Keeyask Generation Project

Aquatic Effects Monitoring Plan

Development of Nearshore and Aquatic Macrophyte Habitat Report

AEMP-2023-15

KEEYASK

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KEEYASK GENERATION PROJECT

AQUATIC EFFECTS MONITORING PLAN

REPORT #AEMP-2023-15

DEVELOPMENT OF NEARSHORE AND AQUATIC MACROPHYTE HABITAT IN THE KEEYASK STUDY AREA, 2022

Prepared for

Manitoba Hydro

By

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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. They were brought into service one at a time with the final of seven turbines completed on March 9, 2022.

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 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 jackfish (Northern Pike) 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) 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. 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 2022, the second open-water season after flooding.

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 newly flooded shallow areas upstream of the Keeyask and three shallow areas downstream in Stephens Lake. Stephens Lake is an old reservoir and 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 below) and identified.

Aquatic plants as seen from the boat (left), photographed under water (middle), and sampled (right) in the Keeyask reservoir in 2022.

Substrate type was identified at each site by using a Ponar dredge (to grab a sample of the bottom; see photos below), 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.

Substrates sampled with a Ponar dredge (left) showing gravel (middle) and organics (right) from the Keeyask reservoir in 2022.

What was found?

Nearshore habitats were monitored in nine areas within the Keeyask reservoir and three areas in Stephens Lake in 2022. Between nine and 15 sites were sampled in each area.

Substrates in the nearshore of the Keeyask reservoir were mostly organic material made up of soft mud (like silt and clay) and some organic (plant) matter.

More aquatic plants were found in nearshore areas in the Keeyask reservoir during sampling in 2022 than in 2021. In 2022, aquatic plants were found in eight of nine sampling areas including flooded reservoir backbays. Although aquatic plants were found at water depths between <0.5 and 5.9 m in 2022, areas deeper than 3 m may not have enough light for plants to grow. Aquatic plants were found at 67% (48 of 72) sites sampled at water depths less than 3 m. Most aquatic plants were found in the area upstream of Birthday Rapids, two reservoir backbays, and the north shore of Gull Lake.

Several areas sampled in the Keeyask reservoir in 2022 showed little or no aquatic plant growth, as in 2021. These included the south shore of Gull Lake and lower Gull Lake. These areas were the deepest sampled and there likely wasn't enough light for plants to grow.

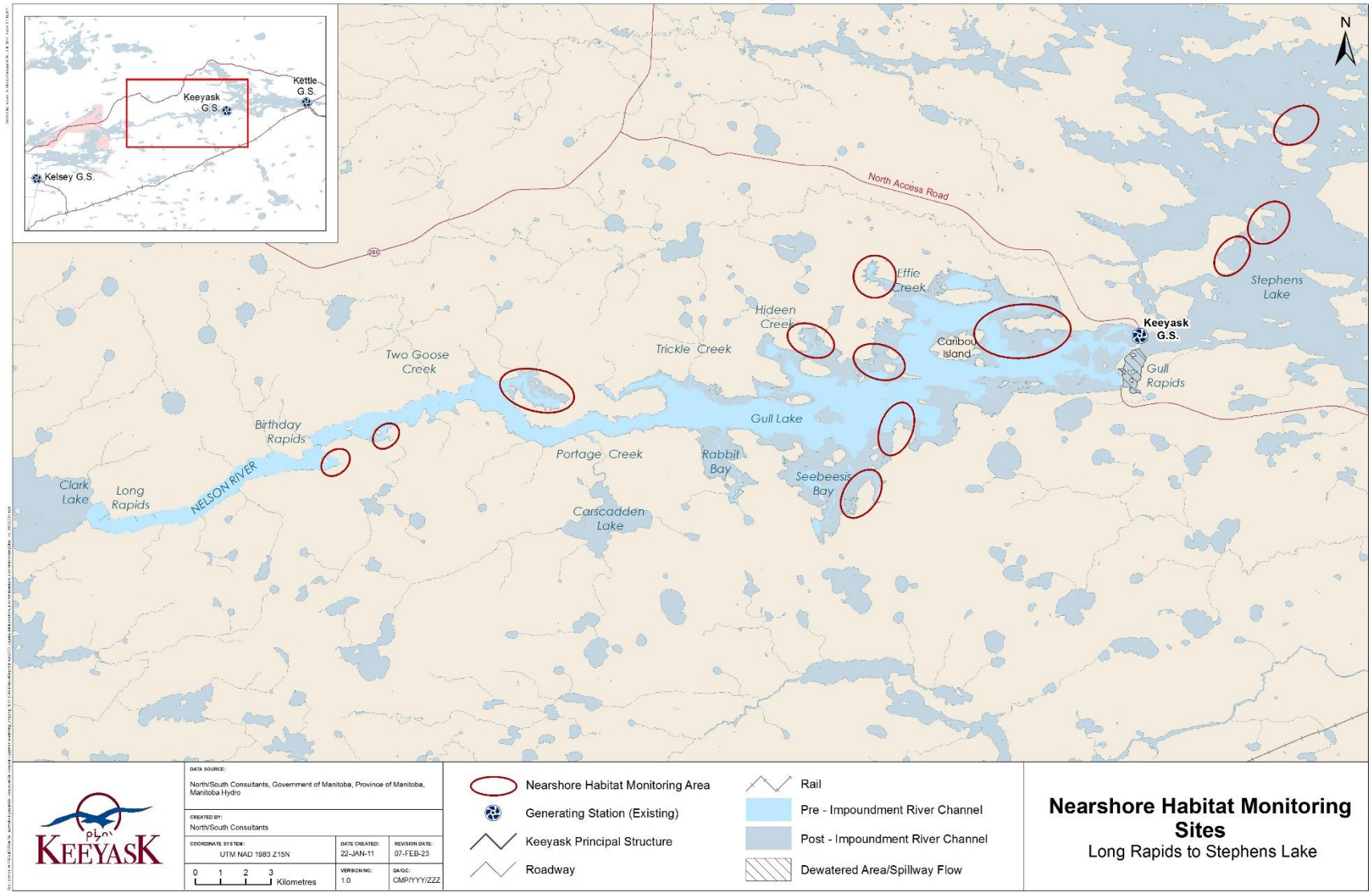
Substrates in Stephens Lake were mostly silt and clay with some organics. As in the Keeyask reservoir, several sites sampled in 2022 were deeper than 3 m. Aquatic plants were found at nine of 26 sites (35%) measuring less than 3 m of depth.

What does it mean?

Sampling in 2022 provides a second year of monitoring after flooding and is early in the development of nearshore habitat in the Keeyask reservoir. It seems that aquatic plants are beginning to grow in the Keeyask reservoir after flooding.

What will be done next?

The program will be repeated again in 2023. Where possible, plant and substrate data will be collected in the same areas and the same sites to document changes. In future years, an effort will be made to sample at shallower sites within both the Keeyask reservoir and Stephens Lake.



Map showing sites surveyed for nearshore habitat monitoring, August 2022.

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1.0 INTRODUCTION

The Keeyask Generation Project (the Project) is a 695-megawatt (MW) hydroelectric generating station on the lower Nelson River in northern Manitoba. The GS is approximately 725 kilometres (km) northeast of Winnipeg, 35 km upstream of the existing Kettle Generating Station, 60 km east of the community of Split Lake, 180 km east-northeast of Thompson and 30 km west of Gillam. Construction of the GS began in July 2014 and the seven generating units were all in-service in March 2022.

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. 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 2022 represented the second 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 based on data collected in August 2022, two years 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.

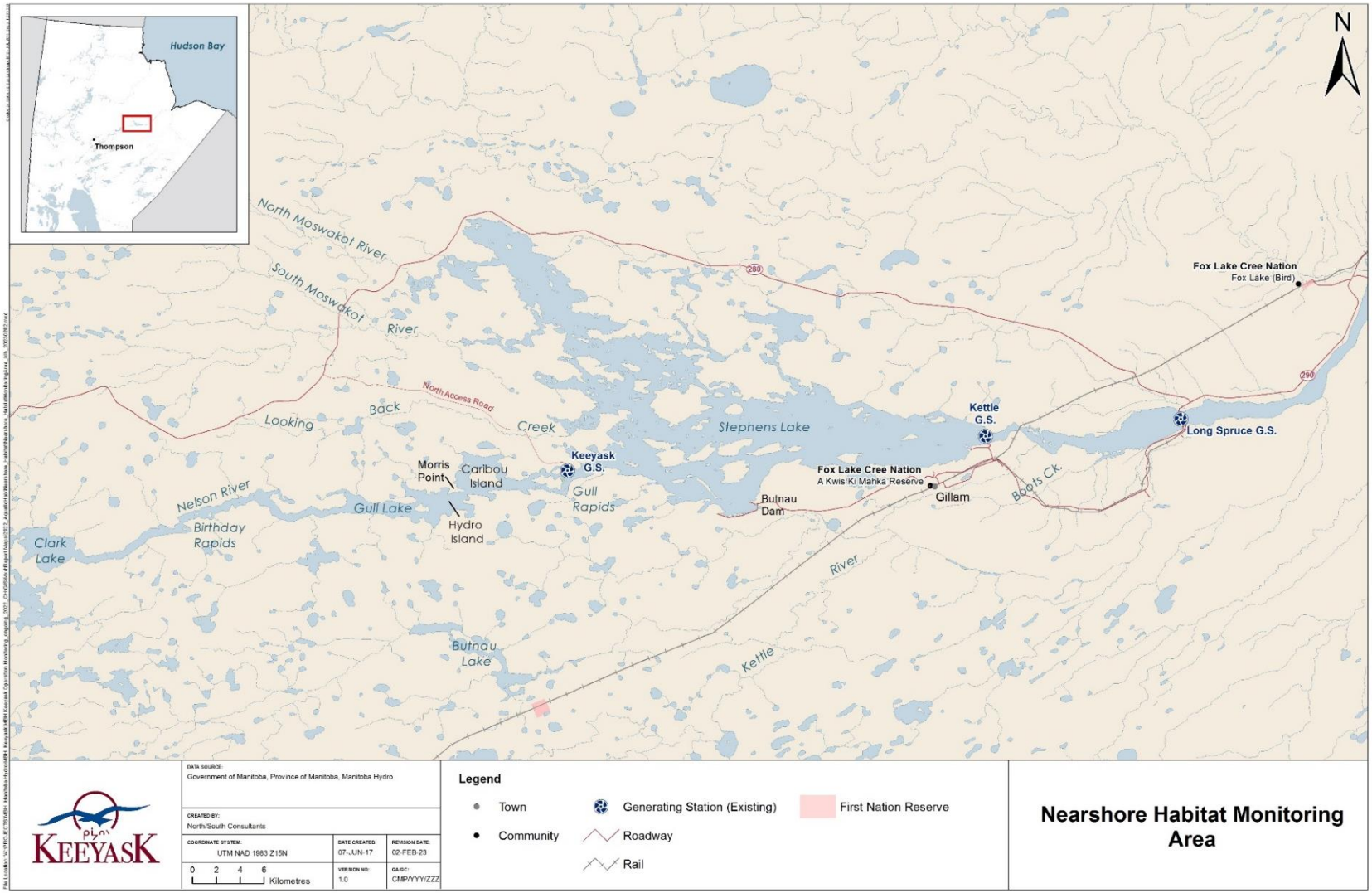
2.0 STUDY SETTING

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 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 nearly level, albeit a 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, and is referred to herein as the middle Keeyask reservoir.

Prior to impoundment, Gull Lake was a widening of the Nelson River, with moderate to low water velocity beginning approximately 20 km upstream 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 larger than prior to impoundment, this portion of the Keeyask reservoir 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.



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

3.0 METHODS

3.1 SUBSTRATE

3.1.1 SUBSTRATE MAPPING

A BioSonics MX 200 kHz single-beam echosounder 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 transect.

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

A model was created using Visual Habitat software which classed acoustic signals into 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).

3.1.2 DIRECT SUBSTRATE SAMPLING

Substrate grab samples were collected to validate acoustic bottom typing data. 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 sampling site and classified using a modified Wentworth scale (Table 1) and the percent composition of each type was estimated (e.g., 50% clay, 30% silt, 20% sand; Table 1; Wentworth 1922). At several sites where fine or organic substrates were encountered, grab samples were preserved for particle size analysis (PSA) and organic content analysis, conducted at ALS Laboratories in Winnipeg, Manitoba. 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.

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

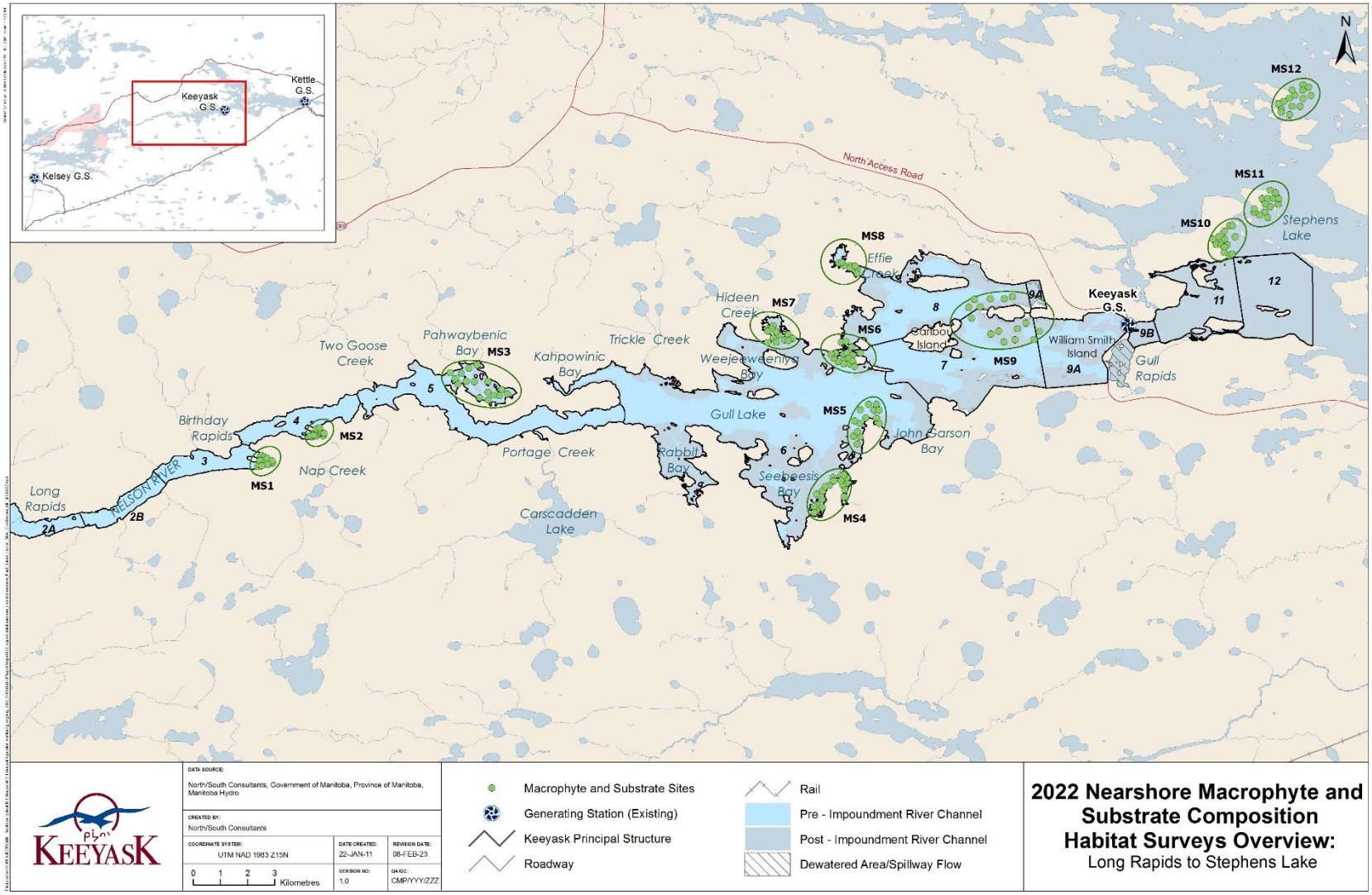
Size Range	Wentworth Class	General Class	Basic Class
-	-	Bedrock	Rock
>256 mm	Boulder	Boulder	
64–256 mm	Cobble	Cobble	
32–64 mm	Very coarse gravel	Gravel	
16–32 mm	Coarse gravel		
8–16 mm	Medium gravel		
4–8 mm	Fine gravel		
2–4 mm	Very fine gravel		
1–2 mm	Very coarse sand	Sand	Sand
0.5–1 mm	Coarse 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

3.2 MACROPHYTE SAMPLING

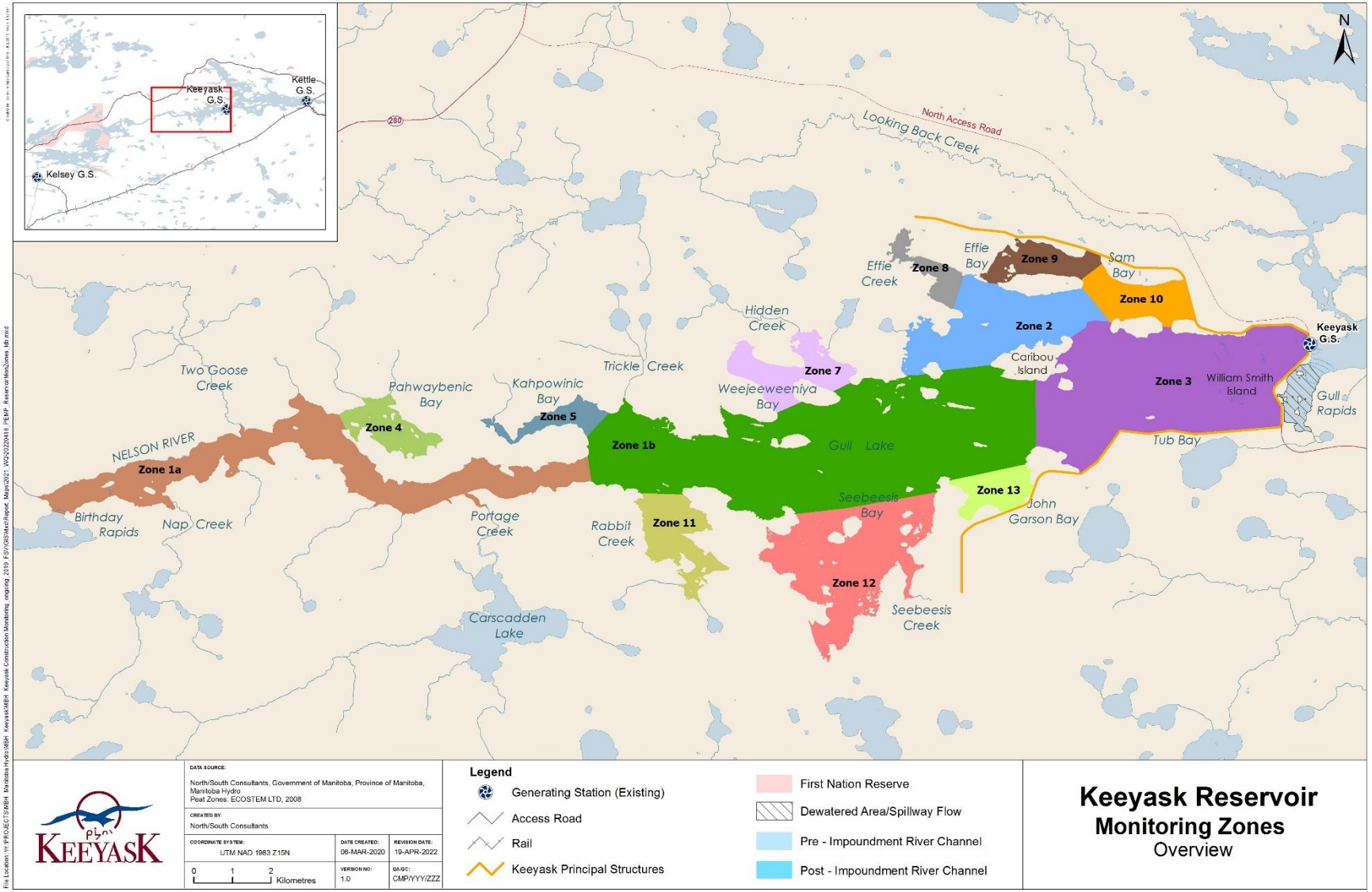
The Point Intercept method was used to survey aquatic macrophytes (also referred to herein as aquatic plants) at regularly spaced points in a grid pattern. These survey data can be used to identify and delineate plant communities and bed types.

Nine areas in the Keeyask reservoir (sites MS1–MS9) and three areas in Stephens Lake (sites MS10–MS12) were sampled (Map 2). Several areas 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 3). Sampling sites within each area were randomly selected prior to sampling. Each 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, sparse, common, or abundant, and the proportion of each species within the sample was estimated (1–100%). 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).



Map 2: Map illustrating the locations of the pre-defined nearshore substrate composition and aquatic macrophyte sampling sites for the Keeyask study area.



Map 3: **Keeyask reservoir backbay areas (zones) – zones 4, 7, 8, and 12 were sampled for substrate, aquatic macrophytes, and light extinction as part of the nearshore aquatic habitat monitoring surveys in 2022.**

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).

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

3.3 LIGHT EXTINCTION SAMPLING

Secchi depth measurements were taken once per sampling area to measure water clarity and the depth to which light can penetrate into water. The Secchi disk was lowered in the water until it disappeared from sight and the depth was noted. The disk was then lowered an additional 1 m and then raised until visible again and the depth was noted. The average of these two readings was recorded as the final secchi depth.

At three sites in each sampling area a light profile measurement was taken using a LI-1400 data logger (LI-COR). There are three sensors associated with the LI-COR: terrestrial sensor (air); spherical sensor (underwater); and the flat sensor (underwater). The air sensor was placed on a flat surface in direct sunlight, close to the surface of the water. Both underwater sensors were lowered in the water on the sunny side of the boat. Light readings were recorded just below the water surface and at 10 cm vertical increments until the point of light extinction was reached. At that point, the LI-COR was lowered an additional 20 cm to ensure that all readings had been recorded.

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 images of the reservoir were obtained from the ESA Copernicus Open Access Hub website (https://scihub.copernicus.eu/). Images of the Keeyask study area were captured three times during the 2022 open-water season (spring, summer, and fall) and were analyzed using ESA's SNAP processing software. Areas were 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 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 and calculate an estimated total open-water area of the reservoir.

4.0 RESULTS

4.1 NEARSHORE HABITAT SURVEYS

4.1.1 UPSTREAM OF BIRTHDAY RAPIDS (MS1)

Mean water surface elevation was 162.5 m at site MS1 at the time of sampling on August 11, 2022 (Table 2). Depth in flooded, previously terrestrial areas ranged from 1.6–4.0 m. Depth in the area of the pre-impoundment shoreline ranged from 2.5–12.7 m.

Table 2: Minimum, maximum, and mean depth (m), and water levels as measured at each nearshore habitat monitoring site, 2022. 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), Gull Lake (05UF596), and Stephens Lake (05UF586).

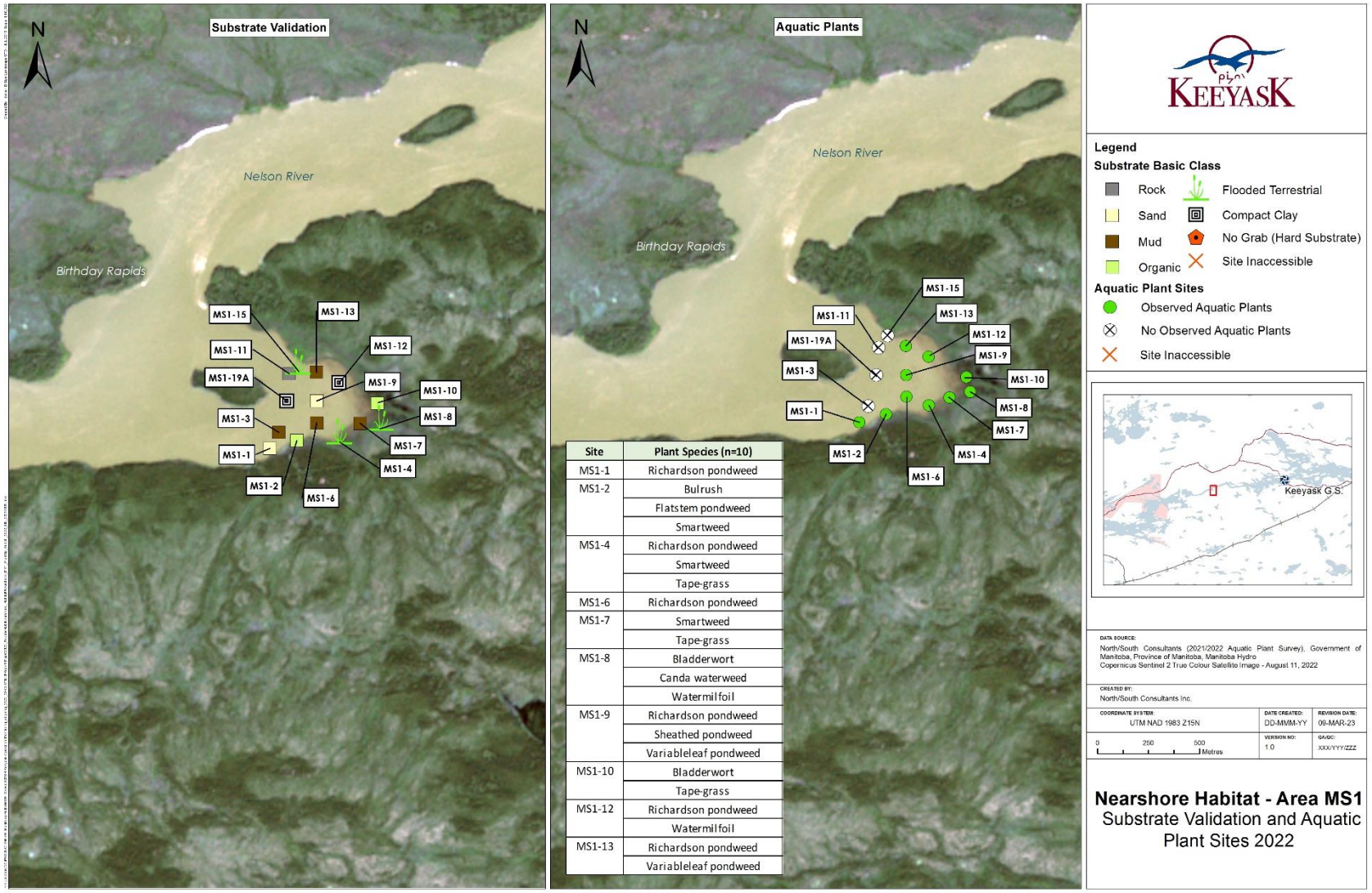
Location	Date	Area	Pre-Impoundment Shoreline			Flooded Shoreline (Previously Terrestrial)			Mean Water Surface Elevation (m)[1]
			Depth			Depth			
			Mean (m)	Min (m)	Max (m)	Mean (m)	Min (m)	Max (m)	
Keeyask reservoir	11-Aug	MS1	4.38	2.47	12.69	2.67	1.57	3.98	162.522
Keeyask reservoir	15-Aug	MS2	5.77	1.46	9.81	2.80	1.23	4.52	160.710
Keeyask reservoir	18-Aug	MS3	5.23	3.71	5.94	3.04	1.23	5.19	160.683
Keeyask reservoir	16-Aug	MS4	-	-	-	2.66	1.01	5.92	159.037
Keeyask reservoir	16-Aug	MS5	9.66	0.71	17.31	3.18	0.99	6.98	159.037
Keeyask reservoir	17-Aug	MS6	7.15	6.31	7.52	2.50	0.68	6.62	159.038
Keeyask reservoir	17-Aug	MS7	6.23	5.19	6.81	3.38	0.94	5.96	159.578
Keeyask reservoir	16-Aug	MS8	-	-	-	2.53	1.23	3.97	158.580
Keeyask reservoir	14-Aug	MS9	7.01	4.92	12.69	3.45	0.46	6.51	159.033
Stephens Lake	12-Aug	MS10	4.44	1.31	9.31	-	-	-	141.395
Stephens Lake	15-Aug	MS11	3.59	1.06	10.15	-	-	-	141.395
Stephens Lake	15-Aug	MS12	4.61	1.26	9.06	-	-	-	141.395

1 – Water surface elevations were taken from stations located at least 7 km upstream of the Keeyask GS. The immediate Keeyask forebay is held to 158.9 m, while more variation in elevations occurs farther upstream.

Substrate was sampled at 14 sites within the area (Map 4). A petite Ponar was used at 13 sites and a weighted sounding line at one (Table 3). Poor grabs were obtained from two sites that contained hard, compact clay substrate. Most sites were classified as soft compact clay, silt and sand, and organic/flooded terrestrial composition (Photo 2). The acoustic classification model indicated that the area was dominated by organic/flooded terrestrial substrates (37%) followed silt/clay (29%) (Table 4). Enough substrate was collected for PSA at a single site (MS1-9) which consisted largely of sand (96%) (Table 5).

Photo 2: Substrate collected upstream of Birthday Rapids (MS1), showing flooded terrestrial mixed with organic substrate.

Aquatic plants were observed at ten sampling sites, which ranged from 1.0–5.9 m in depth (Appendix A1-1; Map 4). Ten species of aquatic macrophytes were present, the most abundant of which was Richardson pondweed (*Potamogeton richardsonii*) and smartweed (*Persicaria spp*.).



Site	Plant Species (n=10)
MS1-1	Richardson pondweed
MS1-2	Bulrush
	Flatstem pondweed
	Smartweed
MS1-4	Richardson pondweed
	Smartweed
	Tape-grass
MS1-6	Richardson pondweed
MS1-7	Smartweed
	Tape-grass
MS1-8	Bladderwort
	Canda waterweed
	Watermilfoil
MS1-9	Richardson pondweed
	Sheathed pondweed
	Variableleaf pondweed
MS1-10	Bladderwort
	Tape-grass
MS1-12	Richardson pondweed
	Watermilfoil
MS1-13	Richardson pondweed
	Variableleaf pondweed

Map 4: Map illustrating basic substrate class results of sediment grabs and basic macrophyte sampling results taken at pre-selected sampling sites in the area upstream of Birthday Rapids (MS1), August 2022.

Table 3: Locations and results of substrate grab type validation sampling and post-survey class verification in the area upstream of Birthday Rapids (MS1), 2022.

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	11-Aug	331881	6241973	4.0	soft	silt	65	sand	30	gravel	5	sand	silt/sand/gravel
MS1-2	petite Ponar	12-Aug	332013	6242013	5.9	soft	organics	100	-	-	-	-	organic	organics
MS1-3	petite Ponar	11-Aug	331925	6242052	4.9	soft	silt	55	clay	25	sand	20	mud	silt/clay/clay
MS1-4	-	12-Aug	332223	6242056	1.3	-	-	-	-	-	-	-	-	flooded terrestrial
MS1-6	petite Ponar	11-Aug	332113	6242098	3.3	moderate	clay	60	silt	30	sand	10	mud	clay/silt/sand
MS1-7	petite Ponar	12-Aug	332324	6242095	1.5	soft	silt	70	organics	30	-	-	mud	silt/organics
MS1-8	-	12-Aug	332425	6242123	1.2	-	-	-	-	-	-	-	-	flooded terrestrial
MS1-9	petite Ponar	11-Aug	332111	6242205	3.0	soft	sand	95	organics	5	-	-	sand	sand/organics
MS1-10	petite Ponar	12-Aug	332408	6242194	1.1	soft	organics	100	-	-	-	-	organic	organics
MS1-11	weighted sounding line	11-Aug	331976	6242339	5.0	hard	boulder	100	-	-	-	-	rock	boulder
MS1-12	petite Ponar	11-Aug	332221	6242295	2.4	hard	-	-	-	-	-	-	-	compact clay
MS1-13	petite Ponar	11-Aug	332110	6242347	3.0	moderate	clay	60	silt	30	sand	10	mud	clay/silt/organic
MS1-15	-	11-Aug	332019	6242398	3.0	-	-	-	-	-	-	-	-	flooded terrestrial
MS1-19A	petite Ponar	11-Aug	331964	6242205	1.0	hard	-	-	-	-	-	-	-	compact clay

1 – Class verified with digital images and sidescan imagery post-survey.

Table 4: Results of acoustic classification of single beam data collected from the Keeyask reservoir and upper Stephens Lake, 2022.

Area	Date	Total Samples	Acoustic Substrate Classification Composition (% Membership)								Total
			Organics	Mud	Sand		Rock				
			Organics/FT[1]	Silt/Clay	Silty 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	11-Aug	1593	37	29	9	4	8	7	4	2	100
MS2	15-Aug	1874	12	21	17	5	12	13	15	4	100
MS3	18-Aug	5412	41	45	8	5	1	0	0	-	100
MS4	16-Aug	1978	35	34	17	9	5	0	0	-	100
MS5	16-Aug	2781	28	36	13	5	5	4	6	3	100
MS6	17-Aug	1449	48	40	7	3	1	0	1	-	100
MS7	17-Aug	1712	31	42	16	8	2	1	-	-	100
MS8	16-Aug	164	27	26	20	19	8	-	-	-	100
MS9	14-Aug	6250	27	37	18	8	5	2	2	0	100
MS10	12-Aug	3008	41	41	13	3	2	0	0	-	100
MS11	15-Aug	3422	48	34	13	3	2	0	-	-	100
MS12	15-Aug	2951	38	24	25	6	5	1	1	-	100
	Summary	**32594**	**35**	**36**	**14**	**6**	**4**	**2**	**2**	**1**	**100**

Table 5: Results of particle size analysis (conducted at ALS Laboratories) from samples collected at selected sites in the Keeyask reservoir and upper Stephens Lake, 2022.

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 (0.05-2µm)	% Clay (<2 µm)	Texture
Keeyask reservoir	12-Aug	MS1	nearshore	MS1-9	0.746	6.21	1.33	0.58	96.3	3	<1.0	sand
Keeyask reservoir	12-Aug	MS2	nearshore	MS2-8	1.47	12.2	3.26	1.79	25	62.6	12.5	silt loam
Keeyask reservoir	12-Aug	MS2	nearshore	MS2-9	0.589	4.91	6.41	5.82	28.5	49	22.5	silt loam/loam
Keeyask reservoir	12-Aug	MS2	nearshore	MS2-11	0.502	4.18	4.59	4.09	50.4	35.8	13.7	loam
Keeyask reservoir	18-Aug	MS3	nearshore	MS3-4	0.171	1.43	8.26	8.09	9.5	55.5	34.9	silty clay loam
Keeyask reservoir	18-Aug	MS3	nearshore	MS3-13	0.442	3.69	3.62	3.18	43.4	37.9	18.7	loam
Keeyask reservoir	16-Aug	MS4	nearshore	MS4-7	0.588	4.9	35.7	35.1	3.8	89	7.2	silt
Keeyask reservoir	16-Aug	MS4	nearshore	MS4-10	0.182	1.52	17	16.8	17.4	36.1	46.4	clay
Keeyask reservoir	16-Aug	MS5	nearshore	MS5-1	0.328	2.73	34.4	34.1	<1.0	80.3	19.4	loam
Keeyask reservoir	16-Aug	MS5	nearshore	MS5-6	1.37	11.4	4.38	3.01	43.4	45.1	11.6	loam
Keeyask reservoir	16-Aug	MS5	nearshore	MS5-7	1.67	13.9	15.8	14.1	<1.0	83.4	16	silt loam
Keeyask reservoir	17-Aug	MS6	nearshore	MS6-3	1.44	12	7.47	6.03	9.8	80.6	9.5	silt
Keeyask reservoir	17-Aug	MS6	nearshore	MS6-6-1	0.451	3.76	36.6	36.1	<1.0	79.7	20	silt loam
Keeyask reservoir	17-Aug	MS7	nearshore	MS7-3	0.42	3.5	35.2	34.8	<1.0	68	31.5	silty clay loam
Keeyask reservoir	17-Aug	MS7	nearshore	MS7-10	0.453	3.78	40.7	40.2	<1.0	86.2	12.8	silt loam
Keeyask reservoir	16-Aug	MS8	nearshore	MS8-4	0.499	4.16	41.4	40.9	3.1	71.9	25.1	silt loam
Keeyask reservoir	16-Aug	MS8	nearshore	MS8-6	0.315	2.63	26.4	26.1	1.9	81.5	16.6	silt loam
Keeyask reservoir	14-Aug	MS9	nearshore	MS9-9	0.927	7.72	1.53	0.6	86.4	7.1	6.4	loamy sand
Keeyask reservoir	14-Aug	MS9	nearshore	MS9-11	0.696	5.8	37.3	36.6	2.2	83.5	14.2	silt loam
Keeyask reservoir	14-Aug	MS9	nearshore	MS9-15	0.402	3.35	26.9	26.5	<1.0	54	45.2	silty clay
Stephens Lake	15-Aug	MS10	nearshore	MS10-8	1.78	14.8	3.33	1.55	73.2	14.2	12.6	sandy loam
Stephens Lake	15-Aug	MS10	nearshore	MS10-10	2.54	21.2	4.56	2.02	29.8	49.4	20.8	silt loam
Stephens Lake	15-Aug	MS10	nearshore	MS10-12	2.45	20.4	4.66	2.21	8.9	64.8	26.3	silt loam
Stephens Lake	15-Aug	MS11	nearshore	MS11-8	2.24	18.7	4.27	2.03	22.7	56.3	21	silt loam
Stephens Lake	15-Aug	MS11	nearshore	MS11-9	1.79	14.9	3.13	1.34	57.1	21	21.9	sandy clay loam
Stephens Lake	15-Aug	MS11	nearshore	MS11-10	1.56	13	4.14	2.58	43.6	34.1	22.3	loam
Stephens Lake	15-Aug	MS12	nearshore	MS12-3	1.12	9.3	21.7	20.6	4.4	57.8	37.8	silty clay loam
Stephens Lake	15-Aug	MS12	nearshore	MS12-9	2.18	18.2	5.6	3.4	<1.0	98.7	<1.0	silt
Stephens Lake	15-Aug	MS12	nearshore	MS12-10	1.51	12.5	25.8	24.3	4.7	62.5	32.9	silty clay loam

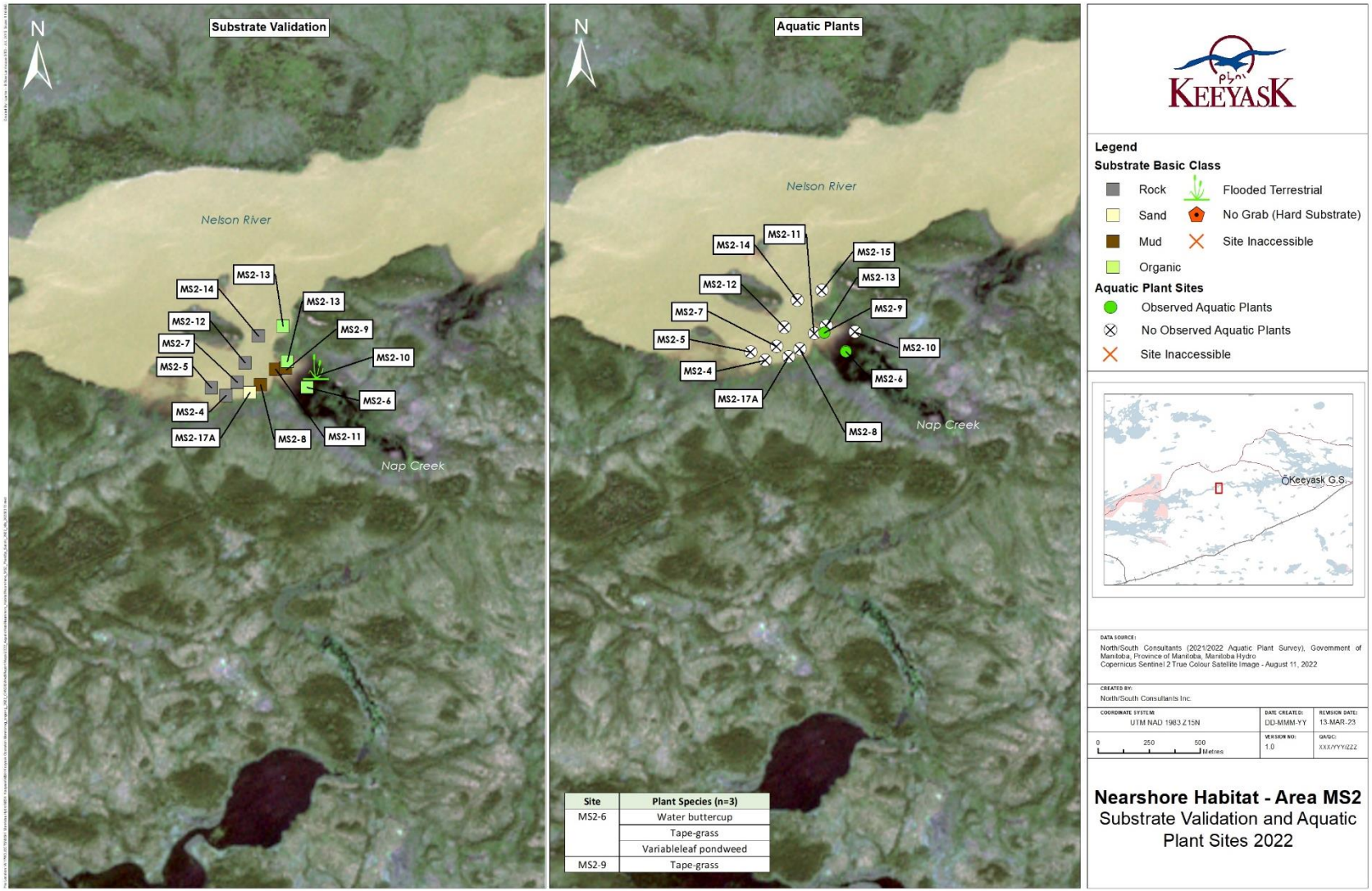
4.1.2 DOWNSTREAM OF BIRTHDAY RAPIDS (MS2)

Mean water surface elevation was 160.7 m at site MS2 at the time of sampling on August 15, 2022 (Table 2). Depth in flooded, previously terrestrial areas ranged from 1.2–4.5 m. Depth in the area of the pre-impoundment shoreline ranged from 1.5–9.8 m (Table 2).

Substrate was sampled at 13 sites within the area (Map 5). A petite Ponar was used at seven sites and a weighted sounding line at six (Table 6). Most sites were classified as hard rock followed by soft substrate containing silt, clay, and sand. Two sites contained only organics. A single site was composed of flooded terrestrial substrate.

The acoustic classification model indicated that the area was dominated by silt/clay substrate (21%) followed by silty sand (17%; Table 4). PSA analysis was conducted at three sites, two of which were classified as silt loam and one as loam (Table 5).

Plants were observed at two sampling sites at 2.6 and 1.9 m deep (Appendix A1-1; Map 5). Three species were present including water buttercup (*Ranunculus spp*.), tape grass (*Vallisneria spp*.), and variableleaf pondweed (*Potamogeton gramineus*).



Map 5: **Map illustrating basic substrate class results of sediment grabs and basic macrophyte sampling results taken at pre-selected sampling sites in the area downstream of Birthday Rapids (MS2), August 2022.**

Table 6: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir downstream of Birthday Rapids (MS2), 2022.

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	%		
MS2-4	weighted sounding line	12-Aug	333879	6243074	5.0	hard	boulder	100	-	-	-	-	rock	boulder
MS2-5	petite Ponar	12-Aug	333807	6243113	6.3	hard	boulder	100	-	-	-	-	rock	boulder
MS2-6	weighted sounding line	12-Aug	334276	6243115	2.6	soft	organics	100	-	-	-	-	organic	organics
MS2-7	weighted sounding line	12-Aug	333934	6243140	9.0	hard	boulder	100	-	-	-	-	rock	boulder
MS2-8	petite Ponar	12-Aug	334048	6243128	5.9	soft	silt	90	sand	5	organics	5	mud	silt/sand/organics
MS2-9	petite Ponar	12-Aug	334170	6243209	1.9	soft	silt	70	clay	10	organics	20	mud	silt/clay/organics
MS2-10	petite Ponar	12-Aug	334320	6243213	0.7	-	-	-	-	-	-	-	-	flooded terrestrial
MS2-11	petite Ponar	12-Aug	334121	6243204	4.8	soft	silt	55	clay	35	sand	10	mud	silt/clay/sand
MS2-12	weighted sounding line	12-Aug	333972	6243235	6.0	hard	boulder	100	-	-	-	-	rock	boulder
MS2-13	petite Ponar	12-Aug	334179	6243242	1.0	soft	organics	100	-	-	-	-	organic	organics
MS2-14	weighted sounding line	12-Aug	334037	6243367	6.5	hard	boulder	100	-	-	-	-	rock	boulder
MS2-15	weighted sounding line	12-Aug	334157	6243416	4.7	hard	-	-	-	-	-	-	rock	-
MS2-17A	petite Ponar	12-Aug	333994	6243090	5.0	moderate	silt	60	sand	20	gravel	20	sand	silt/sand/gravel

1 – Class verified with digital images and sidescan imagery post-survey.

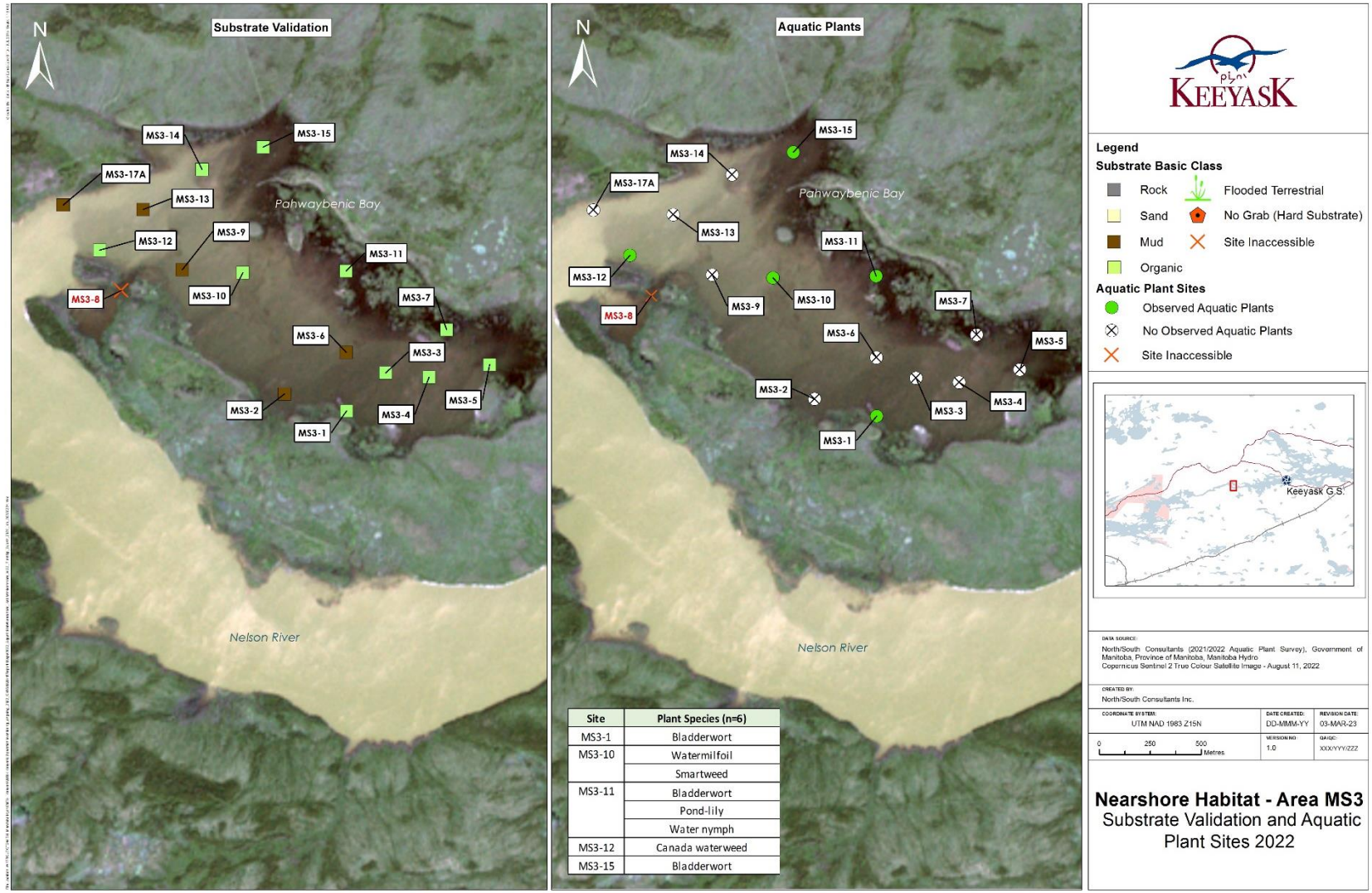
4.1.3 KEEYASK RESERVOIR BACKBAY ZONE 4 (MS3)

Mean water surface elevation was 160.7 m at site MS3 on August 18, 2022 (Table 2). Depth in flooded, previously terrestrial areas ranged from 1.2–5.2 m. Depth in the area of the pre-impoundment shoreline ranged from 3.7–5.9 m.

Fifteen were sampled for substrate using a petite Ponar, while one site (MS3-8) was too shallow to access with a boat at the time of sampling (Map 6; Table 7). Substrate at most sites was classified as organic and silty/clay (Photo 3). The acoustic classification model indicated that the area was dominated by mud (45%) and organic (41%) substrates (Table 4). PSA analysis was conducted at two sites, which were classified as silt clay loam and loam (Table 5).

Aquatic plant species were observed at five sites that ranged in depth from 1.2–2.8 m (Appendix A1-1; Map 6). Four species of aquatic plants were observed. Bladderwort (*Utricularia spp.*) was most abundant while watermilfoil (*Myriophyllum spp*.), smartweed, and Canada waterweed (*Elodea canadensis*) were present but sparse.

Photo 3: Substrate collected in the Keeyask reservoir backbay Zone 4 (MS3) showing silty/clay (mud) substrate.



Map 6: **Map illustrating basic substrate class results of sediment grabs and basic macrophyte sampling results taken at pre-selected sampling sites in the Keeyask reservoir in backbay Zone 4 (MS3), August 2022.**

Table 7: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir in backbay Zone 4 (MS3), 2022.

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	18-Aug	340357	6244436	2.5	soft	organics	100	-	-	-	-	organic	organic
MS3-2	petite Ponar	18-Aug	340052	6244519	4.0	soft	clay	60	silt	20	organics	20	mud	clay/silt/organic
MS3-3	petite Ponar	18-Aug	340550	6244623	5.0	soft	organics	60	silt	40	-	-	organic	organic/silt
MS3-4	petite Ponar	18-Aug	340762	6244601	5.1	soft	organics	85	silt	15	-	-	organic	organic/silt
MS3-5	petite Ponar	18-Aug	341060	6244664	1.5	soft	organics	10	-	-	-	-	organic	organic
MS3-6	petite Ponar	18-Aug	340356	3244723	4.9	soft	clay	50	silt	25	organics	25	mud	clay/silt/organic
MS3-7	petite Ponar	18-Aug	340848	6244834	1.1	soft	organics	100	-	-	-	-	organic	organic
MS3-9	petite Ponar	18-Aug	339551	6245127	5.0	soft	clay	40	organics	40	silt	20	mud	clay/organic/silt
MS3-10	petite Ponar	18-Aug	339848	6245114	2.0	soft	organics	100	-	-	-	-	organic	organic
MS3-11	petite Ponar	18-Aug	340354	6245122	1.2	soft	organics	100	-	-	-	-	organic	organic
MS3-12	petite Ponar	18-Aug	339146	6245224	2.7	soft	organics	50	silt	50	-	-	organic	organic/silt
MS3-13	petite Ponar	18-Aug	339358	6245422	5.0	moderate	clay	85	silt	15	-	-	mud	clay/silt
MS3-14	petite Ponar	18-Aug	339648	6245618	4.5	soft	organics	60	clay	30	silt	10	organic	organic/clay/silt
MS3-15	petite Ponar	18-Aug	339948	6245728	2.8	soft	organics	100	-	-	-	-	organic	organic
MS3-17A	petite Ponar	18-Aug	338967	6245445	5.1	moderate	clay	75	silt	20	sand	5	mud	clay/silt/sand

1 – Class verified with digital images and sidescan imagery post-survey.

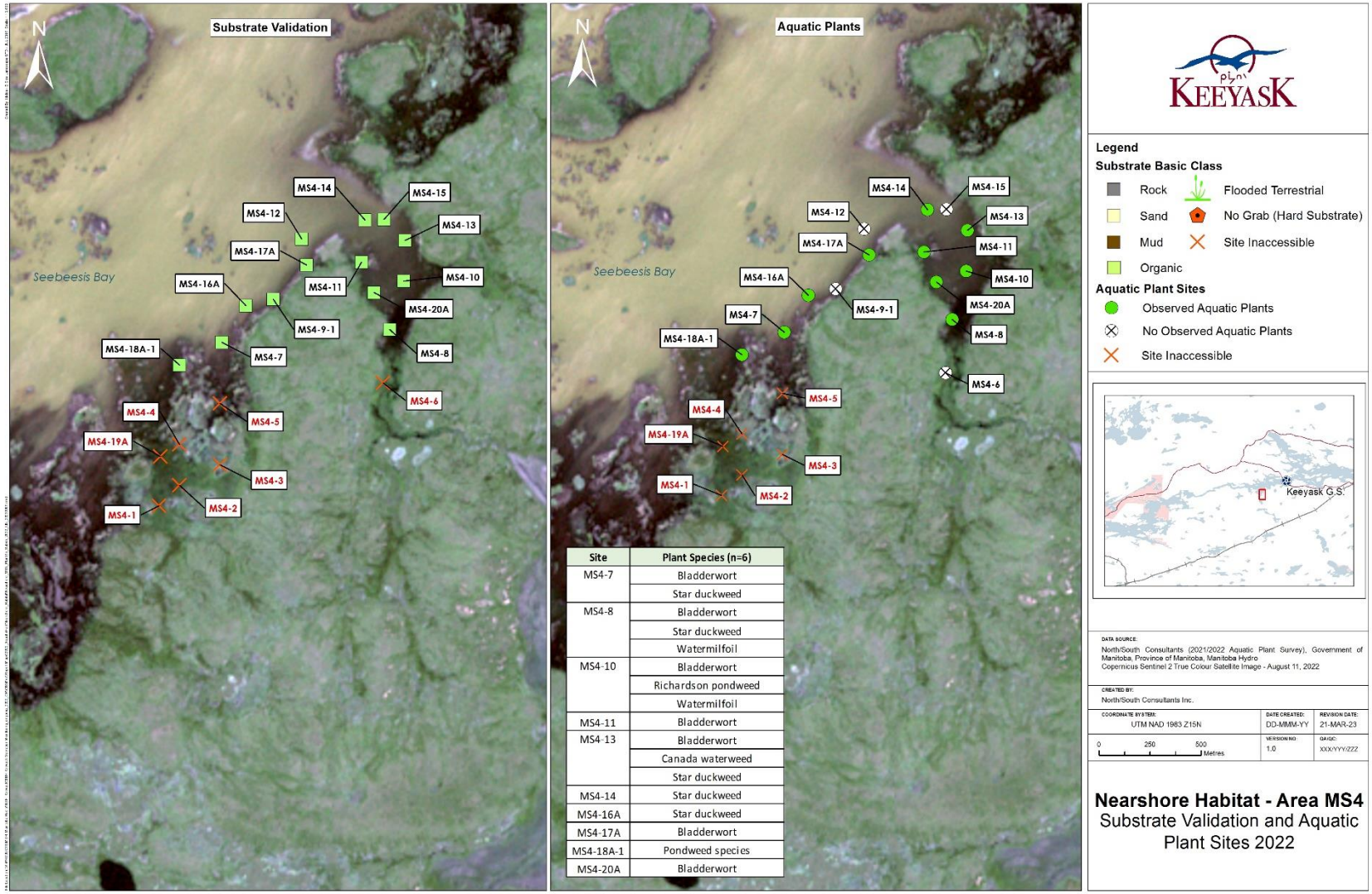
4.1.4 KEEYASK RESERVOIR BACKBAY ZONE 12 (MS4)

Mean water surface elevation was 159.0 m at site MS4 on August 16, 2022 (Table 2). Depth in the flooded terrestrial area ranged from 1.0–5.9 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 to sample substrates 13 of 20 sites (Map 7). The remaining seven sites were too shallow to access with a boat at the time of sampling (Table 8). Because the area was located within a flooded bay, all sites were classified as organic (Photo 4). The acoustic classification model indicated that the area was dominated by organic (35%) and silt/clay (34%) substrates (Table 4). PSA analysis was conducted at two sites that were classified as silt and clay (Table 5).

Aquatic plant species were observed at ten sites ranging in depth from <0.5–3.0 m (Appendix A1-1; Map 7). Six species of aquatic plants were observed. Watermilfoil and Richardson pondweed were abundant while bladderwort, Canada waterweed, pondweed species (*Potamogeton spp*.), and star duckweed (*Lemna trisulca*) were present but sparse.

Photo 4: Substrate collected in the Keeyask reservoir backbay Zone 12 (MS4) showing organic substrate.



Map 7: **Map illustrating basic substrate class results of sediment grabs and basic macrophyte sampling results taken at pre-selected sampling sites in the Keeyask reservoir in backbay Zone 12 (MS4), August 2022.**

Table 8: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir in backbay Zone 12 (MS4), 2022.

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	%		
MS4-7	petite Ponar	16-Aug	352660	6241075	0.8	soft	organics	100	-	-	-	-	organic	organic
MS4-8	petite Ponar	16-Aug	353484	6241137	<0.5	soft	organics	100	-	-	-	-	organic	organic
MS4-9-1	petite Ponar	16-Aug	352912	6241286	-	soft	organics	100	-	-	-	-	organic	organic
MS4-10	petite Ponar	16-Aug	353553	6241374	2.8	soft	organics	100	-	-	-	-	organic	organic
MS4-11	petite Ponar	16-Aug	353346	6241467	1.5	soft	organics	100	-	-	-	-	organic	organic
MS4-12	petite Ponar	16-Aug	353052	6241580	2.6	soft	organics	100	-	-	-	-	organic	organic
MS4-13	petite Ponar	16-Aug	353558	6241573	1.6	soft	organics	100	-	-	-	-	organic	organic
MS4-14	petite Ponar	16-Aug	353362	6241674	3.0	soft	organics	100	-	-	-	-	organic	organic
MS4-15	petite Ponar	16-Aug	353456	6241676	2.5	soft	organics	100	-	-	-	-	organic	organic
MS4-16A	petite Ponar	16-Aug	352778	6241255	1.3	soft	organics	100	-	-	-	-	organic	organic
MS4-17A	petite Ponar	16-Aug	353076	6241453	0.8	soft	organics	100	-	-	-	-	organic	organic
MS4-18A-1	petite Ponar	16-Aug	352452	6240964	2.1	soft	organics	100	-	-	-	-	organic	organic
MS4-20A	petite Ponar	16-Aug	353406	6241320	1.3	soft	organics	100	-	-	-	-	organic	organic

1 – Class verified with digital images and sidescan imagery post-survey.

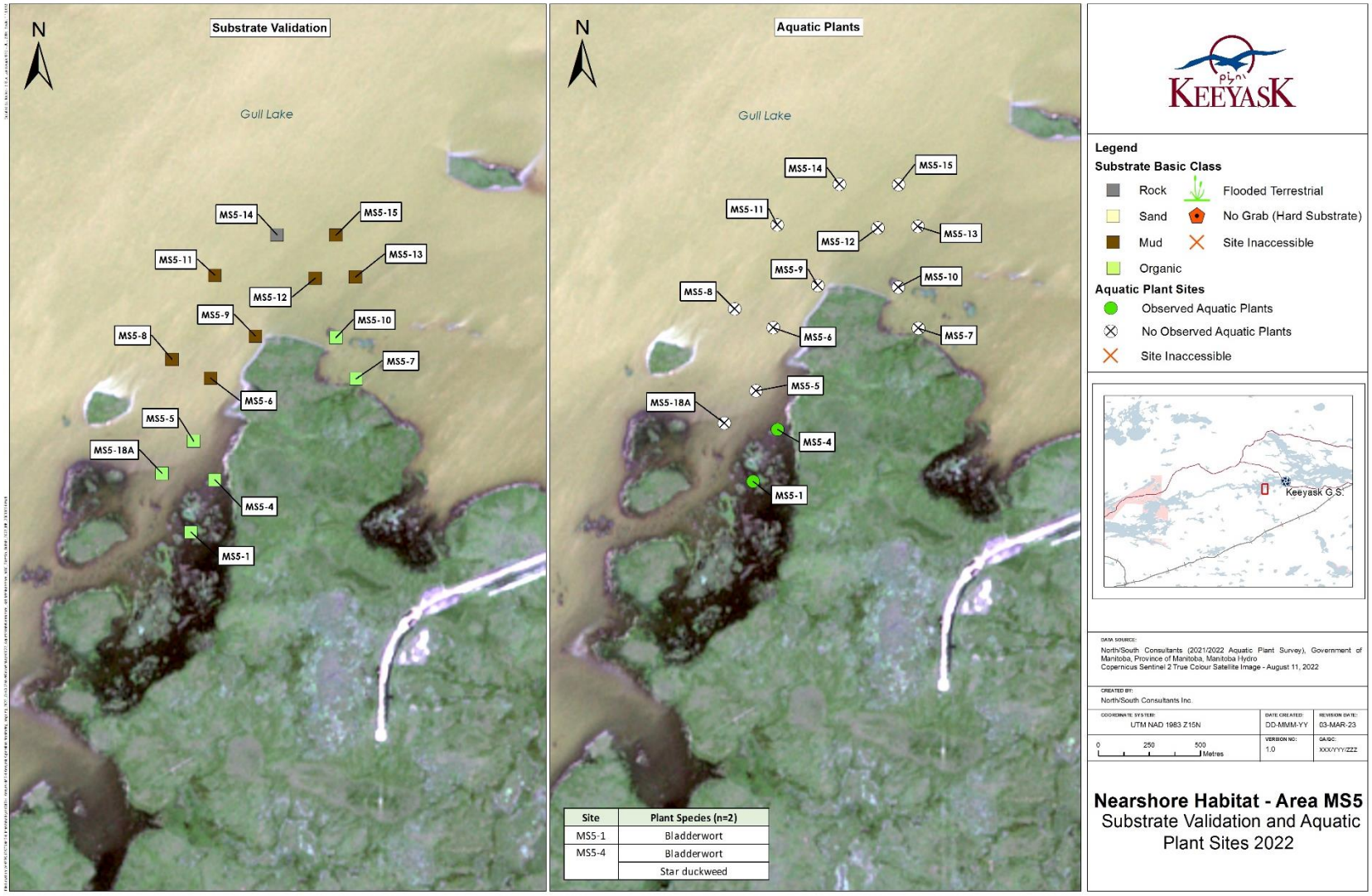
4.1.5 SOUTH SHORE OF GULL LAKE (MS5)

Mean water surface elevation was 159.0 m at site MS5 on August 16, 2022 (Table 2). Depth in flooded, previously terrestrial areas ranged from 1.0–7.0 m. Depth in the area of the pre-impoundment shoreline ranged from 0.7–17.3 m.

A petite Ponar was used to collect substrate at all 14 sites (Map 8; Table 9). Most sites were classified as soft/moderate organic and mud substrates. The acoustic classification model indicated that the area was dominated silt/clay (36%), organics (28%), and silty sand (13%) (Table 4). PSA analysis was conducted at three sites and were classified as silt loam and loam (Table 5).

Plants were observed at two sampling sites at 1.4 and 2.6 m deep (Appendix A1-1; Map 8). Two aquatic plant species were observed; bladderwort and star duckweed (Photo 5).

Photo 5: Aquatic plants collected on the south shore of Gull Lake (MS5) including bladderwort and star duckweed.



Map 8: **Map illustrating basic substrate class results of sediment grabs and basic macrophyte sampling results taken at pre-selected sampling sites in the south shore of the Keeyask reservoir (MS5), August 2022.**

Table 9: Locations and results of substrate grab type validation sampling and post-survey class verification in the south shore of the Keeyask reservoir (MS5), 2022.

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	petite Ponar	16-Aug	353944	6242823	2.6	soft	organics	100	-	-	-	-	organic	organic
MS5-4	petite Ponar	16-Aug	354063	6243078	1.4	soft	organics	100	-	-	-	-	organic	organic
MS5-5	petite Ponar	16-Aug	353958	6243267	3.0	soft	organics	100	-	-	-	-	organic	organic
MS5-6	petite Ponar	16-Aug	354042	6243575	8.3	soft	clay	70	organics	20	silt	10	mud	clay/organic/silt
MS5-7	petite Ponar	16-Aug	354755	6243572	2.8	soft	organics	90	silt	10	-	-	organic	organic/silt
MS5-8	petite Ponar	16-Aug	353853	6243667	8.4	soft	silt	70	clay	20	sand	10	mud	silt/clay/sand
MS5-9	petite Ponar	16-Aug	354261	6243781	5.5	soft	clay	40	silt	40	organics	20	mud	clay/silt/organic
MS5-10	petite Ponar	16-Aug	354656	6243773	3.5	soft	organics	100	-	-	-	-	organic	organic
MS5-11	petite Ponar	16-Aug	354062	6244078	13.9	moderate	clay	85	sand	10	silt	5	mud	clay/sand/silt
MS5-12	petite Ponar	16-Aug	354555	6244064	8.0	soft	silt	80	clay	20	-	-	mud	silt/clay
MS5-13	petite Ponar	16-Aug	354752	6244070	8.0	moderate	clay	80	silt	20	-	-	mud	clay/silt/organic
MS5-14	petite Ponar	16-Aug	354367	6244276	7.0	hard	cobble	100	-	-	-	-	rock	cobble
MS5-15	petite Ponar	16-Aug	354657	6244275	12.2	moderate	gravel	80	silt	10	clay	10	rock	gravel/silt/clay
MS5-18A	petite Ponar	16-Aug	353803	6243109	3.1	soft	organics	100	-	-	-	-	organic	organic

1 – Class verified with digital images and sidescan imagery post-survey.

4.1.6 NORTH SHORE OF GULL LAKE (MS6)

Mean water surface elevation was 159.0 m at site MS6 on August 17, 2022 (Table 2). Depth in flooded, previously terrestrial areas ranged from 0.7–6.6 m. Depth in the area of the pre-impoundment shoreline ranged from 6.3–7.5 m.

A petite Ponar was used at 15 of 17 bottom type validation sites (Map 9). The remaining two sites were too shallow to access (Table 10). Most sites were classified as organic substrate with some silt/clay. The acoustic classification model indicated that the area was dominated by soft substrates including organic (48%) and silt/clay (40%; Table 4). PSA analysis was conducted at two sites that were classified as silt and silt loam (Table 5).

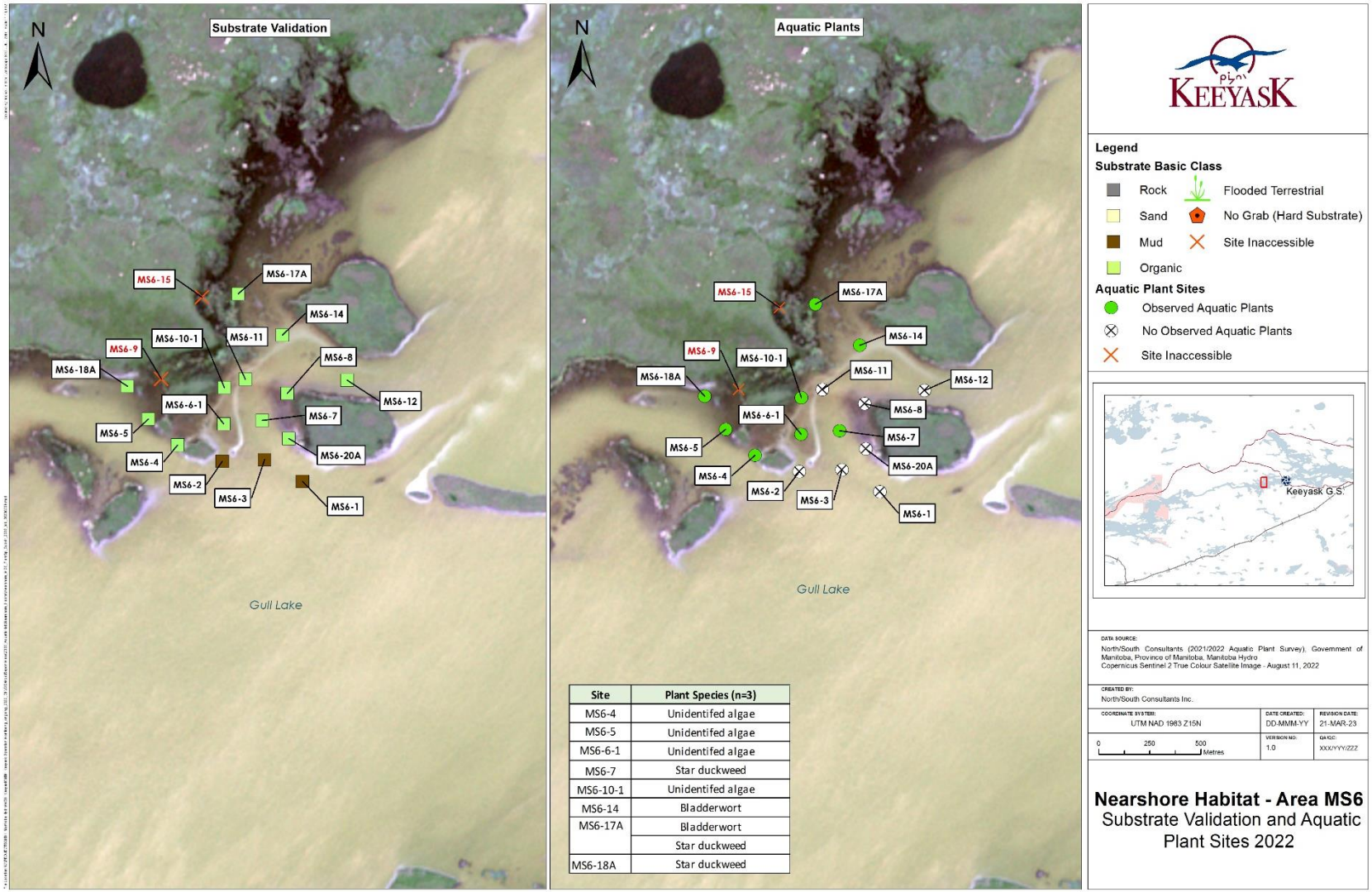
Aquatic plants were observed at eight sampling sites, ranging in depth from <0.5–1.9 m (Appendix A1-1; Map 9). Bladderwort was abundant at a single site. Star duckweed was identified at three sites in sparse quantities. Unidentified filamentous algae (phylum Charophyta) were also observed at four of the sampling sites.

4.1.7 KEEYASK RESERVOIR BACKBAY ZONE 7 (MS7)

Mean water surface elevation was 159.6 m at site MS7 on August 17, 2022 (Table 2). Depth in flooded, previously terrestrial areas ranged from 0.9–6.0 m. Depth in the area of the pre-impoundment shoreline ranged from 5.2–6.8 m.

A petite Ponar was used to collect substrates at 12 of 13 sites (Map 10; Table 11). The remaining site was too shallow to access with a boat at the time of sampling. 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 that the area was dominated by soft substrates including silt/clay (42%), organics (31%), and silty sand (16%) (Table 4). PSA analysis was conducted at two sites that were classified as silt clay loam and silt loam (Table 5).

Aquatic plants were observed at six sampling sites, which ranged in depth from 0.6–2.2 m (Appendix A1-1; Map 10). Nine aquatic plant species were present. Watermilfoil was abundant at two sites. Bladderwort, common bogbean (*Menyanthes trifoliata*), pond-lily (*Nuphar spp.*), smartweed, star duckweed, and water horsetail (*Equisetum fluviatile*) were present but sparse. Unidentified algae and terrestrial moss (*Sphagnum spp*.) was also observed.

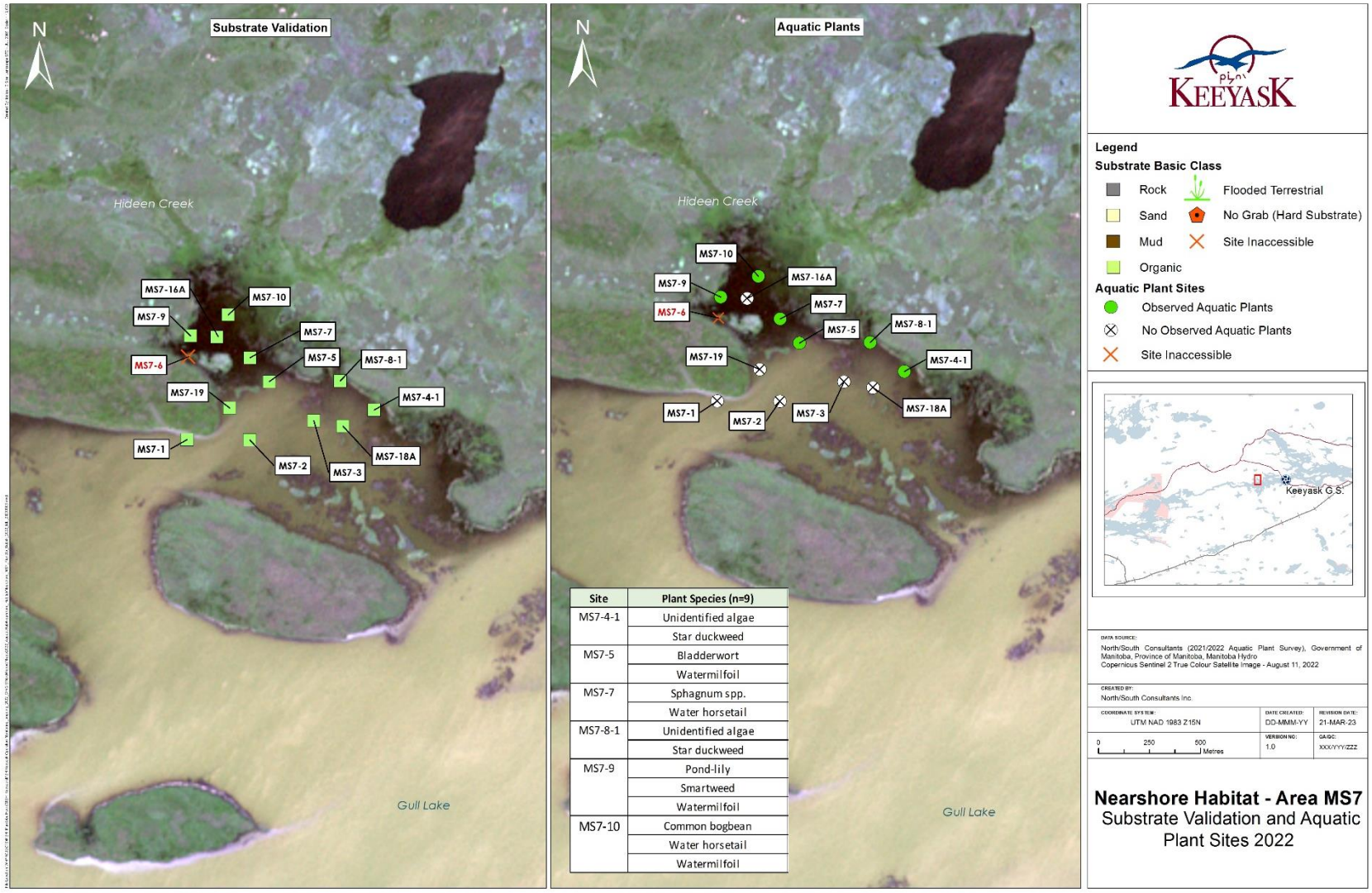


Map 9: Map illustrating basic substrate class results of sediment grabs and basic macrophyte sampling results taken at pre-selected sampling sites in the north shore of the Keeyask reservoir (MS6), August 2022.

Table 10: Locations and results of substrate grab type validation sampling and post-survey class verification in the north shore of the Keeyask reservoir (MS6), 2022.

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	17-Aug	353844	6245673	6.8	soft	clay	75	silt	25	-	-	mud	clay/silt
MS6-2	petite Ponar	17-Aug	353450	6245772	3.9	soft	sand	40	clay	40	silt	20	mud	sand/clay/silt
MS6-3	petite Ponar	17-Aug	353658	6245780	6.4	soft	clay	75	silt	20	organics	5	mud	clay/silt/organic
MS6-4	petite Ponar	17-Aug	353232	6245852	1.1	soft	organics	100	-	-	-	-	organic	organic
MS6-5	petite Ponar	17-Aug	353088	6245979	0.8	soft	organics	70	silt	15	sand	15	organic	organic/silt/sand
MS6-6-1	petite Ponar	17-Aug	353458	6245956	<0.5	soft	organics	100	-	-	-	-	organic	organic
MS6-7	petite Ponar	17-Aug	353647	6245973	1.9	soft	organics	100	-	-	-	-	organic	organic
MS6-8	petite Ponar	17-Aug	353770	6246105	0.5	soft	organics	100	-	-	-	-	organic	organic
MS6-10-1	petite Ponar	17-Aug	353460	6246134	<0.5	soft	organics	100	-	-	-	-	organic	organic
MS6-11	petite Ponar	17-Aug	353563	6246174	1.5	soft	organics	100	-	-	-	-	organic	organic
MS6-12	petite Ponar	17-Aug	354063	6246170	4.7	soft	organics	90	silt	10	-	-	organic	organic/silt
MS6-14	petite Ponar	17-Aug	353746	6246392	0.8	soft	organics	95	silt	5	-	-	organic	organic/silt
MS6-17A	petite Ponar	17-Aug	353528	6246593	<0.5	soft	organics	100	-	-	-	-	organic	organic
MS6-18A	petite Ponar	17-Aug	352985	6246141	1.2	soft	organics	100	-	-	-	-	organic	organic
MS6-20A	petite Ponar	17-Aug	353776	6245883	1.5	soft	organics	100	-	-	-	-	organic	organic

1 – Class verified with digital images and sidescan imagery post-survey.



Map 10: Map illustrating basic substrate class results of sediment grabs and basic macrophyte sampling results taken at pre-selected sampling sites in the Keeyask reservoir, backbay Zone 7 (MS7), August 2022.

Table 11: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir, backbay Zone 7 (MS7), 2022.

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	17-Aug	350647	6246569	2.3	soft	organics	90	silt	10	-	-	organic	organic
MS7-2	petite Ponar	17-Aug	350954	6246568	6.0	soft	organics	60	silt	40	-	-	organic	organic
MS7-3	petite Ponar	17-Aug	351269	6246663	2.7	soft	organics	95	silt	5	-	-	organic	organic
MS7-4-1	petite Ponar	17-Aug	351565	6246714	0.6	soft	organics	100	-	-	-	-	organic	organic
MS7-5	petite Ponar	17-Aug	351050	6246854	2.2	soft	organics	100	-	-	-	-	organic	organic
MS7-7	petite Ponar	17-Aug	350956	6246972	1.1	soft	organics	100	-	-	-	-	organic	organic
MS7-8-1	petite Ponar	17-Aug	351398	6246857	0.7	soft	organics	100	-	-	-	-	organic	organic
MS7-9	petite Ponar	17-Aug	350664	6247079	1.7	soft	organics	100	-	-	-	-	organic	organic
MS7-10	petite Ponar	17-Aug	350849	6247181	0.9	soft	organics	100	-	-	-	-	organic	organic
MS7-16A	petite Ponar	17-Aug	350793	6247073	2.3	soft	organics	50	silt	50	-	-	organic	organic
MS7-18A	petite Ponar	17-Aug	351412	6246635	3.1	soft	organics	100	-	-	-	-	organic	organic
MS7-19	petite Ponar	17-Aug	350855	6246724	1.8	soft	organics	100	-	-	-	-	organic	organic

1 – Class verified with sidescan imagery post-survey.

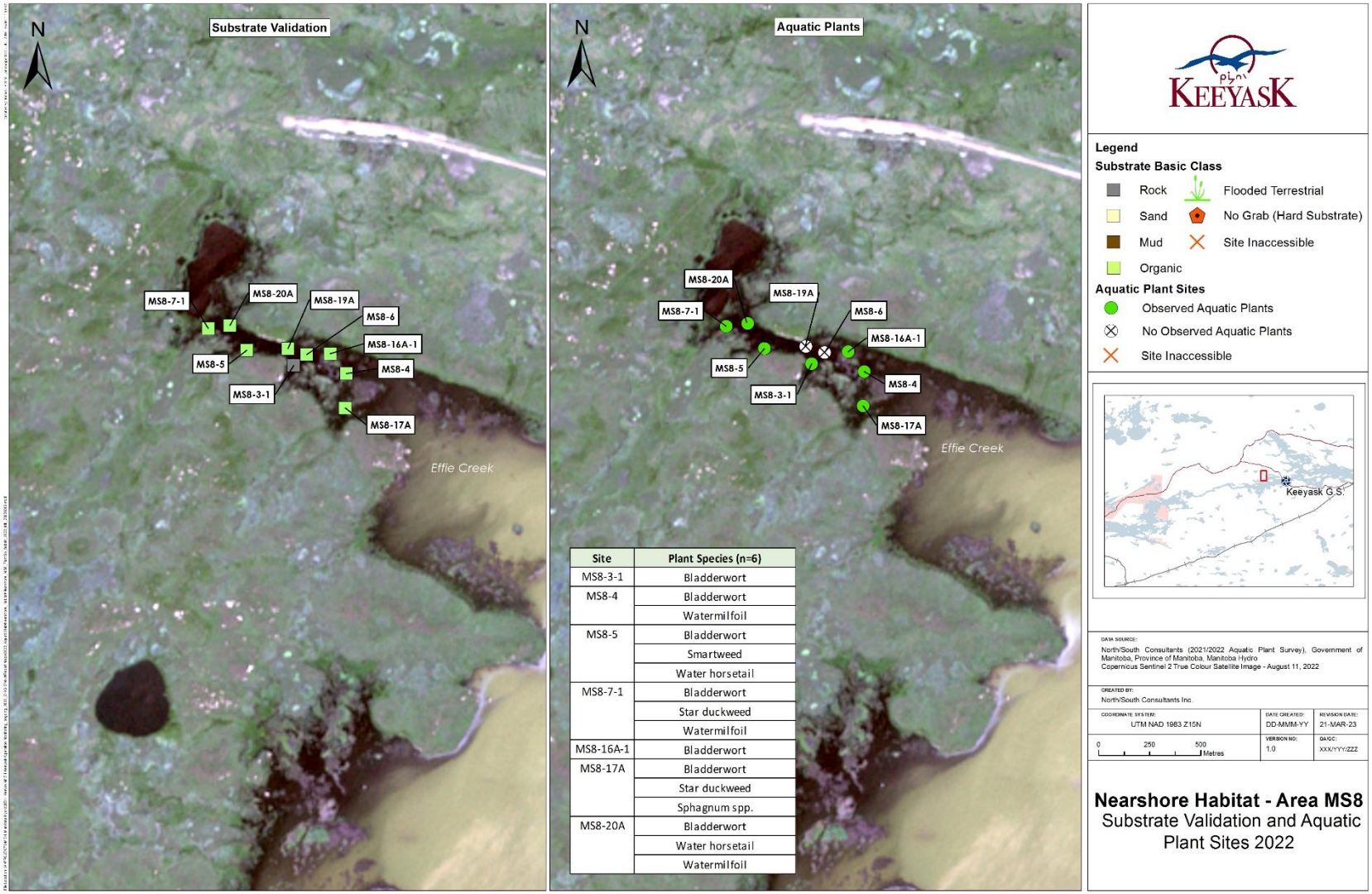
4.1.8 KEEYASK RESERVOIR BACKBAY ZONE 8 (MS8)

Mean water surface elevation was 158.6 m at site MS8 on August 16, 2022 (Table 2). Depth in the flooded terrestrial area ranged from 1.2–4.0 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 to collect substrates at nine sites (Map 11; 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, although rock was found at a single site. The acoustic classification model indicated that the area was dominated by organic (27%), silt/clay (26%), silty sand and sand (20% and 19%, respectively) substrates (Table 4). PSA analysis was conducted at two sites that were both composed of silt loam (Table 5).

Aquatic plants were observed at seven sampling sites, which ranged in depth from 0.5–2.0 m (Appendix A1-1; Map 11). Six aquatic plant species were observed. Two sites contained abundant aquatic plants including bladderwort, star duckweed, and watermilfoil (Photo 6). Canada waterweed, smartweed, and water horsetail (*Equisetum fluviatile*) were also found in sparse abundance.

Photo 6: Underwater photo taken in reservoir backbay Zone 8 (MS8) showing abundant bladderwort.



Map 11: Map illustrating basic substrate class results of sediment grabs and basic macrophyte sampling results taken at pre-selected sampling sites in the Keeyask reservoir, backbay Zone 8 (MS8), August 2022.

Table 12: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir, backbay Zone 8 (MS8), 2022.

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	%		
MS8-3-1	petite Ponar	16-Aug	353692	6249318	0.5	hard	boulder	90	organics	10	-	-	rock	boulder/organic
MS8-4	petite Ponar	16-Aug	353950	6249279	2.0	soft	organics	100	-	-	-	-	organic	organic
MS8-5	petite Ponar	16-Aug	353461	6249393	1.5	soft	organics	100	-	-	-	-	organic	organic
MS8-6	petite Ponar	16-Aug	353755	6249372	2.6	soft	organics	100	-	-	-	-	organic	organic
MS8-7-1	petite Ponar	16-Aug	353273	6249501	0.5	soft	organics	100	-	-	-	-	organic	organic
MS8-16A-1	petite Ponar	16-Aug	353871	6249377	1.8	soft	organics	100	-	-	-	-	organic	organic
MS8-17A	petite Ponar	16-Aug	353944	6249111	1.5	soft	organics	100	-	-	-	-	organic	organic
MS8-19A	petite Ponar	16-Aug	353663	6249402	2.7	soft	organics	100	-	-	-	-	organic	organic
MS8-20A	petite Ponar	16-Aug	353379	6249515	1.1	soft	organics	100	-	-	-	-	organic	organic

1 – Class verified with digital images and sidescan imagery post-survey.

4.1.9 LOWER GULL LAKE (MS9)

Mean water surface elevation was 159.0 m at site MS9 on August 14, 2022 (Table 2). Depth in flooded, previously terrestrial areas ranged from 0.5–6.5 m. Depth in the area of the pre-impoundment shoreline ranged from 4.9–12.7 m.

A petite Ponar was used to collect substrate at 15 sites (Map 12; Table 13). Most sites were classified as organic substrates including detritus and loose and broken-down plant matter, with silt. The acoustic classification model indicated that the area was dominated by soft substrates including silt/clay (37%) and organics (27%) (Table 4). PSA analysis was conducted at three sites which were classified as loamy sand, silt loam, and silty clay (Table 5).

No aquatic plants were observed (Appendix A1-1; Map 12).

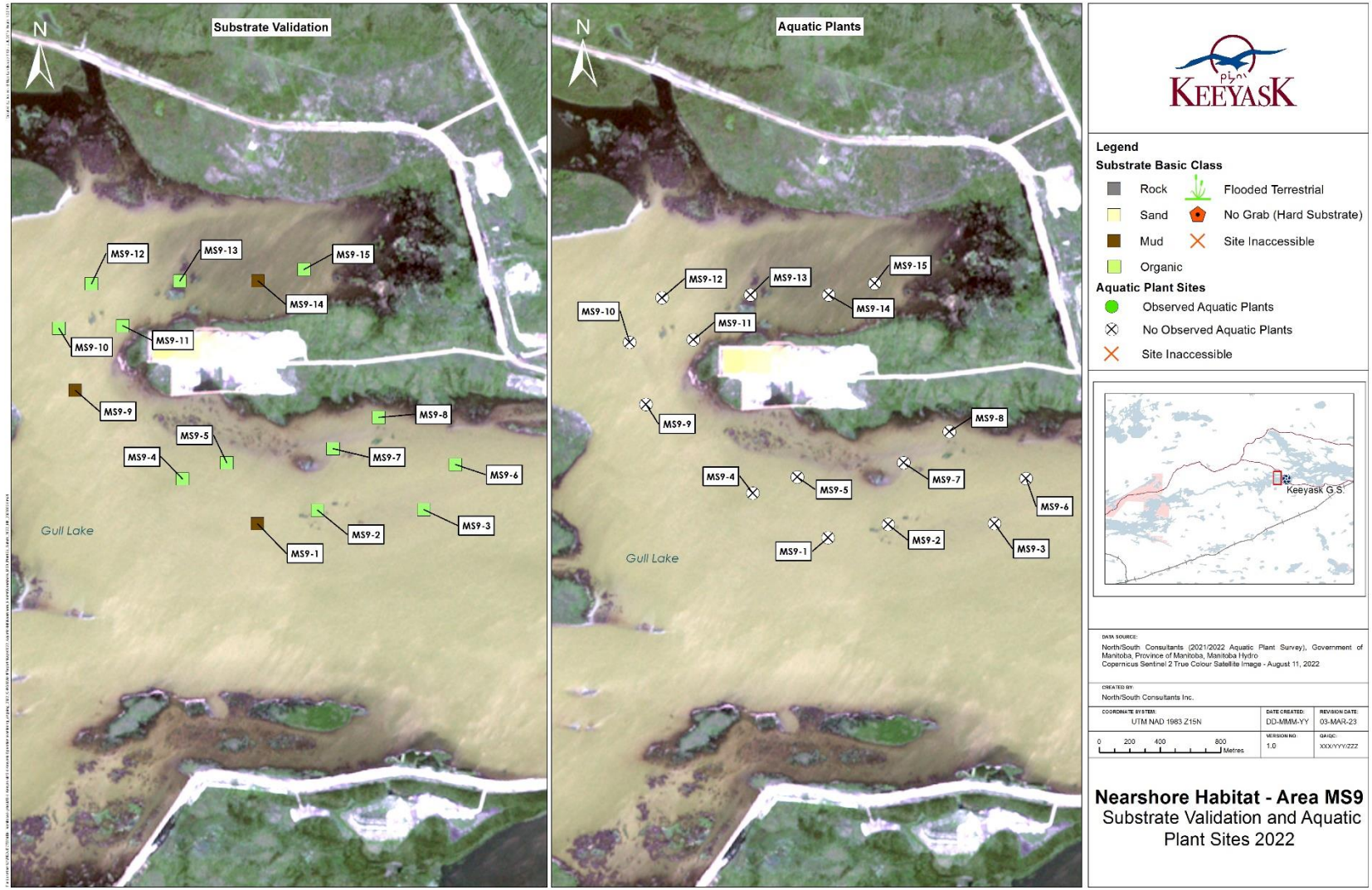
4.1.10 STEPHENS LAKE (MS10)

Mean water surface elevation was 141.4 m at site MS10 on August 12, 2022 (Table 2). Shoreline depth ranged from 1.3–9.3 m.

A petite Ponar was used to collect substrate at 15 sites (Map 13; Table 14). Clay was observed at most sites, confirmed as clay/silt from analysis of sidescan image data. The acoustic classification model indicated that the area was dominated by soft substrates including silt/clay (41%), organics (41%), and silty sand (13%) (Table 4; Photo 7). PSA analysis was conducted at three sites which were classified as sandy loam and silt loam (Table 5).

Aquatic plant species were observed at four sites ranging in depth from 1.0–1.8 m (Appendix A1-2; Map 13). Three species were present including Richardson pondweed, sago pondweed (*Stuckenia pectinata*), and star duckweed. Plant abundance ranged from common to sparse.

Photo 7: Substrate collected in Stephens Lake (MS10), showing sand substrate.

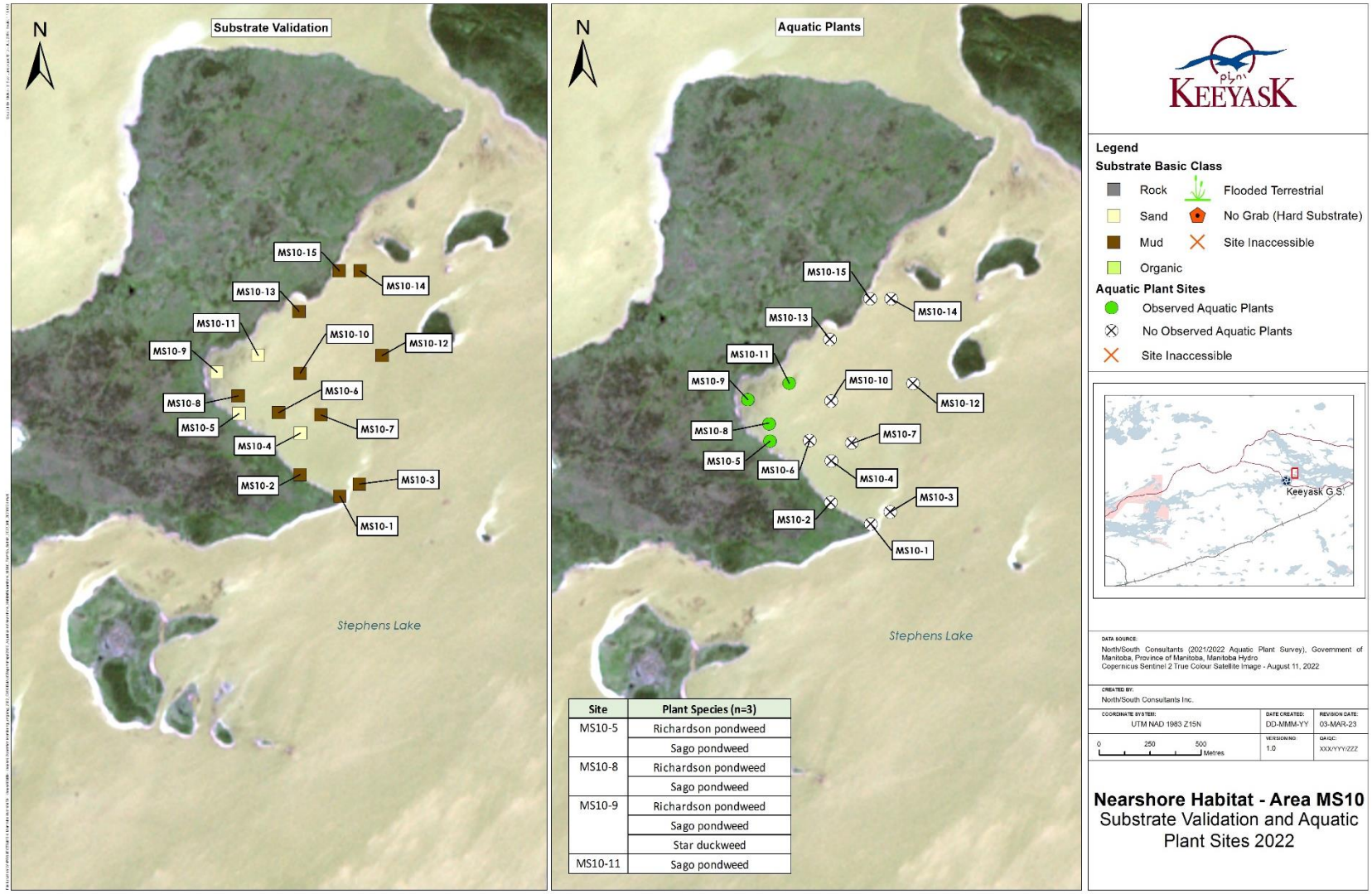


Map 12: Map illustrating basic substrate class results of sediment grabs and basic macrophyte sampling results taken at pre-selected sampling sites in the lower Keeyask reservoir (MS9), August 2022.

Table 13: Locations and results of substrate grab type validation sampling and post-survey class verification in the lower Keeyask reservoir (MS9), 2022.

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	14-Aug	359355	6246576	5.5	soft	silt	70	organics	30	-	-	mud	silt/organic
MS9-2	petite Ponar	14-Aug	359750	6246664	2.3	soft	organics	80	silt	20	-	-	organic	organic/silt
MS9-3	petite Ponar	14-Aug	360450	6246668	2.5	soft	organics	100	-	-	-	-	organic	organic
MS9-4	petite Ponar	14-Aug	358860	6246870	4.2	soft	organics	60	silt	40	-	-	organic	organic/silt
MS9-5	petite Ponar	14-Aug	359152	6246976	3.1	soft	organics	100	-	-	-	-	organic	organic
MS9-6	petite Ponar	14-Aug	360658	6246966	3.5	soft	organics	100	-	-	-	-	organic	organic
MS9-7	petite Ponar	14-Aug	359853	6247070	3.5	soft	organics	90	silt	10	-	-	organic	organic/silt
MS9-8	petite Ponar	14-Aug	360153	6247275	3.0	soft	organics	100	-	-	-	-	organic	organic
MS9-9	petite Ponar	14-Aug	358155	6247454	11.5	soft	silt	60	sand	40	-	-	mud	sand/silt
MS9-10	petite Ponar	14-Aug	358047	6247862	3.8	soft	organics	100	-	-	-	-	organic	organic
MS9-11	petite Ponar	14-Aug	358468	6247879	2.0	soft	organics	90	silt	10	-	-	organic	organic
MS9-12	petite Ponar	14-Aug	358262	6248155	6.0	soft	organics	70	silt	30	-	-	organic	organic/silt
MS9-13	petite Ponar	14-Aug	358844	6248175	3.0	soft	organics	100	-	-	-	-	organic	organic
MS9-14	petite Ponar	14-Aug	359358	6248175	6.3	soft	silt	70	organics	30	-	-	mud	silt/organic
MS9-15	petite Ponar	14-Aug	359661	6248250	4.7	soft	organics	90	silt	10	-	-	organic	organic/silt

1 – Class verified with digital images and sidescan imagery post-survey.



Map 13: Map illustrating basic substrate class results of sediment grabs and basic macrophyte sampling results taken at pre-selected sampling sites in Stephens Lake (MS10), August 2022.

Table 14: Locations and results of substrate grab type validation sampling and post-survey class verification in Stephens Lake (MS10), 2022.

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	petite Ponar	15-Aug	367653	6249768	0.9	moderate	clay	90	silt	5	sand	5	mud	clay/silt/sand
MS10-2	petite Ponar	15-Aug	367457	6249874	1.1	soft	sand	40	silt	30	clay	30	mud	sand/silt/clay
MS10-3	petite Ponar	15-Aug	367749	6249828	3.2	moderate	clay	60	silt	20	organics	20	mud	clay/silt/organic
MS10-4	petite Ponar	15-Aug	367460	6250077	3.0	soft	sand	80	silt	10	clay	10	sand	sand/silt/clay
MS10-5	petite Ponar	15-Aug	367158	6250174	1.0	soft	sand	100	-	-	-	-	sand	sand
MS10-6	petite Ponar	15-Aug	367353	6250178	2.4	soft	sand	65	clay	30	silt	5	mud	sand/clay/silt
MS10-7	petite Ponar	15-Aug	367560	6250166	2.7	moderate	clay	65	silt	20	sand	15	mud	clay/silt/sand
MS10-8	petite Ponar	15-Aug	367154	6250259	1.5	soft	sand	40	clay	40	silt	20	mud	sand/clay/silt
MS10-9	petite Ponar	15-Aug	367049	6250377	1.0	soft	sand	60	silt	25	clay	15	sand	sand/silt/clay
MS10-10	petite Ponar	15-Aug	367459	6250371	3.9	moderate	clay	75	sand	15	silt	10	mud	clay/sand/silt
MS10-11	petite Ponar	15-Aug	367252	6250458	1.8	soft	sand	80	clay	10	silt	10	sand	sand/clay/silt
MS10-12	petite Ponar	15-Aug	367861	6250457	8.7	moderate	clay	90	silt	10	-	-	mud	clay/silt
MS10-13	petite Ponar	15-Aug	367453	6250673	3.2	soft	clay	60	silt	40	-	-	mud	clay/silt
MS10-14	petite Ponar	15-Aug	367754	6250872	6.8	moderate	clay	90	silt	10	-	-	mud	clay/silt
MS10-15	petite Ponar	15-Aug	367650	6250872	1.3	moderate	silt	50	sand	40	organics	10	mud	silt/sand/organic

1 – Class verified with sidescan imagery post-survey.

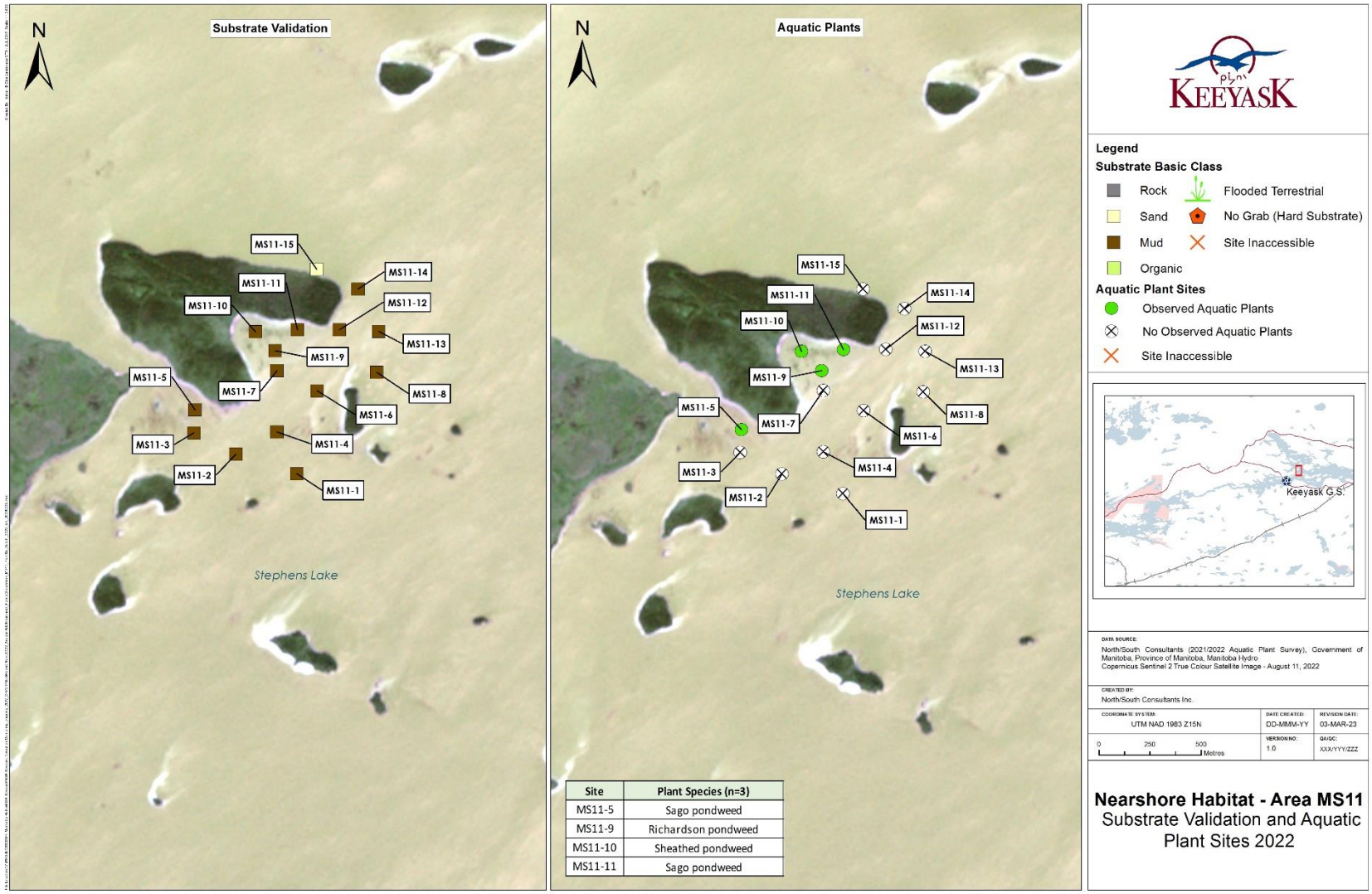
4.1.11 STEPHENS LAKE (MS11)

Mean water surface elevation was 141.4 m at site MS11 on August 15, 2022 (Table 2). Shoreline depth ranged from 1.1–10.2 m.

A petite Ponar was used to collect substrate at 15 sites (Map 14; Table 15). Clay was determined to be the dominant substrate, confirmed as clay or clay/silt from analysis of sidescan image data. Sand was present at a single site. The acoustic classification model indicated that the area was dominated by soft substrates including organics (48%), silt/clay (34%), and silty sand (13%) (Table 4). PSA analysis was conducted at three sites which were classified as silty loam, sandy clay loam, and loam (Table 5).

Aquatic plant species were observed at four sites ranging in depth from 1.5–2.4 m (Appendix A1-2; Map 14). Three species were present: Richardson pondweed, sago pondweed, and sheathed pondweed (*Stuckenia vaginata*; Photo 8).

Photo 8: Aquatic plants collected in Stephens Lake (MS11) showing abundant sheathed pondweed.



Map 14: Map illustrating basic substrate class results of sediment grabs and basic macrophyte sampling results taken at pre-selected sampling sites in Stephens Lake (MS11), August 2022.

Table 15: Locations and results of substrate grab type validation sampling and post-survey class verification in the Northern portion of Stephens Lake (MS11), 2022.

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	15-Aug	369055	6251171	5.2	soft	clay	60	silt	35	organics	5	mud	clay/silt/organic
MS11-2	petite Ponar	15-Aug	368756	6251267	3.8	moderate	clay	45	sand	40	silt	15	mud	clay/sand/silt
MS11-3	petite Ponar	15-Aug	368551	6251372	1.9	moderate	clay	50	sand	30	silt	20	mud	clay/sand/silt
MS11-4	petite Ponar	15-Aug	368958	6251375	2.4	moderate	sand	50	clay	35	silt	15	mud	sand/clay/silt
MS11-5	petite Ponar	15-Aug	368556	6251484	1.6	moderate	silt	50	clay	45	sand	5	mud	silt/clay/sand
MS11-6	petite Ponar	15-Aug	369156	6251577	2.2	moderate	sand	45	clay	45	silt	10	mud	sand/clay/silt
MS11-7	petite Ponar	15-Aug	368958	6251676	2.5	moderate	clay	70	silt	20	sand	10	mud	clay/silt/sand
MS11-8	petite Ponar	15-Aug	369448	6251668	4.2	moderate	clay	70	silt	20	sand	10	mud	clay/silt/sand
MS11-9	petite Ponar	15-Aug	368950	6251773	2.4	moderate	clay	45	sand	45	silt	10	mud	clay/sand/silt
MS11-10	petite Ponar	15-Aug	368852	6251867	1.5	soft	clay	60	silt	35	organics	5	mud	clay/silt/organic
MS11-11	petite Ponar	15-Aug	369058	6251876	1.8	moderate	clay	40	sand	40	silt	20	mud	clay/sand/silt
MS11-12	petite Ponar	15-Aug	369265	6251877	3.4	soft	silt	80	sand	20	-	-	mud	silt/sand
MS11-13	petite Ponar	15-Aug	369458	6251868	6.7	moderate	clay	45	sand	45	silt	10	mud	clay/sand/silt
MS11-14	petite Ponar	15-Aug	369356	6252076	5.5	soft	clay	75	silt	25	-	-	mud	clay/silt
MS11-15	petite Ponar	15-Aug	369153	6252172	2.0	soft	sand	85	silt	15	-	-	sand	sand/silt

1 – Class verified with digital images and sidescan imagery post-survey.

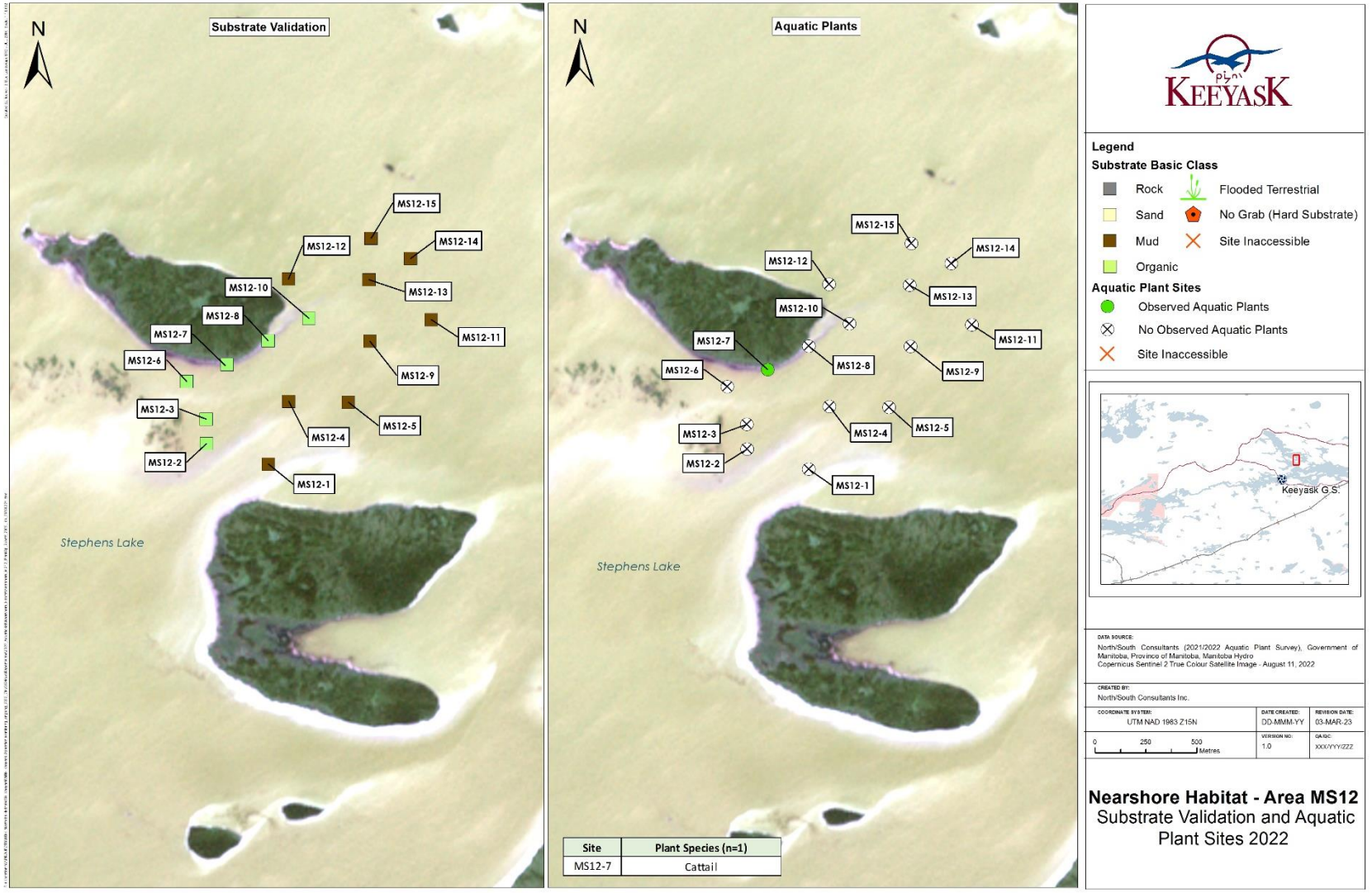
4.1.12 STEPHENS LAKE (MS12)

Mean water surface elevation was 141.4 m at site MS12 on August 15, 2022 (Table 2). Shoreline depth ranged from 1.3–9.1 m.

A petite Ponar was used to collect substrate at 15 sites (Map 15; Table 16). Clay was 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 six sites, consisting of detritus and decomposing vegetation (Photo 9). The acoustic classification model indicated that the area was dominated by soft substrates including organics (38%), silty sand (25%), and silt/clay (24%) (Table 4). PSA analysis was conducted at three sites which were classified as silty clay loam and silt (Table 5).

One aquatic plant species, Cattail (*Typha spp*.) was found at one site at a depth of 0.9 m (Appendix A1-2; Map 15).

Photo 9: Substrate collected in Stephens Lake (MS12) showing organic matter (detritus and decomposing vegetation).



Map 15: Map illustrating basic substrate class results of sediment grabs and basic macrophyte sampling results taken at pre-selected sampling sites in Stephens Lake (MS12), August 2022.

Table 16: Locations and results of substrate grab type validation sampling and post-survey class verification in the Northern portion of Stephens Lake (MS12), 2022.

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	15-Aug	369856	6254964	2.7	soft	silt	70	organics	30	-	-	mud	silt/organic
MS12-2	petite Ponar	15-Aug	369552	6255063	2.4	soft	organics	100	-	-	-	-	organic	organic
MS12-3	petite Ponar	15-Aug	369551	6255184	2.5	soft	organics	85	silt	15	-	-	organic	organic/silt
MS12-4	petite Ponar	15-Aug	369957	6255271	3.2	soft	clay	50	silt	40	organics	10	mud	clay/silt/organic
MS12-5	petite Ponar	15-Aug	370250	6255267	5.6	soft	clay	80	silt	15	organics	5	mud	clay/silt/organic
MS12-6	petite Ponar	15-Aug	369455	6255368	1.5	soft	organics	100	-	-	-	-	organic	organic
MS12-7	petite Ponar	15-Aug	369654	6255452	0.9	soft	organics	100	-	-	-	-	organic	organic
MS12-8	petite Ponar	15-Aug	369855	6255568	1.1	soft	organics	100	-	-	-	-	organic	organic
MS12-9	petite Ponar	15-Aug	370356	6255566	5.9	soft	clay	80	silt	15	organics	5	mud	clay/silt/organic
MS12-10	petite Ponar	15-Aug	370056	6255678	2.5	soft	organics	100	-	-	-	-	organic	organic
MS12-11	petite Ponar	15-Aug	370658	6255672	6.0	soft	clay	80	silt	15	organics	5	mud	clay/silt/organic
MS12-12	petite Ponar	15-Aug	369956	6255871	3.3	soft	silt	70	organics	30	-	-	mud	silt/organic
MS12-13	petite Ponar	15-Aug	370352	6255867	8.0	soft	clay	90	silt	10	-	-	mud	clay/silt
MS12-14	petite Ponar	15-Aug	370556	6255972	8.2	soft	clay	90	silt	10	-	-	mud	clay/silt
MS12-15	petite Ponar	15-Aug	370361	6256071	8.6	soft	clay	90	silt	10	-	-	mud	clay/silt

1 – Class verified with digital images and sidescan imagery post-survey.

4.1.13 LIGHT EXTINCTION

LI-COR light penetration data were collected for future analysis of plant growth and are presented in Appendix 2.

4.2 SATELLITE REMOTE SENSING

Satellite remote sensing data were collected from the Copernicus/European Space Agency. These data were used to map the Keeyask reservoir showing shoreline and water mass boundary positions for the spring (June 17), summer (August 11), and fall (October 10) of 2022 (Map 16).

The open-water area within the Keeyask reservoir was similar between the spring (8,893 ha), summer (8,726 ha), and fall (8,691 ha) periods (Table 17). Inflows remained high throughout the open-water period. Floating peat islands that first appeared in spring 2021 and became abundant by fall 2021 were present throughout the 2022 open-water period, seen as small green island areas within backbays in Map 17.

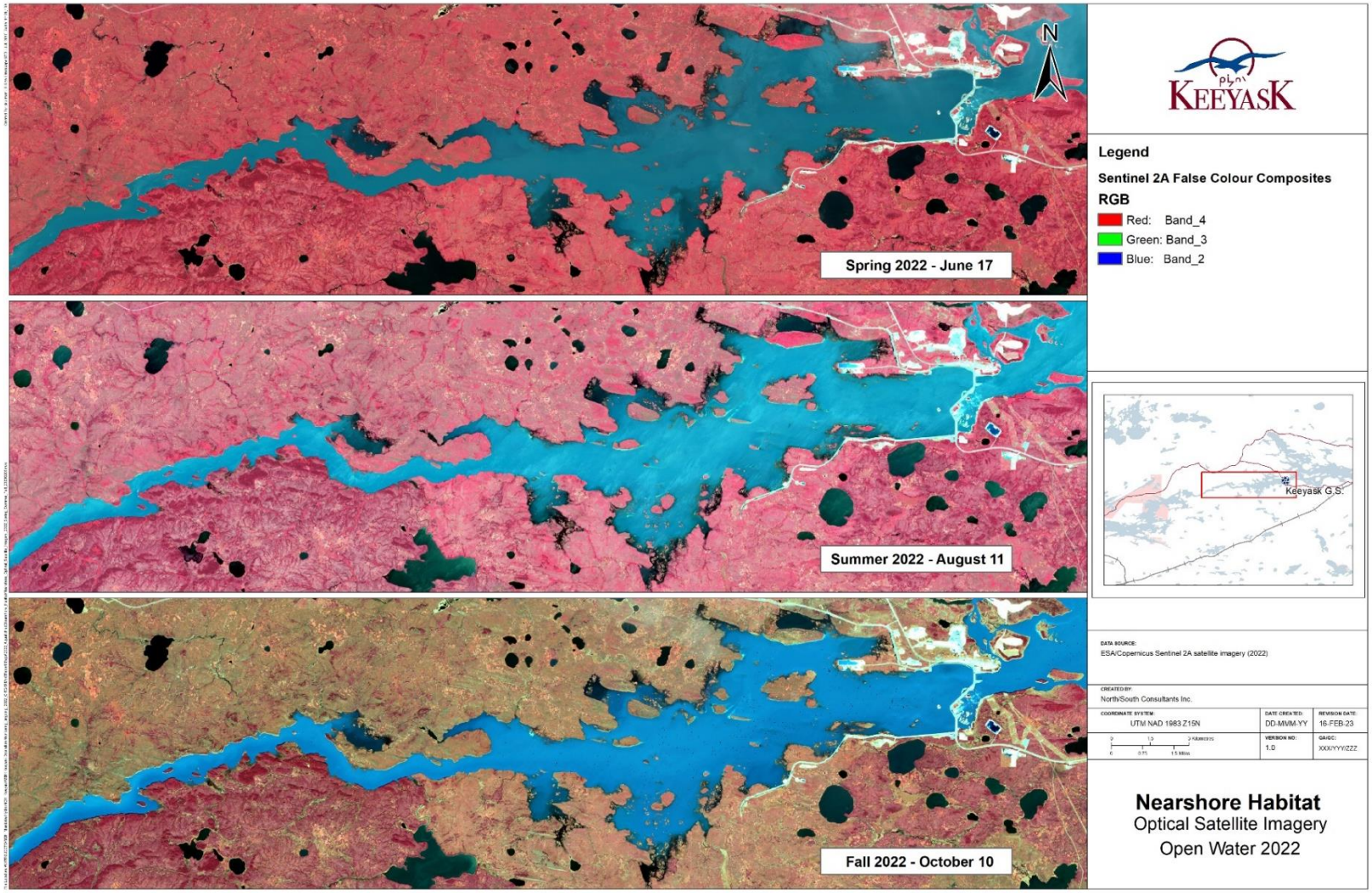
Turbid water masses were predominant throughout the mainstem of the Nelson River and into the Keeyask reservoir in spring, summer, and fall (Table 17; Map 18). The Keeyask reservoir backbays contained the highest proportion of humic water. A clear transition of mixed water could be seen between the humic and turbid water masses. As was seen in 2021, the fall had the highest amount of turbid water (7,433 ha) and the lowest amount of humic and mixed water masses.

Table 17: Summary of reservoir humic, mixed, and turbid water mass areas (spring, summer, and fall 2022) derived from the analysis of optical (Sentinel-2) satellite remote sensing data.

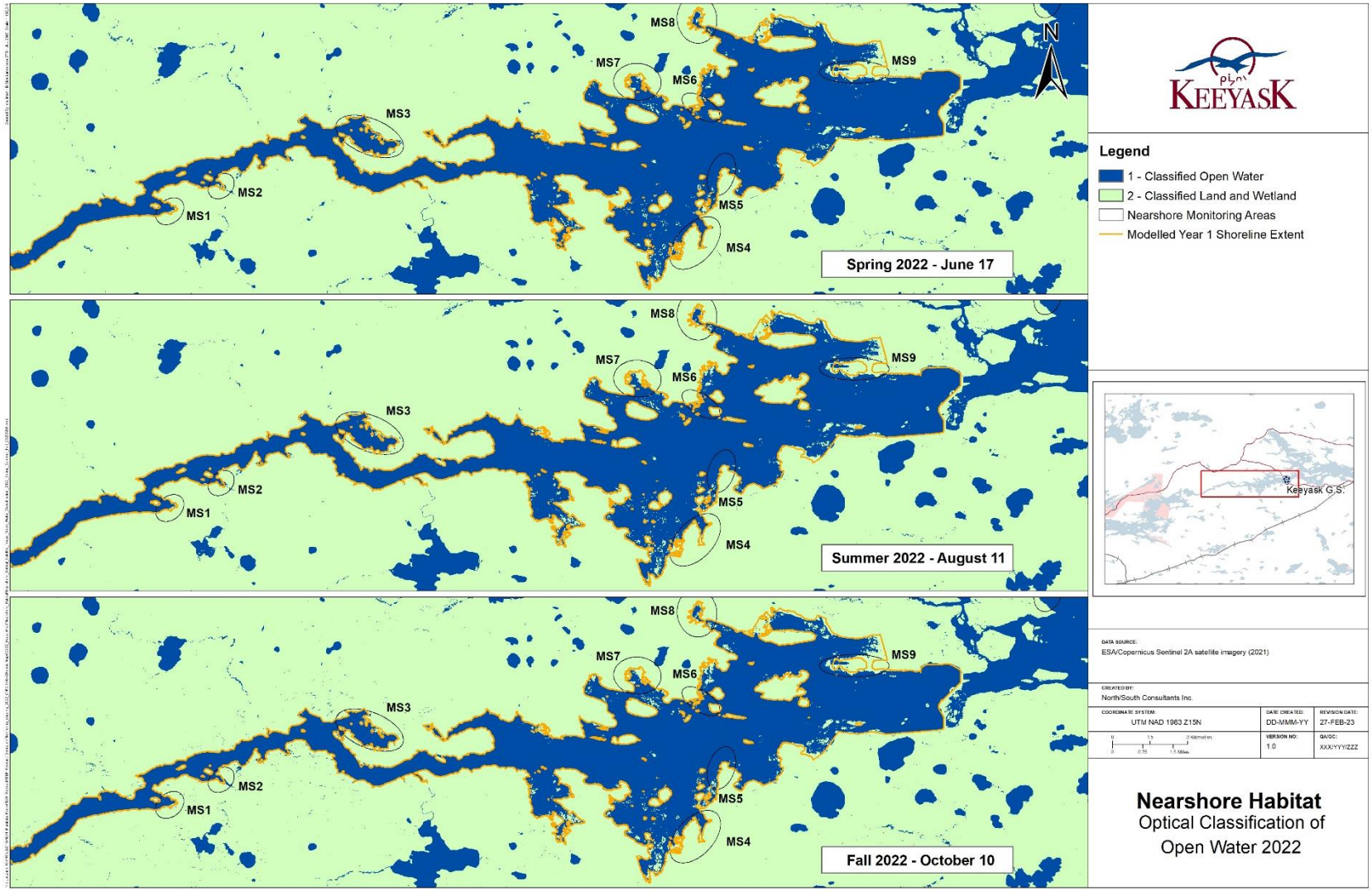
Image Date	Inflow (cms)[2]	Water Level (m)[2]	Estimated Area (ha)[1]			
			Open-Water Area	Humic Water	Mixed Water	Turbid Water
17-Jun	5,860	159.00	8,893	989	1,336	6,568
11-Aug	6,582	159.02	8,726	843	647	7,236
10-Oct	6,082	159.02	8,691	729	529	7,433

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.

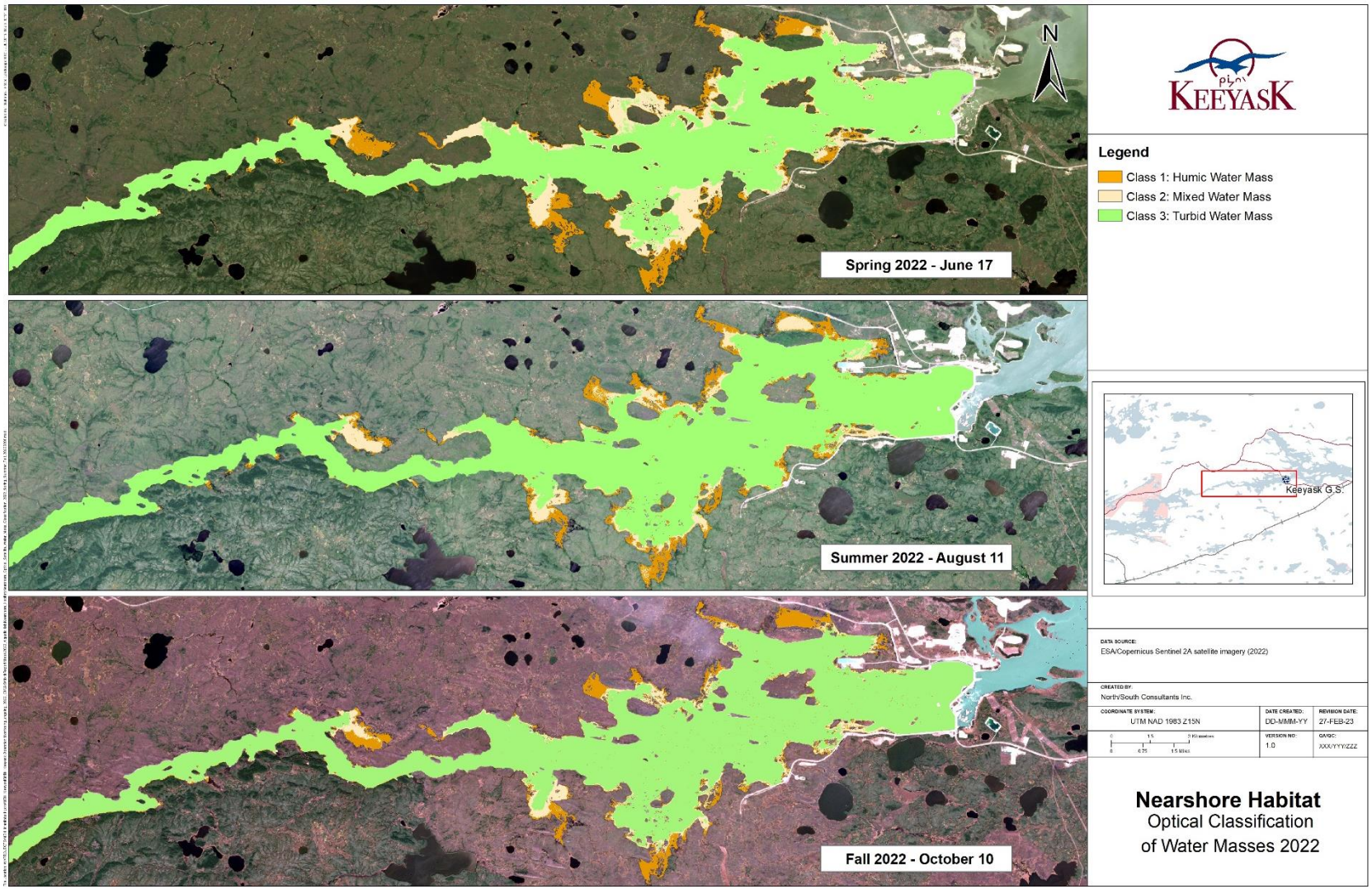
2 - Estimated daily mean inflow and daily mean water level provided by Manitoba Hydro



Map 16: 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, 2022.



Map 17: Map showing results of the optical near infrared band land and water threshold masking analysis and classification for spring, summer, and fall, 2022, and relative to year 1 modelled shorelines (orange).



Map 18: Map showing results of the optical supervised classification of humic, mixed, and turbid water mass analysis and classification for spring, summer, and fall, 2022.

5.0 DISCUSSION

The primary objective of nearshore habitat monitoring is to monitor changes in shallow 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 (measuring less than 3 m of depth) were sampled within nine areas in the Keeyask reservoir and three areas in Stephens Lake in 2022, during the second year following reservoir impoundment.

Substrates within sampling areas in the Keeyask reservoir in 2022 consisted largely of soft (silt and clay) substrates and organics. Similar substrates were observed during sampling in 2021, although fewer sites sampled in 2022 contained flooded terrestrial vegetation. It is likely that this vegetation is decomposing and/or being carried away by water and ice.

Aquatic plants were found in the Keeyask reservoir at more sampling sites in 2022 than in 2021. In 2021, plants sampled within the Keeyask reservoir largely consisted of terrestrial species that persisted following flooding. The one exception was the area sampled upstream of Birthday Rapids (MS1) where flooding was minimal. In 2022, aquatic plants were found in eight of nine sampling areas including flooded reservoir backbays. Although aquatic plants were found at water depths between <0.5 and 5.9 m in 2022, areas deeper than 3 m may not allow for sufficient light penetration to allow for plant growth. Water depth was greater than the target depth of 3 m at 48 of 120 sites sampled. Aquatic plants were present at 67% (48 of 72) sites sampled at water depths <3 m. Aquatic plants were relatively abundant in the area upstream of Birthday Rapids (MS1; at eight of nine sites <3 m in depth), reservoir backbay Zone 12 (MS4; at ten of 13 sites), the north shore of Gull Lake (MS6; at eight of 11 sites), and in reservoir backbay Zone 8 (MS8; at seven of nine sites).

Several areas sampled in the Keeyask reservoir in 2022 showed little or no aquatic plant growth, as in 2021. Aquatic plants were sparse and only found at two of 14 sites sampled on the south shore of Gull Lake (MS5) while no aquatic plants were found at any of the 15 sites sampled in lower Gull Lake (MS9). Water depths were greatest within these areas, ranging from 2.0–13.9 m. Only five sites at MS5 and four sites at MS9 were less than 3 m of depth. The majority of sites were likely too deep for light penetration and the establishment of aquatic plants. In future years, an effort will be made to sample at shallower sites within both areas.

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, silt, and sand with organics present in the most northern sampling area (MS12). Few aquatic plants were found at sites in Stephens Lake during sampling in 2021 (only present at four of 45 sites sampled). It was hypothesized that low flows combined with water fluctuations due to Keeyask GS powerhouse commissioning limited plant growth (Dolce Blanchard *et al*.

2022). As in the Keeyask reservoir, several sites sampled in 2022 were deeper than 3 m. Aquatic plants were found at nine of 26 sites (35%) measuring less than 3 m of depth.

Satellite remote sensing data revealed that floating peat islands first observed in 2021 have persisted within the Keeyask reservoir backbays. Peat islands were first evident in spring 2021 and increased in size and number over the 2021 open-water period, decreasing the overall open-water area within the Keeyask reservoir. The quantity of peat islands remained similar throughout the 2022 open-water period and the overall open-water area changed little. Peat islands can impede the growth of rooted plants within backbays. As in 2021, the boundaries of humic, mixed, and turbid water masses were clearly visible with humic water largely found within the reservoir backbays.

Data collected in 2022 represent the second open-water period following impoundment of the Keeyask reservoir. Because of this, it is too soon to make comparisons to EIS predictions about development of nearshore areas within the Keeyask reservoir. Surveys will be repeated using the same measures to describe changes to nearshore habitats as the Keeyask reservoir ages. A comprehensive report will follow that includes a detailed analysis of changes in nearshore habitats and aquatic plant development in the three years following reservoir impoundment.

6.0 SUMMARY AND CONCLUSIONS

- Nearshore habitats were monitored in nine areas within the Keeyask reservoir and three areas in Stephens Lake in 2022. Between nine and 15 sites were sampled in each area.
- Substrates within sampling areas in the Keeyask reservoir consisted largely of soft (silt and clay) substrates and organics.
- More aquatic plants were found in the Keeyask reservoir during sampling in 2022 than in 2021 when plants present consisted largely of terrestrial species that persisted after flooding. In 2022, aquatic plants were found in eight of nine sampling areas including flooded reservoir backbays. Although aquatic plants were found at water depths between <0.5 and 5.9 m in 2022, areas deeper than 3 m may not allow for sufficient light penetration to allow for plant growth. Aquatic plants were present at 67% (48 of 72) sites sampled at water depths <3 m. Aquatic plants were relatively abundant in the area upstream of Birthday Rapids, reservoir backbay Zone 12, the north shore of Gull Lake, and in reservoir backbay Zone 8.
- Several areas sampled in the Keeyask reservoir in 2022 showed little or no aquatic plant growth, as in 2021. These included the south shore of Gull Lake and lower Gull Lake where water depths may be too great for light penetration.
- 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, silt, and sand with organics present in the most northern sampling area. As in the Keeyask reservoir, several sites sampled in 2022 were deeper than 3 m. Aquatic plants were found at nine of 26 sites (35%) measuring less than 3 m of depth.
- Satellite remote sensing data revealed that floating peat islands first seen in 2021 have persisted within the Keeyask reservoir backbays. The quantity of peat islands remained similar throughout the 2022 open-water period and the overall open-water area changed little. Peat islands may inhibit the growth of rooted macrophytes within backbays. The boundaries of humic, mixed, and turbid water masses were clearly visible with humic water largely found within the reservoir backbays.
- Data collected in 2022 represent the second open-water period following impoundment of the Keeyask reservoir. Surveys will be repeated using the same measures to describe changes to nearshore habitats as the Keeyask reservoir ages. In future years, an effort will be made to sample at shallower sites within both the Keeyask reservoir and Stephens Lake.

7.0 LITERATURE CITED

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APPENDICES

APPENDIX 1:
AQUATIC MACROPHYTE OBSERVATIONS FROM THE KEEYASK RESERVOIR AND STEPHENS LAKE, 2022.

Table A1-1: Aquatic macrophyte observations in the Keeyask reservoir from pre-selected sites, 2022.

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS1-1	331881	6241973	4.0	Y	*Potamogeton richardsonii*	Richardson pondweed	Sparse
MS1-2	332013	6242013	5.9	Y	*Persicaria spp.*	Smartweed	Abundant
					Potamogeton zosterformis	Flatstem pondweed	Sparse
					Scirpus spp.	Bulrush	Sparse
MS1-3	331925	6242052	4.9	N	-	-	-
MS1-4	332223	6242056	1.3	Y	*Persicaria spp.*	Smartweed	Common
					Vallisneria spp.	Tapegrass	Sparse
					Potamogeton richardsonii	Richardson pondweed	Sparse
MS1-6	332113	6242098	3.3	Y	*Potamogeton richardsonii*	Richardson pondweed	Sparse
MS1-7	332324	6242095	1.5	Y	*Vallisneria spp.*	Tapegrass	Abundant
					Persicaria spp.	Smartweed	Sparse
					Myriophyllum spp.	Watermilfoil	Sparse
MS1-8	332425	6242123	1.2	Y	*Utricularia spp.*	Bladderwort	Common
					Elodea canadensis	Canada waterweed	Sparse
					Myriophyllum spp.	Watermilfoil	Sparse
MS1-9	332111	6242205	3.0	Y	*Potamogeton gramineus*	Variableleaf pondweed	Abundant
					Potamogeton richardsonii	Richardson pondweed	Abundant
					Stuckenia vaginata	Sheathed pondweed	Abundant
MS1-10	332408	6242194	1.1	Y	*Vallisneria spp.*	Tapegrass	Common
					Utricularia spp.	Bladderwort	Common
MS1-11	331976	6242339	5.0	N	-	-	-
MS1-12	332221	6242295	2.4	Y	*Potamogeton richardsonii*	Richardson pondweed	Abundant
					Myriophyllum spp.	Watermilfoil	Sparse
MS1-13	332110	6242347	3.0	Y	*Potamogeton richardsonii*	Richardson pondweed	Sparse
					Potamogeton gramineus	Variableleaf pondweed	Sparse
MS1-15	332019	6242398	3.0	N	-	-	-
MS1-19A	331964	6242205	1.0	N	-	-	-
MS2-4	333879	6243074	5.0	N	-	-	-
MS2-5	333807	6243113	6.3	N	-	-	-

Table A1-1: Aquatic macrophyte observations in the Keeyask reservoir from pre-selected sites, 2022 (continued).

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS2-6	334276	6243115	2.6	Y	*Potamogeton gramineus*	Variableleaf pondweed	Sparse
					Ranunculus spp.	Water buttercup	Sparse
					Vallisneria spp.	Tapegrass	Sparse
MS2-7	333934	6243140	9.0	N	-	-	-
MS2-8	334048	6243128	5.9	N	-	-	-
MS2-9	334170	6243209	1.9	Y	*Vallisneria spp.*	Tapegrass	Sparse
MS2-10	334320	6243213	0.7	N	-	-	-
MS2-11	334121	6243204	4.8	N	-	-	-
MS2-12	333972	6243235	6.0	N	-	-	-
MS2-13	334179	6243242	1.0	N	-	-	-
MS2-13	334157	6243416	4.7	N	-	-	-
MS2-14	334037	6243367	6.5	N	-	-	-
MS2-17a	333994	6243090	5.0	N	-	-	-
MS3-1	340357	6244436	2.5	Y	*Utricularia spp.*	Bladderwort	Sparse
MS3-2	340052	6244519	4.0	N	-	-	-
MS3-3	340550	6244623	5.0	N	-	-	-
MS3-4	340762	6244601	5.1	N	-	-	-
MS3-5	341060	6244664	1.5	N	-	-	-
MS3-6	340356	3244723	4.9	N	-	-	-
MS3-7	340848	6244834	1.1	N	-	-	-
MS3-8	-	-	-	-	-	-	-
MS3-9	339551	6245127	5.0	N	-	-	-
MS3-10	339848	6245114	2.0	Y	*Myriophyllum spp.*	Watermilfoil	Sparse
					Persicaria spp.	Smartweed	Sparse
MS3-11	340354	6245122	1.2	Y	*Utricularia spp.*	Bladderwort	Abundant
MS3-12	339146	6245224	2.7	Y	*Elodea canadensis*	Canada waterweed	Sparse
MS3-13	339358	6245422	5.0	N	-	-	-
MS3-14	339648	6245618	4.5	N	-	-	-
MS3-15	339948	6245728	2.8	Y	*Utricularia spp.*	Bladderwort	Sparse
MS3-17A	338967	6245445	5.1	N	-	-	-
MS4-1	-	-	-	-	-	-	-

Table A1-1: Aquatic macrophyte observations in the Keeyask reservoir from pre-selected sites, 2022 (continued).

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS4-2	-	-	-	-	-	-	-
MS4-3	-	-	-	-	-	-	-
MS4-4	-	-	-	-	-	-	-
MS4-5	-	-	-	-	-	-	-
MS4-6	-	-	-	-	-	-	-
MS4-7	352660	6241075	0.8	Y	*Lemna trisulca*	Star duckweed	Sparse
					Utricularia spp.	Bladderwort	Sparse
MS4-8	353484	6241137	<0.5	Y	*Myriophyllum spp.*	Watermilfoil	Abundant
					Lemna trisulca	Star duckweed	Sparse
					Utricularia spp.	Bladderwort	Sparse
MS4-9-1	352912	6241286	-	N	-	-	-
MS4-10	353553	6241374	2.8	Y	*Potamogeton richardsonii*	Richardson Pondweed	Abundant
					Myriophyllum spp.	Watermilfoil	Abundant
					Utricularia spp.	Bladderwort	Abundant
MS4-11	353346	6241467	1.5	Y	*Utricularia spp.*	Bladderwort	Common
MS4-12	353052	6241580	2.6	N	-	-	-
MS4-13	353558	6241573	1.6	Y	*Utricularia spp.*	Bladderwort	Abundant
					Lemna trisulca	Star duckweed	Common
					Elodea canadensis	Canada waterweed	Sparse
MS4-14	353362	6241674	3.0	Y	*Lemna trisulca*	Star duckweed	Sparse
MS4-15	353456	6241676	2.5	N	-	-	-
MS4-16a	352778	6241255	1.3	Y	*Lemna trisulca*	Star duckweed	Sparse
MS4-17A	353076	6241453	0.8	Y	*Utricularia spp.*	Bladderwort	Sparse
MS4-18A-1	352452	6240964	2.1	Y	*Potamogeton spp.*	Pondweed	Sparse
MS4-19A	-	-	-	-	-	-	-
MS4-20A	353406	6241320	1.3	Y	*Utricularia spp.*	Bladderwort	Sparse
MS5-1	353944	6242823	2.6	Y	*Utricularia spp.*	Bladderwort	Sparse
MS5-4	354063	6243078	1.4	Y	*Utricularia spp.*	Bladderwort	Sparse
					Lemna trisulca	Star duckweed	Sparse
MS5-5	353958	6243267	3.0	N	-	-	-
MS5-6	354042	6243575	8.3	N	-	-	-

Table A1-1: Aquatic macrophyte observations in the Keeyask reservoir from pre-selected sites, 2022 (continued).

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS5-7	354755	6243572	2.8	N	-	-	-
MS5-8	353853	6243667	8.4	N	-	-	-
MS5-9	354261	6243781	5.5	N	-	-	-
MS5-10	354656	6243773	3.5	N	-	-	-
MS5-11	354062	6244078	13.9	N	-	-	-
MS5-12	354555	6244064	8.0	N	-	-	-
MS5-13	354752	6244070	8.0	N	-	-	-
MS5-14	354367	6244276	7.0	N	-	-	-
MS5-15	354657	6244275	12.2	N	-	-	-
MS5-18A	353803	6243109	3.1	N	-	-	-
MS6-1	353844	6245673	6.8	N	-	-	-
MS6-2	353450	6245772	3.9	N	-	-	-
MS6-3	353658	6245780	6.4	N	-	-	-
MS6-4	353232	6245852	1.1	Y	Charophyta	Filamentous algae	Sparse
MS6-5	353088	6245979	0.8	Y	Charophyta	Filamentous algae	Sparse
MS6-6-1	353458	6245956	<0.5	Y	Charophyta	Filamentous algae	Sparse
MS6-7	353647	6245973	1.9	Y	*Lemna trisulca*	Star duckweed	Sparse
MS6-8	353770	6246105	0.5	N	-	-	-
MS6-9	-	-	-	-	-	-	-
MS6-10-1	353460	6246134	<0.5	Y	Charophyta	Filamentous algae	Sparse
MS6-11	353563	6246174	1.5	N	-	-	-
MS6-12	354063	6246170	4.7	N	-	-	-
MS6-14	353746	6246392	0.8	Y	*Utricularia spp.*	Bladderwort	Sparse
MS6-15	-	-	-	-	-	-	-
MS6-17A	353528	6246593	<0.5	Y	*Utricularia spp.*	Bladderwort	Abundant
					Lemna trisulca	Star duckweed	Sparse
MS6-18A	352985	6246141	1.2	Y	*Lemna trisulca*	Star duckweed	Sparse
MS6-20A	353776	6245883	1.5	N	-	-	-
MS7-1	350647	6246569	2.3	N	-	-	-
MS7-2	350954	6246568	6.0	N	-	-	-
MS7-3	351269	6246663	2.7	N	-	-	-

Table A1-1: Aquatic macrophyte observations in the Keeyask reservoir from pre-selected sites, 2022 (continued).

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS7-4-1	351565	6246714	0.6	Y	Charophyta	Unidentified algae	Sparse
					Lemna trisulca	Star duckweed	Sparse
MS7-5	351050	6246854	2.2	Y	*Myriophyllum spp.*	Watermilfoil	Abundant
					Utricularia spp.	Bladderwort	Sparse
MS7-6	-	-	-	-	-	-	-
MS7-7	350956	6246972	1.1	Y	*Sphagnum spp.*	Moss	Sparse
					Equisetum fluviatile	Water horsetail	Sparse
MS7-8-1	351398	6246857	0.7	Y	*Charophyta*	Unidentified algae	Sparse
					Lemna trisulca	Star duckweed	Sparse
MS7-9	350664	6247079	1.7	Y	*Nuphar spp.*	Pond-lily	Sparse
					Myriophyllum spp.	Watermilfoil	Sparse
					Persicaria spp.	Smartweed	Sparse
MS7-10	350849	6247181	0.9	Y	*Myriophyllum spp.*	Watermilfoil	Abundant
					Equisetum fluviatile	Water horsetail	Sparse
					Menyanthes trifoliata	Common bogbean	Sparse
MS7-16A	350793	6247073	2.3	N	-	-	-
MS7-18A	351412	6246635	3.1	N	-	-	-
MS7-19	350855	6246724	1.8	N	-	-	-
MS8-3-1	353692	6249318	0.5	Y	*Utricularia spp.*	Bladderwort	Common
MS8-4	353950	6249279	2.0	Y	*Myriophyllum spp.*	Watermilfoil	Abundant
					Utricularia spp.	Bladderwort	Sparse
MS8-5	353461	6249393	1.5	Y	*Utricularia spp.*	Bladderwort	Abundant
					Equisetum fluviatile	Water horsetail	Sparse
					Persicaria spp.	Smartweed	Sparse
MS8-6	353755	6249372	2.6	N	-	-	-
MS8-7-1	353273	6249501	0.5	Y	*Myriophyllum spp.*	Watermilfoil	Abundant
					Utricularia spp.	Bladderwort	Abundant
					Lemna trisulca	Star duckweed	Abundant
MS8-16A-1	353871	6249377	1.8	Y	*Utricularia spp.*	Bladderwort	Sparse

Table A1-1: Aquatic macrophyte observations in the Keeyask reservoir from pre-selected sites, 2022 (continued).

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS8-17A	353944	6249111	1.5	Y	*Lemna trisulca*	Star duckweed	Sparse
					Utricularia spp.	Bladderwort	Sparse
					Elodea canadensis	Canada waterweed	Sparse
MS8-19A	353663	6249402	2.7	N	-	-	-
MS8-20A	353379	6249515	1.1	Y	*Myriophyllum spp.*	Watermilfoil	Common
					Equisetum fluviatile	Water horsetail	Sparse
					Utricularia spp.	Bladderwort	Sparse
MS9-1	359355	6246576	5.5	N	-	-	-
MS9-2	359750	6246664	2.3	N	-	-	-
MS9-3	360450	6246668	2.5	N	-	-	-
MS9-4	358860	6246870	4.2	N	-	-	-
MS9-5	359152	6246976	3.1	N	-	-	-
MS9-6	360658	6246966	3.5	N	-	-	-
MS9-7	359853	6247070	3.5	N	-	-	-
MS9-8	360153	6247275	3.0	N	-	-	-
MS9-9	358155	6247454	11.5	N	-	-	-
MS9-10	358047	6247862	3.8	N	-	-	-
MS9-11	358468	6247879	2.0	N	-	-	-
MS9-12	358262	6248155	6.0	N	-	-	-
MS9-13	358844	6248175	3.0	N	-	-	-
MS9-14	359358	6248175	6.3	N	-	-	-
MS9-15	359661	6248250	4.7	N	-	-	-

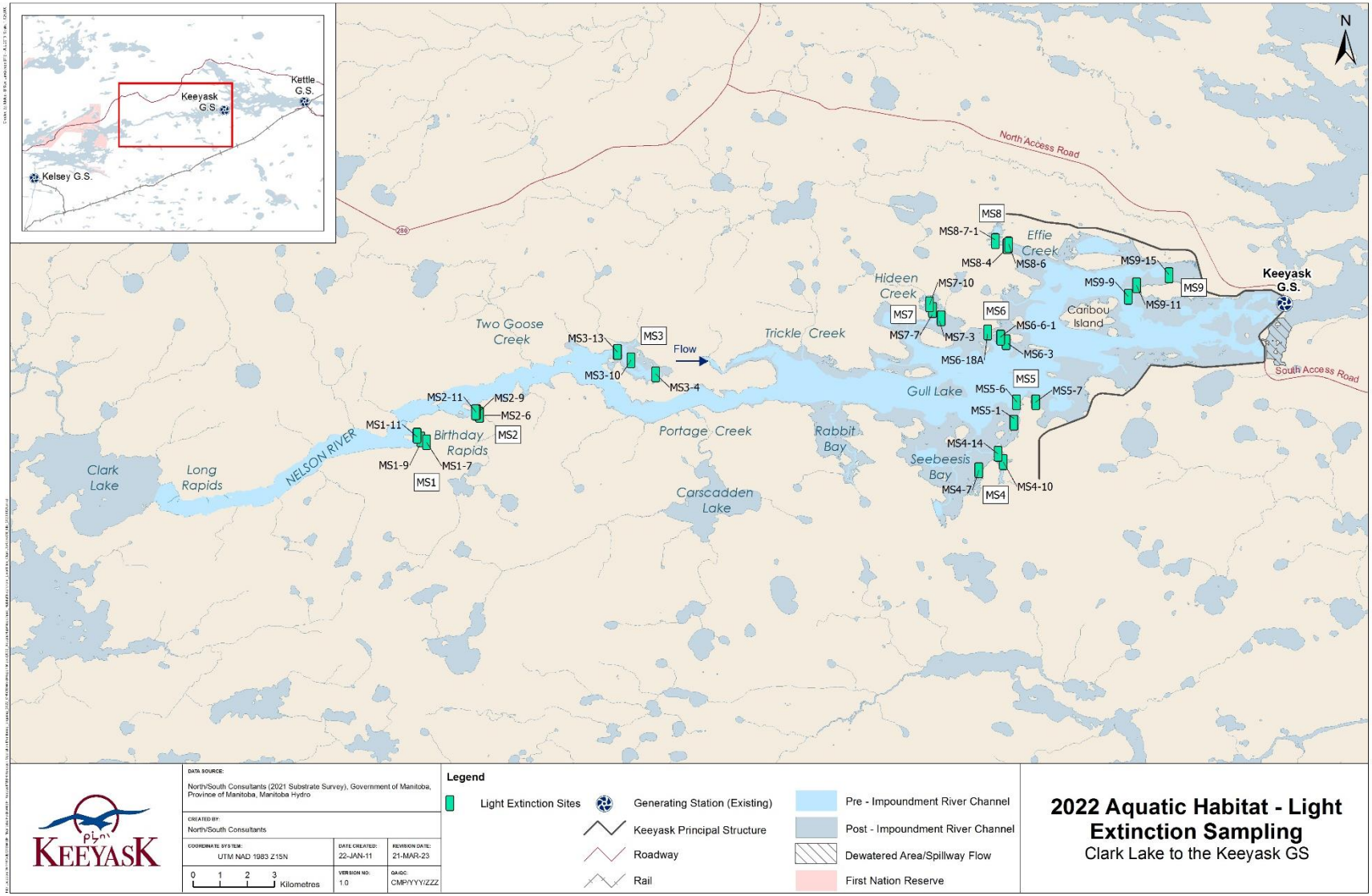
Table A1-2: Aquatic macrophyte observations from Stephens Lake, 2022.

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS10-1	367653	6249768	0.9	N	-	-	-
MS10-2	367457	6249874	1.1	N	-	-	-
MS10-3	367749	6249828	3.2	N	-	-	-
MS10-4	367460	6250077	3.0	N	-	-	-
MS10-5	367158	6250174	1.0	Y	*Stuckenia pectinata*	Sago pondweed	Sparse
					Potamogeton richardsonii	Richardson pondweed	Sparse
MS10-6	367353	6250178	2.4	N	-	-	-
MS10-7	367560	6250166	2.7	N	-	-	-
MS10-8	367154	6250259	1.5	Y	*Stuckenia pectinata*	Sago pondweed	Common
					Potamogeton richardsonii	Richardson pondweed	Common
MS10-9	367049	6250377	1.0	Y	*Potamogeton richardsonii*	Richardson pondweed	Common
					Stuckenia pectinata	Sago pondweed	Common
					Lemna trisulca	Star duckweed	Common
MS10-10	367459	6250371	3.9	N	-	-	-
MS10-11	367252	6250458	1.8	Y	*Stuckenia pectinata*	Sago pondweed	Sparse
MS10-12	367861	6250457	8.7	N	-	-	-
MS10-13	367453	6250673	3.2	N	-	-	-
MS10-14	367754	6250872	6.8	N	-	-	-
MS10-15	367650	6250872	1.3	N	-	-	-
MS11-1	369055	6251171	5.2	N	-	-	-
MS11-2	368756	6251267	3.8	N	-	-	-
MS11-3	368551	6251372	1.9	N	-	-	-
MS11-4	368958	6251375	2.4	N	-	-	-
MS11-5	368556	6251484	1.6	Y	*Stuckenia pectinata*	Sago pondweed	Sparse
MS11-6	369156	6251577	2.2	N	-	-	-
MS11-7	368958	6251676	2.5	N	-	-	-
MS11-8	369448	6251668	4.2	N	-	-	-
MS11-9	368950	6251773	2.4	Y	*Potamogeton richardsonii*	Richardson pondweed	Sparse
MS11-10	368852	6251867	1.5	Y	*Stuckenia vaginata*	Sheathed pondweed	Common
MS11-11	369058	6251876	1.8	Y	*Stuckenia pectinata*	Sago pondweed	Abundant
MS11-12	369265	6251877	3.4	N	-	-	-

Table A1-2: Aquatic macrophyte observations from the Northern portion of Stephens Lake, 2022 (continued).

Site	Location		Water Depth (m)	Plant Presence	Aquatic Plant Species		
	Easting	Northing			Scientific Name	Common Name	Abundance
MS11-13	369458	6251868	6.7	N	-	-	-
MS11-14	369356	6252076	5.5	N	-	-	-
MS11-15	369153	6252172	2.0	N	-	-	-
MS12-1	369856	6254964	2.7	N	-	-	-
MS12-2	369552	6255063	2.4	N	-	-	-
MS12-3	369551	6255184	2.5	N	-	-	-
MS12-4	369957	6255271	3.2	N	-	-	-
MS12-5	370250	6255267	5.6	N	-	-	-
MS12-6	369455	6255368	1.5	N	-	-	-
MS12-7	369654	6255452	0.9	Y	*Typha spp.*	Cattail	Sparse
MS12-8	369855	6255568	1.1	N	-	-	-
MS12-9	370356	6255566	5.9	N	-	-	-
MS12-10	370056	6255678	2.5	N	-	-	-
MS12-11	370658	6255672	6.0	N	-	-	-
MS12-12	369956	6255871	3.3	N	-	-	-
MS12-13	370352	6255867	8.0	N	-	-	-
MS12-14	370556	6255972	8.2	N	-	-	-
MS12-15	370361	6256071	8.6	N	-	-	-

APPENDIX 2:
LI-COR LIGHT SENSOR DATA COLLECTED FROM THE KEEYASK RESERVOIR AND STEPHENS LAKE, 2022.



Map A2-1: Map illustrating pre-selected light extinction sampling sites in the Keeyask reservoir, August 2022.

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022.

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS1-7	8/12/2022	0.0	1189	1261	24.4
MS1-7	8/12/2022	0.1	1185	1102	25.6
MS1-7	8/12/2022	0.2	1184	1113	25.3
MS1-7	8/12/2022	0.3	1185	1086	25.6
MS1-7	8/12/2022	0.4	1185	890.7	25.5
MS1-7	8/12/2022	0.5	1183	1101	25
MS1-7	8/12/2022	0.6	1181	819.1	23.3
MS1-7	8/12/2022	0.7	1177	632.2	22.2
MS1-7	8/12/2022	0.8	1169	596.7	20.2
MS1-7	8/12/2022	0.9	1156	496.7	14.1
MS1-7	8/12/2022	1.0	1158	342	10.6
MS1-7	8/12/2022	1.1	1165	320.7	8.9
MS1-7	8/12/2022	1.2	1180	313.9	7.3
MS1-9	8/12/2022	0.0	25	1749	68.8
MS1-9	8/12/2022	0.1	1135	1615	64.4
MS1-9	8/12/2022	0.2	1130	1392	63.4
MS1-9	8/12/2022	0.3	1126	1374	60.1
MS1-9	8/12/2022	0.4	1124	1412	52.4
MS1-9	8/12/2022	0.5	1128	1116	50.4
MS1-9	8/12/2022	0.6	1132	876.5	45.9
MS1-9	8/12/2022	0.7	1128	833	41.3
MS1-9	8/12/2022	0.8	1126	745.9	36.5
MS1-9	8/12/2022	0.9	1125	699.8	28.1
MS1-9	8/12/2022	1.0	1128	595.8	26
MS1-9	8/12/2022	1.1	1126	551.6	24.6
MS1-9	8/12/2022	1.2	1131	481.1	24.2
MS1-9	8/12/2022	1.3	1130	457.4	20.1
MS1-9	8/12/2022	1.4	1128	401.1	18
MS1-9	8/12/2022	1.5	1127	303.2	14.6
MS1-9	8/12/2022	1.6	1128	276.6	7.6
MS1-9	8/12/2022	1.7	1132	245.7	6.3
MS1-9	8/12/2022	1.8	1134	199.1	11.2
MS1-9	8/12/2022	1.9	1135	206	8.7
MS1-9	8/12/2022	2.0	1138	165	8.4
MS1-9	8/12/2022	2.1	1140	141.9	8.1
MS1-9	8/12/2022	2.2	1143	104.6	7.3
MS1-9	8/12/2022	2.3	1146	87.8	6.5
MS1-9	8/12/2022	2.4	1147	82.1	5.4
MS1-9	8/12/2022	2.5	1144	86.6	3.9

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS1-9	8/12/2022	2.6	1142	63.2	4.3
MS1-9	8/12/2022	2.7	1142	54.1	3.9
MS1-9	8/12/2022	2.8	1142	47.3	4
MS1-9	8/12/2022	2.9	1144	22.6	3.3
MS1-9	8/12/2022	3.0	1147	57.4	2.1
MS1-9	8/12/2022	3.1	1144	55.6	1.9
MS1-9	8/12/2022	3.2	1136	47.8	2.1
MS1-11	8/12/2022	0.1	1494	213.5	84.3
MS1-11	8/12/2022	0.2	639.8	711.4	37.12
MS1-11	8/12/2022	0.3	904.4	768.7	57.03
MS1-11	8/12/2022	0.4	896.7	721.3	39.16
MS1-11	8/12/2022	0.5	575.3	596.2	24.1
MS1-11	8/12/2022	0.6	536.6	387.4	21.9
MS1-11	8/12/2022	0.7	552.1	397.7	18.8
MS1-11	8/12/2022	0.8	508.6	351.2	17.3
MS1-11	8/12/2022	0.9	648.1	432.2	17.9
MS1-11	8/12/2022	1.0	590.5	315.9	15
MS1-11	8/12/2022	1.1	562.7	260.5	13
MS1-11	8/12/2022	1.2	544.5	242.5	11.9
MS1-11	8/12/2022	1.3	524.3	214.8	10.9
MS1-11	8/12/2022	1.4	530.7	182.4	9.5
MS1-11	8/12/2022	1.5	547.8	179.4	8.9
MS1-11	8/12/2022	1.6	500.9	164	8.1
MS1-11	8/12/2022	1.7	551.8	145.9	7.6
MS1-11	8/12/2022	1.8	563.6	123.3	6.7
MS1-11	8/12/2022	1.9	738	172	7.6
MS1-11	8/12/2022	2.0	681.8	190.8	7.8
MS1-11	8/12/2022	2.1	974.7	161.2	10.6
MS1-11	8/12/2022	2.2	1085	177.2	9.2
MS1-11	8/12/2022	2.3	1330	154.4	8.3
MS1-11	8/12/2022	2.4	1312	146.1	7.3
MS1-11	8/12/2022	2.5	1302	131.3	6.4
MS1-11	8/12/2022	2.6	1247	102	5.7
MS1-11	8/12/2022	2.7	1110	80.4	4.7
MS1-11	8/12/2022	2.8	1280	71.7	4.4
MS1-11	8/12/2022	2.9	1214	70.3	4.5
MS1-11	8/12/2022	3.0	1254	68.2	4.2
MS1-11	8/12/2022	3.1	1172	74.7	3.8
MS1-11	8/12/2022	3.2	1243	43.7	3.9

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS1-11	8/12/2022	3.3	1246	49.7	3.3
MS1-11	8/12/2022	3.4	1266	41	3.5
MS1-11	8/12/2022	3.5	1274	36.9	2.5
MS1-11	8/12/2022	3.6	1304	35.3	2.3
MS1-11	8/12/2022	3.7	1059	21.8	1.5
MS1-11	8/12/2022	3.8	1175	20.1	1.4
MS1-11	8/12/2022	3.9	1274	20	1.3
MS1-11	8/12/2022	4.0	1058	11.1	1.2
MS1-11	8/12/2022	4.1	1213	11.1	1.1
MS1-11	8/12/2022	4.2	1203	12.4	1
MS1-11	8/12/2022	4.3	1211	11.1	1.1
MS1-11	8/12/2022	4.4	1186	9.4	0.9
MS1-11	8/12/2022	4.5	1182	11	1.3
MS1-11	8/12/2022	4.6	1201	11.7	1.1
MS1-11	8/12/2022	4.7	1150	11.4	1
MS1-11	8/12/2022	4.8	1161	11.3	1.1
MS1-11	8/12/2022	4.9	1150	10.9	1.1
MS1-11	8/12/2022	5.0	1150	11	1.2
MS1-11	8/12/2022	5.1	1172	11.1	1.1
MS2-6	8/12/2022	0.0	822.2	710.2	1
MS2-6	8/12/2022	0.1	1110	800.8	2.6
MS2-6	8/12/2022	0.2	1213	673.3	2.2
MS2-6	8/12/2022	0.3	1216	663.4	2.3
MS2-6	8/12/2022	0.4	1210	493.4	2
MS2-6	8/12/2022	0.5	1199	437.1	1.7
MS2-6	8/12/2022	0.6	1048	213.1	1
MS2-6	8/12/2022	0.7	522	78.5	0.8
MS2-6	8/12/2022	0.8	395.1	86.3	0.9
MS2-6	8/12/2022	0.9	924.4	188.8	1
MS2-6	8/12/2022	1.0	965.1	18.9	0.7
MS2-6	8/12/2022	1.1	948.5	25.6	0.9
MS2-6	8/12/2022	1.2	1035	91.5	0.9
MS2-6	8/12/2022	1.3	1120	119	0.8
MS2-6	8/12/2022	1.4	795.1	47.3	0.7
MS2-6	8/12/2022	1.5	391	15.3	0.7
MS2-6	8/12/2022	1.6	1279	67	0.8
MS2-6	8/12/2022	1.7	1237	71.9	0.8
MS2-6	8/12/2022	1.8	1225	48.3	0.8
MS2-6	8/12/2022	1.9	1095	30.7	0.7

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS2-6	8/12/2022	2.0	804.7	36.9	0.7
MS2-6	8/12/2022	2.1	1132	39.1	0.8
MS2-6	8/12/2022	2.2	1081	10	0.6
MS2-6	8/12/2022	2.3	440	6.9	0.6
MS2-6	8/12/2022	2.4	640	20	0.7
MS2-6	8/12/2022	2.5	996	9.6	0.6
MS2-6	8/12/2022	2.6	1090	4.5	0.6
MS2-6	8/12/2022	2.7	1127	8.5	0.6
MS2-9	8/12/2022	0.0	807.1	1014	24.5
MS2-9	8/12/2022	0.1	1328	1066	36.3
MS2-9	8/12/2022	0.2	1213	1086	32.4
MS2-9	8/12/2022	0.3	851.5	730	20.9
MS2-9	8/12/2022	0.4	489.2	482.2	25.5
MS2-9	8/12/2022	0.5	1102	1129	50.4
MS2-9	8/12/2022	0.6	1220	1035	41.2
MS2-9	8/12/2022	0.7	1181	864.4	33.7
MS2-9	8/12/2022	0.8	1189	629.1	31
MS2-9	8/12/2022	0.9	1198	397	24.6
MS2-9	8/12/2022	1.0	1209	256.1	19.5
MS2-9	8/12/2022	1.1	1192	224.2	14.6
MS2-9	8/12/2022	1.2	1102	183.6	11.6
MS2-9	8/12/2022	1.3	1214	152.8	10.5
MS2-9	8/12/2022	1.4	943.9	110.5	7.4
MS2-9	8/12/2022	1.5	950.2	127.9	9.2
MS2-9	8/12/2022	1.6	1193	129.2	8.4
MS2-9	8/12/2022	1.7	1207	147.7	8.4
MS2-9	8/12/2022	1.8	1185	167.2	8.8
MS2-9	8/12/2022	1.9	1157	181.1	9.4
MS2-9	8/12/2022	2.0	1159	142.6	7.9
MS2-9	8/12/2022	2.1	1166	117.1	7
MS2-9	8/12/2022	2.2	1172	96.4	6
MS2-9	8/12/2022	2.3	1181	82.2	4.8
MS2-9	8/12/2022	2.4	1190	67.5	3.9
MS2-9	8/12/2022	2.5	1191	59.5	3.4
MS2-9	8/12/2022	2.6	1193	54.8	2.9
MS2-9	8/12/2022	2.7	1202	49.8	2.7
MS2-9	8/12/2022	2.8	1213	47.8	2.7
MS2-11	8/12/2022	0.0	1132	1798	70.2
MS2-11	8/12/2022	0.1	1125	1581	59

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS2-11	8/12/2022	0.2	1104	1274	28.3
MS2-11	8/12/2022	0.3	1068	272.8	23
MS2-11	8/12/2022	0.4	1064	276.6	21.3
MS2-11	8/12/2022	0.5	1065	253.7	19.9
MS2-11	8/12/2022	0.6	1061	267.2	18.4
MS2-11	8/12/2022	0.7	1060	355.7	18.4
MS2-11	8/12/2022	0.8	1073	513	17.9
MS2-11	8/12/2022	0.9	1085	482.9	19
MS2-11	8/12/2022	1.0	1090	450.3	15.6
MS2-11	8/12/2022	1.1	1054	180.3	15.1
MS2-11	8/12/2022	1.2	1059	167.8	15.6
MS2-11	8/12/2022	1.3	1072	221.3	15.8
MS2-11	8/12/2022	1.4	1121	321	15.9
MS2-11	8/12/2022	1.5	1188	323	15.3
MS2-11	8/12/2022	1.6	1197	290	13.6
MS2-11	8/12/2022	1.7	1206	256.3	12.6
MS2-11	8/12/2022	1.8	1206	231.5	11.1
MS2-11	8/12/2022	1.9	1200	210.5	9.9
MS2-11	8/12/2022	2.0	1198	181.8	9
MS2-11	8/12/2022	2.1	1198	163.2	8.4
MS2-11	8/12/2022	2.2	1194	142.5	7.7
MS2-11	8/12/2022	2.3	1198	125.4	7.1
MS2-11	8/12/2022	2.4	1197	113.7	6.5
MS2-11	8/12/2022	2.5	1194	101.4	5.9
MS2-11	8/12/2022	2.6	1196	90.9	5.3
MS2-11	8/12/2022	2.7	1198	81.6	4.9
MS2-11	8/12/2022	2.8	1200	74.7	4.6
MS2-11	8/12/2022	2.9	1199	68.2	4.3
MS2-11	8/12/2022	3.0	1203	61.3	3.9
MS2-11	8/12/2022	3.1	1204	54.6	3.5
MS2-11	8/12/2022	3.2	1203	48.8	3.3
MS2-11	8/12/2022	3.3	1199	43.6	3.1
MS2-11	8/12/2022	3.4	1194	39.5	2.9
MS2-11	8/12/2022	3.5	1190	35.6	2.7
MS2-11	8/12/2022	3.6	1198	31.1	2.5
MS2-11	8/12/2022	3.7	1186	28.5	2.3
MS2-11	8/12/2022	3.8	1185	25.6	2.2
MS2-11	8/12/2022	3.9	1182	23.4	2
MS2-11	8/12/2022	4.0	1191	20.2	2

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS2-11	8/12/2022	4.1	1194	18.8	2
MS2-11	8/12/2022	4.2	1201	17.1	1.9
MS2-11	8/12/2022	4.3	1207	15.3	1.8
MS2-11	8/12/2022	4.4	1208	14.4	1.7
MS2-11	8/12/2022	4.5	1204	13.8	1.6
MS3-4	8/18/2022	0.0	354.6	360.6	5.4
MS3-4	8/18/2022	0.1	357.7	324.1	4.7
MS3-4	8/18/2022	0.2	352	271.7	4.8
MS3-4	8/18/2022	0.3	349	223.6	4.2
MS3-4	8/18/2022	0.4	342.9	220.1	3.8
MS3-4	8/18/2022	0.5	340.8	185.3	3.4
MS3-4	8/18/2022	0.6	339.7	163.9	2.9
MS3-4	8/18/2022	0.7	339.9	141.4	2.7
MS3-4	8/18/2022	0.8	340.1	121.5	2.5
MS3-4	8/18/2022	0.9	341.4	95.5	2.3
MS3-4	8/18/2022	1.0	344.5	87.5	2.1
MS3-4	8/18/2022	1.1	343.5	81.8	2
MS3-4	8/18/2022	1.2	343.3	80.6	1.8
MS3-4	8/18/2022	1.3	342.2	73.4	1.7
MS3-4	8/18/2022	1.4	338.3	65.1	1.6
MS3-4	8/18/2022	1.5	338.6	56.7	1.5
MS3-4	8/18/2022	1.6	339.9	52.7	1.4
MS3-4	8/18/2022	1.7	344.5	46.9	1.4
MS3-4	8/18/2022	1.8	347.9	43.2	1.3
MS3-4	8/18/2022	1.9	350.1	36.7	1.3
MS3-4	8/18/2022	2.0	349.5	32.2	1.2
MS3-4	8/18/2022	2.1	350.2	30	1.1
MS3-4	8/18/2022	2.2	348.6	27.7	1
MS3-4	8/18/2022	2.3	344.7	25.3	0.9
MS3-4	8/18/2022	2.4	346.7	23	0.8
MS3-4	8/18/2022	2.5	346.4	21.5	0.7
MS3-4	8/18/2022	2.6	350.1	20	0.7
MS3-4	8/18/2022	2.7	353.2	17.7	0.5
MS3-4	8/18/2022	2.8	353.1	15.3	0.5
MS3-4	8/18/2022	2.9	353.6	13.8	0.4
MS3-4	8/18/2022	3.0	352	12.3	0.4
MS3-4	8/18/2022	3.1	347.3	11.2	0.4
MS3-4	8/18/2022	3.2	343.9	10.2	0.3
MS3-4	8/18/2022	3.3	342.9	8.8	0.3

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS3-4	8/18/2022	3.4	342.3	8	0.3
MS3-4	8/18/2022	3.5	341.1	7.2	0.3
MS3-4	8/18/2022	3.6	340.3	6.4	0.2
MS3-4	8/18/2022	3.7	343.3	5.5	0.2
MS3-4	8/18/2022	3.8	347.4	4.9	0.2
MS3-4	8/18/2022	3.9	347.5	4.3	0.2
MS3-4	8/18/2022	4.0	345.3	3.8	0.2
MS3-4	8/18/2022	4.1	337.1	3.6	0.2
MS3-4	8/18/2022	4.2	334.9	3.2	0.2
MS3-4	8/18/2022	4.3	330.9	2.9	0.2
MS3-4	8/18/2022	4.4	332.7	2.6	0.2
MS3-4	8/18/2022	4.5	332.1	2.1	0.2
MS3-4	8/18/2022	4.6	327.1	1.9	0.2
MS3-4	8/18/2022	4.7	319	1.7	0.2
MS3-4	8/18/2022	4.8	315.3	1.4	0.2
MS3-4	8/18/2022	4.9	311.5	1.5	0.2
MS3-4	8/18/2022	5.0	306.3	1.2	0.2
MS3-10	8/18/2022	5.1	355.2	1.5	0.3
MS3-10	8/18/2022	0.0	264	327.1	5.8
MS3-10	8/18/2022	0.1	266	261.7	5.2
MS3-10	8/18/2022	0.2	268.4	244	4.8
MS3-10	8/18/2022	0.3	269.6	208.8	4.8
MS3-10	8/18/2022	0.4	270.9	184.9	4.6
MS3-10	8/18/2022	0.5	273.3	172.8	4.6
MS3-10	8/18/2022	0.6	275.7	150	4.3
MS3-10	8/18/2022	0.7	278.9	96	4
MS3-10	8/18/2022	0.8	281.9	93	3.7
MS3-10	8/18/2022	0.9	284.9	93	3.6
MS3-10	8/18/2022	1.0	286	87.7	2.6
MS3-10	8/18/2022	1.1	286.3	83.6	2.4
MS3-10	8/18/2022	1.2	287.4	78.7	2.5
MS3-10	8/18/2022	1.3	287	74.2	2.3
MS3-10	8/18/2022	1.4	288	69.4	1.9
MS3-10	8/18/2022	1.5	289.6	64.3	1.8
MS3-10	8/18/2022	1.6	292.5	52.9	2.2
MS3-13	8/18/2022	0.0	371.5	598.1	14
MS3-13	8/18/2022	0.1	367.8	460.7	13
MS3-13	8/18/2022	0.2	368.3	411.3	11.9
MS3-13	8/18/2022	0.3	368.7	345.1	11.8

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS3-13	8/18/2022	0.4	370.2	353.2	10.8
MS3-13	8/18/2022	0.5	370.9	279	9.9
MS3-13	8/18/2022	0.6	371.5	243.1	8.9
MS3-13	8/18/2022	0.7	373.3	209.5	8.3
MS3-13	8/18/2022	0.8	367.2	180.8	7.6
MS3-13	8/18/2022	0.9	364.3	151.7	7
MS3-13	8/18/2022	1.0	365	135.2	6.3
MS3-13	8/18/2022	1.1	365.5	128.6	5.6
MS3-13	8/18/2022	1.2	374.4	123.4	4.9
MS3-13	8/18/2022	1.3	358.1	105.3	4.6
MS3-13	8/18/2022	1.4	354.9	93.6	4.1
MS3-13	8/18/2022	1.5	354.1	82.4	3.8
MS3-13	8/18/2022	1.6	354.1	74	3.5
MS3-13	8/18/2022	1.7	352.9	68.1	3.2
MS3-13	8/18/2022	1.8	352.1	63.1	2.9
MS3-13	8/18/2022	1.9	350.3	55.8	2.6
MS3-13	8/18/2022	2.0	349.3	50.1	2.4
MS3-13	8/18/2022	2.1	348.7	45.8	2.2
MS3-13	8/18/2022	2.2	350	42.9	2
MS3-13	8/18/2022	2.3	351.7	38	1.9
MS3-13	8/18/2022	2.4	353.6	30	1.7
MS3-13	8/18/2022	2.5	353.7	28.8	1.5
MS3-13	8/18/2022	2.6	352.8	26.4	1.4
MS3-13	8/18/2022	2.7	351.8	24.5	1.3
MS3-13	8/18/2022	2.8	351.5	21.1	1.2
MS3-13	8/18/2022	2.9	352.5	18.7	1.1
MS3-13	8/18/2022	3.0	354.8	16.7	1
MS3-13	8/18/2022	3.1	354.7	14.9	1
MS3-13	8/18/2022	3.2	354.1	13.5	0.9
MS3-13	8/18/2022	3.3	353.6	12.3	0.9
MS3-13	8/18/2022	3.4	352.5	11.4	0.8
MS3-13	8/18/2022	3.5	351.1	10.1	0.7
MS3-13	8/18/2022	3.6	351.1	9.3	0.7
MS3-13	8/18/2022	3.7	352	8.8	0.6
MS3-13	8/18/2022	3.8	351.8	7.4	0.6
MS3-13	8/18/2022	3.9	351.2	6.8	0.5
MS3-13	8/18/2022	4.0	351.7	6	0.5
MS3-13	8/18/2022	4.1	353.1	5.3	0.5
MS3-13	8/18/2022	4.2	353.8	4.6	0.4

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS3-13	8/18/2022	4.3	354	4.2	0.4
MS3-13	8/18/2022	4.4	354	3.7	0.4
MS3-13	8/18/2022	4.5	354.3	3.4	0.4
MS3-13	8/18/2022	4.6	355.2	3	0.4
MS3-13	8/18/2022	4.7	355.7	2.5	0.4
MS3-13	8/18/2022	4.8	355.9	2.1	0.3
MS3-13	8/18/2022	4.9	355.2	1.9	0.3
MS3-13	8/18/2022	5.0	355.3	1.7	0.3
MS4-7	8/16/2022	0.0	249	175.3	5.5
MS4-7	8/16/2022	0.1	248.6	131.4	5.4
MS4-7	8/16/2022	0.2	253	119.7	4.9
MS4-7	8/16/2022	0.3	258.8	107.2	4.6
MS4-7	8/16/2022	0.4	258.6	91.3	3.8
MS4-7	8/16/2022	0.5	256.3	81.8	3.2
MS4-7	8/16/2022	0.6	253	77.1	2.6
MS4-7	8/16/2022	0.7	249.5	74.5	2.2
MS4-7	8/16/2022	0.8	246.6	63.2	2.2
MS4-10	8/16/2022	0.0	699.7	936.4	11.1
MS4-10	8/16/2022	0.1	723.6	901.8	10.8
MS4-10	8/16/2022	0.2	735.2	1033	9.1
MS4-10	8/16/2022	0.3	734.7	615.7	7.4
MS4-10	8/16/2022	0.4	729.7	492.3	6.9
MS4-10	8/16/2022	0.5	714.5	551.3	5.7
MS4-10	8/16/2022	0.6	681.5	539.4	4.4
MS4-10	8/16/2022	0.7	670.6	465.6	4
MS4-10	8/16/2022	0.8	673.9	286.6	3.6
MS4-10	8/16/2022	0.9	680	244.5	3.3
MS4-10	8/16/2022	1.0	693.2	236	2.9
MS4-10	8/16/2022	1.1	718.8	256	2.6
MS4-10	8/16/2022	1.2	733.4	210.7	2.2
MS4-10	8/16/2022	1.3	738	202.4	2
MS4-10	8/16/2022	1.4	735.7	161.7	1.7
MS4-10	8/16/2022	1.5	725.6	137	1.3
MS4-10	8/16/2022	1.6	710.5	122.6	1.1
MS4-10	8/16/2022	1.7	690.9	104.1	0.9
MS4-10	8/16/2022	1.8	687.9	85.4	0.9
MS4-10	8/16/2022	1.9	692	72.3	0.8
MS4-10	8/16/2022	2.0	703.1	62.1	0.6
MS4-14	8/16/2022	0.0	308.6	257.5	7.1

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS4-14	8/16/2022	0.1	322.8	543.9	13.3
MS4-14	8/16/2022	0.2	598.5	509.4	11
MS4-14	8/16/2022	0.3	367.4	320.3	8.1
MS4-14	8/16/2022	0.4	314.5	428.6	11.2
MS4-14	8/16/2022	0.5	414.8	313.6	9.6
MS4-14	8/16/2022	0.6	447.7	289.7	7.7
MS4-14	8/16/2022	0.7	307.2	206	5.3
MS4-14	8/16/2022	0.8	320.3	219.4	5.2
MS4-14	8/16/2022	0.9	339	202.2	4.7
MS4-14	8/16/2022	1.0	307.2	123.3	3.1
MS4-14	8/16/2022	1.1	273.3	77.7	2.5
MS4-14	8/16/2022	1.2	360.3	88.2	2.6
MS4-14	8/16/2022	1.3	244.3	65.9	2.3
MS4-14	8/16/2022	1.4	250.5	77.4	2.8
MS4-14	8/16/2022	1.5	257.4	56.2	2
MS4-14	8/16/2022	1.6	255.7	56.8	2
MS4-14	8/16/2022	1.7	280	60.8	2.7
MS4-14	8/16/2022	1.8	624.2	124.6	2.3
MS4-14	8/16/2022	1.9	470.1	107.7	2.3
MS4-14	8/16/2022	2.0	497.7	44	1
MS4-14	8/16/2022	2.1	302.1	41.6	0.9
MS4-14	8/16/2022	2.2	280.1	28.5	0.8
MS4-14	8/16/2022	2.3	238.8	19.2	0.7
MS4-14	8/16/2022	2.4	237.4	18.6	0.8
MS4-14	8/16/2022	2.5	325.4	19.3	0.6
MS4-14	8/16/2022	2.6	259.6	14.4	0.6
MS4-14	8/16/2022	2.7	257.5	12.7	0.5
MS4-14	8/16/2022	2.8	441.3	15.2	0.5
MS5-1	8/16/2022	0.0	1127	1420	7.6
MS5-1	8/16/2022	0.1	1134	1199	7.1
MS5-1	8/16/2022	0.2	1126	1074	6.2
MS5-1	8/16/2022	0.3	1088	900.8	5.6
MS5-1	8/16/2022	0.4	1015	802.6	5.2
MS5-1	8/16/2022	0.5	1087	681.4	4.5
MS5-1	8/16/2022	0.6	1094	567.4	3.9
MS5-1	8/16/2022	0.7	1108	508.8	3.7
MS5-1	8/16/2022	0.8	1122	446.3	3.5
MS5-1	8/16/2022	0.9	1138	389.9	3.5
MS5-1	8/16/2022	1.0	1137	375.4	3.4

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS5-1	8/16/2022	1.1	1139	325.5	2.8
MS5-1	8/16/2022	1.2	1139	262.4	2
MS5-1	8/16/2022	1.3	1140	250.8	1.6
MS5-1	8/16/2022	1.4	1135	224.5	1.3
MS5-1	8/16/2022	1.5	1122	203.2	1.1
MS5-1	8/16/2022	1.6	1103	179.3	0.9
MS5-1	8/16/2022	1.7	1132	157.8	0.8
MS5-1	8/16/2022	1.8	1161	141.5	0.3
MS5-1	8/16/2022	1.9	1153	94.8	0.4
MS5-1	8/16/2022	2.0	472.7	23.7	0.2
MS5-1	8/16/2022	2.1	379.6	23	0.3
MS5-1	8/16/2022	2.2	409.2	59.3	0.3
MS5-1	8/16/2022	2.3	910.9	37.2	0.6
MS5-6	8/16/2022	0.0	255.2	324.6	10
MS5-6	8/16/2022	0.1	251.4	313.8	8.4
MS5-6	8/16/2022	0.2	255.6	305.4	8.2
MS5-6	8/16/2022	0.3	261.1	256	7.4
MS5-6	8/16/2022	0.4	263.2	239.6	6.5
MS5-6	8/16/2022	0.5	265.2	215.4	5.9
MS5-6	8/16/2022	0.6	268.2	190.1	5.7
MS5-6	8/16/2022	0.7	271.3	185.7	5.6
MS5-6	8/16/2022	0.8	283.7	167	5.3
MS5-6	8/16/2022	0.9	285.7	153.3	4.6
MS5-6	8/16/2022	1.0	298.6	138.8	3.9
MS5-6	8/16/2022	1.1	290	113.7	3.4
MS5-6	8/16/2022	1.2	286.5	102.8	3.2
MS5-6	8/16/2022	1.3	297.2	97.5	2.8
MS5-6	8/16/2022	1.4	285.5	82.2	2.3
MS5-6	8/16/2022	1.5	279	67	2.3
MS5-6	8/16/2022	1.6	275.4	57.8	1.6
MS5-6	8/16/2022	1.7	270.5	53.7	1.4
MS5-6	8/16/2022	1.8	269.4	45.8	1
MS5-6	8/16/2022	1.9	270	37.3	0.9
MS5-6	8/16/2022	2.0	271.4	35	0.8
MS5-6	8/16/2022	2.1	269.2	30.7	0.7
MS5-6	8/16/2022	2.2	264.9	28	0.5
MS5-6	8/16/2022	2.3	258.5	24.3	0.4
MS5-6	8/16/2022	2.4	256.4	22.1	0.3
MS5-6	8/16/2022	2.5	255.7	20.7	0.2

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS5-6	8/16/2022	2.6	257.8	18.7	0.1
MS5-6	8/16/2022	2.7	255.5	16.8	0
MS5-6	8/16/2022	2.8	255	15.2	0
MS5-6	8/16/2022	2.9	253.6	13.1	0
MS5-7	8/16/2022	0.0	286	428.4	14.8
MS5-7	8/16/2022	0.1	570.4	1084	52.2
MS5-7	8/16/2022	0.2	866.6	1556	34.9
MS5-7	8/16/2022	0.3	522.1	749	44.9
MS5-7	8/16/2022	0.4	698	518.3	29.4
MS5-7	8/16/2022	0.5	941.2	479.3	8.7
MS5-7	8/16/2022	0.6	269.9	203.4	7.4
MS5-7	8/16/2022	0.7	308.4	382.2	16.6
MS5-7	8/16/2022	0.8	293.6	170.8	5.5
MS5-7	8/16/2022	0.9	275.4	152.8	5
MS5-7	8/16/2022	1.0	291.7	165.8	14.4
MS5-7	8/16/2022	1.1	1038	507.2	7.8
MS5-7	8/16/2022	1.2	292.7	116.4	5.9
MS5-7	8/16/2022	1.3	1139	510	15.4
MS5-7	8/16/2022	1.4	1164	447.1	15.1
MS5-7	8/16/2022	1.5	1169	394.2	13.2
MS5-7	8/16/2022	1.6	1182	351.7	10.9
MS5-7	8/16/2022	1.7	1190	319.7	9.9
MS5-7	8/16/2022	1.8	1185	271.2	6.7
MS5-7	8/16/2022	1.9	1196	199.3	4.8
MS5-7	8/16/2022	2.0	1189	181.1	4.4
MS5-7	8/16/2022	2.1	1188	159.9	4.1
MS5-7	8/16/2022	2.2	1170	120.5	3.7
MS5-7	8/16/2022	2.3	1175	114.4	3.3
MS5-7	8/16/2022	2.4	1173	103.9	3.7
MS6-3	8/17/2022	0.0	623.1	1049	31.9
MS6-3	8/17/2022	0.1	630.4	1054	31.8
MS6-3	8/17/2022	0.2	630.9	810.8	29.4
MS6-3	8/17/2022	0.3	629	812.8	25.5
MS6-3	8/17/2022	0.4	624.5	725.3	23.2
MS6-3	8/17/2022	0.5	626.9	562.2	19.3
MS6-3	8/17/2022	0.6	617.8	550.5	17.3
MS6-3	8/17/2022	0.7	618.5	471.7	15.2
MS6-3	8/17/2022	0.8	613.3	379.3	14.6
MS6-3	8/17/2022	0.9	603.1	332.2	12.9

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS6-3	8/17/2022	1.0	590.3	268.2	11.8
MS6-3	8/17/2022	1.1	591.1	250.2	10.2
MS6-3	8/17/2022	1.2	590	219.3	9.2
MS6-3	8/17/2022	1.3	595.5	201.4	8.2
MS6-3	8/17/2022	1.4	594.2	176.2	7.3
MS6-3	8/17/2022	1.5	599.4	151.4	6.8
MS6-3	8/17/2022	1.6	623.6	139.9	6.4
MS6-3	8/17/2022	1.7	624.6	127.8	5.5
MS6-3	8/17/2022	1.8	630.4	117.9	4.9
MS6-3	8/17/2022	1.9	642.7	109	4.4
MS6-3	8/17/2022	2.0	642.1	93.2	4
MS6-3	8/17/2022	2.1	642.2	85.6	3.6
MS6-3	8/17/2022	2.2	644.3	75.4	3
MS6-3	8/17/2022	2.3	635.1	71	2.8
MS6-3	8/17/2022	2.4	634.7	65.4	2.5
MS6-3	8/17/2022	2.5	636	57.9	2.3
MS6-3	8/17/2022	2.6	628.8	50.9	2
MS6-3	8/17/2022	2.7	615.1	45.6	1.8
MS6-3	8/17/2022	2.8	606.2	39.4	1.6
MS6-3	8/17/2022	2.9	601	35.3	1.5
MS6-3	8/17/2022	3.0	606.8	30.6	1.4
MS6-3	8/17/2022	3.1	612.1	28	1.3
MS6-3	8/17/2022	3.2	614.4	24.4	1.2
MS6-3	8/17/2022	3.3	623.6	22.6	1.1
MS6-3	8/17/2022	3.4	634.9	20.5	1.1
MS6-3	8/17/2022	3.5	631.3	18.7	1
MS6-3	8/17/2022	3.6	644.9	17.2	0.9
MS6-3	8/17/2022	3.7	652.1	15.6	0.8
MS6-3	8/17/2022	3.8	645.8	13.9	0.8
MS6-3	8/17/2022	3.9	647.1	12.6	0.7
MS6-3	8/17/2022	4.0	640.4	11.3	0.6
MS6-3	8/17/2022	4.1	645.2	10.1	0.6
MS6-3	8/17/2022	4.2	644.4	9.1	0.5
MS6-3	8/17/2022	4.3	643.1	8.3	0.5
MS6-3	8/17/2022	4.4	630.6	7.5	0.5
MS6-3	8/17/2022	4.5	637.9	6.6	0.4
MS6-3	8/17/2022	4.6	625.1	6	0.4
MS6-3	8/17/2022	4.7	617	5.5	0.4
MS6-3	8/17/2022	4.8	618.4	4.9	0.3

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS6-3	8/17/2022	4.9	609	4.3	0.3
MS6-3	8/17/2022	5.0	630.1	4	0.3
MS6-3	8/17/2022	5.1	621.7	3.7	0.3
MS6-3	8/17/2022	5.2	641.4	3.3	0.3
MS6-3	8/17/2022	5.3	650.5	3.1	0.3
MS6-3	8/17/2022	5.4	647.6	2.8	0.3
MS6-3	8/17/2022	5.5	644.8	2.7	0.3
MS6-3	8/17/2022	5.6	677.9	2.4	0.3
MS6-3	8/17/2022	5.7	667.5	2.2	0.3
MS6-3	8/17/2022	5.8	655.4	2.1	0.2
MS6-3	8/17/2022	5.9	664.9	1.8	0.2
MS6-3	8/17/2022	6.0	667.5	1.7	0.2
MS6-3	8/17/2022	6.1	670.6	1.5	0.2
MS6-3	8/17/2022	6.2	664.1	1.4	0.2
MS6-3	8/17/2022	6.3	666.1	1.3	0.2
MS6-3	8/17/2022	6.4	658.7	1.1	0.2
MS6-3	8/17/2022	0.0	708.2	1028	10.1
MS6-3	8/17/2022	0.1	706.4	892.7	7.2
MS6-3	8/17/2022	0.2	702.7	762.8	3.5
MS6-6-1	8/17/2022	0.0	708.2	1028	10.1
MS6-6-1	8/17/2022	0.1	706.4	892.7	7.2
MS6-6-1	8/17/2022	0.2	702.7	762.8	3.5
MS6-18A	8/17/2022	0.0	723.5	1096	19.5
MS6-18A	8/17/2022	0.1	715	960.2	17.8
MS6-18A	8/17/2022	0.2	712.2	655.3	15.5
MS6-18A	8/17/2022	0.3	712.7	820.9	12.1
MS6-18A	8/17/2022	0.4	713.1	920.6	9.5
MS6-18A	8/17/2022	0.5	717.7	982.3	6.5
MS6-18A	8/17/2022	0.6	722.3	449.2	5.7
MS7-3	8/17/2022	0.0	1226	1716	38.4
MS7-3	8/17/2022	0.1	1222	1543	40.8
MS7-3	8/17/2022	0.2	1237	1364	35.6
MS7-3	8/17/2022	0.3	1079	876.3	18.8
MS7-3	8/17/2022	0.4	873.2	520.6	10.5
MS7-3	8/17/2022	0.5	620.6	579.3	21.6
MS7-3	8/17/2022	0.6	1126	917.9	18.3
MS7-3	8/17/2022	0.7	1037	608	15.1
MS7-3	8/17/2022	0.8	828.4	478	13.7
MS7-3	8/17/2022	0.9	753.2	373.9	5.4

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS7-3	8/17/2022	1.0	489.3	214.4	5.5
MS7-3	8/17/2022	1.1	446.4	219.2	4.9
MS7-3	8/17/2022	1.2	422.4	151.2	3
MS7-3	8/17/2022	1.3	397.5	135.1	2.5
MS7-3	8/17/2022	1.4	387.2	123.1	2.3
MS7-3	8/17/2022	1.5	442.4	134.1	3.8
MS7-3	8/17/2022	1.6	882.7	278.2	6.7
MS7-3	8/17/2022	1.7	804.2	202.3	2.4
MS7-3	8/17/2022	1.8	415.8	82	1
MS7-3	8/17/2022	1.9	397.2	85.4	1.4
MS7-3	8/17/2022	2.0	519.2	122.7	1.8
MS7-3	8/17/2022	2.1	563.9	93.6	1.1
MS7-3	8/17/2022	2.2	476.6	76	0.9
MS7-3	8/17/2022	2.3	500.6	76.1	0.9
MS7-3	8/17/2022	2.4	605.6	70.9	0.7
MS7-3	8/17/2022	2.5	545.9	77.7	0.7
MS7-3	8/17/2022	2.6	684	99	0.6
MS7-7	8/17/2022	0.0	409.6	436	2.4
MS7-7	8/17/2022	0.1	414.2	469.2	1.9
MS7-7	8/17/2022	0.2	415.8	429.3	1.3
MS7-7	8/17/2022	0.3	423.9	239.7	0.9
MS7-7	8/17/2022	0.4	441.5	279.6	0.8
MS7-7	8/17/2022	0.5	466.2	289.9	0.9
MS7-7	8/17/2022	0.6	546.2	221.4	0.6
MS7-7	8/17/2022	0.7	509	168.8	0.4
MS7-10	8/17/2022	0.0	409.1	418.7	1.2
MS7-10	8/17/2022	0.1	406.8	378.5	1.3
MS7-10	8/17/2022	0.2	412.4	327	1.1
MS7-10	8/17/2022	0.3	410.1	251.1	0.8
MS7-10	8/17/2022	0.4	407	210.3	0.7
MS7-10	8/17/2022	0.5	403.4	171.7	0.4
MS7-10	8/17/2022	0.6	389	171.2	0.2
MS7-10	8/17/2022	0.7	377.1	166.3	0.1
MS8-4	8/16/2022	0.0	1060	1550	12.9
MS8-4	8/16/2022	0.1	1074	1228	11.6
MS8-4	8/16/2022	0.2	1084	953.1	9.7
MS8-4	8/16/2022	0.3	1090	748.2	8.9
MS8-4	8/16/2022	0.4	1100	900.7	8.9
MS8-4	8/16/2022	0.5	1115	786	7.6

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS8-4	8/16/2022	0.6	1116	653.5	6.6
MS8-4	8/16/2022	0.7	1117	632.7	6
MS8-4	8/16/2022	0.8	1111	400.2	4.9
MS8-4	8/16/2022	0.9	1103	454.3	4
MS8-4	8/16/2022	1.0	1097	402	2.7
MS8-4	8/16/2022	1.1	1092	363	1.9
MS8-4	8/16/2022	1.2	1084	285.3	1
MS8-4	8/16/2022	1.3	1072	243.4	0.8
MS8-4	8/16/2022	1.4	1068	236.4	0.6
MS8-6	8/16/2022	0.0	1112	1436	3.4
MS8-6	8/16/2022	0.1	1113	1058	3.4
MS8-6	8/16/2022	0.2	1109	856.9	2.3
MS8-6	8/16/2022	0.3	1108	538.3	1.6
MS8-6	8/16/2022	0.4	1104	470.2	1.3
MS8-6	8/16/2022	0.5	1090	416.1	1
MS8-6	8/16/2022	0.6	1069	353.6	0.9
MS8-6	8/16/2022	0.7	1049	304.3	0.8
MS8-6	8/16/2022	0.8	1046	279.1	0.4
MS8-6	8/16/2022	0.9	1057	220.1	0.1
MS8-6	8/16/2022	1.0	1070	202.1	0.1
MS8-6	8/16/2022	1.1	1090	162.9	0.3
MS8-6	8/16/2022	1.2	1099	163.8	0.4
MS8-6	8/16/2022	1.3	1100	157.3	0.5
MS8-6	8/16/2022	1.4	1099	130.3	0.5
MS8-6	8/16/2022	1.5	1093	87.8	0.5
MS8-6	8/16/2022	1.6	1084	90	0.5
MS8-6	8/16/2022	1.7	1070	61.9	0.6
MS8-6	8/16/2022	1.8	1048	51	0.7
MS8-6	8/16/2022	1.9	1018	43.6	0.7
MS8-6	8/16/2022	2.0	1014	39.8	0.7
MS8-6	8/16/2022	2.1	1031	34.9	0.7
MS8-6	8/16/2022	2.2	1060	30.5	0.7
MS8-6	8/16/2022	2.3	1094	29.3	0.7
MS8-6	8/16/2022	2.4	1100	25.4	0.7
MS8-6	8/16/2022	2.5	1095	20.5	0.7
MS8-6	8/16/2022	2.6	1070	17.1	0.7
MS8-7-1	8/16/2022	0.0	1018	984.5	0.5
MS8-7-1	8/16/2022	0.1	1011	115.8	0.3
MS8-7-1	8/16/2022	0.2	999.9	242.2	0.7

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

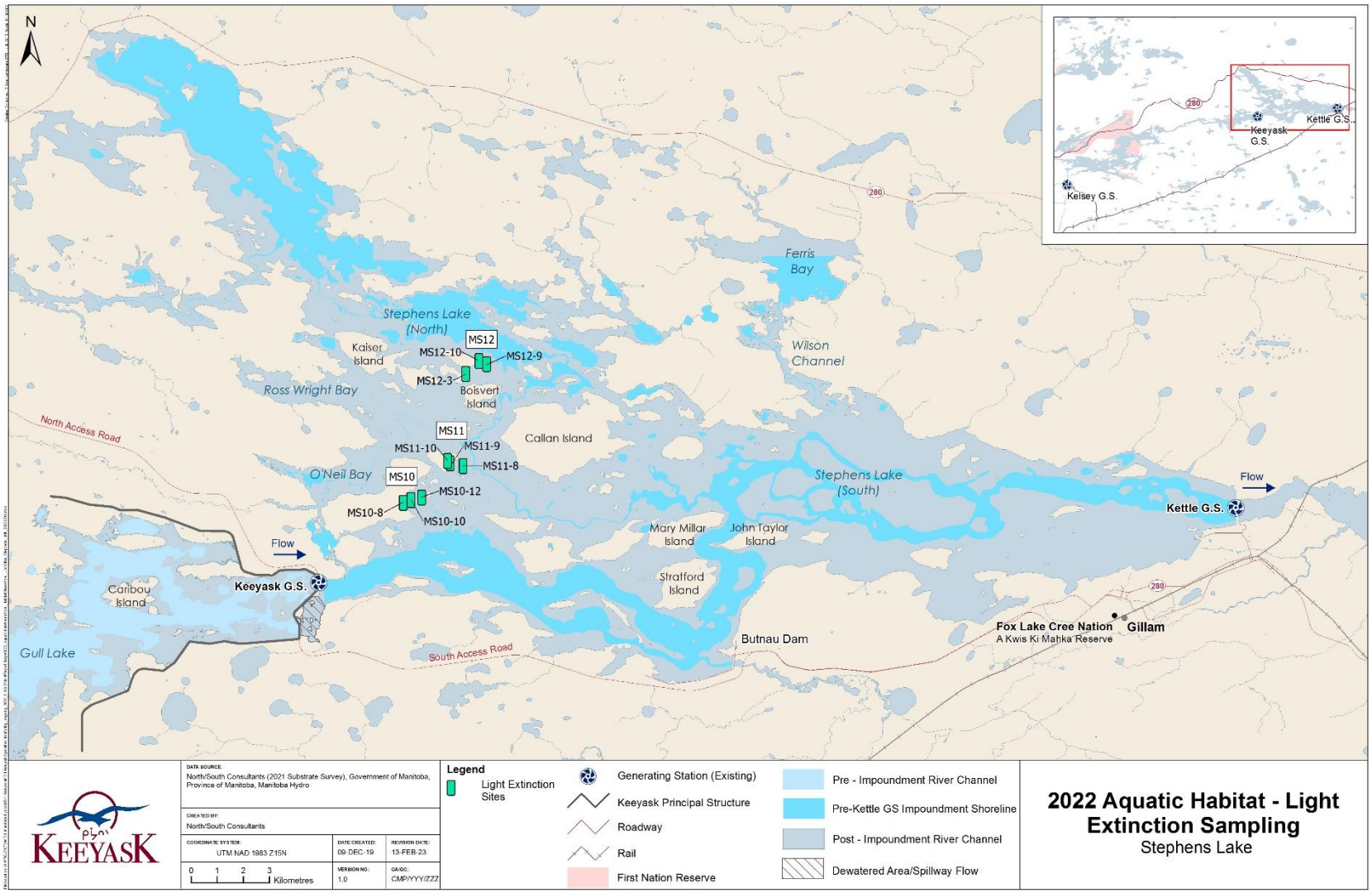
Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS8-7-1	8/16/2022	0.3	1027	398.6	0.1
MS8-7-1	8/16/2022	0.4	1054	120.1	0.6
MS8-7-1	8/16/2022	0.5	1052	62.1	0.1
MS9-9	8/14/2022	0.0	657.6	1278	44.2
MS9-9	8/14/2022	0.1	657.7	1192	37.1
MS9-9	8/14/2022	0.2	659.3	1044	30.7
MS9-9	8/14/2022	0.3	661.7	858.9	28.6
MS9-9	8/14/2022	0.4	660.9	814.4	27.2
MS9-9	8/14/2022	0.5	662.6	714.5	23.8
MS9-9	8/14/2022	0.6	663.9	591.4	18.5
MS9-9	8/14/2022	0.7	665.4	443.4	16.3
MS9-9	8/14/2022	0.8	668.5	431.5	15.7
MS9-9	8/14/2022	0.9	666.2	383.4	13.9
MS9-9	8/14/2022	1.0	669.1	321.4	12.5
MS9-9	8/14/2022	1.1	668	298.9	10.4
MS9-9	8/14/2022	1.2	670.2	252.7	9.5
MS9-9	8/14/2022	1.3	671	227.2	8.2
MS9-9	8/14/2022	1.4	668	189.6	6.7
MS9-9	8/14/2022	1.5	672.2	169.9	5.9
MS9-9	8/14/2022	1.6	672.2	151	5.3
MS9-9	8/14/2022	1.7	674.8	133.1	4.5
MS9-9	8/14/2022	1.8	674	110.9	3.8
MS9-9	8/14/2022	1.9	675.6	105.3	3.2
MS9-9	8/14/2022	2.0	678	93.8	2.7
MS9-9	8/14/2022	2.1	675.9	79.8	2.1
MS9-9	8/14/2022	2.2	680	71.2	1.8
MS9-9	8/14/2022	2.3	680.3	67.1	1.6
MS9-9	8/14/2022	2.4	679.5	58.5	1
MS9-9	8/14/2022	2.5	679.5	53.7	0.8
MS9-9	8/14/2022	2.6	681.9	47	0.6
MS9-9	8/14/2022	2.7	685.8	41.6	0.3
MS9-9	8/14/2022	2.8	686.5	36.6	0.1
MS9-9	8/14/2022	2.9	687.7	32.1	0.1
MS9-9	8/14/2022	3.0	687.5	30.3	0
MS9-9	8/14/2022	3.1	689.8	25.2	0.2
MS9-9	8/14/2022	3.2	691	22.5	0.3
MS9-11	8/14/2022	0.0	661.2	1555	51.3
MS9-11	8/14/2022	0.1	677.6	1408	44
MS9-11	8/14/2022	0.2	680.8	1284	41.5

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS9-11	8/14/2022	0.3	683.1	1127	38.5
MS9-11	8/14/2022	0.4	687	987.4	34.2
MS9-11	8/14/2022	0.5	689.4	870.2	29.6
MS9-11	8/14/2022	0.6	691	770.4	25.3
MS9-11	8/14/2022	0.7	693.1	645.4	22.8
MS9-11	8/14/2022	0.8	694.6	563.1	19.7
MS9-11	8/14/2022	0.9	697.1	485.6	17.1
MS9-11	8/14/2022	1.0	696.7	430	14
MS9-11	8/14/2022	1.1	697.5	385.1	11.2
MS9-11	8/14/2022	1.2	698.6	334.7	9.5
MS9-11	8/14/2022	1.3	697.8	295.4	8.2
MS9-11	8/14/2022	1.4	703.1	254.9	6.4
MS9-11	8/14/2022	1.5	704	222.6	5.1
MS9-11	8/14/2022	1.6	704.5	193.5	3.9
MS9-11	8/14/2022	1.7	706	165.9	2.5
MS9-11	8/14/2022	1.8	706.2	142.3	0.5
MS9-15	8/14/2022	0.0	906.3	1440	47
MS9-15	8/14/2022	0.1	908.6	1369	42.8
MS9-15	8/14/2022	0.2	908.4	1140	37.3
MS9-15	8/14/2022	0.3	908.4	1102	33.5
MS9-15	8/14/2022	0.4	905.3	992.2	29.5
MS9-15	8/14/2022	0.5	903.8	877.1	26.4
MS9-15	8/14/2022	0.6	898.4	793.2	23.2
MS9-15	8/14/2022	0.7	890.3	673.4	20.8
MS9-15	8/14/2022	0.8	883.7	616.4	18.2
MS9-15	8/14/2022	0.9	865.3	544.8	16
MS9-15	8/14/2022	1.0	849.8	482.3	13.1
MS9-15	8/14/2022	1.1	842.3	419.2	11.1
MS9-15	8/14/2022	1.2	836	375.8	10
MS9-15	8/14/2022	1.3	840.3	336.9	8.6
MS9-15	8/14/2022	1.4	840.9	305.4	7.4
MS9-15	8/14/2022	1.5	842.2	268.1	6.5
MS9-15	8/14/2022	1.6	846	232.7	5.5
MS9-15	8/14/2022	1.7	849	211.7	4.8
MS9-15	8/14/2022	1.8	851.5	187.9	4.1
MS9-15	8/14/2022	1.9	856.4	162.2	3.6
MS9-15	8/14/2022	2.0	859.8	140.1	3
MS9-15	8/14/2022	2.1	859.3	121.5	2.2
MS9-15	8/14/2022	2.2	854.2	112	1.8

Table A2-2: Light extinction downloaded readings from pre-selected sites in the Keeyask reservoir, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS9-15	8/14/2022	2.3	848.8	104.7	1.3
MS9-15	8/14/2022	2.4	849.4	87.2	1
MS9-15	8/14/2022	2.5	847.8	79.8	0.7
MS9-15	8/14/2022	2.6	842	71.8	0.4
MS9-15	8/14/2022	2.7	837.8	61.4	0.2
MS9-15	8/14/2022	2.8	836.1	52.6	0.1
MS9-15	8/14/2022	2.9	834	44.4	0
MS9-15	8/14/2022	3.0	832.3	40.8	0.1
MS9-15	8/14/2022	3.1	827.3	36.2	0.2



Map A2-3: Map illustrating pre-selected light extinction sampling sites in Stephens Lake, August 2022.

Table A2-4: Light extinction downloaded readings from pre-selected sites in the Northern portion of Stephens Lake, 2022.

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS10-8	8/15/2022	0.0	1131	2006	75.9
MS10-8	8/15/2022	0.1	1123	1597	69.5
MS10-8	8/15/2022	0.2	1122	1940	60.5
MS10-8	8/15/2022	0.3	1117	1497	58.7
MS10-8	8/15/2022	0.4	1098	1326	52
MS10-8	8/15/2022	0.5	1079	1071	43
MS10-8	8/15/2022	0.6	1080	916	32.7
MS10-8	8/15/2022	0.7	1085	680.5	29.5
MS10-8	8/15/2022	0.8	1092	591.3	25.2
MS10-8	8/15/2022	0.9	1097	444	21.4
MS10-8	8/15/2022	1.0	1105	442.3	17.6
MS10-8	8/15/2022	1.1	1118	432.5	20
MS10-8	8/15/2022	1.2	1119	414.6	21.9
MS10-8	8/15/2022	1.3	1118	334.7	22
MS10-10	8/15/2022	0.0	1248	2111	89.7
MS10-10	8/15/2022	0.1	1282	1806	66.2
MS10-10	8/15/2022	0.2	591.2	623.6	22.9
MS10-10	8/15/2022	0.3	534.8	1151	61.4
MS10-10	8/15/2022	0.4	1305	1467	60
MS10-10	8/15/2022	0.5	1362	1360	49.8
MS10-10	8/15/2022	0.6	1010	1367	26.1
MS10-10	8/15/2022	0.7	475.8	345.4	25.1
MS10-10	8/15/2022	0.8	577.4	253.4	10.3
MS10-10	8/15/2022	0.9	362	191.2	9
MS10-10	8/15/2022	1.0	363.2	175.9	8.4
MS10-10	8/15/2022	1.1	375.5	144.3	9.9
MS10-10	8/15/2022	1.2	726.8	519.1	25.5
MS10-10	8/15/2022	1.3	1232	473	23
MS10-10	8/15/2022	1.4	1207	400.7	19.1
MS10-10	8/15/2022	1.5	1255	320.3	17.4
MS10-10	8/15/2022	1.6	1285	367.6	14.6
MS10-10	8/15/2022	1.7	1289	264	13.9
MS10-10	8/15/2022	1.8	1255	244.7	12.4
MS10-10	8/15/2022	1.9	1219	216.9	11.1
MS10-10	8/15/2022	2.0	1184	199.3	10.4
MS10-10	8/15/2022	2.1	1201	179.4	9.1
MS10-10	8/15/2022	2.2	1210	164.6	8.1
MS10-10	8/15/2022	2.3	1244	139	7.3
MS10-10	8/15/2022	2.4	1267	118.3	6.2

Table A2-4: Light extinction downloaded readings from pre-selected sites in the Northern portion of Stephens Lake, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS10-10	8/15/2022	2.5	1256	105.3	6
MS10-10	8/15/2022	2.6	1224	95.8	5.3
MS10-10	8/15/2022	2.7	1198	88.8	4.9
MS10-10	8/15/2022	2.8	1156	78.9	4.5
MS10-10	8/15/2022	2.9	1159	70.6	4
MS10-10	8/15/2022	3.0	1154	63.9	3.8
MS10-10	8/15/2022	3.1	1183	54.8	3.5
MS10-10	8/15/2022	3.2	1201	48.8	3.1
MS10-10	8/15/2022	3.3	1222	42.9	3
MS10-10	8/15/2022	3.4	1225	36.3	2.9
MS10-12	8/15/2022	0.0	1233	2034	89.7
MS10-12	8/15/2022	0.1	1245	1796	82.6
MS10-12	8/15/2022	0.2	1206	1607	77.9
MS10-12	8/15/2022	0.3	1106	1209	59.4
MS10-12	8/15/2022	0.4	1052	1522	60.7
MS10-12	8/15/2022	0.5	1246	1418	53.6
MS10-12	8/15/2022	0.6	1216	1167	48.4
MS10-12	8/15/2022	0.7	1233	917.1	42.7
MS10-12	8/15/2022	0.8	1242	924.4	39.3
MS10-12	8/15/2022	0.9	1240	810.3	37.1
MS10-12	8/15/2022	1.0	1264	741.6	30
MS10-12	8/15/2022	1.1	1214	412.6	13.1
MS10-12	8/15/2022	1.2	805.3	474.3	26.4
MS10-12	8/15/2022	1.3	830.7	157.9	6.5
MS10-12	8/15/2022	1.4	370.8	87.7	4.6
MS10-12	8/15/2022	1.5	314.7	79.8	4.1
MS10-12	8/15/2022	1.6	310.5	70.3	3.7
MS10-12	8/15/2022	1.7	307.4	67.6	3.6
MS10-12	8/15/2022	1.8	319.9	64.7	3.7
MS10-12	8/15/2022	1.9	354.3	61.8	3.4
MS10-12	8/15/2022	2.0	370.9	63.1	4.2
MS10-12	8/15/2022	2.1	537	158.5	8.5
MS10-12	8/15/2022	2.2	1235	176.7	9.5
MS10-12	8/15/2022	2.3	1281	150.6	8.3
MS10-12	8/15/2022	2.4	1277	136.7	7.4
MS10-12	8/15/2022	2.5	1277	123.6	6.4
MS10-12	8/15/2022	2.6	1276	112.6	5.6
MS10-12	8/15/2022	2.7	1279	98.6	5.2
MS10-12	8/15/2022	2.8	1277	88.1	4.7

Table A2-4: Light extinction downloaded readings from pre-selected sites in the Northern portion of Stephens Lake, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS10-12	8/15/2022	2.9	1279	78.4	4.4
MS10-12	8/15/2022	3.0	1282	70	3.9
MS10-12	8/15/2022	3.1	1280	63.1	3.6
MS10-12	8/15/2022	3.2	1257	56.9	3.3
MS10-12	8/15/2022	3.3	1216	49.3	3
MS10-12	8/15/2022	3.4	1256	45.5	2.8
MS10-12	8/15/2022	3.5	1277	41.5	2.6
MS10-12	8/15/2022	3.6	1264	35	2.3
MS10-12	8/15/2022	3.7	1268	31.5	2.2
MS10-12	8/15/2022	3.8	1264	29.9	2
MS10-12	8/15/2022	3.9	1269	24.8	1.9
MS10-12	8/15/2022	4.0	933.8	12.2	1
MS10-12	8/15/2022	4.1	453.3	7.9	1.1
MS10-12	8/15/2022	4.2	874.2	5.6	0.9
MS10-12	8/15/2022	4.3	1031	13.8	1.4
MS10-12	8/15/2022	4.4	1264	13.7	1.4
MS10-12	8/15/2022	4.5	1289	12.9	1.3
MS10-12	8/15/2022	4.6	473	5.9	0.9
MS10-12	8/15/2022	4.7	707.8	7.3	1
MS10-12	8/15/2022	4.8	963.4	6.2	0.9
MS10-12	8/15/2022	4.9	635.4	2.8	0.7
MS10-12	8/15/2022	5.0	471	3	0.7
MS10-12	8/15/2022	5.1	656.5	2.3	0.7
MS10-12	8/15/2022	5.2	673.9	4.4	0.9
MS10-12	8/15/2022	5.3	1230	4.4	0.8
MS10-12	8/15/2022	5.4	1150	3	0.7
MS10-12	8/15/2022	5.5	666.6	3.4	0.8
MS10-12	8/15/2022	5.6	1026	2.2	0.7
MS10-12	8/15/2022	5.7	677	0.7	0.7
MS10-12	8/15/2022	5.8	1202	1.4	0.7
MS10-12	8/15/2022	5.9	691	0.7	0.7
MS10-12	8/15/2022	6.0	1100	1.9	0.7
MS10-12	8/15/2022	6.1	1243	1.6	0.7
MS10-12	8/15/2022	6.2	1215	1.5	0.7
MS10-12	8/15/2022	6.3	1217	1.3	0.7
MS10-12	8/15/2022	6.4	1233	1.2	0.7
MS10-12	8/15/2022	6.5	1254	1.1	0.7
MS10-12	8/15/2022	6.6	1262	1	0.7
MS10-12	8/15/2022	6.7	1239	0.9	0.7

Table A2-4: Light extinction downloaded readings from pre-selected sites in the Northern portion of Stephens Lake, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS10-12	8/15/2022	6.8	1259	0.8	0.7
MS10-12	8/15/2022	6.9	1268	0.7	0.7
MS10-12	8/15/2022	7.0	1305	0.6	0.7
MS10-12	8/15/2022	7.1	828.8	0.2	0.6
MS10-12	8/15/2022	7.2	381.5	0.1	0.6
MS10-12	8/15/2022	7.3	344.4	0	0.6
MS10-12	8/15/2022	7.4	343.1	0.1	0.6
MS10-12	8/15/2022	7.5	449.3	0.1	0.6
MS11-8	8/15/2022	0.0	975.4	1740	74.7
MS11-8	8/15/2022	0.1	976	1521	66.4
MS11-8	8/15/2022	0.2	988.1	1673	58.9
MS11-8	8/15/2022	0.3	994.5	1267	50.8
MS11-8	8/15/2022	0.4	1012	1115	45.7
MS11-8	8/15/2022	0.5	1023	1001	40.3
MS11-8	8/15/2022	0.6	1054	898.9	35.1
MS11-8	8/15/2022	0.7	1059	946.8	32.9
MS11-8	8/15/2022	0.8	1063	756.3	29.5
MS11-8	8/15/2022	0.9	1060	649.3	26.1
MS11-8	8/15/2022	1.0	1058	585.3	22.9
MS11-8	8/15/2022	1.1	1048	540	21.1
MS11-8	8/15/2022	1.2	1031	496	19
MS11-8	8/15/2022	1.3	1017	440	17
MS11-8	8/15/2022	1.4	880.7	253.4	9
MS11-8	8/15/2022	1.5	983.7	341.3	13.6
MS11-8	8/15/2022	1.6	920.4	194.6	7.3
MS11-8	8/15/2022	1.7	916.9	249.4	11
MS11-8	8/15/2022	1.8	1043	224.1	10.3
MS11-8	8/15/2022	1.9	1061	206.2	9.8
MS11-8	8/15/2022	2.0	1072	182.9	7.8
MS11-8	8/15/2022	2.1	1074	163.1	6.8
MS11-8	8/15/2022	2.2	1073	147	6
MS11-8	8/15/2022	2.3	1068	130.2	5.4
MS11-8	8/15/2022	2.4	1064	115.8	4.9
MS11-8	8/15/2022	2.5	1057	105.1	4.6
MS11-8	8/15/2022	2.6	1058	90.2	4.1
MS11-8	8/15/2022	2.7	1054	81.2	3.6
MS11-8	8/15/2022	2.8	1054	76.2	3.2
MS11-8	8/15/2022	2.9	1049	68.7	2.9
MS11-8	8/15/2022	3.0	1040	60	2.6

Table A2-4: Light extinction downloaded readings from pre-selected sites in the Northern portion of Stephens Lake, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS11-8	8/15/2022	3.1	1046	53.5	2.3
MS11-8	8/15/2022	3.2	1046	49.2	2.1
MS11-8	8/15/2022	3.3	1038	44.6	1.9
MS11-8	8/15/2022	3.4	1030	39.2	1.7
MS11-8	8/15/2022	3.5	1038	35.5	1.5
MS11-8	8/15/2022	3.6	1024	30.3	1.5
MS11-8	8/15/2022	3.7	1001	27.8	1.3
MS11-8	8/15/2022	3.8	987	26	1.2
MS11-8	8/15/2022	3.9	988.4	24.4	1.2
MS11-9	8/15/2022	0.0	993.2	1611	51.7
MS11-9	8/15/2022	0.1	988.4	1438	53
MS11-9	8/15/2022	0.2	1005	1590	47.9
MS11-9	8/15/2022	0.3	1042	1208	43
MS11-9	8/15/2022	0.4	1100	1126	35.2
MS11-9	8/15/2022	0.5	1145	1049	34.1
MS11-9	8/15/2022	0.6	1088	809.2	21.9
MS11-9	8/15/2022	0.7	1058	500.9	20.6
MS11-9	8/15/2022	0.8	1028	566.1	18.2
MS11-9	8/15/2022	0.9	998.4	454.7	15.2
MS11-9	8/15/2022	1.0	979.4	343.2	13.5
MS11-9	8/15/2022	1.1	975	262.8	12
MS11-9	8/15/2022	1.2	954.7	139.7	9.7
MS11-9	8/15/2022	1.3	922.8	151.5	6.5
MS11-9	8/15/2022	1.4	962.6	189.2	9
MS11-9	8/15/2022	1.5	996.4	196.1	8.5
MS11-9	8/15/2022	1.6	1030	176.1	7.9
MS11-9	8/15/2022	1.7	1067	157.1	6.8
MS11-10	8/15/2022	0.0	1079	1695	53.5
MS11-10	8/15/2022	0.1	1082	1672	46.2
MS11-10	8/15/2022	0.2	1075	1290	35.3
MS11-10	8/15/2022	0.3	1077	476.3	25
MS11-10	8/15/2022	0.4	1084	372.6	26.2
MS11-10	8/15/2022	0.5	1084	642.5	35.1
MS11-10	8/15/2022	0.6	1075	970.9	32.3
MS11-10	8/15/2022	0.7	1077	769	30.7
MS11-10	8/15/2022	0.8	1088	492.4	25.1
MS11-10	8/15/2022	0.9	1083	399	24.5
MS11-10	8/15/2022	1.0	1082	167.4	13.9
MS11-10	8/15/2022	1.1	1087	157.6	13.3

Table A2-4: Light extinction downloaded readings from pre-selected sites in the Northern portion of Stephens Lake, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS11-10	8/15/2022	1.2	1074	220.1	13.8
MS12-3	8/15/2022	0.0	1712.3	1402	43.5
MS12-3	8/15/2022	0.1	1714.3	996.4	38.8
MS12-3	8/15/2022	0.2	713.3	967.4	34.8
MS12-3	8/15/2022	0.3	702.7	961.2	32
MS12-3	8/15/2022	0.4	705.5	759.6	27.4
MS12-3	8/15/2022	0.5	713.3	710.4	24.3
MS12-3	8/15/2022	0.6	721.6	586.8	21.1
MS12-3	8/15/2022	0.7	715.9	511	18.5
MS12-3	8/15/2022	0.8	704.7	444.1	16.3
MS12-3	8/15/2022	0.9	707.5	422.1	14.8
MS12-3	8/15/2022	1.0	720.4	397.2	14.1
MS12-3	8/15/2022	1.1	720	318.8	12.4
MS12-3	8/15/2022	1.2	725.5	280.9	11.2
MS12-3	8/15/2022	1.3	718.5	243.4	10.1
MS12-3	8/15/2022	1.4	713.9	207	8.6
MS12-3	8/15/2022	1.5	713.1	192.2	7.9
MS12-3	8/15/2022	1.6	718.3	170	6.9
MS12-3	8/15/2022	1.7	728.5	152.8	5.8
MS12-3	8/15/2022	1.8	734.8	136.3	5.1
MS12-3	8/15/2022	1.9	733.3	122.8	4.4
MS12-3	8/15/2022	2.0	723.9	109.9	3.9
MS12-3	8/15/2022	2.1	733	98.6	3.7
MS12-3	8/15/2022	2.2	725.2	88.6	4
MS12-9	8/15/2022	0.0	747.7	1230	57.7
MS12-9	8/15/2022	0.1	751	1150	50.8
MS12-9	8/15/2022	0.2	751.3	1129	46.4
MS12-9	8/15/2022	0.3	751.3	993.4	42.1
MS12-9	8/15/2022	0.4	751.7	867.3	38.1
MS12-9	8/15/2022	0.5	754.9	760.7	33.2
MS12-9	8/15/2022	0.6	757.6	705.7	28.8
MS12-9	8/15/2022	0.7	758.8	607.2	26.3
MS12-9	8/15/2022	0.8	760.1	550.8	23.8
MS12-9	8/15/2022	0.9	759	489.4	21.6
MS12-9	8/15/2022	1.0	758	424.7	18.9
MS12-9	8/15/2022	1.1	755	389.3	16.8
MS12-9	8/15/2022	1.2	757.2	350.9	15
MS12-9	8/15/2022	1.3	758.8	303.1	13.3
MS12-9	8/15/2022	1.4	760.4	271.4	12

Table A2-4: Light extinction downloaded readings from pre-selected sites in the Northern portion of Stephens Lake, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS12-9	8/15/2022	1.5	763.3	241.3	11
MS12-9	8/15/2022	1.6	764.5	212.6	9.8
MS12-9	8/15/2022	1.7	765.7	186.3	8.7
MS12-9	8/15/2022	1.8	766.5	165.3	7.8
MS12-9	8/15/2022	1.9	764.9	143	7.1
MS12-9	8/15/2022	2.0	763.5	125.9	6.5
MS12-9	8/15/2022	2.1	764.9	109.5	5.8
MS12-9	8/15/2022	2.2	765	99.8	5.3
MS12-9	8/15/2022	2.3	766.6	90.6	4.7
MS12-9	8/15/2022	2.4	767.2	81.1	4.1
MS12-9	8/15/2022	2.5	768.7	73.6	3.7
MS12-9	8/15/2022	2.6	767.8	64.1	3.4
MS12-9	8/15/2022	2.7	767.3	58.3	3.1
MS12-9	8/15/2022	2.8	768.4	53.3	2.7
MS12-9	8/15/2022	2.9	765.3	48.3	2.4
MS12-9	8/15/2022	3.0	769.5	42	2.1
MS12-9	8/15/2022	3.1	763.8	38.5	2
MS12-9	8/15/2022	3.2	758.6	34.2	1.8
MS12-9	8/15/2022	3.3	756.4	29	1.7
MS12-9	8/15/2022	3.4	752.8	25.6	1.5
MS12-9	8/15/2022	3.5	753.1	23	1.4
MS12-9	8/15/2022	3.6	758.3	21.5	1.1
MS12-9	8/15/2022	3.7	758	19.5	1.1
MS12-9	8/15/2022	3.8	759.7	17.7	1
MS12-9	8/15/2022	3.9	763.9	16.6	0.9
MS12-9	8/15/2022	4.0	766.8	14.3	0.8
MS12-9	8/15/2022	4.1	769.1	13.2	0.7
MS12-9	8/15/2022	4.2	774.5	12.1	0.7
MS12-9	8/15/2022	4.3	780.3	10.8	0.6
MS12-9	8/15/2022	4.4	782.4	9.9	0.6
MS12-9	8/15/2022	4.5	784.7	9.1	0.5
MS12-9	8/15/2022	4.6	785.9	8.4	0.5
MS12-9	8/15/2022	4.7	782.4	7.5	0.4
MS12-9	8/15/2022	4.8	784.4	6.7	0.4
MS12-9	8/15/2022	4.9	786.9	6.1	0.3
MS12-9	8/15/2022	5.0	785.8	5.5	0.3
MS12-9	8/15/2022	5.1	787	5.1	0.3
MS12-9	8/15/2022	5.2	788.1	4.5	0.3
MS12-9	8/15/2022	5.3	788.5	3.9	0.2

Table A2-4: Light extinction downloaded readings from pre-selected sites in the Northern portion of Stephens Lake, 2022 (continued).

Site ID	Date	Depth (m)	Air (I1)	Sphere (I2)	Flat (I3)
MS12-9	8/15/2022	5.4	787.2	3.7	0.2
MS12-9	8/15/2022	5.5	788.6	3.4	0.2
MS12-9	8/15/2022	5.6	789.1	3	0.2
MS12-9	8/15/2022	5.7	789	2.7	0.2
MS12-9	8/15/2022	5.8	790.1	2.6	0.2
MS12-9	8/15/2022	5.9	790.4	2.3	0.1
MS12-10	8/15/2022	0.0	642.2	1274	45.4
MS12-10	8/15/2022	0.1	633	1104	40.5
MS12-10	8/15/2022	0.2	645.3	1036	34.3
MS12-10	8/15/2022	0.3	635.2	948.3	31.8
MS12-10	8/15/2022	0.4	649.8	837.6	30
MS12-10	8/15/2022	0.5	643	736.3	26.7
MS12-10	8/15/2022	0.6	643.8	666.9	24
MS12-10	8/15/2022	0.7	647.6	564.3	20.5
MS12-10	8/15/2022	0.8	646	514.6	19.5
MS12-10	8/15/2022	0.9	638.6	447.3	16.1
MS12-10	8/15/2022	1.0	641.5	385.2	14.8
MS12-10	8/15/2022	1.1	643.7	344.9	13.1
MS12-10	8/15/2022	1.2	640.2	306.2	12
MS12-10	8/15/2022	1.3	647.3	273.2	10.8
MS12-10	8/15/2022	1.4	645	240.8	9.8
MS12-10	8/15/2022	1.5	645.9	214	8.8
MS12-10	8/15/2022	1.6	651.4	192	7.9
MS12-10	8/15/2022	1.7	652.2	165.4	7.2
MS12-10	8/15/2022	1.8	656.6	153.2	6.7
MS12-10	8/15/2022	1.9	661.1	132.5	6.1
MS12-10	8/15/2022	2.0	664.2	118	5.9
MS12-10	8/15/2022	2.1	666.6	102.8	5.5
MS12-10	8/15/2022	2.2	665.7	92.2	4.6