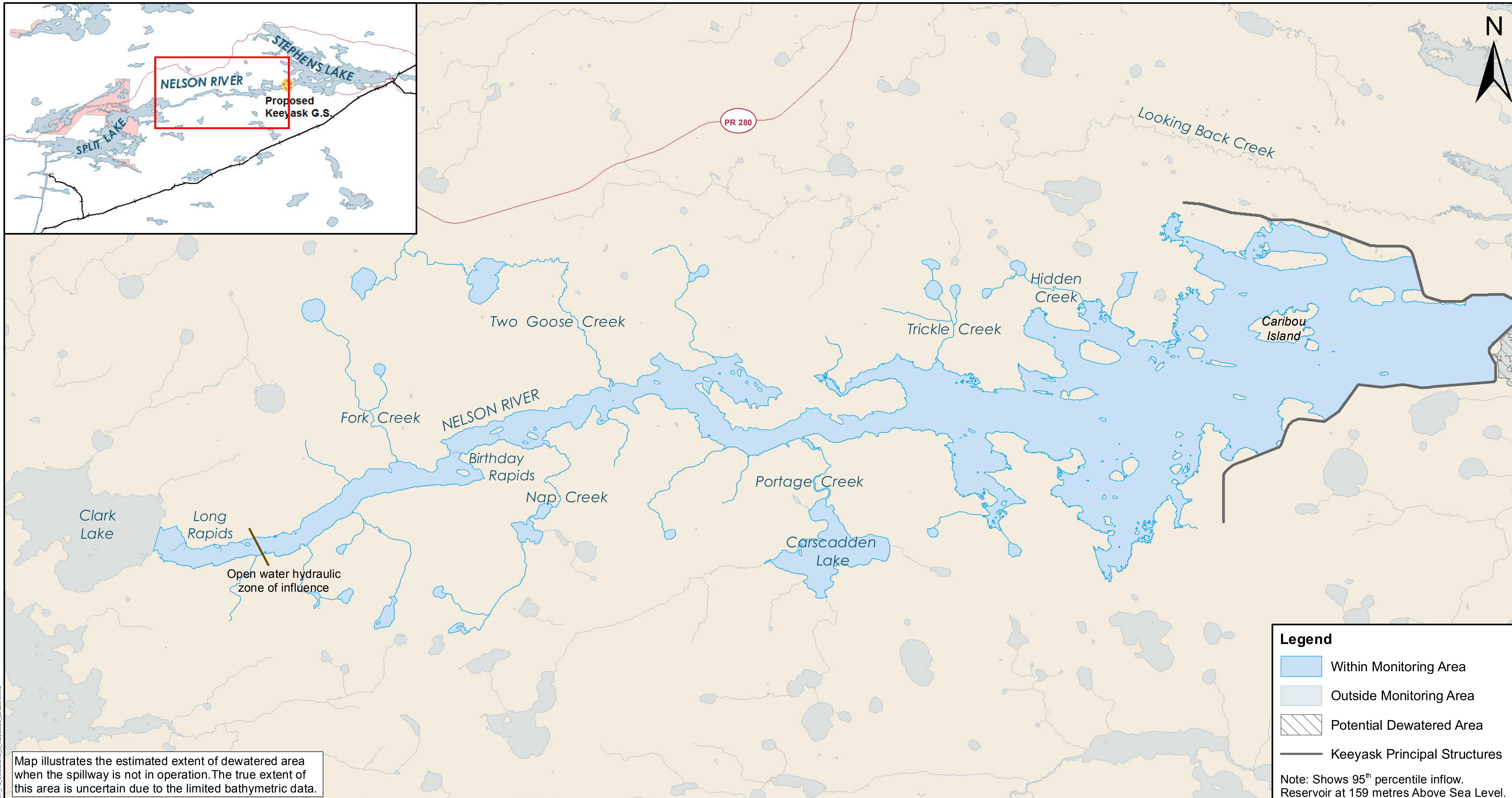


KEEYASK
Hydropower Limited Partnership

0 5 10 20 Kilometres
0 2.5 5 10 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Split Lake Area
Fish Community Monitoring



KEEYASK Hydropower Limited Partnership

0 2.5 5 7.5 10 Kilometres

0 1.25 2.5 3.75 5 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000
Nelson River Shoreline modelled by Manitoba Hydro.
Extents of dewatered area are estimated based on the existing environment 95th percentile flow.

Outlet of Clark Lake to Keeyask Generating Station

Fish Community Monitoring