Keeyask Generation Project

Aquatic Effects Monitoring Plan

Development of Nearshore and Aquatic Macrophyte Habitat Report

AEMP-2022-16

Manitoba Environment, Climate and Parks Client File 5550.00
Manitoba Environment Act Licence No. 3107

2021 - 2022

KEEYASK GENERATION PROJECT

AQUATIC EFFECTS MONITORING PLAN

REPORT #AEMP-2022-16

DEVELOPMENT OF NEARSHORE AND AQUATIC MACROPHYTE HABITAT IN THE KEEYASK STUDY AREA, 2021

Prepared for

Manitoba Hydro

By

L. Dolce Blanchard, C.L. Hrenchuk, and J. Larter

June 2022

North/South Consultants Inc.
Aquatic Environment Specialists
83 Scurfield Blvd.
Winnipeg, Manitoba, R3Y 1G4
Website: www.nscons.ca
Tel.: (204) 284-3366
Fax: (204) 477-4173
E-mail: nscons@nscons.ca

This report should be cited as:

Dolce Blanchard, L., Hrenchuk, C.L., and J. Larter. 2022. Development of nearshore and aquatic macrophyte habitat in the Keeyask Study Area, 2021. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2022-16. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2022. xvi + 85 pp.

SUMMARY

Background

The Keeyask Hydropower Limited Partnership (KHLP) was required to prepare a plan to monitor the effects of construction and operation of the Keeyask Generating Station (GS) on the environment. Besides measuring the accuracy of the predictions made and actual effects of the GS on the environment, monitoring results will provide information on how construction and operation of the GS will affect the environment and if more needs to be done to reduce harmful effects.

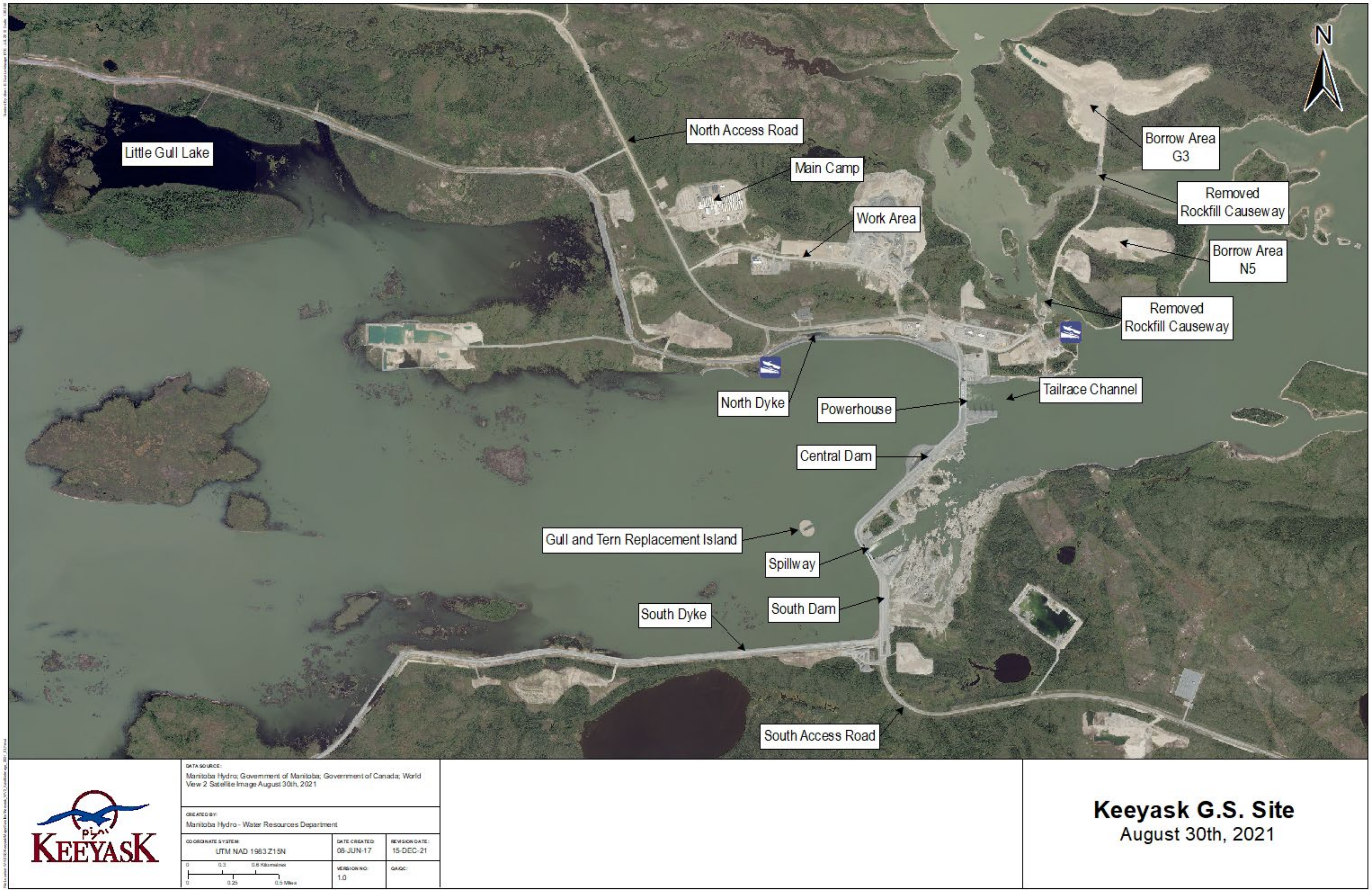
Construction of the Keeyask GS began in mid-July 2014 and instream work was completed in 2020. The reservoir was impounded with water levels being raised to full supply level between August 31 and September 5, 2020. Commissioning of the powerhouse turbines was initiated after impoundment and five of seven units were in-service by fall 2021. During commissioning and as units came into service, substantial flows continued through the spillway until the summer of 2021 when more flow was going through the powerhouse than spillway. By mid-September, the spillway was closed and barely used in the fall.

Aquatic habitat provides the environment in which aquatic plants and animals live. The monitoring of aquatic habitat after construction of the generating station is an important part of the overall plan to monitor the impacts of construction and operation of the Keeyask GS on aquatic life including fish. Some habitats are especially important for fish species to complete their life cycles, such as places to spawn and places to eat. Some of these habitats were lost or changed with construction of the generating station and reservoir impoundment.

Nearshore habitats are important to aquatic plants and animals including fish because they are shallow enough to allow light to reach the bottom, which allows plants to grow. Aquatic plants provide food, cover, and spawning habitat for many kinds of fish. Many fish species prefer shallower nearshore habitats compared to deep offshore areas including Northern Pike (jackfish) and smaller-bodied forage fish (minnows).

Impoundment of the Keeyask reservoir in fall 2020 flooded areas upstream of the GS and changed many types of habitat including nearshore areas. Areas that were nearshore habitats before flooding became deeper, offshore areas. New nearshore areas will develop in shallow water areas (less than 3 m deep) within the reservoir that used to be on land. The development of these areas into healthy nearshore habitats will depend on factors like water level, the type of soil present before flooding, and how much soil and sediment is washed away (erosion) or left behind (deposited) by water in the area. It is not clear how fast these areas will develop into places that will support the growth of aquatic plants and other aquatic life.

This report presents the results of nearshore and aquatic plant monitoring in the Keeyask reservoir in the first full open water season after flooding.



Map illustrating instream structures at the Keeyask Generating Station site, August 2021.

Aquatic plants as seen from the boat (left) and sampled (right).

Why is the study being done?

Monitoring of nearshore habitats is being done to answer three questions:

How will nearshore habitat develop in the Keeyask reservoir?

This question is important because some large-bodied fish species (including jackfish), small-bodied fish species (minnows), and many young fish use nearshore habitats for rearing, feeding, and spawning. It is important that these habitat types develop in the reservoir after flooding.

How will aquatic plant habitat develop in the Keeyask reservoir?

Aquatic plants are important for many aquatic species. Most of the areas in the Keeyask reservoir that are shallow and receive enough light at the bottom for plants to grow are flooded land. It is important that these flooded terrestrial habitats change into suitable habitats for aquatic plants to grow.

How precise were the predictions in the EIS Aquatic Effects Supporting Volume?

This question is important because it will help us to understand how nearshore habitat develops in flooded areas. Detailed studies of how fast nearshore habitats develop in northern Manitoba have not been done in the past. It was predicted that many nearshore areas in the Keeyask reservoir will turn into areas where rooted aquatic plants can grow.

What was done?

Substrate composition (what the bottom is made of) and aquatic plant presence were monitored in 12 general areas including nine upstream of the Keeyask GS in the new reservoir and three downstream in Stephens Lake. The results were compared to the substrate composition of an old reservoir (Stephens Lake), which is considered an example of what the Keeyask reservoir will look like over time (map below). Aquatic plants were sampled using a sampling rake (photo above) and identified.

Substrate type was identified at each site by using a Ponar dredge (to grab a sample of the bottom), a sounding line (to hear or feel if the bottom is rocky or soft), and a sonar (to make a picture of the bottom). A few Ponar grab samples were also sent to the lab to confirm classifications done in the field.

What was found?

Substrates in the nearshore of the Keeyask reservoir were mostly organic material made up of detritus (like leaves) and decomposing plant matter (like root balls). Few plants were found, and most of those present were not aquatic species but terrestrial groups like moss and Labrador tea. This is not surprising because most of the sites were located on flooded land. One exception was at the site upstream of Birthday Rapids where there was not much flooding and aquatic plants were present.

Substrates in Stephens Lake were mostly silt and clay. Fewer plants were found than was expected. This is likely because of very low water levels in 2021.

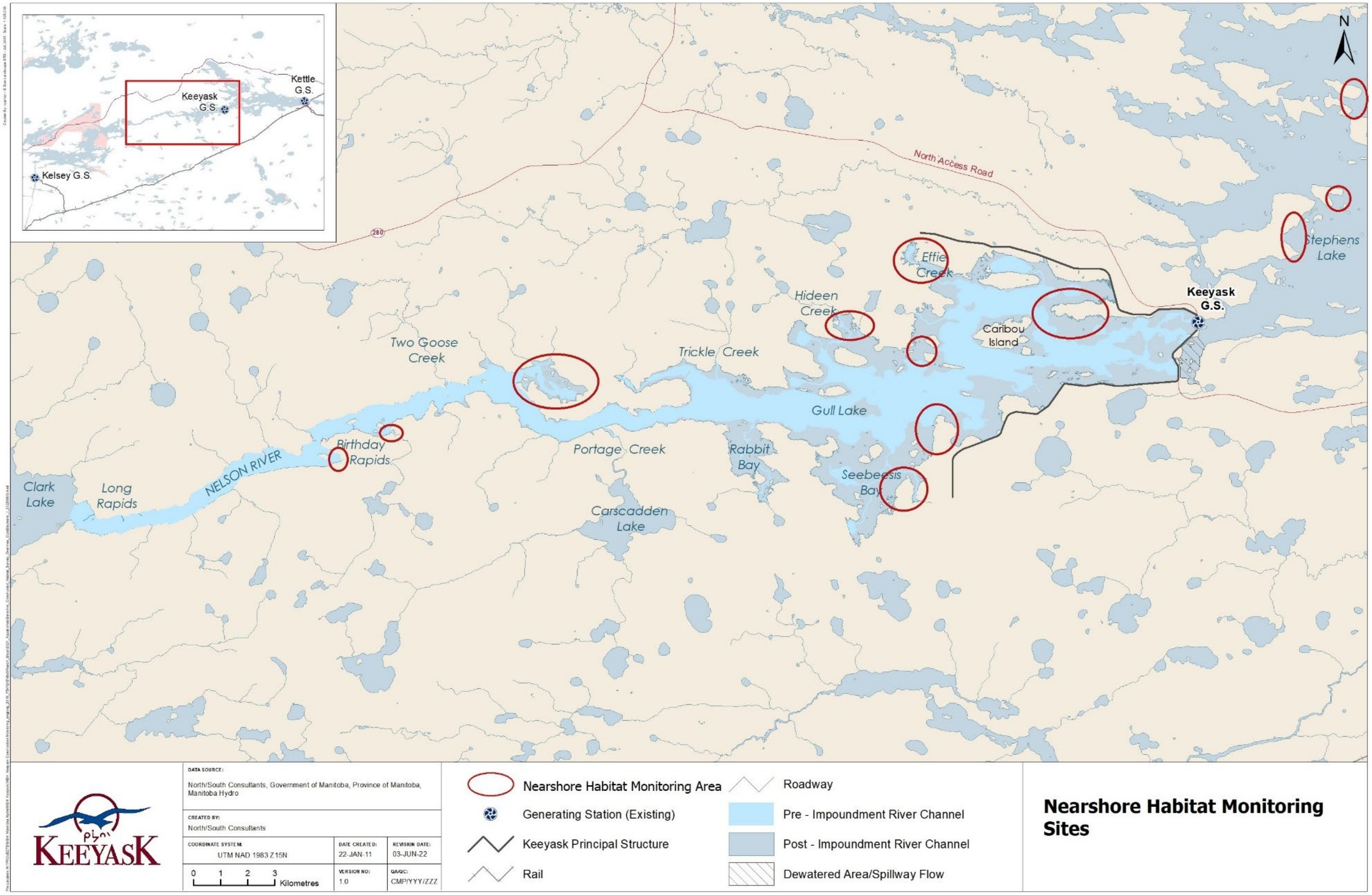
Sites were picked randomly before fieldwork started based on imagery of the newly formed Keeyask reservoir. Water depth was not known. Because of this, some sites could not be sampled because they were in areas that were too shallow to get to using a boat. Also, because water levels were very low in Stephens Lake, some sites that would normally have water were on shore or were too shallow for a boat. Now that depths are known within all of the sampling areas, sites in 2022 will be chosen only in areas that are deep enough for a boat to go. Also, alternate sites will be picked that can be sampled if some can't be accessed.

What does it mean?

Sampling in 2021 provides a starting point for studying the development of nearshore habitat in the Keeyask reservoir. It is still too soon after flooding to see changes from flooded terrestrial to aquatic habitat in the nearshore area of the Keeyask reservoir.

What will be done next?

The program will be repeated yearly until 2023. Where possible, plant and substrate data will be collected in the same areas and the same sites to document changes.



Map showing sites surveyed for nearshore habitat monitoring, August 2021.

ACKNOWLEDGEMENTS

We would like to thank Manitoba Hydro for the opportunity and resources to conduct this study.

Kelvin Kitchekeesik and Tyler Kitchekeesik of Tataskweyak Cree Nation (TCN) are thanked for their local expertise and assistance in conducting the field work. We would also like to thank Keegan Neckoway and Terry Kitchekeesik of TCN for arranging logistic support and personnel needed to conduct the fieldwork.

STUDY TEAM

Data Collection

Celina Unrau

Duane Hudd

Kelvin Kitchekeesik

Thomas Sutton

Tyler Kitchekeesik

Data Analysis, Report Preparation, and Report Review

Claire Hrenchuk

Friederike Schneider-Vieira

Jarod Larter

Jodi Holm

Leanne Dolce Blanchard

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF PHOTOS

LIST OF APPENDICES

1.0 INTRODUCTION

The Keeyask Generation Project (the Project) is a 695-megawatt (MW) hydroelectric generating station at Gull Rapids on the lower Nelson River in northern Manitoba. The Project is approximately 725 kilometres (km) northeast of Winnipeg, 35 km upstream of the existing Kettle Generating Station, where Gull Lake flows into Stephens Lake, 60 km east of the community of Split Lake, 180 km east-northeast of Thompson and 30 km west of Gillam (Map 1). Construction of the Project began in July 2014.

The *Keeyask Generation Project: Response to EIS Guidelines*, completed in June 2012, provides a summary of predicted effects and planned mitigation for the Project. Technical supporting information for the aquatic environment, including a description of the environmental setting, effects and mitigation, and a summary of proposed monitoring and follow-up programs, is provided in the *Keeyask Generation Project Environmental Impact Statement: Aquatic Environment Supporting Volume* (AE SV). As part of the licensing process for the Project, an *Aquatic Effects Monitoring Plan* (AEMP) was developed detailing the monitoring activities of various components of the aquatic environment for the construction and operation phases of the Project.

Aquatic habitat provides the environment in which aquatic biota live, as defined by water depth, velocity, substratum, and structure (including non-living and living (rooted plants) components). Aquatic habitat monitoring programs occur within the area of direct effect between the outlet of Clark Lake and approximately 7 km downstream of the GS. These programs were designed to record changes over time in aquatic habitat that was altered by the Project, document the evolution of flooded terrestrial habitat into productive aquatic areas, and to assess conditions on structures constructed to offset habitat loss. A specific monitoring program was designed to assess the effects of the Project on nearshore habitats and aquatic macrophyte growth.

Data collected in shallow water areas (less than 3 m) will be used to monitor changes in flooded areas that develop into new nearshore and macrophyte habitat as the Keeyask reservoir ages. This program will provide the first detailed study of the rate that nearshore habitats form in a sub-arctic reservoir and will provide an understanding of the variables that create and maintain habitat distributions (*e.g.*, sediment boundaries, macrophyte distributions, effects of water level variation). The post-Project data will be compared to baseline data and reference sites in Stephens Lake, which is considered a future proxy for the Keeyask reservoir at approximately 25 years after flooding.

Impoundment of the Keeyask reservoir was completed on September 5, 2020. Sampling in the Keeyask reservoir in 2021 represented the first year of sampling under operating conditions (water levels and flows). The key questions identified in the AEMP for this monitoring component are:

- *How will nearshore habitat develop in the Keeyask reservoir?*
- *How will aquatic macrophyte habitat develop in the Keeyask reservoir?*

- *How precise were the predictions in the EIS?*

This report provides results collected August 2021, nearly one year following impoundment. These results will be used to describe the initial flooded condition within the Keeyask reservoir. Development of nearshore and macrophyte habitat is expected to be slow and may take up to 15 years to develop, depending on site conditions. Surveys will be repeated over time to describe the development of nearshore habitat as the Keeyask reservoir ages.

2.0 STUDY SETTING

The study area encompasses an approximately 50 km long reach of the Nelson River from Birthday Rapids to the north arm of Stephens Lake (Map 1). This section of river offers a diversity of physical habitat conditions, including a variety of substrate types, and variable water depths (range 0–30 m) and velocities. Birthday Rapids is located approximately 10 km downstream of Clark Lake and 30 km upstream of Gull Rapids/the Keeyask GS and marks the upstream end of major water level changes as a result of impoundment by the Keeyask GS. The drop in elevation from the upstream to downstream side of Birthday Rapids was approximately 2 m prior to impoundment but is now a near level, albeit fast-flowing section of river. The 14 km reach of the Nelson River between Birthday Rapids and Gull Lake was characterized as a large and somewhat uniform channel with medium to high water velocities and a few large bays. This area is now within the Keeyask reservoir, though flooding was limited to mainly shoreline areas.

Prior to impoundment, Gull Lake was a widening of the Nelson River, with moderate to low water velocity beginning approximately 20 km upstream of Gull Rapids/the Keeyask GS. Water levels on Gull Lake increased by several metres following impoundment and flooding along the shoreline and small tributaries entering this reach was extensive. Although this area is now a portion of the Keeyask reservoir, it is referred to herein as Gull Lake.

Just below the Keeyask GS, the Nelson River enters Stephens Lake. Stephens Lake was formed in 1971 by construction of the Kettle GS. Construction of the Keeyask GS has altered the flow distribution immediately downstream of the station.

Construction of the Kettle GS flooded Moose Nose Lake (north arm) and several other small lakes that previously drained into the Nelson River, as well as the old channels of the Nelson River that now lie within the southern portion of the lake. Major tributaries of Stephens Lake include the North and South Moswakot rivers that enter the north arm of the lake. Looking Back Creek is a second order stream that drains into the north arm of Stephens Lake. Kettle GS is located approximately 40 km downstream of the Keeyask GS.

2.1 FLOWS, WATER LEVELS, AND KEEYASK OPERATIONS

From October 2020 to mid-June 2021 the calculated Split Lake outflow varied about the median flow of about 3,300 m^3/s, ranging between about 3,000 m^3/s and 3,900 m^3/s. From mid-June to mid-August, the flows steadily decreased from about 3,700 m^3/s to about 2,000 m^3/s, which is approximately the 5th percentile low flow. Low flow conditions persisted from summer into winter, with flows dropping to a low of about 1,800 m^3/s at the end of November 2021. These are the lowest flows that have occurred during Keeyask construction. It is not since 2005 that flows this low have occurred on the Nelson River.

Water levels on Gull Lake have been held steady between about 158.8–159 m since reservoir impoundment in September 2020. Upstream of Gull Lake at gauges below and above Birthday

Rapids the levels were about 0.5 m and 2 m higher than on Gull Lake, a smaller difference than would have occurred prior to the Project. Upstream levels increased about 3–4 m at these sites in winter due to ice effects as in previous years. Due to low flows in summer 2021 the water surface was relatively flat from Gull Lake to the gauge just upstream of Birthday Rapids, with a difference of only about 0.8–0.9 m between the two.

Keeyask is transitioning from a construction project to an operating station (Map 2). In 2021, the work at site has been focused on bringing units into service. By the end of April 2021, prior to the start of aquatic monitoring, Unit 1 and Unit 2 were in service. Throughout the open-water period more units were being tested and brought into service, one at a time. As units came into service, the distribution of flow between the spillway and powerhouse has gradually shifted, as summarized below. By the end of October 2021 five units were fully in service.

Discharges from the spillway and powerhouse are not measured but have been estimated based on performance design curves. For reference it is noted that the design discharge capacity of the powerhouse is 4,000 m^3/s, giving each turbine unit a discharge capacity of approximately 570 m^3/s.

Table below outlines Keeyask GS operation, including powerhouse and spillway flows, in 2021.

Time 2021	Powerhouse Units	Spillway Gate Operation	Powerhouse (m3/s)	Spillway	Keeyask Total
			Discharge (m^3/s)		
end Apr - end Jun	Unit 2 online Unit 3 testing	Gates 1, 2, 3, 5, 7 in use until mid-Jun. Gates 1, 3, 5, 7 primarily mid to end Jun	Steady at about 1,100 varying down to 600 on a few intermittent days and up to 1,650 during 2 weeks of U3 testing	Generally 2,200–2,800 except during U3 testing it varied from about 1,400–2,400	Generally 3,400–3,900 except during Unit 3 testing it varied from 2,600–3,600
end Jun – mid Sep	Unit 3 online Unit 5 testing	Generally, Gates 1,3, 5, 7 until mid Jul. Gates 3, 5, 7 until end of Jul. Various gates used in Aug. Gates 1 and 7 used in Sep until closure of all gates on Sep 11.	About 1,650, but reduced to 1,100 for 2 weeks with a unit shut down and varying up to 2,100 during 2 weeks of U5 testing	From end Jun to mid Aug Nelson R inflow declined from about 3,600 to about 1,800–2,200 and has remained steady around 2,000–2,200 m^3/s since then – corresponding spillway discharge gradually declined from about 2,400 to 0 by mid-Sep when U5 came into service although daily variations of +/- 200–400 or more in a few instances occurred during this time	Total Keeyask discharge declined from about 3,600 to an average of about 2,000–2,200 corresponding to the decrease in Nelson R inflow, and daily variation of about +/- 200-400 depending on spillway and powerhouse operations
Mid Sep – end Oct	Unit 5 online Unit 4 testing Unit 4 online Oct 25	Various gates used very sporadically. First reopening on Sep 28.	Average discharge about 2,000–2200 with typical daily variation from 1,600–2,200 and a maximum variation between 1,000–2,800 depending on unit operations an U4 testing	No spillway flow except for a few intermittent days of up to 1,000	Same as powerhouse

3.0 METHODS

3.1 SUBSTRATE SAMPLING

3.1.1 BOTTOM TYPE VALIDATION

Bottom type validation or substrate sampling was used to both observe and record substrate characteristics at discrete locations and validate the acoustic bottom typing data. Bottom type or substrate validation sampling was conducted by collecting substrate grab samples and qualitatively assessing substrate composition, through laboratory analysis of selected grab sample, and using sidescan sonar.

Substrate grab samples were collected using a petite Ponar (0.023 m^2 surface area) dredge sampler. Primary, secondary, and tertiary substrate types were identified at each validation site and classified according to a modified Wentworth sediment size classification, an estimate of the relative substrate composition of the sample was recorded (Table 1; Wentworth 1922). At locations where the Ponar could not be used (e.g., in areas of high currents or rock bottom) a weighted sounding line was dragged across the substrate to differentiate between rock versus fine hard-packed substrates.

Sediment grab samples preserved for particle size analysis were sent to ALS Laboratories in Winnipeg, MB (a Canadian Association for Laboratory Accreditations Inc. accredited laboratory) for sediment particle size analysis (PSA), texture classification, and organic content analysis.

Bottom type validation sampling sites were chosen prior to conducting field work based on aerial images of the newly formed reservoir. These sites were chosen randomly and had never been visited and water depths were not known. Because of this, some sites within the Keeyask reservoir were shallower than expected and could not be accessed by a boat. Further, extremely low water levels in Stephens Lake prevented boat access to some nearshore areas. In future years, sites will be chosen based on data collected herein, including areas with depths known to be deep enough for boat access. Further, alternate sites will be chosen prior to field data collection that could be sampled if a site were inaccessible.

3.1.2 ACOUSTIC SURVEYS

A BioSonics MX 200 kHz single-beam echosounder (SBES) beam sonar was used to characterize the substrate and calculate depth within each nearshore habitat area. An initial transect was navigated parallel to the shoreline through the whole sampling area. A second ‘zig-zag' patterned transect was conducted travelling between nearshore and offshore crossing the first.

BioSonics Visual Aquatic software was used to accurately calculate depth across each transect. Sound velocity corrections were completed first by entering daily average water temperature from Manitoba Hydro's water temperature gauging station at Clark Lake into the calibration settings for each file. Bottom depth is detected in the field based on a signal threshold decibel (dB) level set in the BioSonics Visual Acquisition software. Depth detection was reanalyzed in Visual Aquatic software using a -55 dB rising level threshold to extract depth more accurately. Manual editing was completed and checked for signal error, pulse range omission, invalid depths, and acoustic waveform anomalies, and erroneous data.

The BioSonics data were also analyzed using Visual Habitat software to produce an acoustic substrate classification model. The software package analyses the individual depth corrected echo waveforms recorded in the field to produce features or variables that are used to characterize the bottom type based on relative hardness and roughness of a bottom type according to how they interact with sound. A model was created which classed acoustic signals into classes or types, based on the fact that different substrate types have different acoustic signals. Eight substrate classes were chosen including: organics (class 1), silt/clay (class 2), silt/clay/sand (class 3), sand (class 4), gravel/ sand (class 5), gravel (class 6), cobble (class 7), and bedrock/boulder (class 8).

3.2 MACROPHYTE SAMPLING

The Point Intercept method was used to survey aquatic macrophytes at regularly spaced, pre-selected points in a grid pattern. These survey data can be used to identify and delineate plant communities and bed types. The end product includes a map showing the distribution of plant bed types including a list of species for each plant bed type and the waterbody or study area (CCME 2011).

Nine areas in the Keeyask reservoir (MS1-MS9) and three areas in Stephens Lake (MS10-MS12) were sampled at randomly generated points (Map 3). Each pre-selected random point in the survey area was visited and water depth was recorded. Weather conditions, water temperature, and Secchi depth reading were recorded once in each area.

Aquatic plants were identified on site based on presence/absence. Relative abundance of aquatic plants at each site was assessed as absent (0), sparse (1), common (2) or abundant (3), and then the proportion of each species within the sample was estimated (1–100%; Dawson *et al*. 2020). In each area, the species of plants were identified as emergent, submergent, and floating. Macro-algae (*Chara* spp. and *Nitella* spp.), filamentous algae, aquatic mosses, and free-floating vascular plants (*Lemna* spp.) were also recorded if observed. A weighted rake sampler was used at each site to assess the relative abundance of the submerged aquatic plants (Figure 1; Hauxwell *et al.* 2010). The rake sampler consists of a double headed rake, constructed back-to-back with hose clamps and U-bolts with a heavy braided rope (10 m long) to assist in keeping the rake along the bottom (Photo 1).

3.3 LIGHT EXTINCTION SAMPLING

Secchi depth measurements were taken once per sampling area. Measurements were taken on the shady side of the boat with the observer not wearing sunglasses to interfere with readings. The Secchi disk was slowly lowered in the water until it disappeared from sight and that depth was noted. The disk was then lowered down 1 m into the water column or until it was out of sight and then raised slowly until visible again and this depth was noted. The average of these two readings was recorded as the final secchi depth.

At three sites in each of the sampling areas a light profile measurement was taken with the LI-1400 data logger (LiCOR). There are three sensors associated with the LiCOR, terrestrial sensor (air), spherical sensor (underwater), and the flat sensor (underwater). The terrestrial (air) sensor was placed on a flat unobstructed surface and in direct sunlight, close to the surface of the water. The spherical (underwater) sensor was lowered in the water on the sunny side of the boat and light readings were recorded.

Light readings were recorded just below the water surface and at 10 cm vertical increments until the point of extinction was reached. At the point of extinction, the LiCOR was continually lowered vertically 20 cm below the extinction point to ensure that all readings had been recorded. The data will vary depending on cloud cover, time of day, water clarity, and water colour.

3.4 SATELLITE REMOTE SENSING

Changes in the shape of the reservoir and the rate of shoreline changes can affect the availability and quality of nearshore habitats. Moderate/high resolution satellite images are used to track reservoir scale changes over time using optical and microwave electromagnetic frequencies. These changes include shoreline position and shape of nearshore habitats as well as the boundaries of turbid water masses (*i.e.*, water masses with high suspended sediment concentration) and humic water masses (*i.e.*, water masses high in dissolved organic carbon concentration). The European Space Agency's (ESA) Sentinel-2 satellite acquires optical data across the globe using the MultiSpectral Instrument Sensor (MSI) and Sentinel-1 satellite acquires microwave data using synthetic aperture radar (SAR). Microwave data are used in addition to optical as it penetrates cloud cover allowing for imaging on cloudy days.

Sentinel-2 Level-2A optical and Sentinel-1 Level-1 Ground Range Detected (GRD) SAR images of the reservoir were obtained from the ESA Copernicus Open Access Hub website (https://scihub.copernicus.eu/). The images acquired are of the Keeyask study area on select dates between August 2019 and September 2021. Six images captured during the 2021 open-water season (spring, summer, and fall) were processed and analyzed in this study.

Satellite remote sensing data (both optical and microwave) were analyzed in the ESA's SNAP processing software. The spectral bottom of atmosphere reflectance values of the near infrared optical band were used to create a threshold classification of land and water. Each image date will have a slightly different optimal threshold value based on differences in environmental conditions during image acquisition. ArcGIS was used to calculate an estimated total open water area of the reservoir over the three dates (spring, summer, fall) from the classified image data.

An unsupervised image classification approach was used to cluster the pixel values of the optical imagery into ten classes. These were then classified as humic (high in dissolved organic carbon, mixed (a transition class between humic and turbid water masses), or turbid (expected to be high in TSS) according to their apparent optical properties. Humic water appears very dark in the imagery, turbid water is bright, and mixing is obvious between the two. ArcGIS was then used to map and summarize the areas of these three water mass types.

The microwave image data processing and analysis has a different approach to discriminating land and water boundaries (*i.e.*, shorelines). Orbit information was applied to each of the files, followed by radiometric calibration to provide a calibrated measure (Sigma0) that can be used to compare ground targets across multiple dates of imagery. The files were then put through a process known as coregistration to account for any subtle geometric differences between the images. This process also allows the multiple dates of imagery to be directly comparable. Speckle filtering was then used to reduce the natural granular effect inherent in these data. Filtering removes these areas of the images and maintains sharp boundaries between targets (*i.e.*, land and water). A terrain correction procedure used an SRTM 1sec HGT digital elevation model (DEM) to correct geometric distortions present in the data and produce the final mapped product in UTM Zone 15N. Data were then reviewed for an optimal land and water Sigma0 threshold value. Once that value was identified it was used to create a land and water boundary or mask for the reservoir.

4.0 RESULTS

The locations of the nearshore sampling locations are presented in Map 3. Several sites were sampled within flooded backbays in the Keeyask reservoir that are sampled as part of several aquatic monitoring programs and are referred to as zones (Map 4). All aquatic macrophyte taxa observed are shown in Table 2; Appendix A1-1 to A1-2, and LICOR light penetration data (maps 9 and 10) are presented in Appendix A1-3 to A1-4.

4.1 NEARSHORE HABITAT SURVEYS

4.1.1 UPSTREAM OF BIRTHDAY RAPIDS (MS1)

Mean water surface elevation was 159.8 m at site MS1 at the time of sampling on August 14, 2021 (Table 3). Water depth ranged from 1.1–10.4 m.

Eight of 15 bottom type validation sites were sampled within the area (Map 5). The remaining seven sites were shallow and inaccessible at the time of sampling. A petite Ponar was used at seven sites, and a weighted sounding line at one (Table 4). Most sites were classified as hard compact clay and silt with some organics, which was confirmed by substrate mapping derived from analysis of sidescan image data. The acoustic classification model indicated the area to be dominated by organic substrates (50%) followed by bedrock/boulder (10%) and cobble (10%) (Table 5). Enough substrate was collected for PSA at a single site (MS1-9) which consisted of largely silt (47%) and sand (43%) (Table 6).

Aquatic plants were observed at four sampling sites, which ranged in depth from 0.2–1.0 m in depth (Appendix A1-1; Map 6. Four species of aquatic macrophytes were present, the most abundant of which were sago pondweed (*Stuckenia pectinata*) and Richardson pondweed (*Potamogeton richardsonii*). Dense beds of emergent aquatic plants were present in areas farther into the bay that was too shallow to enter and could not be sampled.

4.1.2 DOWNSTREAM OF BIRTHDAY RAPIDS (MS2)

Mean water surface elevation was 159.0 m at site MS2 on August 14, 2021 (Table 3). Depth in flooded, previously terrestrial areas ranged from 1.6–1.9 m. Depth in the area of the pre-impoundment shoreline ranged from 1.9–8.0 m.

Nine of 15 bottom type validation sites were sampled within the area (Map 5). The remaining six sites were too shallow to access with a boat at the time of sampling. A petit Ponar was used at five sites and a weighted sounding line at four (Table 7). Most sites were classified as hard cobble and gravel, which was confirmed by substrate mapping derived from analysis of sidescan image data (Photo 2). Two sites contained organics and silt. The acoustic classification model confirmed that the area was dominated by hard rocky substrates including gravel (23%), cobble (23%), and bedrock/boulder (14%) (Table 5). PSA could not be conducted at any of the sites due to the presence of coarse substrate (Table 6).

Plants were observed at a single sampling site 0.3 m deep (Appendix A1-1; Map 6). A single semi-aquatic plant species (wild celery; *Apium* spp.) was present.

4.1.3 KEEYASK RESERVOIR BACKBAY ZONE 4 (MS3)

Mean water surface elevation was 158.9 m at site MS3 on August 15, 2021 (Table 3). Depth in flooded, previously terrestrial areas ranged from 1.0–4.1 m. Depth in the area of the pre-impoundment shoreline ranged from 2.8–4.9 m.

A petite Ponar was used at 11 of 15 bottom type validation sites (Map 5). The remaining four sites were too shallow to access with a boat at the time of sampling (Table 8). Most sites were classified as silt, clay, and organics, which was confirmed by substrate mapping derived from analysis of sidescan image data. The acoustic classification model indicated the area to be dominated by organic (39%), silt/clay (34%), and silt/clay/sand (21%) substrates (Table 5). PSA analysis was conducted at three sites, two of which were classified as silt loam and one as silt (Table 6).

Aquatic plant species were observed at two sites that ranged in depth from 0.8–1.5 m (Appendix A1-1; Map 6). Watermilfoil (*Myriophyllum* spp.) was most abundant while duck celery (*Vallisneria* spp.) and long-leaf pondweed (*Potamogeton nodosus*) were rare.

4.1.4 KEEYASK RESERVOIR BACKBAY ZONE 12 (MS4)

Mean water surface elevation was 158.9 m at site MS4 on August 16, 2021 (Table 3). Depth in the flooded terrestrial area ranged from 1.0–4.7 m. No existing (*i.e.*, pre-flooded area) shorelines were present as the entire site was located within a flooded area.

A petite Ponar was used at eight of 15 bottom type validation sites (Map 5). The remaining seven sites were too shallow to access with a boat at the time of sampling (Table 9). Because the area was located within a flooded bay, all sites were classified as organic which was confirmed by substrate mapping derived from analysis of sidescan image data (Photo 3). The acoustic classification model indicated the area to be dominated by organic (56%) and silt/clay (24%) substrates (Table 5). PSA analysis was conducted at three sites that were classified as either silt loam, silt, or clay (Table 6).

Aquatic plant species were observed at three sites ranging in depth from 0.8–2.0 m but were classified as sparse in abundance (Appendix A1-1; Map 6). Two species were present including Richardson pondweed and bladderwort (*Utricularia* spp.).

4.1.5 SOUTH SHORE KEEYASK RESERVOIR (MS5)

Mean water surface elevation was 158.9 m at site MS5 on August 22, 2021 (Table 3). Depth in flooded, previously terrestrial areas ranged from 1.5–6.8 m. Depth in the area of the pre-impoundment shoreline ranged from 5.7–15.9 m.

A petite Ponar was used at 12 of 15 bottom type validation sites (Map 5). The remaining three sites were too shallow to access with a boat at the time of sampling (Table 10). Most sites were classified as organic, composed of detritus and loose, broken-down plant matter. Some areas of cobble were observed, as well as clay and silt. The acoustic classification model indicated the area to be dominated by soft substrates including organic (26%), silt/clay (26%), and silt/clay/sand (22%) (Table 5). PSA analysis was conducted at a single site classified as sandy loam (Table 6).

No aquatic plant species were present (Appendix A1-1; Map 6).

4.1.6 NORTH SHORE KEEYASK RESERVOIR (MS6)

Mean water surface elevation was 158.9 m at site MS6 on August 18, 2021 (Table 3). Depth in flooded, previously terrestrial areas ranged from 0.9–6.9 m. Depth in the area of the pre-impoundment shoreline ranged from 5.0–7.3 m.

A petite Ponar was used at nine of 15 bottom type validation sites (Map 5). The remaining six sites were too shallow to access with a boat at the time of sampling (Table 11). Six of the sites sampled with Ponar were too shallow to collect sidescan image data but were observed to be composed of flooded terrestrial vegetation. The remaining three sites were composed only of fines. The acoustic classification model indicated the area to be dominated by soft substrates including organic (59%), silt/clay (22%), and silt/clay/sand (13%) (Table 5). PSA analysis was conducted at two sites that were classified as silty clay loam and silt (Table 6).

No aquatic plant species were present in the area, but two terrestrial species were present in low abundance at three sites: Labrador tea (*Rhododendron groenlandicum*) and horsetail (*Equisetum* spp.) (Appendix A1-1; Map 6). Moss (phylum Bryophyta) was also observed during sediment sampling.

4.1.7 KEEYASK RESERVOIR BACKBAY ZONE 7 (MS7)

Mean water surface elevation was 158.9 m at site on August 18, 2021 (Table 3). Depth in flooded, previously terrestrial areas ranged from 1.2–5.6 m. Depth in the area of the pre-impoundment shoreline ranged from 4.8–6.7 m.

A petite Ponar was used at nine of 15 bottom type validation sites (Map 5). The remaining six sites were too shallow to access with a boat at the time of sampling (Table 12). Because the area was located within a flooded bay, the substrate at each site was composed of organic matter including detritus and loose, broken-down plant matter. The acoustic classification model indicated the area to be dominated by soft substrates including organic (32%), silt/clay (30%), and silt/clay/sand (23%) (Table 5). PSA analysis was conducted at three sites that were classified as silt loam, silt, and clay (Table 6).

Two species of terrestrial plant and four species of aquatic plants were observed at six sites ranging in depth from 0.3–1.5 m (Appendix A1-1; Map 6). Aquatic plants were abundant at most sites and included bladderwort, duck celery, pond-lily (*Nuphar* spp.), and stonewort (*Chara* spp.).

4.1.8 KEEYASK RESERVOIR BACKBAY ZONE 8 (MS8)

Mean water surface elevation was 158.9 m at site MS8 on August 18, 2021 (Table 3). Depth in the flooded terrestrial area ranged from 1.0–4.6 m. No existing (*i.e.*, pre-flooded) shorelines were present as the entire site was located within a flooded area.

A petite Ponar was used at four of 15 bottom type validation sites (Map 5). The remaining 11 sites were too shallow to access with a boat at the time of sampling (Table 13). Because the area was located within a flooded bay, the substrate at each site was composed of organic matter including detritus and loose, broken-down plant matter. The acoustic classification model indicated the area to be dominated by organic (45%), silt/clay (28%), and silt/clay/sand (18%) substrates (Table 5). PSA analysis was conducted at two sites that were both composed of silt (Table 6).

One species of terrestrial plant (smartweed) and one species of aquatic plant (bladderwort) were observed at four sites ranging in depth from 0.3–2.4 m (Appendix A1-1; Map 6).

4.1.9 LOWER KEEYASK RESERVOIR (MS9)

Mean water surface elevation was 158.9 m at site MS9 on August 11, 2021 (Table 3). Depth in flooded, previously terrestrial areas ranged from 1.2–6.7 m. Depth in the area of the pre-impoundment shoreline ranged from 4.9–14.9 m.

A petite Ponar was used at 14 of 15 bottom type validation sites (Map 5). The remaining site was too shallow to access with a boat at the time of sampling (Table 14). Most sites were classified as organic substrates including detritus and loose, broken-down plant matter, with silt. A single site (MS9–9) was classified as sand and silt, which was confirmed during PSA analysis (Photo 4). The acoustic classification model indicated the area to be dominated by soft substrates including silt/clay (23%), silt/clay/sand (20%), and organics (14%) (Table 5). PSA analysis was conducted at three sites which were classified as sand, silty clay loam, and silt loam (Table 6).

No aquatic plant species were observed during aquatic macrophyte surveys. Two species of terrestrial plant (moss, marestail, *Conyza canadensis*) were observed during sediment sampling.

4.1.10 STEPHENS LAKE (MS10)

Mean water surface elevation was 140.1 m at site MS10 on August 17, 2021 (Table 3). Shoreline depth ranged from 1.0–8.6 m.

A petite Ponar was used at 11 of 15 bottom type validation sites (Map 7). The remaining four sites were too shallow to access with a boat at the time of sampling (Table 15). Clay was observed at most sites, confirmed as clay/silt from analysis of sidescan image data. The acoustic classification model indicated the area to be dominated by soft substrates including silt/clay (34%), organics (30%), and silt/clay/sand (28%) (Table 5; Photo 5). PSA analysis was conducted at two sites which were classified as silt loam (Table 6).

Aquatic plant species were observed at three sites ranging in depth from 1.0–2.2 m (Appendix A1-2; Map 8). Two species were present: Richardson pondweed and sago pondweed.

4.1.11 STEPHENS LAKE (MS11)

Mean water surface elevation was 140.1 m at site MS11 on August 17, 2021 (Table 3). Shoreline depth ranged from 1.1–8.4 m.

A petite Ponar was used at 12 of 15 bottom type validation sites (Map 7). The remaining three sites were too shallow to access with a boat at the time of sampling (Table 16). Clay was determined to be the dominant substrate, confirmed as clay or clay/silt from analysis of sidescan image data. Cobble was present at a single site. The acoustic classification model indicated the area to be dominated by soft substrates including organics (49%), silt/clay (24%), and silt/clay/sand (21%) (Table 5). PSA analysis was conducted at two sites which were classified as silty loam and sandy loam (Table 6).

Aquatic plant species were observed at a single site 0.5 m deep (Appendix A1-2; Map 8). Two species were present: Richardson pondweed and sago pondweed.

4.1.12 STEPHENS LAKE (MS12)

Mean water surface elevation was 140.1 m at site MS12 on August 17, 2021 (Table 3). Shoreline depth ranged from 1.1–7.9 m.

A petite Ponar was used at 13 of 15 bottom type validation sites (Map 7). The remaining two sites were too shallow to access with a boat at the time of sampling (Table 17). Clay was observed to be the dominant substrate type at most sites, confirmed as clay or clay/silt from analysis of sidescan image data. Organic matter was also present at four sites, consisting of detritus and decomposing vegetation. The acoustic classification model indicated the area to be dominated by soft substrates including organics (35%), silt/clay/sand (24%), and silt/clay (11%) (Table 5).

PSA analysis was conducted at three sites which were classified as silt clay loam and silt (Table 6).

No aquatic plant species were present.

4.1.13 LIGHT EXTINCTION

LICOR light penetration data were collected for future analysis of plant growth and are presented in Appendix A1-3 to A1-4 and Maps 9 and 10.

4.2 SATELLITE REMOTE SENSING

Satellite remote sensing data (both microwave and optical) were collected from the Copernicus/European Space Agency (Table 18). These data were used to map the Keeyask reservoir showing shoreline and water mass boundary positions for the spring (June), summer (August), and fall (October) of 2021 (Map 11 and 12).

4.2.1 OPEN WATER AREA OF THE RESERVOIR IN YEAR 1

Open water area was calculated from the analysis and classification of optical data from spring (June 14), summer (August 31) and fall (October 17) 2021 (Table 19; Map 13). SAR data was processed and assessed but was determined to not be as accurate in discriminating between land, water, and flooded wetland/peatland environments, therefore, areas are not reported for those data (Figure 2).

Qualitative assessment indicated that the year 1 shorelines predicted in the EIS are in general agreement with the open water boundaries derived from the optical satellite image data (i.e., shorelines). Differences in the predicted shorelines and satellite derived shorelines near the MS-9 monitoring area can be attributed to changes to shoreline modelling data sets post-EIS (Map 13). In general reservoir open water area was greater in the spring (9,190 ha) when inflows were higher and the initially flooded peatlands remained below the surface of the reservoir. Overall open water area dropped to 8,762 ha in summer and 8,777 ha in fall when inflows were low. It appears that after the spring period peat material began to resurface after initial flooding from reservoir impoundment in fall 2021. In the mapping this is evident by the small green island areas apparent in some of the backbays in summer and fall. Total open water area decreased through the open water season as a result of the resurfacing of peat material becoming floating peat islands. This type of erosion process was predicted for the reservoir and is well documented in the EIS.

4.2.2 HUMIC, MIXED, AND TURBID WATER MASS BOUNDARIES IN YEAR 1

Areas of humic (high concentration of dissolved organic carbon), mixed (transition between humic and turbid water masses) and turbid (high concentration of suspended sediment) water masses were calculated from the analysis and classification of optical satellite remote sensing data from spring (June 14), summer (August 31), and fall (October 17) 2021 (Table 19; Map 14).

Turbid water masses were the predominant class throughout the mainstem of the Nelson River and into the reservoir for all three seasons. The backbays in general have the highest proportion of humic water. A clear transition of mixed water exists between the humic and turbid water masses. The fall (October 17) had the highest amount of turbid water (7,111 ha) and the lowest amount of humic and mixed water masses. This may be related to a lack of runoff through surrounding peatlands/organic soils in what was a dry summer/fall.

5.0 DISCUSSION

The primary objective of nearshore habitat monitoring is to monitor changes in shallow (less than 3 m) flooded areas that will develop into new nearshore and aquatic macrophyte habitat as the Keeyask reservoir ages. The development of nearshore habitat and areas suitable for aquatic macrophytes within the Keeyask reservoir depends primarily on changes in water level, exposure, the type and distribution of pre-flood soils, the boundary between humic and turbid water masses, and the processes of erosion, transport, and deposition of sediments. The rate of habitat development in the early years of the reservoir is uncertain. Nearshore areas were sampled within nine areas within the Keeyask reservoir and three areas in Stephens Lake in 2021 during the first year following reservoir impoundment.

Substrates within sampling areas in the Keeyask reservoir consisted largely of flooded terrestrial vegetation with some soft (silt and clay) substrates. This is not unexpected considering these sites represent newly flooded terrestrial areas. Plants present largely consisted of terrestrial species that persisted following flooding. The one exception was the area sampled upstream of Birthday Rapids (MS1). Flooding was minimal in the area and aquatic plants were present on substrates composed of clay, silt, and organics.

Three areas were sampled in Stephens Lake, which is considered a future proxy for the Keeyask reservoir at approximately 25 years after flooding. Substrates within all three areas were largely composed of clay and silt with some areas of sand and cobble. Aquatic plants were present at few sites. Water levels were low on Stephens Lake in 2021, largely driven by low flows throughout the system. From mid-June to mid-August, the flows on the Nelson River at the Split Lake outflow decreased from about 3,700 m^3/s to about 2,000 m^3/s, which is approximately the 5^{th} percentile low flow. Stephens Lake was further impacted by the Keeyask GS powerhouse commissioning, which required water to be held and released, causing water level fluctuations downstream. It is likely that, together, these factors influenced aquatic plant growth on Stephens Lake. It is expected that in future years, under more normal flow scenarios, more aquatic plants would be observed at these three sites.

Substrate sampling sites were chosen prior to conducting field work based on post-impoundment shorelines predicted in the EIS and aided by satellite images of the newly formed reservoir. These sites were chosen randomly and had never been visited and water depths were not known. Because of this, some sites within the Keeyask reservoir were shallower than expected (i.e., contained less than 0.5 m of water) and could not be accessed by a boat. Further, extremely low water levels in Stephens Lake prevented boat access to some nearshore areas. In future years, sites will be chosen based on the data collected herein, including depth profiles within each nearshore sampling area. Sites will be chosen at random only within an area known to be deep enough for boat access. Further, alternate sites will be chosen prior to field data collection that could be sampled if a site were inaccessible.

Satellite remote sensing data revealed an initial qualitative agreement with modelled post-Project shorelines for year 1 of the reservoir predicted in the EIS. The boundaries of humic, mixed, and turbid water masses were clearly visible across the three image sampling dates.

Data were collected during the first open-water period following impoundment of the Keeyask reservoir. Because of this, it is too soon to make inferences about changes in substrate or aquatic plant production in nearshore areas. Surveys will be repeated using the same measures to describe changes to nearshore habitats as the Keeyask reservoir ages.

6.0 SUMMARY AND CONCLUSIONS

- Nearshore habitats were monitored in nine areas within the Keeyask reservoir and three areas in Stephens Lake in 2021.
- Substrates within sampling areas in the Keeyask reservoir consisted largely of flooded terrestrial vegetation with some soft (silt and clay) substrates. Plants present largely consisted of terrestrial species. The one exception is the area sampled upstream of Birthday Rapids (MS1) where flooding was minimal and aquatic macrophytes were established.
- Three areas were sampled in Stephens Lake, which is considered a future proxy for the Keeyask reservoir at approximately 25 years after flooding. Aquatic plants were present at fewer sites than expected likely due to low water levels.
- Sampling could not be conducted at all pre-selected sites. These sites were chosen at random prior to field sampling without knowledge of post-flooding depth within the Keeyask reservoir. Some areas were too shallow to access by boat. Extremely low water levels in Stephens Lake also made some sites inaccessible. In future years, depth data from each nearshore sampling area will be used to select sites. Further, alternate sites will be chosen prior to field data collection that could be sampled if a site were inaccessible.
- Optical and microwave remote sensing was used to map open water and the areas of humic, mixed, and turbid water masses in spring summer and fall. Qualitative agreement with modelled Year 1 post-Project shorelines predicted in the EIS was good.
- As 2021 represents the first year of nearshore monitoring, it is too early to make conclusions regarding changes to these habitats as a result of the Project. This study will be repeated annually until 2023.

7.0 LITERATURE CITED

Canadian Council of Ministers of the Environment (CCME). 2011. Protocols manual for water quality sampling in Canada. Report# PN 1461.

Dawson, K., Dolce Blanchard, L. and J. Larter. 2020. Aquatic habitat monitoring in the Wuskwatim Study Area, 2018. Wuskwatim Generation Project Monitoring Report #20- 02. A report prepared for the Wuskwatim Power Limited Partnership by North/South Consultants Inc., January 2020

Hauxwell, J., S. Knight, K. Wagner, A. Mikulyuk, M. Nault, M. Porzky, and S. Chase. 2010. Recommended baseline monitoring of aquatic plants in Wisconsin: Sampling design, field and laboratory procedures, data entry and analysis, and applications. Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010. Madison, WI.

Larter, J., and C.L. Hrenchuk. 2022. Sensitive and constructed habitat monitoring in the Keeyask Study Area, 2021. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2021-15. A report prepared for Manitoba Hydro by North/South Consultants Inc. June 2022, xx + 79 pp.

Wentworth, C.K. 1922. A scale of grade and class terms for clastic sediments. The Journal of Geology 30: 377–392. https://doi.org/10.1086/622910

TABLES

Table 1: Modified Wentworth scale of material size used to classify substrate *in situ* (after Wentworth 1922).

Size Range	Wentworth Class	General Class	Basic Class
-	-	Bedrock	Rock
>256 mm	Boulder	Boulder	
64–256 mm	Cobble	Cobble	
32–64 mm	Very coarse gravel	Gravel	
16–32 mm	Coarse gravel		
8–16 mm	Medium gravel		
4–8 mm	Fine gravel		
2–4 mm	Very fine gravel		
1–2 mm	Very coarse sand	Sand	Sand
0.5–1 mm	Coarse sand		
0.25–0.5 mm	Medium sand		
125–250 µm	Fine sand		
62.5–125 µm	Very fine sand		
3.9–62.5 µm	Silt	Silt	Mud
0.98–3.9 µm	Clay	Clay	
-	-	Organic	Organic

Table 2: Aquatic macrophytes observed in the Keeyask reservoir and Stephens Lake, 2021.

Common Name	Scientific Name
bladderwort	*Utricularia* spp.
duck celery	*Vallisneria* spp.
horsetail	*Equisetum* spp.
Labrador tea	*Rhododendron groenlandicum*
long-leaf pondweed	*Potamogeton nodosus*
marestail	*Conyza canadensis*
moss	Phylum, Bryophyta
pond-lily	*Nuphar* spp.
Richardson pondweed	*Potamogeton richardsonii*
sago pondweed	*Stuckenia pectinata*
smartweed[1]	*Persicaria* spp.
stoneworts	*Chara* spp.
swaying bulrush	*Schoenoplectus subterminalis*
watermilfoil	*Myriophyllum* spp.
wild celery	*Apium* spp.
willow	*Salix* spp.

1 - smartweed (*Persicaria* spp.) has both a terrestrial and an aquatic form

Table 3: Minimum, maximum, and mean depth (m), and water levels as measured at each nearshore habitat monitoring site, 2021. Water surface elevations were taken from Manitoba Hydro gauges located upstream of Birthday Rapids (05UF770), downstream of Birthday Rapids (05UF771), Upstream of Gull Lake (05UF587), and Gull Lake (05UF596).

Location	Date	Area	Existing Shoreline Depth			Flooded Shoreline Depth			Mean Water Surface Elevation (m)
			Mean (m)	Min (m)	Max (m)	Mean (m)	Min (m)	Max (m)	
Keeyask reservoir	14-Aug-21	MS1	3.36	1.11	10.41	-	-	-	159.758
Keeyask reservoir	14-Aug-21	MS2	4.26	1.93	8.04	1.75	1.62	1.87	159.008
Keeyask reservoir	15-Aug-21	MS3	4.12	2.8	4.9	3	0.96	4.13	158.912
Keeyask reservoir	16-Aug-21	MS4	-	-	-	2	0.95	4.68	158.922
Keeyask reservoir	22-Aug-21	MS5	8.86	5.67	15.93	3.64	1.52	6.77	158.870
Keeyask reservoir	18-Aug-21	MS6	6.99	5	7.3	2.31	0.93	6.85	158.896
Keeyask reservoir	18-Aug-21	MS7	6.04	4.81	6.65	3.08	1.23	5.64	158.896
Keeyask reservoir	18-Aug-21	MS8	-	-	-	2.27	0.95	4.63	158.896
Keeyask reservoir	11-Aug-21	MS9	6.42	4.88	14.86	3.46	1.17	6.74	158.856
Stephens Lake	17-Aug-21	MS10	3.36	0.96	8.55	-	-	-	140.086
Stephens Lake	17-Aug-21	MS11	2.89	1.08	8.44	-	-	-	140.086
Stephens Lake	17-Aug-21	MS12	3.44	1.12	7.92	-	-	-	140.086

Table 4: Locations and results of substrate grab type validation sampling and post-survey class verification in the area upstream of Birthday Rapids (MS1), 2021.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
MS1-1	petite Ponar	14-Aug-21	331877	6241951	2.0	hard	boulder	100	-	-	-	-	rock	boulder
MS1-2	-	14-Aug-21	332027	6242001	0.5	hard	gravel	90	cobble	10	-	-	rock	gravel/cobble
MS1-3	petite Ponar	14-Aug-21	331927	6242051	2.5	hard	clay	70	sand	25	gravel	5	mud	clay/sand/gravel
MS1-4	-	14-Aug-21	332227	6242051	-	-	-	-	-	-	-	-	-	-
MS1-5	-	14-Aug-21	332377	6242051	-	-	-	-	-	-	-	-	-	-
MS1-6	petite Ponar	14-Aug-21	332127	6242101	0.2	hard	clay	95	organics	5	-	-	mud	clay/organics
MS1-7	-	14-Aug-21	332327	6242101	-	-	-	-	-	-	-	-	-	-
MS1-8	-	14-Aug-21	332427	6242101	-	-	-	-	-	-	-	-	-	-
MS1-9	petite Ponar	14-Aug-21	332127	6242201	1.0	moderate	clay	90	silt	5	organics	5	mud	clay/silt/organics
MS1-10	-	14-Aug-21	332427	6242201	-	-	-	-	-	-	-	-	-	-
MS1-11	weighted sounding line	14-Aug-21	331977	6242301	3.5	hard	cobble	100	-	-	-	-	rock	cobble
MS1-12	petite Ponar	14-Aug-21	332227	6242301	0.5	moderate	clay	90	silt	5	organics	5	mud	clay/silt/organics
MS1-13	petite Ponar	14-Aug-21	332127	6242351	0.4	moderate	clay	90	silt	5	organics	5	mud	clay/silt/organics
MS1-14	-	14-Aug-21	332277	6242351	-	-	-	-	-	-	-	-	-	-
MS1-15	petite Ponar	14-Aug-21	332027	6242401	-	-	clay	80	cobble	20	-	-	mud	clay/cobble

1 – Class verified with sidescan imagery post-survey.

Table 5: Results of acoustic classification of single beam data collected from the Keeyask reservoir and upper Stephens Lake, 2021.

Area	Date	Total Samples	Acoustic Substrate Classification Composition (% Membership)								Total
			Organics	Mud		Sand	Rock				
			organics/FT	silt/clay	silt/clay/sand	sand	gravel/ sand	gravel	cobble	bedrock/boulder	
			Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	
MS1	14-Aug-21	796	50	5	9	4	6	8	10	10	100
MS2	14-Aug-21	1278	4	10	12	6	8	23	23	14	100
MS3	15-Aug-21	8280	39	34	21	3	1	2	1	0	100
MS4	16-Aug-21	3465	56	24	13	5	2	1	0	0	100
MS5	22-Aug-21	2846	26	26	22	5	5	7	7	1	100
MS6	18-Aug-21	4031	59	22	13	3	1	1	1	0	100
MS7	18-Aug-21	1938	32	30	23	6	3	4	2	0	100
MS8	18-Aug-21	1139	45	28	18	6	2	1	0	0	100
MS9	11-Aug-21	8599	14	23	20	10	9	11	9	3	100
MS10	17-Aug-21	2866	30	34	28	4	1	2	1	0	100
MS11	17-Aug-21	3469	49	24	21	3	1	2	1	0	100
MS12	17-Aug-21	3483	35	11	24	9	8	6	8	0	100
	Summary	**42190**	**35**	**25**	**19**	**5**	**4**	**5**	**4**	**1**	**100**

Table 6: Results of particle size analysis (conducted at ALS Laboratories) from samples collected at selected sites in the Keeyask reservoir and upper Stephens Lake, 2021.

Area Name	Date	Area Code	Habitat	Field Site No.	Inorganic Carbon (%)	CaCO3 Equivalent	Total Carbon by Combustion (%)	Total Organic Carbon (%)	% Sand (2.0-0.05 mm)	% Silt (0.05-2 µm)	% Clay (<2 µm)	Texture
Keeyask reservoir	14-Aug	MS1	Nearshore	MS1-9	1.45	12.1	3.82	2.37	42.8	46.7	10.5	loam
Keeyask reservoir	14-Aug	MS2	Nearshore	MS2-11	*[1]	*	*	*	*	*	*	*
Keeyask reservoir	14-Aug	MS2	Nearshore	MS2-12	*	*	*	*	*	*	*	*
Keeyask reservoir	15-Aug	MS3	Nearshore	MS3-4	0.202	1.69	10.8	10.6	1.4	85.5	13.1	silt loam
Keeyask reservoir	15-Aug	MS3	Nearshore	MS3-10	0.232	1.93	7.76	7.53	26.3	61	12.7	silt loam
Keeyask reservoir	15-Aug	MS3	Nearshore	MS3-13	0.822	6.85	4.76	3.94	5.6	83.6	10.8	silt
Keeyask reservoir	16-Aug	MS4	Nearshore	MS4-7	0.393	3.27	40.6	40.2	13.1	70.2	16.7	silt loam
Keeyask reservoir	16-Aug	MS4	Nearshore	MS4-10	0.382	3.18	31.1	30.7	6.7	83.9	9.4	silt
Keeyask reservoir	16-Aug	MS4	Nearshore	MS4-14	0.313	2.61	26.9	26.6	12.5	36.4	51.1	clay
Keeyask reservoir	22-Aug	MS5	Nearshore	MS5-6	1.57	13.1	3.05	1.48	51.1	42.2	6.7	sandy loam
Keeyask reservoir	18-Aug	MS6	Nearshore	MS6-3	0.968	8.06	4.24	3.27	6.4	52.7	40.9	silty clay loam/silty clay
Keeyask reservoir	18-Aug	MS6	Nearshore	MS6-6	0.529	4.41	35.9	35.4	<1.0	88.8	10.6	silt
Keeyask reservoir	18-Aug	MS7	Nearshore	MS7-3	0.39	3.25	35.7	35.3	1.2	86.4	12.4	silt loam
Keeyask reservoir	18-Aug	MS7	Nearshore	MS7-7	0.499	4.16	41	40.5	<1.0	93.9	5.8	silt
Keeyask reservoir	18-Aug	MS7	Nearshore	MS7-10	0.505	4.21	40.2	39.7	6.1	18.2	75.8	clay
Keeyask reservoir	18-Aug	MS8	Nearshore	MS8-4	0.529	4.41	35	34.5	1.7	96.2	2.1	silt
Keeyask reservoir	18-Aug	MS8	Nearshore	MS8-6	0.469	3.9	36.3	35.8	<1.0	93.2	6.5	silt
Keeyask reservoir	11-Aug	MS9	Nearshore	MS9-9	0.908	7.57	1.89	0.98	88.3	10.4	1.4	sand
Keeyask reservoir	11-Aug	MS9	Nearshore	MS9-11	0.594	4.95	29.8	29.2	5.1	43.4	51.5	silty clay
Keeyask reservoir	11-Aug	MS9	Nearshore	MS9-15	0.387	3.23	28.3	27.9	<1.0	68.1	31.2	silty clay loam
Stephens Lake	17-Aug	MS10	Nearshore	MS10-10	3.07	25.6	4.67	1.6	14.4	62.3	23.3	silt loam
Stephens Lake	17-Aug	MS10	Nearshore	MS10-12	2.95	24.5	4.59	1.64	8	79.2	12.8	silt loam/silt
Stephens Lake	17-Aug	MS11	Nearshore	MS11-8	2.84	23.7	4.67	1.83	16	61.9	22.1	silt loam
Stephens Lake	17-Aug	MS11	Nearshore	MS11-9	2.34	19.5	4.17	1.83	47.9	45.7	6.3	sandy loam
Stephens Lake	17-Aug	MS12	Nearshore	MS12-3	0.89	7.41	33.9	33	1.5	71	27.4	silt loam/silty clay loam
Stephens Lake	17-Aug	MS12	Nearshore	MS12-9	1.78	14.9	7.49	5.71	<1.0	89.5	9.8	silt
Stephens Lake	17-Aug	MS12	Nearshore	MS12-10	1.44	12	21.4	20	2.5	65	32.5	silty clay loam

1 – Lab unable to sample (coarse Substrate)

Table 7: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir downstream of Birthday Rapids (MS2), 2021.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
MS2-1	-	14-Aug-21	334264	6242964	-	-	-	-	-	-	-	-	-	-
MS2-2	-	14-Aug-21	334239	6243014	-	-	-	-	-	-	-	-	-	-
MS2-3	-	14-Aug-21	334364	6243039	-	-	-	-	-	-	-	-	-	-
MS2-4	weighted sounding line	14-Aug-21	333889	6243064	4.6	hard	cobble	100	-	-	-	-	rock	cobble
MS2-5	weighted sounding line	14-Aug-21	333839	6243114	4.8	hard	cobble	100	-	-	-	-	rock	cobble
MS2-6	-	14-Aug-21	334264	6243114	-	-	-	-	-	-	-	-	-	-
MS2-7	Ponar/sounding line	14-Aug-21	333914	6243139	7.7	hard	cobble	100	-	-	-	-	rock	cobble
MS2-8	petite Ponar	14-Aug-21	334064	6243139	4.0	hard	gravel	100	-	-	-	-	rock	gravel
MS2-9	petite Ponar	14-Aug-21	334164	6243189	0.3	moderate	organic	90	silt	10	-	-	organics	organic/silt
MS2-10	-	14-Aug-21	334314	6243189	-	-	-	-	-	-	-	-	-	-
MS2-11	petite Ponar	14-Aug-21	334114	6243214	0.6	moderate	silt	100	-	-	-	-	mud	silt
MS2-12	petite Ponar	14-Aug-21	333964	6243239	4.2	hard	gravel	100	-	-	-	-	rock	gravel
MS2-13	-	14-Aug-21	334189	6243239	-	-	-	-	-	-	-	-	-	-
MS2-14	weighted sounding line	14-Aug-21	334039	6243339	4.0	hard	cobble	100	-	-	-	-	rock	cobble
MS2-15	weighted sounding line	14-Aug-21	334164	6243414	4.4	hard	gravel	100	-	-	-	-	rock	gravel

1 – Class verified with sidescan imagery post-survey.

Table 8: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir in backbay Zone 4 (MS3), 2021.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
MS3-1	petite Ponar	15-Aug-21	340352	6244426	1.5	moderate	silt	100	-	-	-	-	mud	silt
MS3-2	petite Ponar	15-Aug-21	340052	6244526	3.1	moderate	silt	95	organic	5	-	-	mud	silt/organic
MS3-3	petite Ponar	15-Aug-21	340552	6244626	3.6	moderate	silt	95	organic	5	-	-	mud	silt/organic
MS3-4	petite Ponar	15-Aug-21	340752	6244626	3.1	moderate	silt	95	organic	5	-	-	mud	silt/organic
MS3-5	-	15-Aug-21	341052	6244626	-	-	-	-	-	-	-	-	-	-
MS3-6	petite Ponar	15-Aug-21	340352	6244726	3.9	moderate	silt	95	organic	5	-	-	mud	silt/organic
MS3-7	-	15-Aug-21	340852	6244826	-	-	-	-	-	-	-	-	-	-
MS3-8	-	15-Aug-21	339252	6245026	-	-	-	-	-	-	-	-	-	-
MS3-9	petite Ponar	15-Aug-21	339552	6245126	3.5	moderate	clay	95	silt	5	-	-	mud	clay/silt
MS3-10	petite Ponar	15-Aug-21	339852	6245126	0.8	hard	clay	100	-	-	-	-	-	-
MS3-11	-	15-Aug-21	340352	6245126	-	-	-	-	-	-	-	-	-	-
MS3-12	petite Ponar	15-Aug-21	339152	6245226	2.1	moderate	clay	95	silt	5	-	-	mud	clay/silt
MS3-13	petite Ponar	15-Aug-21	339352	6245426	4.0	soft	clay	100	-	-	-	-	mud	clay
MS3-14	petite Ponar	15-Aug-21	339652	6245626	3.7	moderate	clay	95	silt	5	-	-	mud	clay/silt
MS3-15	petite Ponar	15-Aug-21	339952	6245726	2.1	moderate	silt	100	-	-	-	-	mud	silt

1 – Class verified with sidescan imagery post-survey.

Table 9: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir in backbay Zone 12 (MS4), 2021.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
MS4-1	-	16-Aug-21	352352	6240276	-	-	-	-	-	-	-	-	-	-
MS4-2	-	16-Aug-21	352452	6240376	-	-	-	-	-	-	-	-	-	-
MS4-3	-	16-Aug-21	352652	6240476	-	-	-	-	-	-	-	-	-	-
MS4-4	-	16-Aug-21	352452	6240576	-	-	-	-	-	-	-	-	-	-
MS4-5	-	16-Aug-21	352652	6240776	-	-	-	-	-	-	-	-	-	-
MS4-6	-	16-Aug-21	353452	6240876	-	-	-	-	-	-	-	-	-	-
MS4-7	petite Ponar	16-Aug-21	352652	6241076	1.2	hard	organic	100	-	-	-	-	organics	organic
MS4-8	petite Ponar	16-Aug-21	353452	6241076	0.8	-	organic	100	-	-	-	-	organics	organic
MS4-9	-	16-Aug-21	352952	6241276	-	-	-	-	-	-	-	-	-	-
MS4-10	petite Ponar	16-Aug-21	353552	6241376	1.6	-	organic	100	-	-	-	-	organics	organic
MS4-11	petite Ponar	16-Aug-21	353352	6241476	0.9	-	-	-	-	-	-	-	-	-
MS4-12	petite Ponar	16-Aug-21	353052	6241576	1.9	hard	organic	100	-	-	-	-	organics	organic
MS4-13	petite Ponar	16-Aug-21	353552	6241576	1.0	-	organic	100	-	-	-	-	organics	organic
MS4-14	petite Ponar	16-Aug-21	353352	6241676	2.0	-	organic	100	-	-	-	-	organics	organic
MS4-15	petite Ponar	16-Aug-21	353452	6241676	2.0	-	organic	100	-	-	-	-	organics	organic

1 – Class verified with sidescan imagery post-survey.

Table 10: Locations and results of substrate grab type validation sampling and post-survey class verification in the south shore of the Keeyask reservoir (MS5), 2021.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
MS5-1	-	22-Aug-21	353952	6242776	-	-	-	-	-	-	-	-	-	-
MS5-2	petite Ponar	22-Aug-21	354052	6242876	1.0	-	organic	100	-	-	-	-	organics	organic
MS5-3	-	22-Aug-21	353952	6242976	-	-	-	-	-	-	-	-	-	-
MS5-4	petite Ponar	22-Aug-21	354052	6243076	1.0	-	organic	100	-	-	-	-	organics	organic
MS5-5	-	22-Aug-21	353952	6243276	2.0	-	-	-	-	-	-	-	-	-
MS5-6	petite Ponar	22-Aug-21	354052	6243576	9.0	hard	clay	95	silt	5	-	-	mud	clay/silt
MS5-7	petite Ponar	22-Aug-21	354752	6243576	2.5	-	organic	100	-	-	-	-	organics	organic
MS5-8	petite Ponar	22-Aug-21	353852	6243676	9.0	hard	gravel	100	-	-	-	-	rock	gravel
MS5-9	petite Ponar	22-Aug-21	354252	6243776	5.0	hard	cobble	100	-	-	-	-	rock	cobble
MS5-10	petite Ponar	22-Aug-21	354652	6243776	1.3	-	organic	100	-	-	-	-	organics	organic
MS5-11	petite Ponar	22-Aug-21	354052	6244076	9.0	hard	cobble	100	-	-	-	-	rock	cobble
MS5-12	petite Ponar	22-Aug-21	354552	6244076	8.0	hard	clay	95	silt	5	-	-	mud	clay/silt
MS5-13	petite Ponar	22-Aug-21	354752	6244076	8.0	moderate	clay	95	silt	5	-	-	mud	clay/silt
MS5-14	petite Ponar	22-Aug-21	354352	6244276	16.0	hard	cobble	100	-	-	-	-	rock	cobble
MS5-15	petite Ponar	22-Aug-21	354652	6244276	10.0	hard	cobble	-	clay	-	-	-	rock	cobble/clay

1 – Class verified with sidescan imagery post-survey.

Table 11: Locations and results of substrate grab type validation sampling and post-survey class verification in the north shore of the Keeyask reservoir (MS6), 2021.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
MS6-1	petite Ponar	18-Aug-21	353852	6245676	6.8	moderate	clay	100	-	-	-	-	mud	clay
MS6-2	petite Ponar	18-Aug-21	353452	6245776	4.8	soft	clay	100	-	-	-	-	mud	clay
MS6-3	petite Ponar	18-Aug-21	353652	6245776	6.7	moderate	clay	100	-	-	-	-	mud	clay
MS6-4	-	18-Aug-21	353252	6245876	-	-	-	-	-	-	-	-	-	-
MS6-5	-	18-Aug-21	353152	6245976	-	-	-	-	-	-	-	-	-	-
MS6-6	petite Ponar	18-Aug-21	353452	6245976	0.5	-	-	-	-	-	-	-	-	-
MS6-7	petite Ponar	18-Aug-21	353652	6245976	2.5	-	-	-	-	-	-	-	-	-
MS6-8	petite Ponar	18-Aug-21	353752	6246076	0.5	-	-	-	-	-	-	-	-	-
MS6-9	-	18-Aug-21	353152	6246176	-	-	-	-	-	-	-	-	-	-
MS6-10	-	18-Aug-21	353452	6246176	-	-	-	-	-	-	-	-	-	-
MS6-11	petite Ponar	18-Aug-21	353552	6246176	1.0	-	-	-	-	-	-	-	-	-
MS6-12	petite Ponar	18-Aug-21	354052	6246176	-	-	-	-	-	-	-	-	-	-
MS6-13	-	18-Aug-21	353352	6246276	-	-	-	-	-	-	-	-	-	-
MS6-14	petite Ponar	18-Aug-21	353752	6246376	0.5	-	-	-	-	-	-	-	-	-
MS6-15	-	18-Aug-21	353352	6246576	-	-	-	-	-	-	-	-	-	-

1 – Class verified with sidescan imagery post-survey.

Table 12: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir, backbay Zone 7 (MS7), 2021.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
MS7-1	petite Ponar	18-Aug-21	350652	6246576	2.0	moderate	organic	100	-	-	-	-	organics	organic
MS7-2	petite Ponar	18-Aug-21	350952	6246576	3.0	soft	organic	100	-	-	-	-	organics	organic
MS7-3	petite Ponar	18-Aug-21	351252	6246676	2.4	-	organic	100	-	-	-	-	organics	organic
MS7-4	petite Ponar	18-Aug-21	351552	6246776	0.3	moderate	organic	100	-	-	-	-	organics	organic
MS7-5	petite Ponar	18-Aug-21	351052	6246876	1.0	-	organic	100	-	-	-	-	organics	organic
MS7-6	-	18-Aug-21	350652	6246976	-	-	-	-	-	-	-	-	-	-
MS7-7	petite Ponar	18-Aug-21	350952	6246976	0.5	-	organic	100	-	-	-	-	organics	organic
MS7-8	petite Ponar	18-Aug-21	351352	6246976	0.5	-	organic	100	-	-	-	-	organics	organic
MS7-9	petite Ponar	18-Aug-21	350652	6247076	1.5	soft	organic	100	-	-	-	-	organics	organic
MS7-10	petite Ponar	18-Aug-21	350852	6247176	0.5	-	organic	100	-	-	-	-	organics	organic
MS7-11	-	18-Aug-21	350952	6247276	-	-	-	-	-	-	-	-	-	-
MS7-12	-	18-Aug-21	350552	6247376	-	-	-	-	-	-	-	-	-	-
MS7-13	-	18-Aug-21	350852	6247376	-	-	-	-	-	-	-	-	-	-
MS7-14	-	18-Aug-21	351052	6247376	-	-	-	-	-	-	-	-	-	-
MS7-15	-	18-Aug-21	350752	6247476	-	-	-	-	-	-	-	-	-	-

1 – Class verified with sidescan imagery post-survey.

Table 13: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir, backbay Zone 8 (MS8), 2021.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
MS8-1	-	18-Aug-21	353552	6249176	-	-	-	-	-	-	-	-	-	-
MS8-2	petite Ponar	18-Aug-21	353952	6249176	0.3	-	organic	100	-	-	-	-	organics	organic
MS8-3	-	18-Aug-21	353652	6249276	-	-	-	-	-	-	-	-	-	-
MS8-4	petite Ponar	18-Aug-21	353952	6249276	2.4	moderate	organic	100	-	-	-	-	organics	organic
MS8-5	petite Ponar	18-Aug-21	353452	6249376	0.9	moderate	organic	100	-	-	-	-	organics	organic
MS8-6	petite Ponar	18-Aug-21	353752	6249376	0.7	-	organic	100	-	-	-	-	organics	organic
MS8-7	-	18-Aug-21	353252	6249476	-	-	-	-	-	-	-	-	-	-
MS8-8	-	18-Aug-21	352952	6249576	-	-	-	-	-	-	-	-	-	-
MS8-9	-	18-Aug-21	353252	6249676	-	-	-	-	-	-	-	-	-	-
MS8-10	-	18-Aug-21	353352	6249676	-	-	-	-	-	-	-	-	-	-
MS8-11	-	18-Aug-21	353052	6249776	-	-	-	-	-	-	-	-	-	-
MS8-12	-	18-Aug-21	353252	6249876	-	-	-	-	-	-	-	-	-	-
MS8-13	-	18-Aug-21	353452	6249876	-	-	-	-	-	-	-	-	-	-
MS8-14	-	18-Aug-21	353352	6249976	-	-	-	-	-	-	-	-	-	-
MS8-15	-	18-Aug-21	353352	6250076	-	-	-	-	-	-	-	-	-	-

1 – Class verified with sidescan imagery post-survey.

Table 14: Locations and results of substrate grab type validation sampling and post-survey class verification in the lower Keeyask reservoir (MS9), 2021.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
MS9-1	petite Ponar	11-Aug-21	359352	6246576	3.5	-	organic	60	silt	40	-	-	organics	organic/silt
MS9-2	-	11-Aug-21	359752	6246676	-	-	-	-	-	-	-	-	-	-
MS9-3	petite Ponar	11-Aug-21	360452	6246676	5.5	moderate	organic	70	silt	30	-	-	organics	organic/silt
MS9-4	petite Ponar	11-Aug-21	358852	6246876	2.9	moderate	organic	60	silt	40	-	-	organics	organic/silt
MS9-5	petite Ponar	11-Aug-21	359152	6246976	4.0	-	organic	70	silt	30	-	-	organics	organic/silt
MS9-6	petite Ponar	11-Aug-21	360652	6246976	4.2	-	organic	50	silt	50	-	-	organics	organic/silt
MS9-7	petite Ponar	11-Aug-21	359852	6247076	3.0	-	organic	90	-	10	-	-	-	-
MS9-8	petite Ponar	11-Aug-21	360152	6247276	3.0	moderate	organic	90/10	-	-	-	-	-	-
MS9-9	petite Ponar	11-Aug-21	358152	6247476	9.0	soft	sand	95	silt	5	-	-	sand	sand/silt
MS9-10	petite Ponar	11-Aug-21	358052	6247876	4.2	-	-	-	-	-	-	-	-	-
MS9-11	petite Ponar	11-Aug-21	358452	6247876	3.5	soft	organic	100	-	-	-	-	organics	organic
MS9-12	petite Ponar	11-Aug-21	358252	6248176	3.0	soft	silt	60	organic	40	-	-	mud	silt/organic
MS9-13	petite Ponar	11-Aug-21	358852	6248176	2.7	hard	organic	100	-	-	-	-	organics	organic
MS9-14	petite Ponar	11-Aug-21	359352	6248176	6.0	soft	silt	100	-	-	-	-	mud	silt
MS9-15	petite Ponar	11-Aug-21	359652	6248276	12.8	soft	organic	100	-	-	-	-	organics	organic

1 – Class verified with sidescan imagery post-survey.

Table 15: Locations and results of substrate grab type validation sampling and post-survey class verification in Stephens Lake (MS10), 2021.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
MS10-1	-	17-Aug-21	367652	6249776	-	-	-	-	-	-	-	-	-	-
MS10-2	petite Ponar	17-Aug-21	367452	6249876	0.5	moderate	sand	100	-	-	-	-	sand	sand
MS10-3	petite Ponar	17-Aug-21	367752	6249876	2.0	hard	clay	95	silt	5	-	-	mud	clay/silt
MS10-4	petite Ponar	17-Aug-21	367452	6250076	1.4	moderate	sand	95	silt	5	-	-	sand	sand/silt
MS10-5	-	17-Aug-21	367152	6250176	-	-	-	-	-	-	-	-	-	-
MS10-6	petite Ponar	17-Aug-21	367352	6250176	-	moderate	sand	95	silt	5	-	-	sand	sand/silt
MS10-7	petite Ponar	17-Aug-21	367552	6250176	2.2	hard	clay	95	silt	5	-	-	mud	clay/silt
MS10-8	-	17-Aug-21	367152	6250276	-	-	-	-	-	-	-	-	-	-
MS10-9	-	17-Aug-21	367052	6250376	-	-	-	-	-	-	-	-	-	-
MS10-10	petite Ponar	17-Aug-21	367452	6250376	3.0	moderate	clay	95	silt	5	-	-	mud	clay/silt
MS10-11	petite Ponar	17-Aug-21	367252	6250476	1.0	moderate	clay	100	-	-	-	-	mud	clay
MS10-12	petite Ponar	17-Aug-21	367852	6250476	6.8	moderate	clay	95	silt	5	-	-	mud	clay/silt
MS10-13	petite Ponar	17-Aug-21	367452	6250676	2.4	hard	clay	95	silt	5	-	-	mud	clay/silt
MS10-14	petite Ponar	17-Aug-21	367752	6250676	6.0	moderate	clay	95	silt	5	-	-	mud	clay/silt
MS10-15	petite Ponar	17-Aug-21	367652	6250876	2.0	moderate	clay	100	-	-	-	-	mud	clay

1 – Class verified with sidescan imagery post-survey.

Table 16: Locations and results of substrate grab type validation sampling and post-survey class verification in the Northern portion of Stephens Lake (MS11), 2021.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
MS11-1	petite Ponar	17-Aug-21	369052	6251176	3.8	moderate	clay	70	sand	30	-	-	mud	clay/sand
MS11-2	petite Ponar	17-Aug-21	368752	6251276	3.0	moderate	clay	85	gravel	10	silt	5	mud	clay/gravel/silt
MS11-3	petite Ponar	17-Aug-21	368552	6251376	1.3	moderate	clay	100	-	-	-	-	mud	clay
MS11-4	petite Ponar	17-Aug-21	368952	6251376	1.2	hard	clay	100	-	-	-	-	mud	clay
MS11-5	-	17-Aug-21	368552	6251476	-	-	-	-	-	-	-	-	-	-
MS11-6	petite Ponar	17-Aug-21	369152	6251576	1.5	-	clay	100	-	-	-	-	mud	clay
MS11-7	petite Ponar	17-Aug-21	368952	6251676	1.2	moderate	clay	95	silt	5	-	-	mud	clay/silt
MS11-8	petite Ponar	17-Aug-21	369452	6251676	3.5	moderate	clay	95	sand	5	-	-	mud	clay/sand
MS11-9	petite Ponar	17-Aug-21	368952	6251776	0.5	moderate	clay	95	silt	5	-	-	mud	clay/silt
MS11-10	-	17-Aug-21	368852	6251876	-	-	-	-	-	-	-	-	-	-
MS11-11	-	17-Aug-21	369052	6251876	-	-	-	-	-	-	-	-	-	-
MS11-12	petite Ponar	17-Aug-21	369252	6251876	-	-	cobble	100	-	-	-	-	rock	cobble
MS11-13	petite Ponar	17-Aug-21	369452	6251876	6.6	moderate	clay	95	silt	5	-	-	mud	clay/silt
MS11-14	petite Ponar	17-Aug-21	369352	6252076	1.9	moderate	clay	90	sand	5	silt	5	mud	clay/sand/silt
MS11-15	petite Ponar	17-Aug-21	369152	6252176	1.0	moderate	sand	100	-	-	-	-	sand	sand

1 – Class verified with sidescan imagery post-survey.

Table 17: Locations and results of substrate grab type validation sampling and post-survey class verification in the Northern portion of Stephens Lake (MS12), 2021.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
MS12-1	petite Ponar	17-Aug-21	369852	6254976	1.9	soft	clay	100	-	-	-	-	mud	clay
MS12-2	petite Ponar	17-Aug-21	369552	6255076	2.0	moderate	organic	95	silt	5	-	-	organics	organic/silt
MS12-3	petite Ponar	17-Aug-21	369552	6255176	2.0	-	organic	100	-	-	-	-	organics	organic
MS12-4	petite Ponar	17-Aug-21	369952	6255276	4.4	moderate	clay	100	-	-	-	-	mud	clay
MS12-5	petite Ponar	17-Aug-21	370252	6255276	4.7	moderate	clay	100	-	-	-	-	mud	clay
MS12-6	petite Ponar	17-Aug-21	369452	6255376	0.5	soft	organic	95	silt	5	clay	5	organics	organic/silt/clay
MS12-7	-	17-Aug-21	369652	6255476	-	-	-	-	-	-	-	-	-	-
MS12-8	-	17-Aug-21	369852	6255576	-	-	-	-	-	-	-	-	-	-
MS12-9	petite Ponar	17-Aug-21	370352	6255576	6.2	moderate	clay	80	silt	15	organic	5	mud	clay/silt/organic
MS12-10	petite Ponar	17-Aug-21	370052	6255676	1.2	soft	organic	95	silt	5	-	-	organics	organic/silt
MS12-11	petite Ponar	17-Aug-21	370652	6255676	4.0	moderate	clay	95	silt	5	-	-	mud	clay/silt
MS12-12	petite Ponar	17-Aug-21	369952	6255876	2.3	moderate	clay	95	silt	5	-	-	mud	clay/silt
MS12-13	petite Ponar	17-Aug-21	370352	6255876	5.6	moderate	clay	95	silt	5	-	-	mud	clay/silt
MS12-14	petite Ponar	17-Aug-21	370552	6255976	7.5	moderate	clay	95	silt	5	-	-	mud	clay/silt
MS12-15	petite Ponar	17-Aug-21	370352	6256076	6.0	moderate	clay	95	silt	5	-	-	mud	clay/silt

1 – Class verified with sidescan imagery post-survey

Table 18: Summary of satellite image data acquired for monitoring shoreline change and water mass boundaries in the Keeyask reservoir, 2021.

Data Type	Platform	Sensor	Provider	Image Data Filename	Date	Time (UTC)	Season
Microwave	Sentinel-1B	SAR-C	Copernicus/European Space Agency	S1B_IW_GRDH_1SDV_20190810T000833_20190810T000858_017516_020F10_EBF9.SAFE	8/10/2019	T00:08:33.937Z	summer
Optical	Sentinel-2B	MSI	Copernicus/European Space Agency	S2B_MSIL2A_20190812T173909_N0213_R098_T15VUC_20190813T154030.SAFE	8/12/2019	T17:39:09.024Z	summer
Microwave	Sentinel-1B	SAR-C	Copernicus/European Space Agency	S1B_IW_GRDH_1SDV_20200612T000033_20200612T000057_021993_029BD9_A7B0.SAFE	6/12/2020	T00:00:33.483Z	spring
Optical	Sentinel-2A	MSI	Copernicus/European Space Agency	S2A_MSIL2A_20200612T173911_N0214_R098_T15VUC_20200612T235124.SAFE	6/12/2020	T17:39:11.024Z	spring
Microwave	Sentinel-1B	SAR-C	Copernicus/European Space Agency	S1B_IW_GRDH_1SDV_20200804T000839_20200804T000904_022766_02B351_18FB.SAFE	8/4/2020	T00:08:39.982Z	summer
Optical	Sentinel-2B	MSI	Copernicus/European Space Agency	S2B_MSIL2A_20200806T173909_N0214_R098_T15VUC_20200806T202922.SAFE	8/6/2020	T17:39:09.024Z	summer
Microwave	Sentinel-1B	SAR-C	Copernicus/European Space Agency	S1B_IW_GRDH_1SDV_20200904T000038_20200904T000102_023218_02C176_DD2F.SAFE	9/4/2020	T00:00:38.195Z	summer
Optical	Sentinel-2B	MSI	Copernicus/European Space Agency	S2B_MSIL2A_20200905T173909_N0214_R098_T15VUC_20200905T203423.SAFE	9/5/2020	T17:39:09.024Z	summer
Microwave	Sentinel-1B	SAR-C	Copernicus/European Space Agency	S1B_IW_GRDH_1SDV_20200909T000841_20200909T000906_023291_02C3B9_8476.SAFE	9/9/2020	T00:08:41.871Z	summer
Optical	Sentinel-2A	MSI	Copernicus/European Space Agency	S2A_MSIL2A_20200920T174031_N0214_R098_T15VUC_20200920T222223.SAFE	9/20/2020	T17:40:31.024Z	summer
Microwave	Sentinel-1B	SAR-C	Copernicus/European Space Agency	S1B_IW_GRDH_1SDV_20200921T000842_20200921T000907_023466_02C932_4F4C.SAFE	9/21/2020	T00:08:42.220Z	fall
Microwave	Sentinel-1B	SAR-C	Copernicus/European Space Agency	S1B_IW_GRDH_1SDV_20210612T000842_20210612T000907_027316_034338_4CA3.SAFE	6/12/2021	T00:08:42.706Z	spring
Optical	Sentinel-2A	MSI	Copernicus/European Space Agency	S2A_MSIL2A_20210614T172901_N0300_R055_T15VUC_20210614T223756.SAFE	6/14/2021	T17:29:01.024Z	spring
Optical	Sentinel-2B	MSI	Copernicus/European Space Agency	S2B_MSIL2A_20210831T173859_N0301_R098_T15VUC_20210831T214202.SAFE	8/31/2021	T17:38:59.024Z	summer
Microwave	Sentinel-1B	SAR-C	Copernicus/European Space Agency	S1B_IW_GRDH_1SDV_20210904T000847_20210904T000912_028541_0367EB_270E.SAFE	9/4/2021	T00:08:47.334Z	summer
Microwave	Sentinel-1B	SAR-C	Copernicus/European Space Agency	S1B_IW_GRDH_1SDV_20211010T000848_20211010T000913_029066_0377E6_E7B6.SAFE	10/10/2021	T00:08:48.322Z	fall
Optical	Sentinel-2B	MSI	Copernicus/European Space Agency	S2B_MSIL2A_20211017T173329_N0301_R055_T15VUC_20211017T214901.SAFE	10/17/2021	T17:33:29.024Z	fall

Table 19: Summary of reservoir humic, mixed, and turbid water mass areas (spring, summer, and fall 2021) derived from the analysis of optical (Sentinel-2) satellite remote sensing data.

Season	Image Date	Inflow (cms)[2]	Water Level (m)[2]	Estimated Area (ha)[1]			
				Open Water Area	Humic Water	Mixed Water	Turbid Water
Spring	14-Jun-21	3458	158.92	9,190	1,188	1,368	6,634
Summer	31-Aug-21	2025	158.90	8,762	1,147	1,298	6,317
Fall	17-Oct-21	2066	158.95	8,777	690	976	7,111

1. Area of reservoir is estimated from open water classification from Keeyask GS upstream to Long Rapids at the boundary of Reach 2A and 2B.
2. Estimated daily mean inflow and daily mean water level provided by Manitoba Hydro

FIGURES

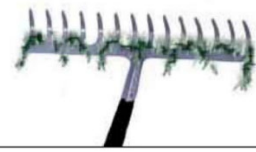
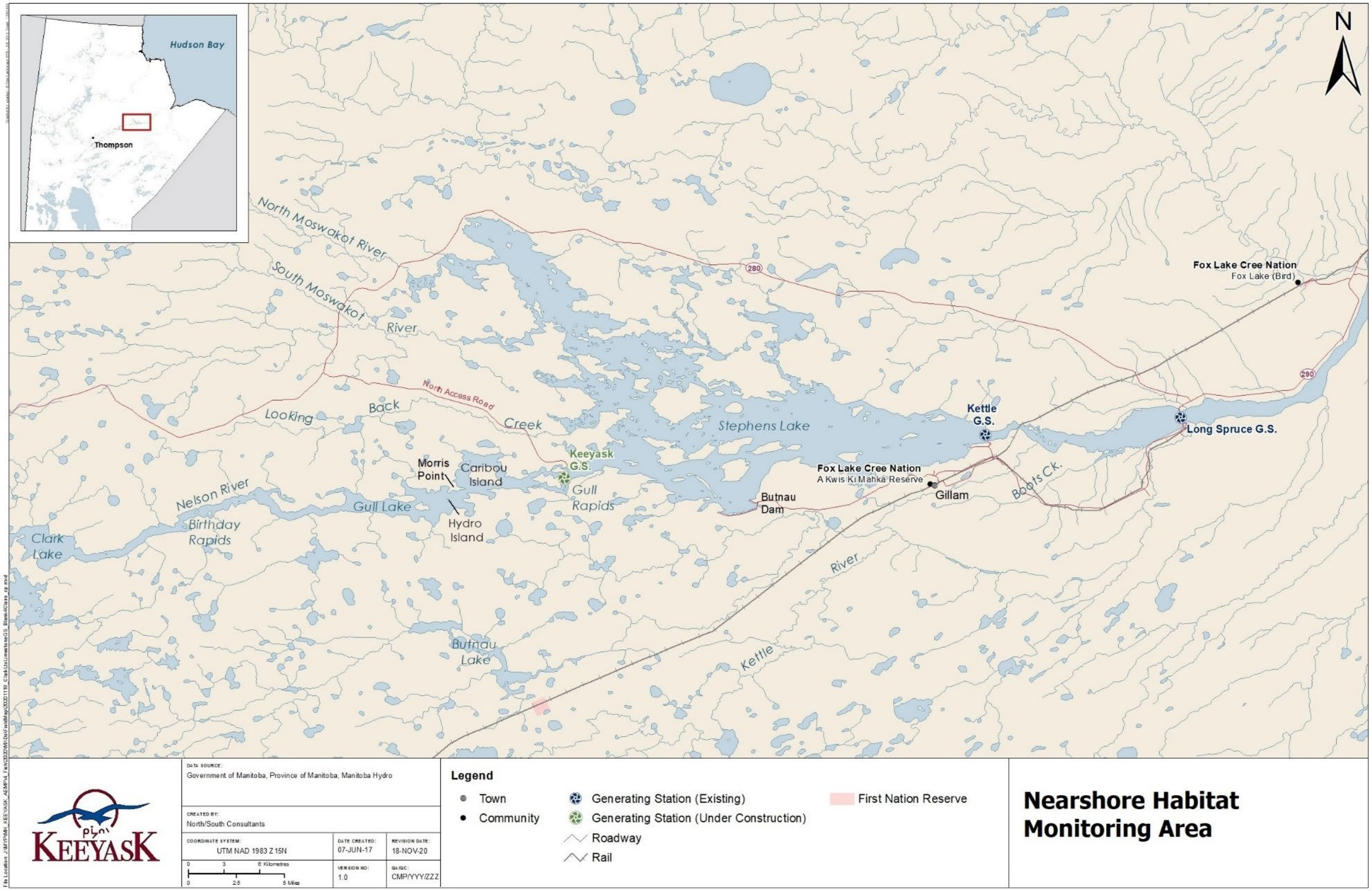
Fullness Rating	Coverage	Description
1		Only few plants. There are not enough plants to entirely cover the length of the rake head in a single layer.
2		There are enough plants to cover the length of the rake head in a single layer, but not enough to fully cover the tines.
3		The rake is completely covered and tines are not visible.

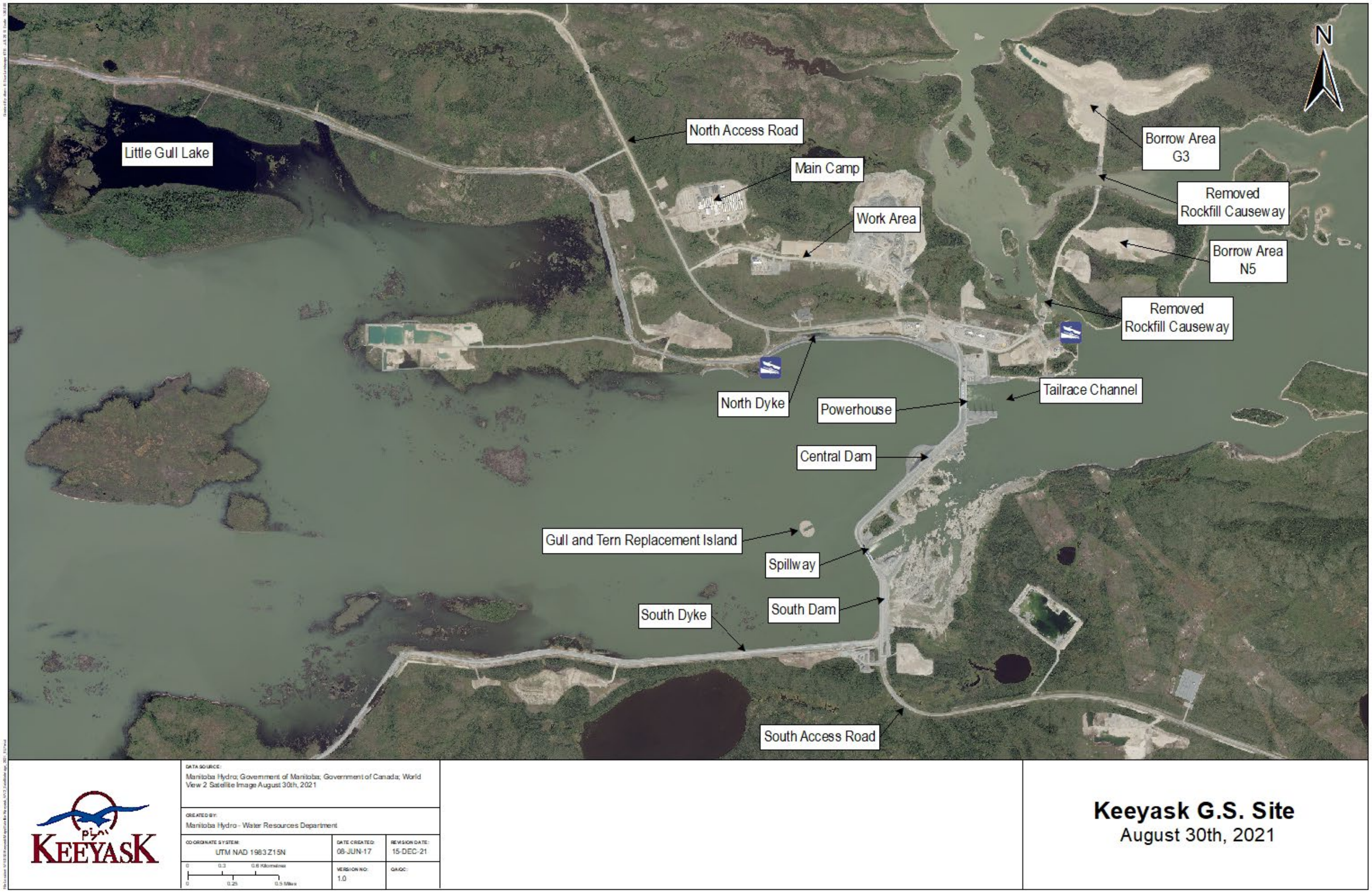
Figure 1: Plant density based on rake collection (0 - absent; 1 - sparse; 2 - common; and 3 - abundant; Hauxwell *et al*. 2010).

Figure 2: Image of SAR June 12, 2021 threshold value of -18.5 dB used to discriminate water (blue) from land (June 14, 2021 Sentinel-2 image in background) in the Keeyask GS reservoir near the Hidden Creek (MS7) nearshore monitoring site. Note that the method often underestimates open water extent closer to shore, while overestimating water over floating peat, debris, and wetland targets likely saturated with water.

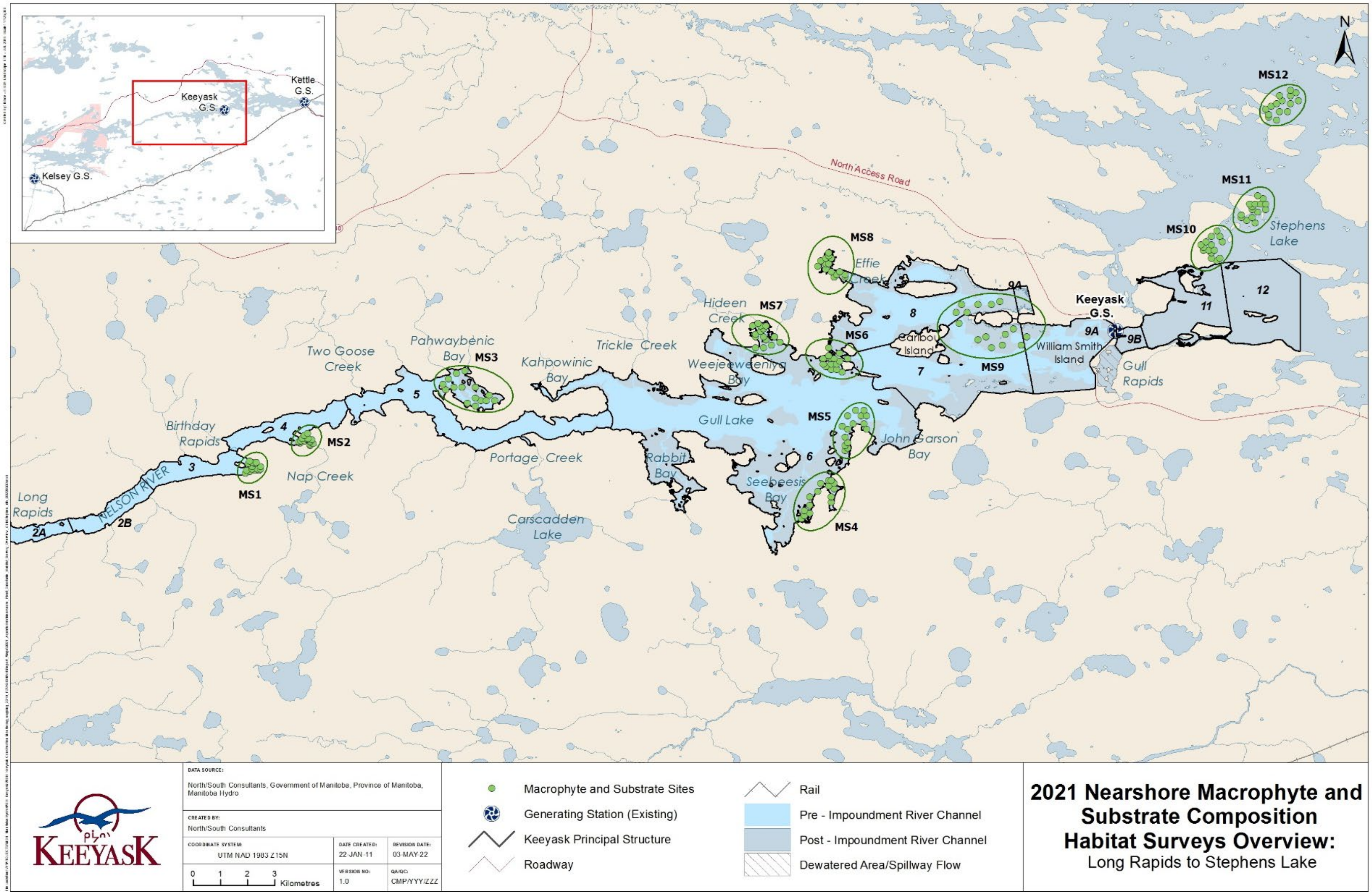
MAPS



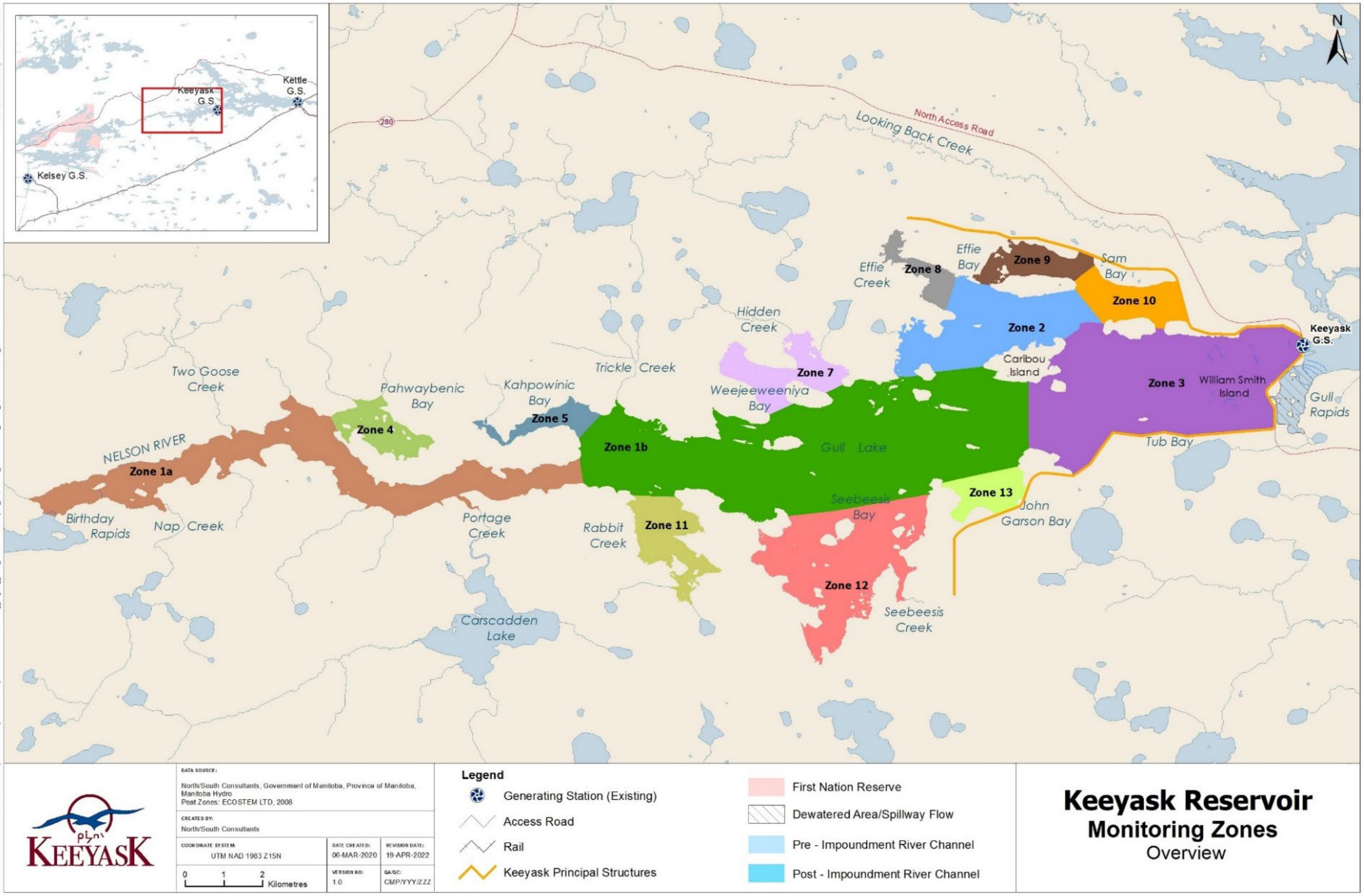
Map 1: **Map of the Nelson River showing the site of the Keeyask Generating Station and the nearshore habitat monitoring study setting.**



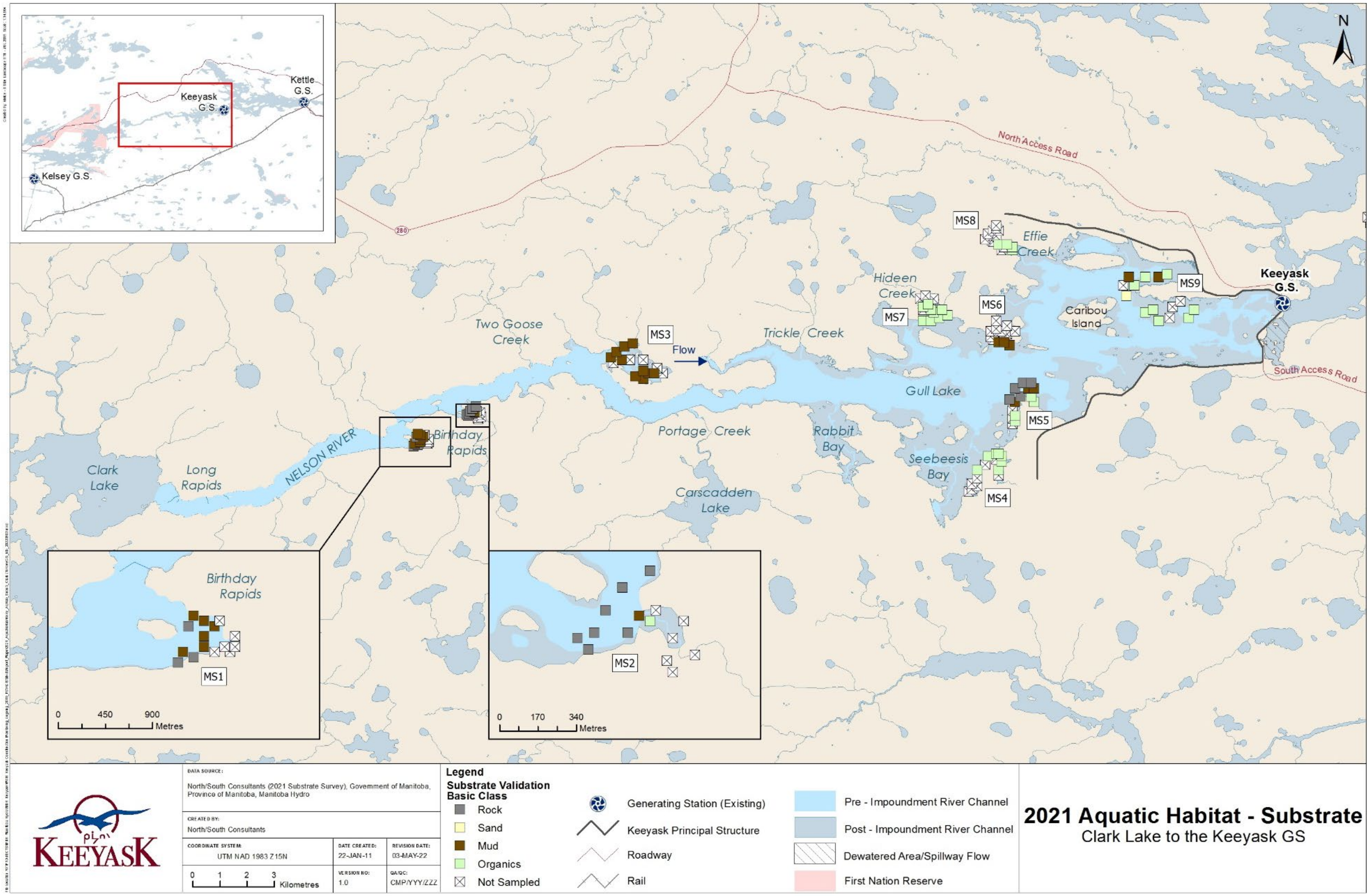
Map 2: **Map illustrating instream structures at the Keeyask Generating Station site after reservoir flooding, August 2021.**



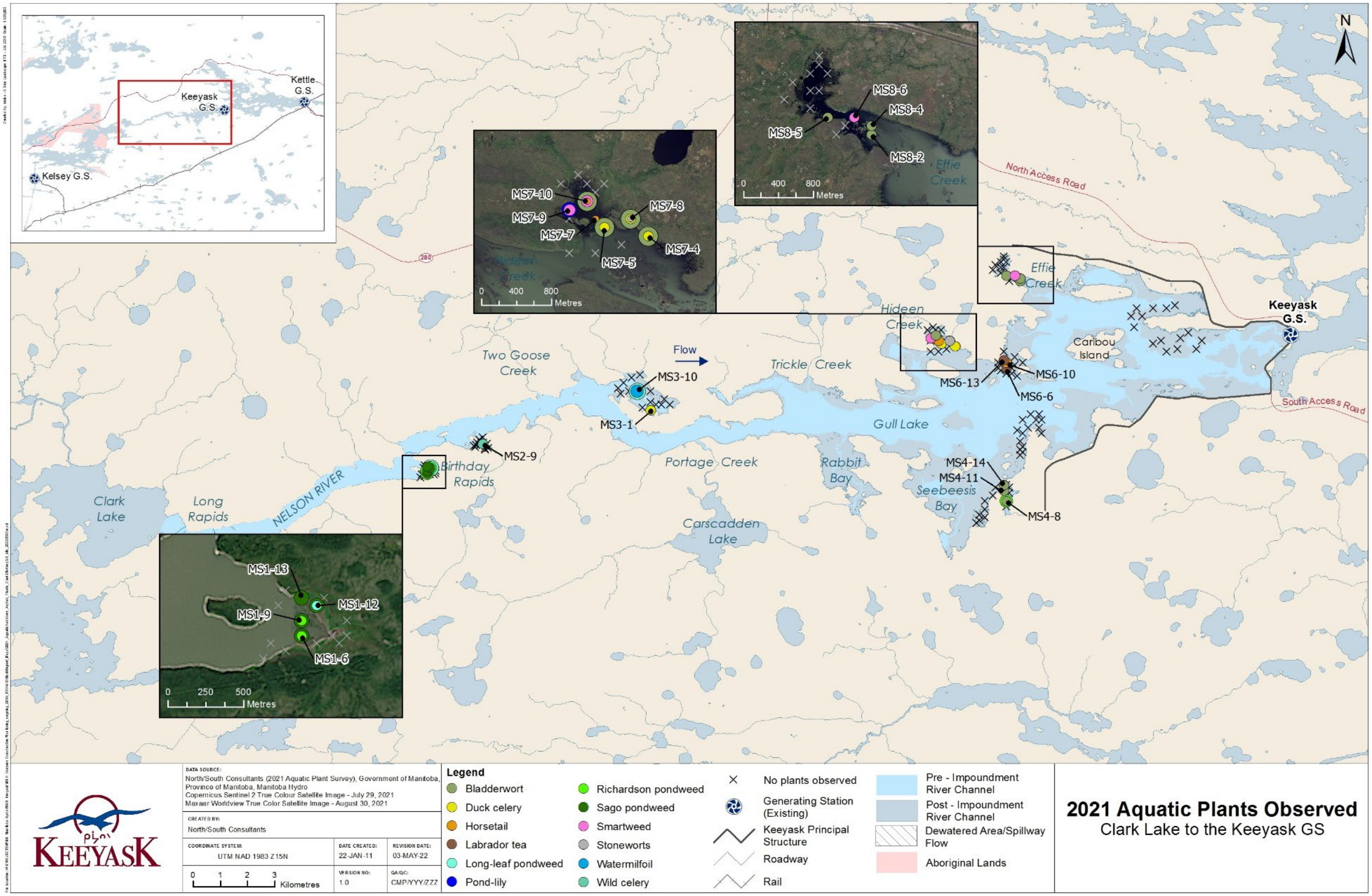
Map 3: **Map illustrating the locations of the pre-selected nearshore substrate composition and aquatic macrophyte sampling sites for the Keeyask study area.**



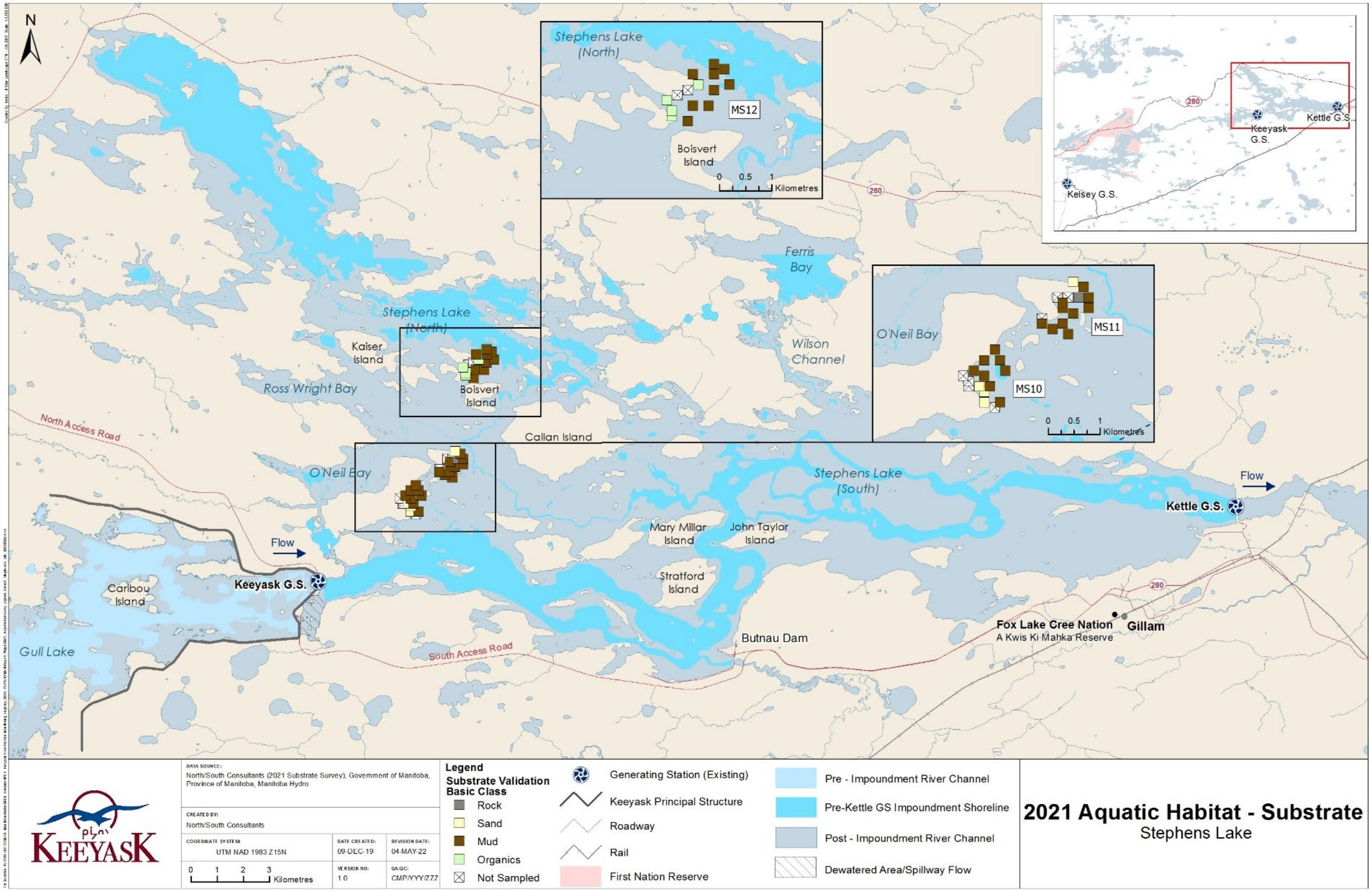
Map 4: **Keeyask reservoir backbay areas (zones) – zones 4, 7, 8, and 12 were sampled for substrate, macrophytes, and light extinction as part of the nearshore aquatic habitat monitoring surveys in 2021.**



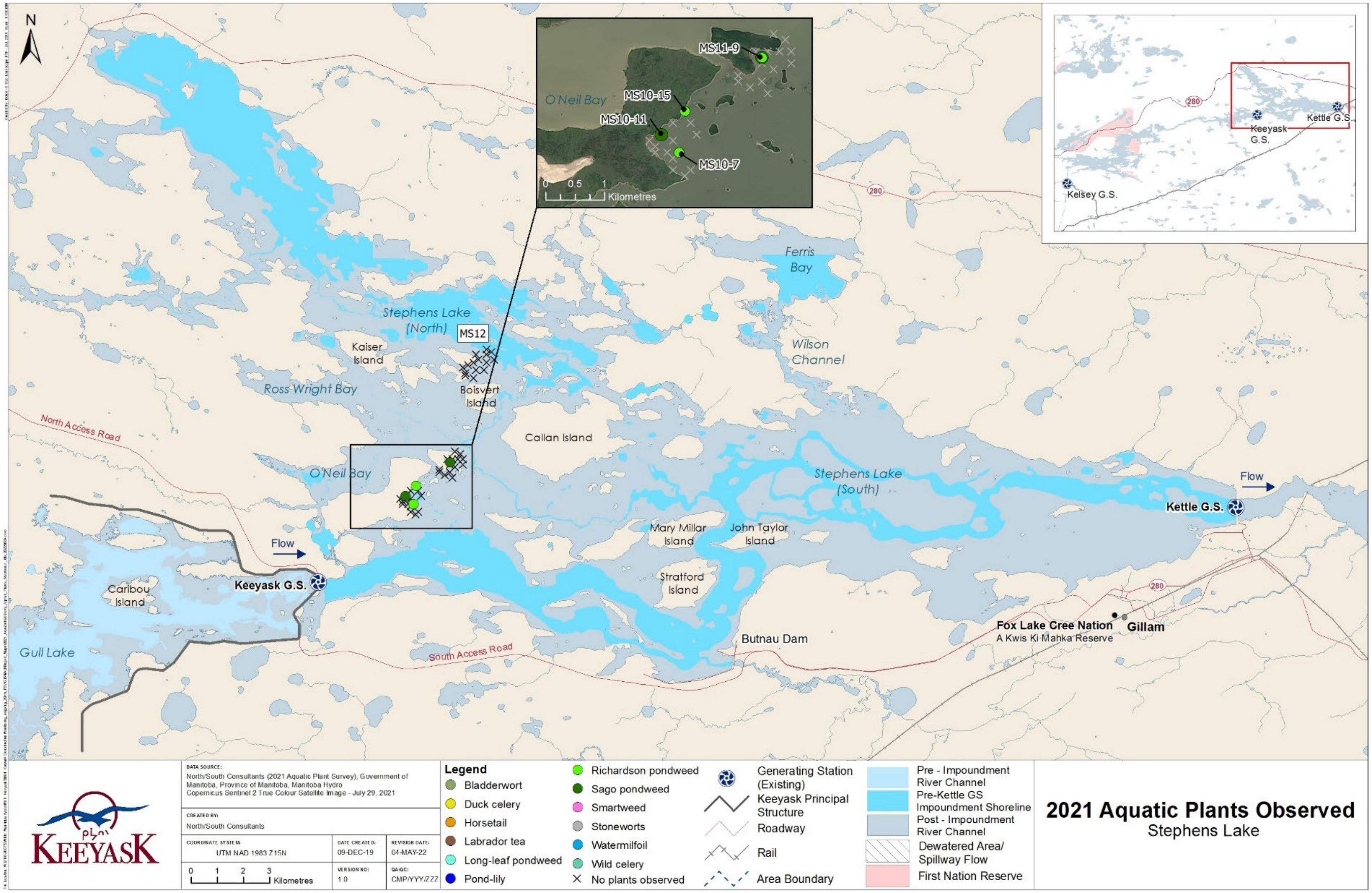
Map 5: **Map illustrating basic substrate class results of sediment grabs taken at pre-selected sampling sites in the Keeyask reservoir, August 2021.**



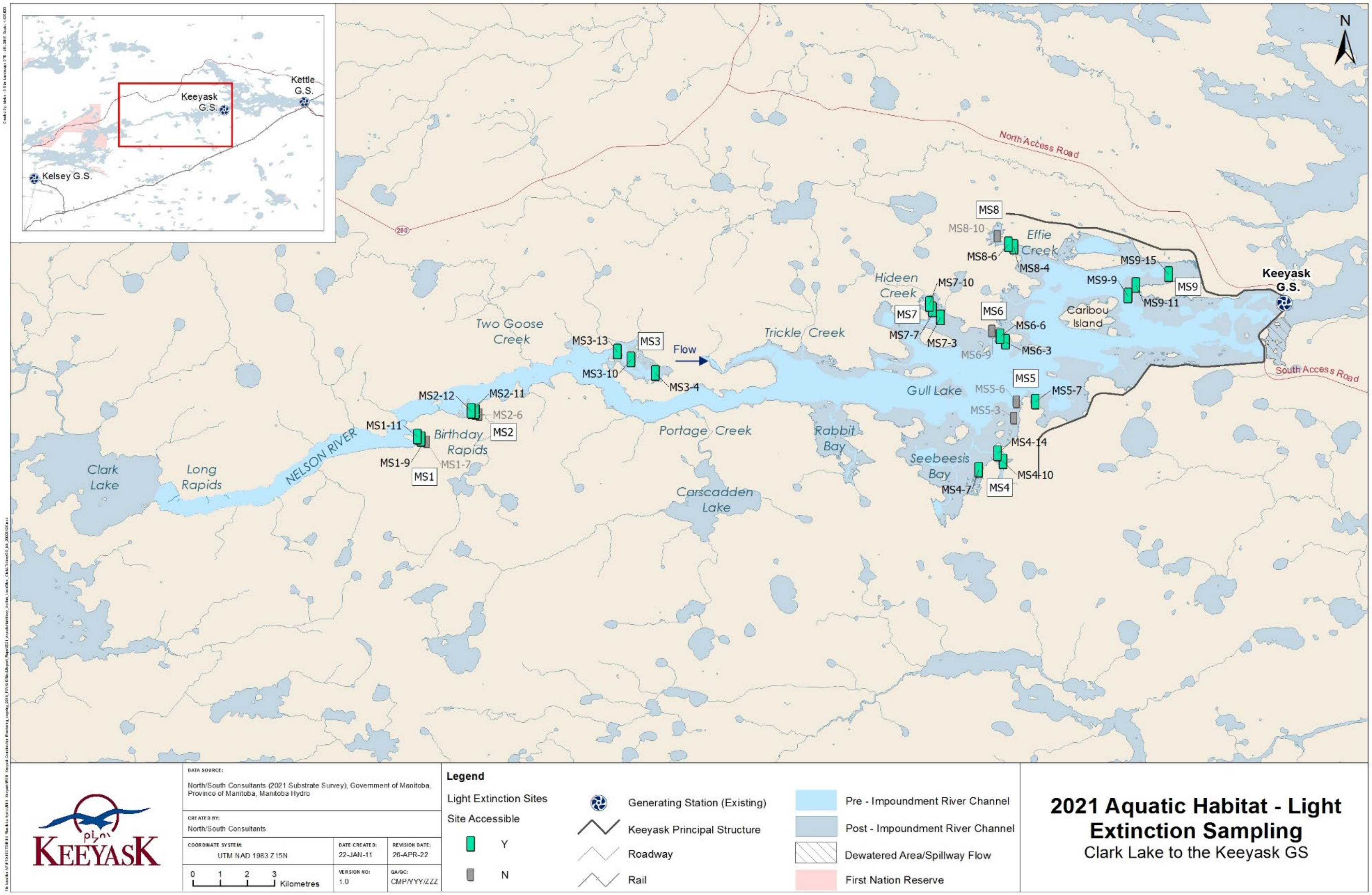
Map 6: Map illustrating basic macrophyte sampling results from pre-selected areas in the Keeyask reservoir, August 2021.



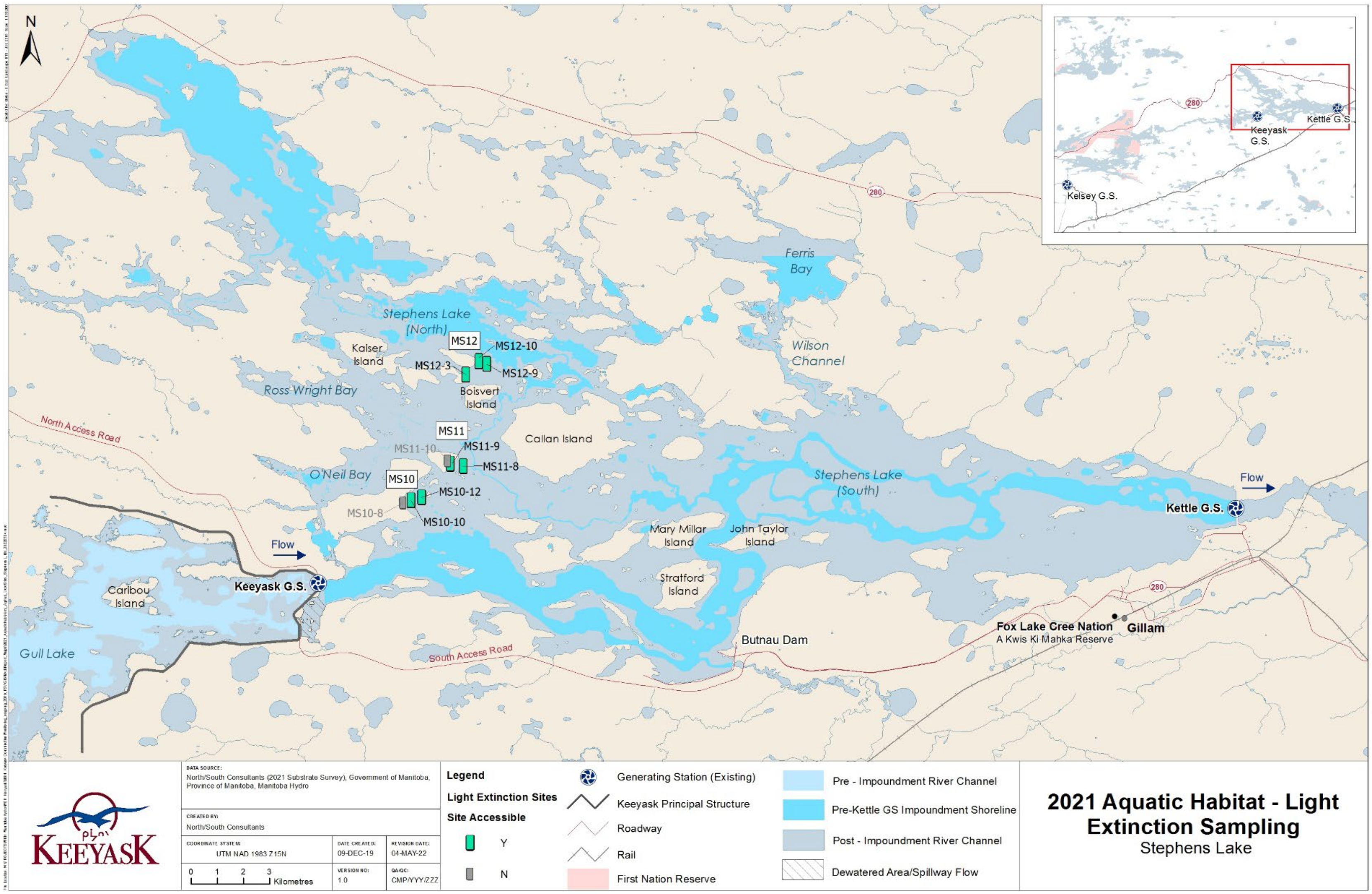
Map 7: **Map illustrating basic substrate class results of sediment grabs taken at pre-selected sampling sites in Stephens Lake, August 2021.**



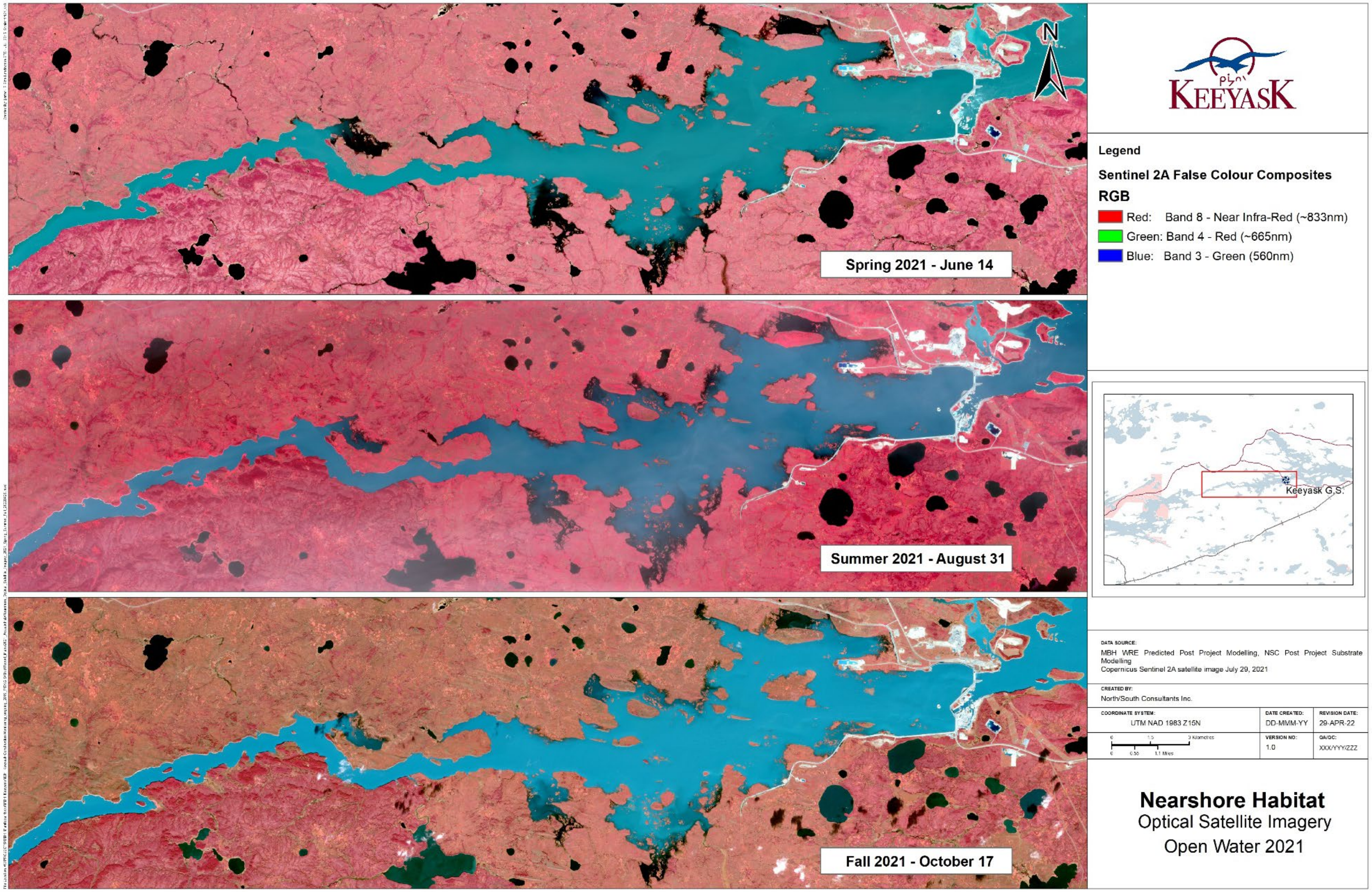
Map 8: **Map illustrating basic macrophyte sampling results from pre-selected areas in Stephens Lake, August 2021.**



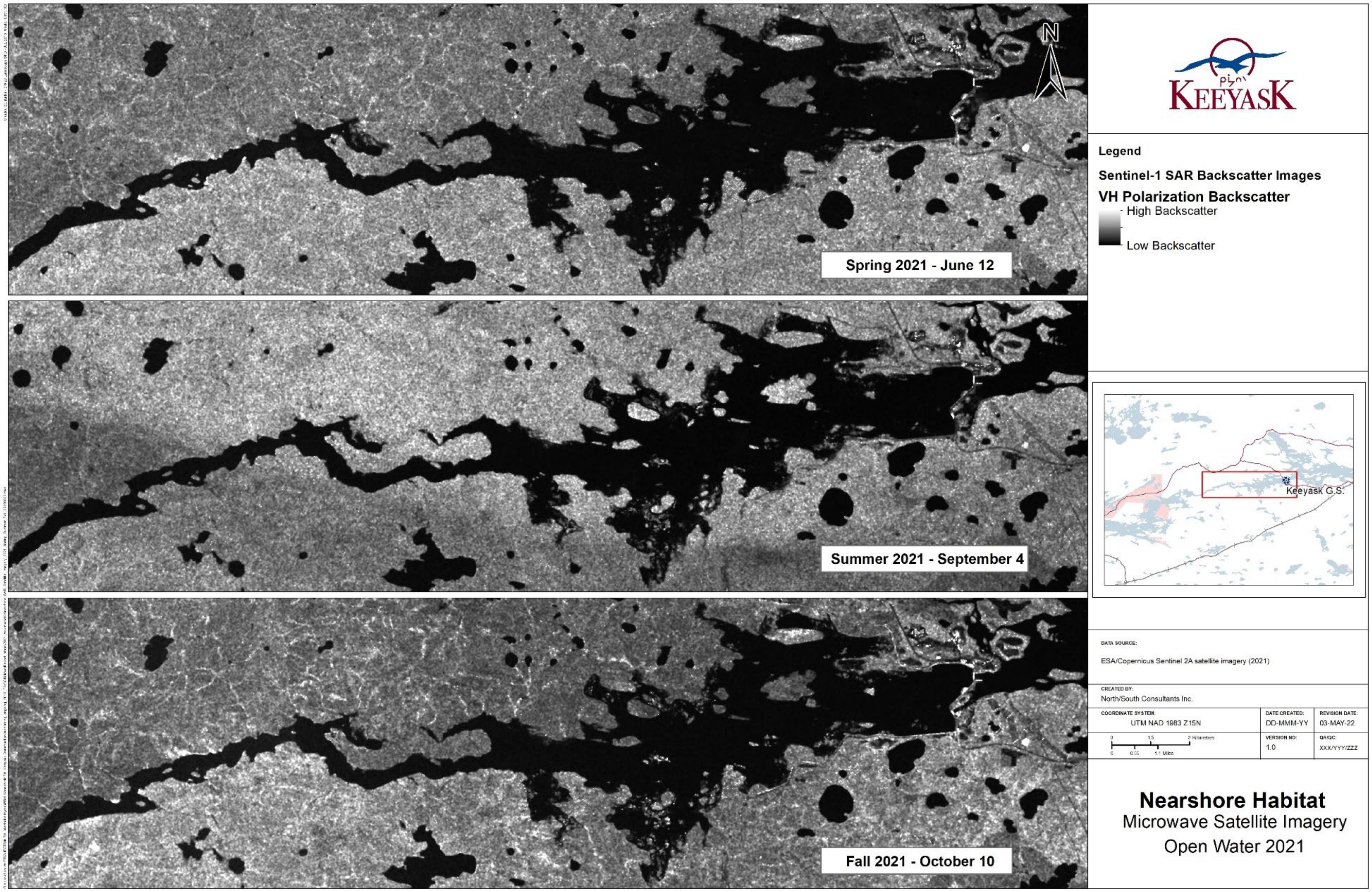
Map 9: **Map illustrating pre-selected light extinction sampling sites in the Keeyask reservoir, August 2021.**



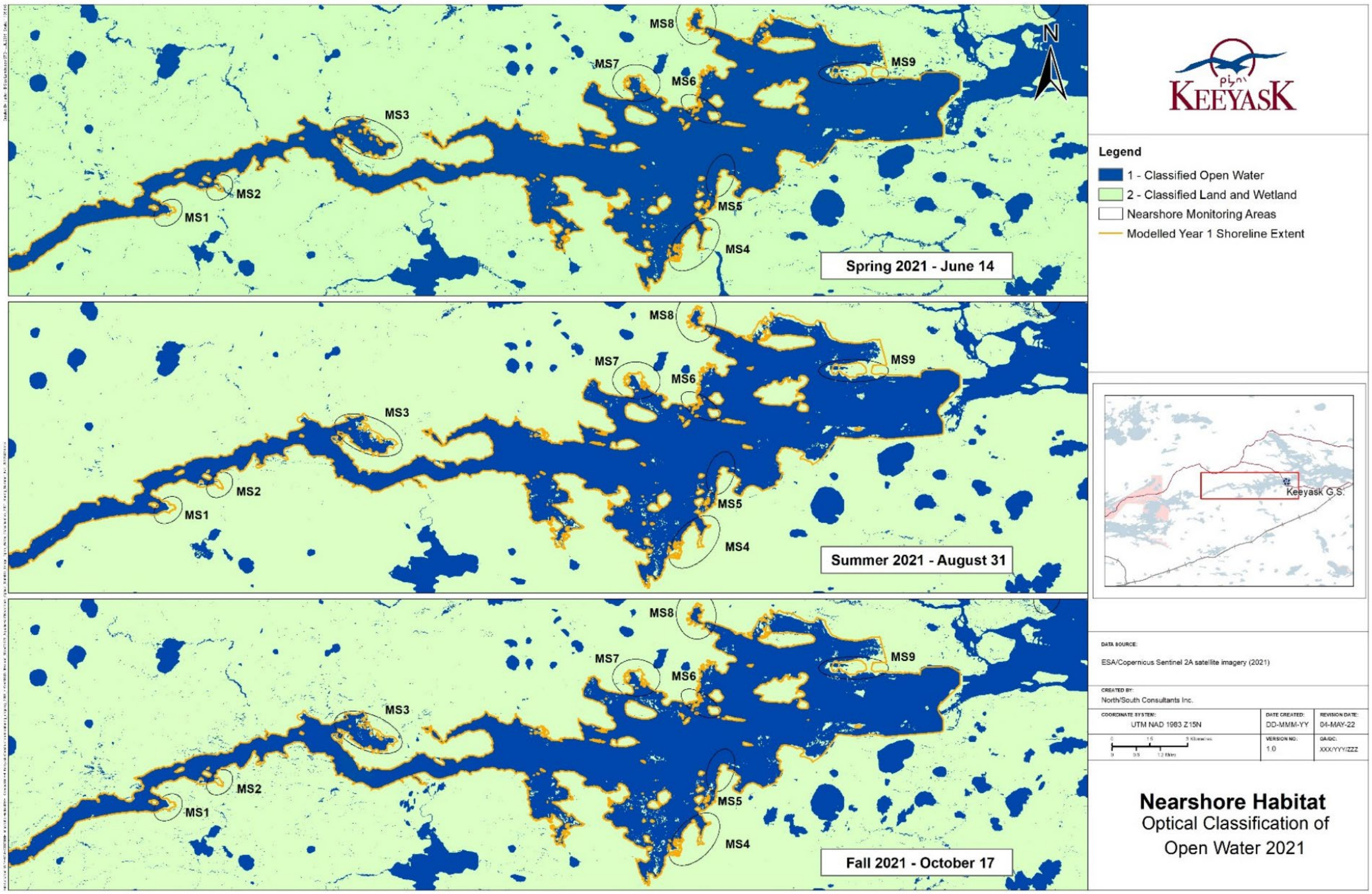
Map 10: **Map illustrating pre-selected light extinction sampling sites in Stephens Lake, August 2021.**



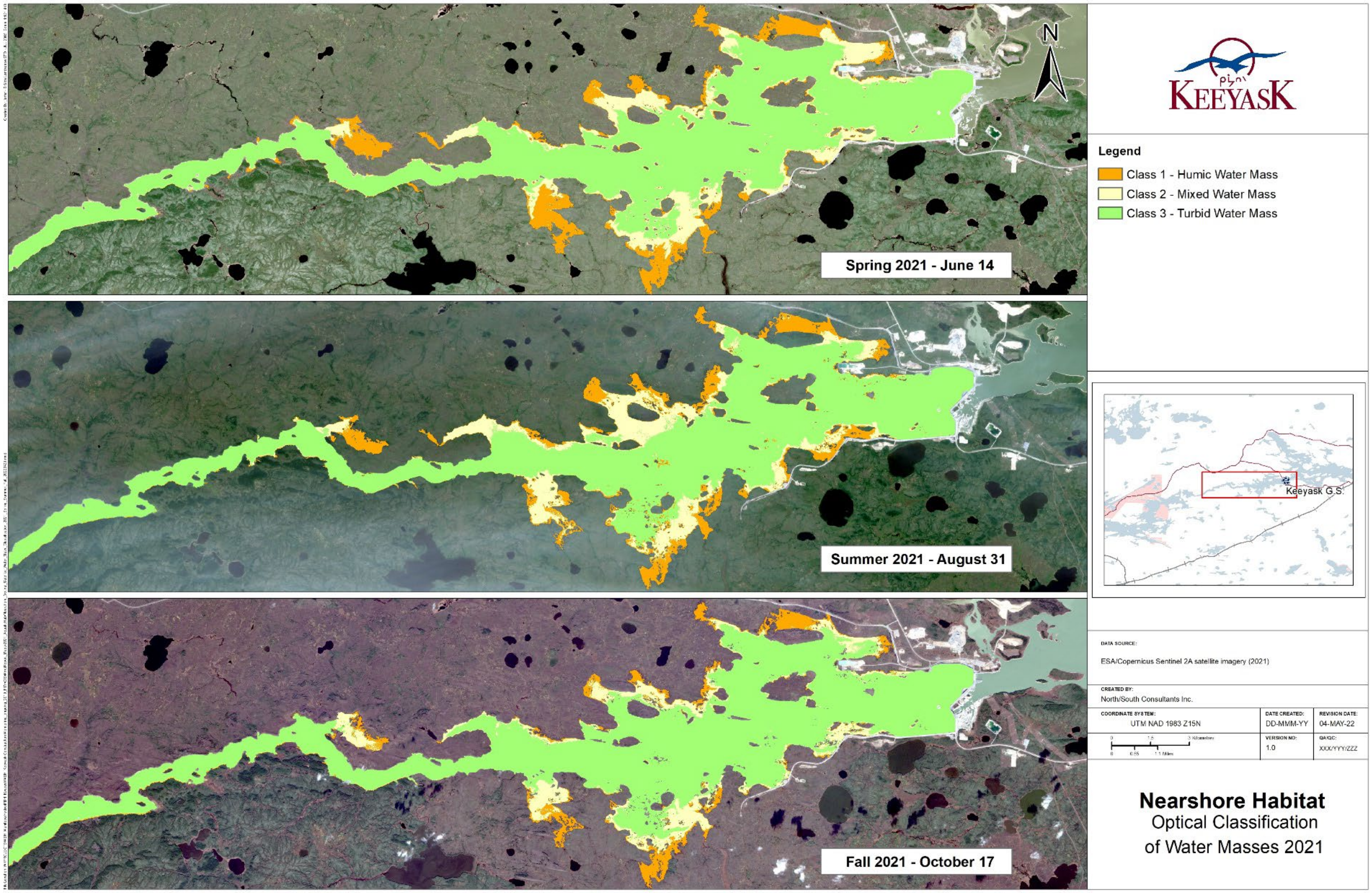
Map 11: **Sentinel-2 optical satellite imagery false colour near infrared composites of the Keeyask reservoir showing shoreline and turbid (blue) and humic (black) water mass boundary positions during spring, summer, and fall, 2021.**



Map 12: Sentinel-1 SAR satellite imagery of the Keeyask reservoir showing distinct boundaries between water (dark pixels) and land (bright pixels) during spring, summer, and fall, 2021



Map 13: **Map showing results of the optical near infrared band land and water threshold masking analysis and classification for spring, summer, and fall, 2021, and relative to year 1 modelled shorelines (orange).**



Map 14: Map showing results of the optical supervised classification of humic, mixed, and turbid water mass analysis and classification for spring, summer, and fall, 2021.

PHOTOS

Photo 1: Image of the weighted double headed rake sampler.

Photo 2: Substrate collected downstream of Birthday Rapids (MS2), showing cobble with smaller gravel substrate.

Photo 3: Substrate collected in the Keeyask reservoir backbay Zone 12 (MS4) showing organic matter.

Photo 4: Substrate collected in the lower Keeyask reservoir (MS9), showing sand/silt substrate.

Photo 5: Substrate collected in Stephens Lake (MS10), showing silt/clay/sand and organic substrate.

APPENDICES

APPENDIX 1: RAW DATA COLLECTED FROM NEARSHORE HABITAT MONITORING SITES IN THE KEEYASK RESERVOIR AND STEPHENS LAKE, 2021.

Table A1-1: Aquatic macrophyte observations in the Keeyask reservoir from pre-selected sites, 2021.

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS1-1	331877	6241951	2.0	N			
MS1-2	332027	6242001	0.5	N			
MS1-3	331927	6242051	2.5	N			
MS1-4	332227	6242051	-	N			
MS1-5	332377	6242051	-	N			
MS1-6	332127	6242101	0.2	Y	*Stuckenia pectinata*	Sago pondweed	common
					Potamogeton richardsonii	Richardson pondweed	common
MS1-7	332327	6242101	-	N			
MS1-8	332427	6242101	-	N			
MS1-9	332127	6242201	1.0	Y	*Stuckenia pectinata*	Sago pondweed	abundant
					Potamogeton richardsonii	Richardson pondweed	sparse
MS1-10	332427	6242201	-	N			
MS1-11	331977	6242301	3.5	N			
MS1-12	332227	6242301	0.5	Y	*Stuckenia pectinata*	Sago pondweed	abundant
					Potamogeton richardsonii	Richardson pondweed	sparse
					Potamogeton nodosus	Long-leaf pondweed	sparse
MS1-13	332127	6242351	0.4	Y	*Stuckenia pectinata*	Sago pondweed	abundant
MS1-14	332277	6242351	-	N			
MS1-15	332027	6242401	-	N			
MS2-1	334264	6242964	-	N			
MS2-2	334239	6243014	-	N			
MS2-3	334364	6243039	-	N			
MS2-4	333889	6243064	4.6	N			
MS2-5	333839	6243114	4.8	N			
MS2-6	334264	6243114	-	N			
MS2-7	333914	6243139	7.7	N			
MS2-8	334064	6243139	4.0	N			
MS2-9	334164	6243189	0.3	Y	*Apium* spp.	Wild celery	abundant
MS2-10	334314	6243189	-	N			
MS2-11	334114	6243214	0.6	N			
MS2-12	333964	6243239	4.2	N			

Table A1-1: Aquatic macrophyte observations in the Keeyask reservoir from pre-selected sites, 2021 (continued).

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS2-13	334189	6243239	-	N			
MS2-14	334039	6243339	4.0	N			
MS2-15	334164	6243414	4.4	N			
MS3-1	340352	6244426	1.5	Y	*Vallisneria* spp.	Duck celery	sparse
MS3-2	340052	6244526	3.1	N			
MS3-3	340552	6244626	3.6	N			
MS3-4	340752	6244626	3.1	N			
MS3-5	341052	6244626	-	N			
MS3-6	340352	6244726	3.9	N			
MS3-7	340852	6244826	-	N			
MS3-8	339252	6245026	-	N			
MS3-9	339552	6245126	3.5	N			
MS3-10	339852	6245126	0.8	Y	*Myriphyllum* spp.	Watermilfoil	abundant
					Potamogeton nodosus	Long-leaf pondweed	sparse
MS3-11	340352	6245126	-	N			
MS3-12	339152	6245226	2.1	N			
MS3-13	339352	6245426	4.0	N			
MS3-14	339652	6245626	3.7	N			
MS3-15	339952	6245726	2.1	N			
MS4-1	352352	6240276	-	N			
MS4-2	352452	6240376	-	N			
MS4-3	352652	6240476	-	N			
MS4-4	352452	6240576	-	N			
MS4-5	352652	6240776	-	N			
MS4-6	353452	6240876	-	N			
MS4-7	352652	6241076	1.2	N			
MS4-8	353452	6241076	0.8	Y	*Utricularia* spp.	Bladderwort	sparse
					Potamogeton richardsonii	Richardson pondweed	sparse
MS4-9	352952	6241276	-	N			
MS4-10	353552	6241376	1.6	N			
MS4-11	353352	6241476	0.9	Y	*Utricularia* spp.	Bladderwort	sparse

Table A1-1: Aquatic macrophyte observations in the Keeyask reservoir from pre-selected sites, 2021 (continued).

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS4-12	353052	6241576	1.9	N			
MS4-13	353552	6241576	1.0	N			
MS4-14	353352	6241676	2.0	Y	*Utricularia* spp.	Bladderwort	sparse
MS4-15	353452	6241676	2.0	N			
MS5-1	353952	6242776	-	N			
MS5-2	354052	6242876	1.0	N			
MS5-3	353952	6242976	-	N			
MS5-4	354052	6243076	1.0	N			
MS5-5	353952	6243276	2.0	N			
MS5-6	354052	6243576	9.0	N			
MS5-7	354752	6243576	2.5	N			
MS5-8	353852	6243676	9.0	N			
MS5-9	354252	6243776	5.0	N			
MS5-10	354652	6243776	1.3	N			
MS5-11	354052	6244076	9.0	N			
MS5-12	354552	6244076	8.0	N			
MS5-13	354752	6244076	8.0	N			
MS5-14	354352	6244276	16.0	N			
MS5-15	354652	6244276	10.0	N			
MS6-1	353852	6245676	6.8	N			
MS6-2	353452	6245776	4.8	N			
MS6-3	353652	6245776	6.7	N			
MS6-4	353252	6245876	-	N			
MS6-5	353152	6245976	-	N			
MS6-6	353452	6245976	0.5	Y	*Rhododendron groenlandicum*	Labrador tea	sparse
MS6-7	353652	6245976	2.5	N			
MS6-8	353752	6246076	0.5	N			
MS6-9	353152	6246176	-	N			
MS6-10	353452	6246176	-	Y	*Equisetum* spp.	Horsetail	sparse
MS6-11	353552	6246176	1.0	N			
MS6-12	354052	6246176	-	N			

Table A1-1: Aquatic macrophyte observations in the Keeyask reservoir from pre-selected sites, 2021 (continued).

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS6-13	353352	6246276	-	Y	*Rhododendron groenlandicum*	Labrador tea	sparse
MS6-14	353752	6246376	0.5	N			
MS6-15	353352	6246576	-	N			
MS7-1	350652	6246576	2.0	N			
MS7-2	350952	6246576	3.0	N			
MS7-3	351252	6246676	2.4	N			
MS7-4	351552	6246776	0.3	Y	*Utricularia* spp.	Bladderwort	abundant
					Vallisneria spp.	Duck celery	sparse
MS7-5	351052	6246876	1.0	Y	*Utricularia* spp.	Bladderwort	abundant
					Vallisneria spp.	Duck celery	sparse
MS7-6	350652	6246976	-	N			
MS7-7	350952	6246976	0.5	Y	*Equisetum* spp.	Horsetail	abundant
MS7-8	351352	6246976	0.5	Y	*Utricularia* spp.	Bladderwort	abundant
					Vallisneria spp.	Duck celery	sparse
					Chara spp.	Stoneworts	sparse
MS7-9	350652	6247076	1.5	Y	*Nuphar* spp.	Pond-lily	common
					Persicaria spp.	Smartweed	common
MS7-10	350852	6247176	0.5	Y	*Persicaria* spp.	Smartweed	abundant
					Equisetum spp.	Horsetail	abundant
					Utricularia spp.	Bladderwort	abundant
MS7-11	350952	6247276	-	N			
MS7-12	350552	6247376	-	N			
MS7-13	350852	6247376	-	N			
MS7-14	351052	6247376	-	N			
MS7-15	350752	6247476	-	N			
MS8-1	353552	6249176	-	N			
MS8-2	353952	6249176	0.3	Y	*Utricularia* spp.	Bladderwort	abundant
MS8-3	353652	6249276	-	N			
MS8-4	353952	6249276	2.4	Y	*Utricularia* spp.	Bladderwort	sparse
MS8-5	353452	6249376	0.9	Y	*Utricularia* spp.	Bladderwort	sparse
MS8-6	353752	6249376	0.7	Y	*Persicaria* spp.	Smartweed	sparse

Table A1-1: Aquatic macrophyte observations in the Keeyask reservoir from pre-selected sites, 2021 (continued).

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS8-7	353252	6249476	-	N			
MS8-8	352952	6249576	-	N			
MS8-9	353252	6249676	-	N			
MS8-10	353352	6249676	-	N			
MS8-11	353052	6249776	-	N			
MS8-12	353252	6249876	-	N			
MS8-13	353452	6249876	-	N			
MS8-14	353352	6249976	-	N			
MS8-15	353352	6250076	-	N			
MS9-1	359352	6246576	3.5	N			
MS9-2	359752	6246676	-	N			
MS9-3	360452	6246676	5.5	N			
MS9-4	358852	6246876	2.9	N			
MS9-5	359152	6246976	4.0	N			
MS9-6	360652	6246976	4.2	N			
MS9-7	359852	6247076	3.0	N			
MS9-8	360152	6247276	3.0	N			
MS9-9	358152	6247476	9.0	N			
MS9-10	358052	6247876	4.2	N			
MS9-11	358452	6247876	3.5	N			
MS9-12	358252	6248176	3.0	N			
MS9-13	358852	6248176	2.7	N			
MS9-14	359352	6248176	6.0	N			
MS9-15	359652	6248276	12.8	N			

Table A1-2: Aquatic macrophyte observations from Stephens Lake, 2021.

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS10-1	367652	6249776	-	N			
MS10-2	367452	6249876	0.5	N			
MS10-3	367752	6249876	2.0	N			
MS10-4	367452	6250076	1.4	N			
MS10-5	367152	6250176	-	N			
MS10-6	367352	6250176	-	N			
MS10-7	367552	6250176	2.2	Y	*Potamogeton richardsonii*	Richardson pondweed	common
MS10-8	367152	6250276	-	N			
MS10-9	367052	6250376	-	N			
MS10-10	367452	6250376	3.0	N			
MS10-11	367252	6250476	1.0	Y	*Stuckenia pectinata*	Sago pondweed	common
MS10-12	367852	6250476	6.8	N			
MS10-13	367452	6250676	2.4	N			
MS10-14	367752	6250676	6.0	N			
MS10-15	367652	6250876	2.0	Y	*Potamogeton richardsonii*	Richardson pondweed	sparse
MS11-1	369052	6251176	3.8	N			
MS11-2	368752	6251276	3.0	N			
MS11-3	368552	6251376	1.3	N			
MS11-4	368952	6251376	1.2	N			
MS11-5	368552	6251476	-	N			
MS11-6	369152	6251576	1.5	N			
MS11-7	368952	6251676	1.2	N			
MS11-8	369452	6251676	3.5	N			
MS11-9	368952	6251776	0.5	Y	*Potamogeton richardsonii*	Richardson pondweed	common
					Stuckenia pectinata	Sago pondweed	sparse
MS11-10	368852	6251876	-	N			
MS11-11	369052	6251876	-	N			
MS11-12	369252	6251876	-	N			
MS11-13	369452	6251876	6.6	N			
MS11-14	369352	6252076	1.9	N			
MS11-15	369152	6252176	1.0	N			

Table A1-2: Aquatic macrophyte observations from the Northern portion of Stephens Lake, 2021 (continued).

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS12-1	369852	6254976	1.9	N			
MS12-2	369552	6255076	2.0	N			
MS12-3	369552	6255176	2.0	N			
MS12-4	369952	6255276	4.4	N			
MS12-5	370252	6255276	4.7	N			
MS12-6	369452	6255376	0.5	N			
MS12-7	369652	6255476	-	N			
MS12-8	369852	6255576	-	N			
MS12-9	370352	6255576	6.2	N			
MS12-10	370052	6255676	1.2	N			
MS12-11	370652	6255676	4.0	N			
MS12-12	369952	6255876	2.3	N			
MS12-13	370352	6255876	5.6	N			
MS12-14	370552	6255976	7.5	N			
MS12-15	370352	6256076	6.0	N			

Table A1-3: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2021.

Site ID	Date	Time	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS1-7[1]	8/14/2021	11:10-13:00	-	-	-	-
MS1-9	8/14/2021	11:10-13:00	0.0	88.3	75.7	2.7
MS1-9	8/14/2021	11:10-13:00	0.2	105	43	1.7
MS1-9	8/14/2021	11:10-13:00	0.4	119	22	0.6
MS1-11	8/14/2021	11:10-13:00	0.0	301	415	20.0
MS1-11	8/14/2021	11:10-13:00	0.2	308	311	15.4
MS1-11	8/14/2021	11:10-13:00	0.4	318	234	11.9
MS1-11	8/14/2021	11:10-13:00	0.6	327	178	10.3
MS1-11	8/14/2021	11:10-13:00	0.8	348	152	7.4
MS1-11	8/14/2021	11:10-13:00	1.0	357	101	5.7
MS1-11	8/14/2021	11:10-13:00	1.2	368	38	4.1
MS1-11	8/14/2021	11:10-13:00	1.4	381	55	3.0
MS1-11	8/14/2021	11:10-13:00	1.6	387	39	2.2
MS1-11	8/14/2021	11:10-13:00	1.8	400	30	1.5
MS1-11	8/14/2021	11:10-13:00	2.0	429	24	1.1
MS1-11	8/14/2021	11:10-13:00	2.2	461	20.2	0.9
MS1-11	8/14/2021	11:10-13:00	2.4	438	13.3	0.5
MS1-11	8/14/2021	11:10-13:00	2.6	401	9.7	0.2
MS1-11	8/14/2021	11:10-13:00	2.8	394	6.9	0.0
MS1-11	8/14/2021	11:10-13:00	3.0	390	4.7	0.0
MS1-11	8/14/2021	11:10-13:00	3.2	383	3.7	0.0
MS1-11	8/14/2021	11:10-13:00	3.4	373	2.6	0.0
MS1-11	8/14/2021	11:10-13:00	3.6	361	1.7	0.0
MS1-11	8/14/2021	11:10-13:00	3.8	357	1.1	0.0
MS1-11	8/14/2021	11:10-13:00	4.0	353	0.7	0.0
MS1-11	8/14/2021	11:10-13:00	4.2	357	0.6	0.0
MS1-11	8/14/2021	11:10-13:00	4.4	367	0.3	0.0
MS2-6[1]	8/14/2021	15:35-16:45	-	-	-	-
MS2-11	8/14/2021	15:35-16-45	0.0	690	1450	19.4
MS2-11	8/14/2021	15:35-16-45	0.2	460	1035	52.2
MS2-11	8/14/2021	15:35-16-45	0.4	584	810	36.1
MS2-11	8/14/2021	15:35-16-45	0.6	709	226	7.8
MS2-11	8/14/2021	15:35-16-45	0.8	345	239	12.0
MS2-12	8/14/2021	15:35-16:45	0.0	627	998	44.1
MS2-12	8/14/2021	15:35-16:45	0.2	646	688	35.7
MS2-12	8/14/2021	15:35-16:45	0.4	658	626	29.7
MS2-12	8/14/2021	15:35-16:45	0.6	753	423	24.2
MS2-12	8/14/2021	15:35-16:45	0.8	792	281	15.4
MS2-12	8/14/2021	15:35-16:45	1.0	773	221	12.8

Table A1-3: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2021 (continued).

Site ID	Date	Time	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS2-12	8/14/2021	15:35-16:45	1.2	732	158	8.8
MS2-12	8/14/2021	15:35-16:45	1.4	759	111.3	6.1
MS2-12	8/14/2021	15:35-16:45	1.6	678	72.7	4.1
MS2-12	8/14/2021	15:35-16:45	1.8	672	60.3	3.1
MS2-12	8/14/2021	15:35-16:45	2.0	650	43.5	2.3
MS2-12	8/14/2021	15:35-16:45	2.2	559	26.6	1.2
MS2-12	8/14/2021	15:35-16:45	2.4	562	15.4	0.6
MS2-12	8/14/2021	15:35-16:45	2.6	637	15.1	0.5
MS2-12	8/14/2021	15:35-16:45	2.8	417	7.6	0.2
MS2-12	8/14/2021	15:35-16:45	3.0	428	5.5	0.0
MS2-12	8/14/2021	15:35-16:45	3.2	555	6.4	0.0
MS2-12	8/14/2021	15:35-16:45	3.4	759	4.8	0.0
MS2-12	8/14/2021	15:35-16:45	3.6	451	2.3	0.0
MS2-12	8/14/2021	15:35-16:45	3.8	511	2.0	0.0
MS2-12	8/14/2021	15:35-16:45	4.0	510	2.2	0.0
MS2-12	8/14/2021	15:35-16:45	4.2	552	2.0	0.0
MS2-12	8/14/2021	15:35-16:45	4.4	381	1.2	0.0
MS3-4	8/15/2021	10:00	0.0	1043	1328	23.9
MS3-4	8/15/2021	10:00	0.2	1175	1042	17.1
MS3-4	8/15/2021	10:00	0.4	1103	620	13.1
MS3-4	8/15/2021	10:00	0.6	1034	375	8.6
MS3-4	8/15/2021	10:00	0.8	1165	279	6.3
MS3-4	8/15/2021	10:00	1.0	1031	213	5.1
MS3-4	8/15/2021	10:00	1.2	1147	118	3.0
MS3-4	8/15/2021	10:00	1.4	1125	76.2	2.0
MS3-4	8/15/2021	10:00	1.6	1096	67.1	1.6
MS3-4	8/15/2021	10:00	1.8	1063	48.2	0.9
MS3-4	8/15/2021	10:00	2.0	1119	26	0.2
MS3-4	8/15/2021	10:00	2.2	1047	18.4	0.1
MS3-4	8/15/2021	10:00	2.4	1086	12.5	0.0
MS3-4	8/15/2021	10:00	2.6	1070	7.1	0.0
MS3-10	8/15/2021	10:00	0.0	683	1311	33.1
MS3-10	8/15/2021	10:00	0.2	705	726	19.5
MS3-10	8/15/2021	10:00	0.4	746	512	8.8
MS3-10	8/15/2021	10:00	0.6	702	249	8.0
MS3-13	8/15/2021	10:00	0.0	614	217	10.3
MS3-13	8/15/2021	10:00	0.2	619	149	8.6
MS3-13	8/15/2021	10:00	0.4	645	155	7.5

Table A1-3: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2021 (continued).

Site ID	Date	Time	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS3-13	8/15/2021	10:00	0.6	603	77.8	5.9
MS3-13	8/15/2021	10:00	0.8	568	70.6	4.8
MS3-13	8/15/2021	10:00	1.0	622	58.4	3.9
MS3-13	8/15/2021	10:00	1.2	596	42.3	3.1
MS3-13	8/15/2021	10:00	1.4	606	38.9	2.4
MS3-13	8/15/2021	10:00	1.6	610	30.3	1.9
MS3-13	8/15/2021	10:00	1.8	622	27.7	1.4
MS3-13	8/15/2021	10:00	2.0	630	20.4	0.9
MS3-13	8/15/2021	10:00	2.2	576	15.7	0.7
MS3-13	8/15/2021	10:00	2.4	538	12.1	0.5
MS3-13	8/15/2021	10:00	2.6	576	9.1	0.3
MS3-13	8/15/2021	10:00	2.8	613	8.1	0.1
MS3-13	8/15/2021	10:00	3.0	605	6.2	0.1
MS3-13	8/15/2021	10:00	3.2	567	4.9	0.0
MS3-13	8/15/2021	10:00	3.4	633	4	0.0
MS3-13	8/15/2021	10:00	3.6	603	2.6	0.0
MS3-13	8/15/2021	10:00	3.8	599	2.1	0.0
MS3-13	8/15/2021	10:00	4.0	594	2.3	0.0
MS4-7	8/16/2021	13:25-14:50	0.0	275	267	3.7
MS4-7	8/16/2021	13:25-14:50	0.2	270	167	2.5
MS4-7	8/16/2021	13:25-14:50	0.4	265	136	1.6
MS4-7	8/16/2021	13:25-14:50	0.6	258	87.7	1.1
MS4-7	8/16/2021	13:25-14:50	0.8	252	67	0.7
MS4-7	8/16/2021	13:25-14:50	1.0	250	42.9	0.3
MS4-7	8/16/2021	13:25-14:50	1.2	248	29	0.0
MS4-10	8/16/2021	13:25-14:50	0.0	355	425	5.3
MS4-10	8/16/2021	13:25-14:50	0.2	356	256	3.5
MS4-10	8/16/2021	13:25-14:50	0.4	356	196	2.4
MS4-10	8/16/2021	13:25-14:50	0.6	356	144	1.6
MS4-10	8/16/2021	13:25-14:50	0.8	354	99.2	1.0
MS4-10	8/16/2021	13:25-14:50	1.0	348	67.8	0.5
MS4-10	8/16/2021	13:25-14:50	1.2	348	49.3	0.2
MS4-10	8/16/2021	13:25-14:50	1.4	344	32.2	0.0
MS4-10	8/16/2021	13:25-14:50	1.6	343	22.3	0.0
MS4-14	8/16/2021	13:25-14:50	0.0	242	309	4.7
MS4-14	8/16/2021	13:25-14:50	0.2	243	226	3.5
MS4-14	8/16/2021	13:25-14:50	0.4	242	155	2.4
MS4-14	8/16/2021	13:25-14:50	0.6	240	105	1.6

Table A1-3: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2021 (continued).

Site ID	Date	Time	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS4-14	8/16/2021	13:25-14:50	0.8	236	76	1.1
MS4-14	8/16/2021	13:25-14:50	1.0	232	52.5	0.7
MS4-14	8/16/2021	13:25-14:50	1.2	229	37.8	0.4
MS4-14	8/16/2021	13:25-14:50	1.4	224	25.5	0.2
MS4-14	8/16/2021	13:25-14:50	1.6	220	20.6	0.1
MS4-14	8/16/2021	13:25-14:50	1.8	217	15	0.0
MS4-14	8/16/2021	13:25-14:50	2.0	213	12.3	0.0
MS4-14	8/16/2021	13:25-14:50	2.2	213	7.7	0.0
MS4-14	8/16/2021	13:25-14:50	2.4	213	5.2	0.0
MS4-14	8/16/2021	13:25-14:50	2.6	213	3.7	0.0
MS5-3[1]	8/22/2021	9:00	-	-	-	-
MS5-6[1]	8/22/2021	9:00	-	-	-	-
MS5-7	8/22/2021	9:00	0.0	205	268	8.9
MS5-7	8/22/2021	9:00	0.2	205	216	7.8
MS5-7	8/22/2021	9:00	0.4	202	128	5.0
MS5-7	8/22/2021	9:00	0.6	201	88	4.0
MS5-7	8/22/2021	9:00	0.8	200	62.7	2.8
MS5-7	8/22/2021	9:00	1.0	200	44.5	2.1
MS5-7	8/22/2021	9:00	1.2	198	31.1	1.5
MS5-7	8/22/2021	9:00	1.4	197	21	1.1
MS5-7	8/22/2021	9:00	1.6	197	16.7	0.8
MS5-7	8/22/2021	9:00	1.8	198	13.5	0.6
MS5-7	8/22/2021	9:00	2.0	192	8.7	0.5
MS5-7	8/22/2021	9:00	2.2	197	6.2	0.3
MS5-7	8/22/2021	9:00	2.4	198	2.8	0.0
MS6-3	8/18/2021	11:15	0.0	267	345	13.1
MS6-3	8/18/2021	11:15	0.2	287	272	10.9
MS6-3	8/18/2021	11:15	0.4	307	192	7.8
MS6-3	8/18/2021	11:15	0.6	318	176	7.4
MS6-3	8/18/2021	11:15	0.8	347	138	6.2
MS6-3	8/18/2021	11:15	1.0	353	92.3	4.1
MS6-3	8/18/2021	11:15	1.2	351	71.6	3.5
MS6-3	8/18/2021	11:15	1.4	353	56	2.7
MS6-3	8/18/2021	11:15	1.6	348	42.6	2.0
MS6-3	8/18/2021	11:15	1.8	356	31.1	1.6
MS6-3	8/18/2021	11:15	2.0	355	23.3	1.1
MS6-3	8/18/2021	11:15	2.2	353	19.4	0.8
MS6-3	8/18/2021	11:15	2.4	348	14.6	0.6

Table A1-3: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2021 (continued).

Site ID	Date	Time	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS6-3	8/18/2021	11:15	2.6	349	10.7	0.4
MS6-3	8/18/2021	11:15	2.8	308	7.7	0.3
MS6-3	8/18/2021	11:15	3.0	329	6.7	0.2
MS6-3	8/18/2021	11:15	3.2	345	5.2	0.1
MS6-3	8/18/2021	11:15	3.4	344	3.5	0.0
MS6-3	8/18/2021	11:15	3.6	346	3.0	0.0
MS6-3	8/18/2021	11:15	3.8	345	2.0	0.0
MS6-3	8/18/2021	11:15	4.0	348	1.5	0.0
MS6-3	8/18/2021	11:15	4.2	347	1.1	0.0
MS6-3	8/18/2021	11:15	4.4	332	0.6	0.0
MS6-3	8/18/2021	11:15	4.6	310	0.4	0.0
MS6-3	8/18/2021	11:15	4.8	274	0.2	0.0
MS6-3	8/18/2021	11:15	5.0	268	0.0	0.0
MS6-6	8/18/2021	11:15	0.0	543	729	13.1
MS6-6	8/18/2021	11:15	0.2	540	575	10.2
MS6-9[1]	8/18/2021	11:15	-	-	-	-
MS7-3	8/18/2021	9:35	0.0	120	202	2.0
MS7-3	8/18/2021	9:35	0.2	117	97	1.4
MS7-3	8/18/2021	9:35	0.4	115	77	1.2
MS7-3	8/18/2021	9:35	0.6	114	53	0.9
MS7-3	8/18/2021	9:35	0.8	117	38.9	0.4
MS7-3	8/18/2021	9:35	1.0	109	31	0.5
MS7-3	8/18/2021	9:35	1.2	117	23	0.2
MS7-3	8/18/2021	9:35	1.4	119	17.5	0.4
MS7-3	8/18/2021	9:35	1.6	113	13	0.3
MS7-3	8/18/2021	9:35	1.8	114	9.7	0.2
MS7-3	8/18/2021	9:35	2.0	122	8.4	0.1
MS7-3	8/18/2021	9:35	2.2	122	6.5	0.0
MS7-7	8/18/2021	9:35	0.0	214	286	0.2
MS7-7	8/18/2021	9:35	0.2	213	113	0.0
MS7-7	8/18/2021	9:35	0.4	234	69	0.0
MS7-10	8/18/2021	9:35	0.0	250	199	0.2
MS7-10	8/18/2021	9:35	0.2	252	129	0.0
MS7-10	8/18/2021	9:35	0.4	253	81	0.0
MS8-4	8/18/2021	13:50	0.0	736	94	12.7
MS8-4	8/18/2021	13:50	0.2	708	531	11.1
MS8-4	8/18/2021	13:50	0.4	831	516	8.7
MS8-4	8/18/2021	13:50	0.6	1093	628	11.7

Table A1-3: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2021 (continued).

Site ID	Date	Time	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS8-4	8/18/2021	13:50	0.8	1315	565	9.3
MS8-4	8/18/2021	13:50	1.0	848	228	4.4
MS8-4	8/18/2021	13:50	1.2	926	158	3.7
MS8-4	8/18/2021	13:50	1.4	923	104	2.7
MS8-4	8/18/2021	13:50	1.6	596	52.3	1.0
MS8-4	8/18/2021	13:50	1.8	578	39.7	0.5
MS8-4	8/18/2021	13:50	2.0	533	23.7	0.0
MS8-6	8/18/2021	13:50	0.0	515	613	2.4
MS8-6	8/18/2021	13:50	0.2	527	412	2.1
MS8-6	8/18/2021	13:50	0.4	544	211	1.6
MS8-6	8/18/2021	13:50	0.6	539	173	0.8
MS8-10[1]	8/18/2021	13:50	-	-	-	-
MS9-9[2]	8/11/2021	9:30	0.0	269.6	394	28.6
MS9-9	8/11/2021	9:30	0.1[2]	349	502	17.5
MS9-9	8/11/2021	9:30	0.2	349	487	15.6
MS9-9	8/11/2021	9:30	0.3	305	374	13.2
MS9-9	8/11/2021	9:30	0.4	327	332	11.7
MS9-9	8/11/2021	9:30	0.5	340	287	10.1
MS9-9	8/11/2021	9:30	0.6	358	258	9.3
MS9-9	8/11/2021	9:30	0.7	411	254	10.3
MS9-9	8/11/2021	9:30	0.8	405	221	8.0
MS9-9	8/11/2021	9:30	0.9	333	169	6.9
MS9-9	8/11/2021	9:30	1.0	344	129	5.3
MS9-9	8/11/2021	9:30	1.1	323	107	4.5
MS9-9	8/11/2021	9:30	1.2	326	96	3.9
MS9-9	8/11/2021	9:30	1.3	327	79.6	3.1
MS9-9	8/11/2021	9:30	1.4	323	57.9	2.3
MS9-9	8/11/2021	9:30	1.5	301	50.6	2.3
MS9-9	8/11/2021	9:30	1.6	296	53.2	2.3
MS9-9	8/11/2021	9:30	1.7	325	42.4	1.7
MS9-9	8/11/2021	9:30	1.8	339	42.6	1.7
MS9-9	8/11/2021	9:30	1.9	361	36.4	1.5
MS9-9	8/11/2021	9:30	2.0	367	32.8	1.4
MS9-9	8/11/2021	9:30	2.1	315	34.1	1.6
MS9-9	8/11/2021	9:30	2.2	408	29.2	1.1
MS9-9	8/11/2021	9:30	2.3	298	20.1	0.6
MS9-9	8/11/2021	9:30	2.4	257	15.1	0.4
MS9-9	8/11/2021	9:30	2.5	251	14.3	0.4

Table A1-3: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2021 (continued).

Site ID	Date	Time	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS9-9	8/11/2021	9:30	2.6	551	23.8	1.5
MS9-9	8/11/2021	9:30	2.7	1120	32.3	1.9
MS9-9	8/11/2021	9:30	2.8	1266	26.9	1.4
MS9-9	8/11/2021	9:30	2.9	1151	21.6	1.1
MS9-9	8/11/2021	9:30	3.0	710	11.1	0.3
MS9-9	8/11/2021	9:30	3.1	604	8.2	0.1
MS9-9	8/11/2021	9:30	3.2	635	9.4	0.4
MS9-9	8/11/2021	9:30	3.3	863	9.0	0.2
MS9-9	8/11/2021	9:30	3.4	612	7.0	0.1
MS9-9	8/11/2021	9:30	3.5	563	6.5	0.0
MS9-9	8/11/2021	9:30	3.6	564	5.9	0.0
MS9-9	8/11/2021	9:30	3.7	501	4.3	0.0
MS9-9	8/11/2021	9:30	3.8	518	3.0	0.0
MS9-9	8/11/2021	9:30	3.9	639	3.9	0.0
MS9-9	8/11/2021	9:30	4.0	783	3.6	0.0
MS9-11	8/11/2021	9:30	0.0	739	1205	44.8
MS9-11	8/11/2021	9:30	0.1	788	1021	34.0
MS9-11	8/11/2021	9:30	0.2	834	949	25.6
MS9-11	8/11/2021	9:30	0.3	1094	1016	32.5
MS9-11	8/11/2021	9:30	0.4	853	657	25.8
MS9-11	8/11/2021	9:30	0.5	844	478	22.6
MS9-11	8/11/2021	9:30	0.6	916	668	19.1
MS9-11	8/11/2021	9:30	0.7	934	407	13.6
MS9-11	8/11/2021	9:30	0.8	639	259	10.2
MS9-11	8/11/2021	9:30	0.9	787	262	9.7
MS9-11	8/11/2021	9:30	1.0	742	234	8.4
MS9-11	8/11/2021	9:30	1.1	594	146	5.4
MS9-11	8/11/2021	9:30	1.2	517	111	4.1
MS9-11	8/11/2021	9:30	1.3	486	83.9	3.2
MS9-11	8/11/2021	9:30	1.4	462	68.2	2.5
MS9-11	8/11/2021	9:30	1.5	443	54.9	1.6
MS9-11	8/11/2021	9:30	1.6	427	43.8	0.8
MS9-11	8/11/2021	9:30	1.7	410	35.1	0.5
MS9-11	8/11/2021	9:30	1.8	396	29.2	0.1
MS9-15	8/11/2021	9:30	0.0	480	648	11.0
MS9-15	8/11/2021	9:30	0.1	478	554	10.0
MS9-15	8/11/2021	9:30	0.2	475	434	9.1
MS9-15	8/11/2021	9:30	0.3	478	326	8.9

Table A1-3: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2021 (continued).

Site ID	Date	Time	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS9-15	8/11/2021	9:30	0.4	481	260	7.9
MS9-15	8/11/2021	9:30	0.5	486	221	7.1
MS9-15	8/11/2021	9:30	0.6	489	171	5.8
MS9-15	8/11/2021	9:30	0.7	490	155	4.5
MS9-15	8/11/2021	9:30	0.8	492	191	3.9
MS9-15	8/11/2021	9:30	0.9	490	162	3.4
MS9-15	8/11/2021	9:30	1.0	487	134	2.8
MS9-15	8/11/2021	9:30	1.1	456	123	2.5
MS9-15	8/11/2021	9:30	1.2	450	93.6	2.0
MS9-15	8/11/2021	9:30	1.3	442	82.3	1.9
MS9-15	8/11/2021	9:30	1.4	426	70.8	1.5
MS9-15	8/11/2021	9:30	1.5	429	57.6	1.3
MS9-15	8/11/2021	9:30	1.6	427	47.8	1.1
MS9-15	8/11/2021	9:30	1.7	421	41.6	0.9
MS9-15	8/11/2021	9:30	1.8	427	38.1	0.8
MS9-15	8/11/2021	9:30	1.9	427	32.9	0.6
MS9-15	8/11/2021	9:30	2.0	430	27.5	0.5
MS9-15	8/11/2021	9:30	2.1	431	2.5	0.4
MS9-15	8/11/2021	9:30	2.2	452	21.4	0.3
MS9-15	8/11/2021	9:30	2.3	454	19.6	0.2
MS9-15	8/11/2021	9:30	2.4	447	16.8	0.1
MS9-15	8/11/2021	9:30	2.5	438	14.2	0.1
MS9-15	8/11/2021	9:30	2.6	430	12.3	0.0
MS9-15	8/11/2021	9:30	2.7	424	11.0	0.0
MS9-15	8/11/2021	9:30	2.8	419	9.3	0.0
MS9-15	8/11/2021	9:30	2.9	412	8.1	0.0
MS9-15	8/11/2021	9:30	3.0	410	6.8	0.0
MS9-15	8/11/2021	9:30	3.1	408	6.2	0.0
MS9-15	8/11/2021	9:30	3.2	407	5.6	0.0
MS9-15	8/11/2021	9:30	3.3	409	4.8	0.0
MS9-15	8/11/2021	9:30	3.4	411	4.2	0.0
MS9-15	8/11/2021	9:30	3.5	414	3.9	0.0
MS9-15	8/11/2021	9:30	3.6	418	3.2	0.0
MS9-15	8/11/2021	9:30	3.7	422	2.9	0.0
MS9-15	8/11/2021	9:30	3.8	431	2.6	0.0
MS9-15	8/11/2021	9:30	3.9	431	2.0	0.0
MS9-15	8/11/2021	9:30	4.0	430	1.7	0.0
MS9-15	8/11/2021	9:30	4.1	430	1.6	0.0

Table A1-3: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2021 (continued).

Site ID	Date	Time	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS9-15	8/11/2021	9:30	4.2	430	1.3	0.0
MS9-15	8/11/2021	9:30	4.3	431	1.2	0.0
MS9-15	8/11/2021	9:30	4.4	432	1.0	0.0
MS9-15	8/11/2021	9:30	4.5	433	0.9	0.0
MS9-15	8/11/2021	9:30	4.6	431	0.8	0.0
MS9-15	8/11/2021	9:30	4.7	428	0.7	0.0
MS9-15	8/11/2021	9:30	4.8	423	0.6	0.0
MS9-15	8/11/2021	9:30	4.9	427	0.6	0.0
MS9-15	8/11/2021	9:30	5.0	395	0.5	0.0
MS9-15	8/11/2021	9:30	5.1	399	0.5	0.0

1 – site was inaccessible
2 – data in increments of 0.1m rather than 0.2m

Table A1-4: Light extinction downloaded readings from pre-selected sites in the Northern portion of Stephens Lake, 2021.

Site ID	Date	Time	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS10-8	8/17/2021	13:45-15:05	-[1]	-	-	-
MS10-10	8/17/2021	13:45-15:05	0.0	449	668	25.2
MS10-10	8/17/2021	13:45-15:05	0.2	427	405	14.2
MS10-10	8/17/2021	13:45-15:05	0.4	420	291	11.7
MS10-10	8/17/2021	13:45-15:05	0.6	406	173	7.2
MS10-10	8/17/2021	13:45-15:05	0.8	394	121	5.1
MS10-10	8/17/2021	13:45-15:05	1.0	407	76.6	3.4
MS10-10	8/17/2021	13:45-15:05	1.2	409	57.2	2.4
MS10-10	8/17/2021	13:45-15:05	1.4	428	43.7	1.9
MS10-10	8/17/2021	13:45-15:05	1.6	682	83.6	1.5
MS10-10	8/17/2021	13:45-15:05	1.8	443	22.2	0.8
MS10-10	8/17/2021	13:45-15:05	2.0	436	16.9	0.5
MS10-10	8/17/2021	13:45-15:05	2.2	445	11.8	0.2
MS10-10	8/17/2021	13:45-15:05	2.4	449	8.2	0.0
MS10-10	8/17/2021	13:45-15:05	2.6	448	5.0	0.0
MS10-10	8/17/2021	13:45-15:05	2.8	456	2.9	0.0
MS10-12	8/17/2021	13:45-15:05	0.0	420	674	22.3
MS10-12	8/17/2021	13:45-15:05	0.2	417	447	22.3
MS10-12	8/17/2021	13:45-15:05	0.4	421	328	14.5
MS10-12	8/17/2021	13:45-15:05	0.6	421	222	9.7
MS10-12	8/17/2021	13:45-15:05	0.8	418	155	7.1
MS10-12	8/17/2021	13:45-15:05	1.0	413	125	5.1
MS10-12	8/17/2021	13:45-15:05	1.2	412	84.0	4.8
MS10-12	8/17/2021	13:45-15:05	1.4	423	64.3	3.3
MS10-12	8/17/2021	13:45-15:05	1.6	433	53.1	2.3
MS10-12	8/17/2021	13:45-15:05	1.8	456	46.3	1.8
MS10-12	8/17/2021	13:45-15:05	2.0	456	28.6	1.0
MS10-12	8/17/2021	13:45-15:05	2.2	484	23.4	0.7
MS10-12	8/17/2021	13:45-15:05	2.4	430	19.4	0.6
MS10-12	8/17/2021	13:45-15:05	2.6	681	16.3	0.3
MS10-12	8/17/2021	13:45-15:05	2.8	517	9.9	0.1
MS10-12	8/17/2021	13:45-15:05	3.0	510	6.8	0.0
MS10-12	8/17/2021	13:45-15:05	3.2	517	5.2	0.0
MS10-12	8/17/2021	13:45-15:05	3.4	520	4.2	0.0
MS10-12	8/17/2021	13:45-15:05	3.6	591	3.4	0.0
MS10-12	8/17/2021	13:45-15:05	3.8	941	3.3	0.0
MS10-12	8/17/2021	13:45-15:05	4.0	667	1.8	0.0
MS10-12	8/17/2021	13:45-15:05	4.2	615	1.3	0.0

1 – site was inaccessible

Table A1-4: Light extinction downloaded readings from pre-selected sites in the Northern portion of Stephens Lake, 2021 (continued).

Site ID	Date	Time	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS10-12	8/17/2021	13:45-15:05	4.4	608	1.0	0.0
MS10-12	8/17/2021	13:45-15:05	4.6	624	0.8	0.0
MS10-12	8/17/2021	13:45-15:05	4.8	705	0.9	0.0
MS10-12	8/17/2021	13:45-15:05	5.0	647	0.3	0.0
MS10-12	8/17/2021	13:45-15:05	5.2	574	0.2	0.0
MS10-12	8/17/2021	13:45-15:05	5.4	562	0.1	0.0
MS10-12	8/17/2021	13:45-15:05	5.6	513	0.0	0.0
MS11-8	8/17/2021	11:50	0.0	1130	2064	82.9
MS11-8	8/17/2021	11:50	0.2	919	1142	33.7
MS11-8	8/17/2021	11:50	0.4	948	845	38.1
MS11-8	8/17/2021	11:50	0.6	963	391	26.7
MS11-8	8/17/2021	11:50	0.8	948	251	16.9
MS11-8	8/17/2021	11:50	1.0	945	127	10.6
MS11-8	8/17/2021	11:50	1.2	932	110	9.3
MS11-8	8/17/2021	11:50	1.4	918	74.5	6.4
MS11-8	8/17/2021	11:50	1.6	927	56.5	4.4
MS11-8	8/17/2021	11:50	1.8	919	40.3	2.8
MS11-8	8/17/2021	11:50	2.0	913	28.2	1.9
MS11-8	8/17/2021	11:50	2.2	893	21.5	1.2
MS11-8	8/17/2021	11:50	2.4	930	14.8	0.8
MS11-8	8/17/2021	11:50	2.6	946	11.1	0.5
MS11-8	8/17/2021	11:50	2.8	1058	7.9	0.3
MS11-8	8/17/2021	11:50	3.0	1090	5.0	0.0
MS11-8	8/17/2021	11:50	3.2	475	2.0	0.0
MS11-9	8/17/2021	11:50	0.0	1306	2615	100.6
MS11-9	8/17/2021	11:50	0.2	1355	1577	77.5
MS11-9	8/17/2021	11:50	0.4	1189	283	14.3
MS11-10	8/17/2021	11:50	-	-	-	-
MS12-3	8/17/2021	9:10	0.0	182	278	9.1
MS12-3	8/17/2021	9:10	0.2	187	195	6.6
MS12-3	8/17/2021	9:10	0.4	189	107	3.8
MS12-3	8/17/2021	9:10	0.6	187	64.3	2.4
MS12-3	8/17/2021	9:10	0.8	184	32.8	1.6
MS12-3	8/17/2021	9:10	1.0	173	17.4	0.5
MS12-3	8/17/2021	9:10	1.2	171	12.7	0.6
MS12-9	8/17/2021	9:10	0.0	239	306	18.5
MS12-9	8/17/2021	9:10	0.2	238	217	13.3
MS12-9	8/17/2021	9:10	0.4	243	104	8.4

Table A1-4: Light extinction downloaded readings from pre-selected sites in the Northern portion of Stephens Lake, 2021 (continued).

Site ID	Date	Time	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS12-9	8/17/2021	9:10	0.6	245	51.2	4.5
MS12-9	8/17/2021	9:10	0.8	248	36.3	3.0
MS12-9	8/17/2021	9:10	1.0	254	24.3	1.8
MS12-9	8/17/2021	9:10	1.2	266	15.3	1.1
MS12-9	8/17/2021	9:10	1.4	276	10.2	0.6
MS12-9	8/17/2021	9:10	1.6	284	7.2	0.3
MS12-9	8/17/2021	9:10	1.8	294	4.6	0.1
MS12-9	8/17/2021	9:10	2.0	298	3.4	0.0
MS12-9	8/17/2021	9:10	2.2	300	2.2	0.0
MS12-9	8/17/2021	9:10	2.4	302	1.4	0.0
MS12-9	8/17/2021	9:10	2.6	308	0.9	0.0
MS12-9	8/17/2021	9:10	2.8	315	0.6	0.0
MS12-9	8/17/2021	9:10	3.0	322	0.3	0.0
MS12-9	8/17/2021	9:10	3.2	329	0.2	0.0
MS12-9	8/17/2021	9:10	3.4	332	0.1	0.0
MS12-9	8/17/2021	9:10	3.6	337	0.0	0.0
MS12-10	8/17/2021	9:10	0.0	192	306	10.3
MS12-10	8/17/2021	9:10	0.2	201	225	6.5
MS12-10	8/17/2021	9:10	0.4	212	138	4.9
MS12-10	8/17/2021	9:10	0.6	224	64.3	2.5
MS12-10	8/17/2021	9:10	0.8	234	34.5	1.4
MS12-10	8/17/2021	9:10	1.0	247	25.6	0.5