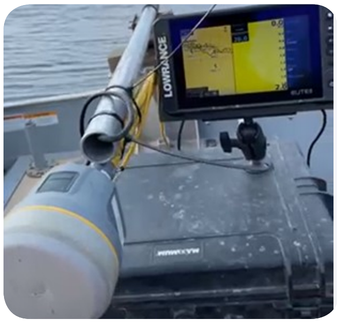
Keeyask Generation Project

Aquatic Effects Monitoring Plan

Deep Water and Constructed Habitat Monitoring Report

AEMP-2024-12



KEEYASK

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

2023 - 2024

KEEYASK GENERATION PROJECT

AQUATIC EFFECTS MONITORING PLAN

REPORT #AEMP-2024-12

DEEP WATER AND CONSTRUCTED HABITAT MONITORING IN THE KEEYASK STUDY AREA, 2023

Prepared for

Manitoba Hydro

by

S.M. Morrison and C.L. Hrenchuk

June 2024

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

This report should be cited as:

Morrison, S.M., and C.L. Hrenchuk. 2024. Deep water and constructed habitat monitoring in the Keeyask Study Area, 2023. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2024-12. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2024. xix + 104 pp.

SUMMARY

Background

The Keeyask Hydropower Limited Partnership (KHLP) was required to prepare a plan to monitor the effects of construction and operation of the Keeyask Generating Station (GS) on the environment. Monitoring results provide information to assess the accuracy of predictions, information to determine the actual effects of construction and operation of the GS on the environment, and whether 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 is the environment in which aquatic organisms live. The monitoring of aquatic habitat after construction of the generating station is an important part of the overall plan to monitor the impacts of construction and operation of the Keeyask GS on aquatic life including fish. Some habitats are especially important for fish species to complete their life cycles, such as places to spawn and places where larval fish can grow. Some of these habitats were lost or changed with reservoir impoundment and operation of the generating station.

Deep water, offshore areas provide important feeding and rearing habitat for many fish species including whitefish and Lake Sturgeon. Substrate types (what the bottom is made of) in these offshore habitats are often important because fish species seek out certain areas. For example, juvenile Lake Sturgeon are found more in deep areas with sand or gravel substrates than with fine silty substrates.

Several studies were conducted in the Keeyask area before construction of the Keeyask GS that identified areas that were important for Lake Sturgeon (called sensitive habitats). These areas include places where young-of-the-year (YOY) Lake Sturgeon can grow (such as the channel around Caribou Island in lower Gull Lake) and areas where Lake Sturgeon spawn (such as at Birthday Rapids [see map below]). Impoundment of the Keeyask reservoir in fall 2020 changed water depth and flows at Birthday Rapids where Lake Sturgeon spawn. Flooding also changed depths and flows in areas important for YOY Lake Sturgeon. Construction of the GS eliminated Gull Rapids and changed flows downstream. It is expected that changes in flows upstream and downstream of the Keeyask GS will cause shifts in the types of substrates found in deepwater areas.

Construction of the Keeyask GS also changed spawning habitats used by other fish species including pickerel and whitefish. Rocky spawning shoals were built upstream of the GS before

reservoir impoundment to provide additional areas for these species to spawn after flooding (see map below).

This report presents the results of habitat monitoring conducted at constructed spawning shoals and deepwater sites, including areas identified as sensitive Lake Sturgeon habitats in the Keeyask reservoir and Stephens Lake during the third year post-impoundment.

Why is the study being done?

Habitat monitoring at deep water and constructed habitats is being done to answer several questions:

Will Birthday Rapids continue to provide spawning habitat for Lake Sturgeon?

This question is important because if Lake Sturgeon do not have a place to spawn in the Keeyask reservoir, the population will decrease.

Will sand and gravel continue to be present in the river upstream and downstream of the GS where it is accessible to YOY Lake Sturgeon?

YOY Lake Sturgeon are commonly found in areas of low water velocity over sand and gravel bottom. Impoundment of the reservoir and operation of the GS will change flow patterns, which may change the areas where sand and gravel is present in the riverbed both upstream and downstream of the GS. It is important to determine the effect of impoundment on these habitats to determine if YOY Lake Sturgeon have enough of the habitat that they need to survive and grow.

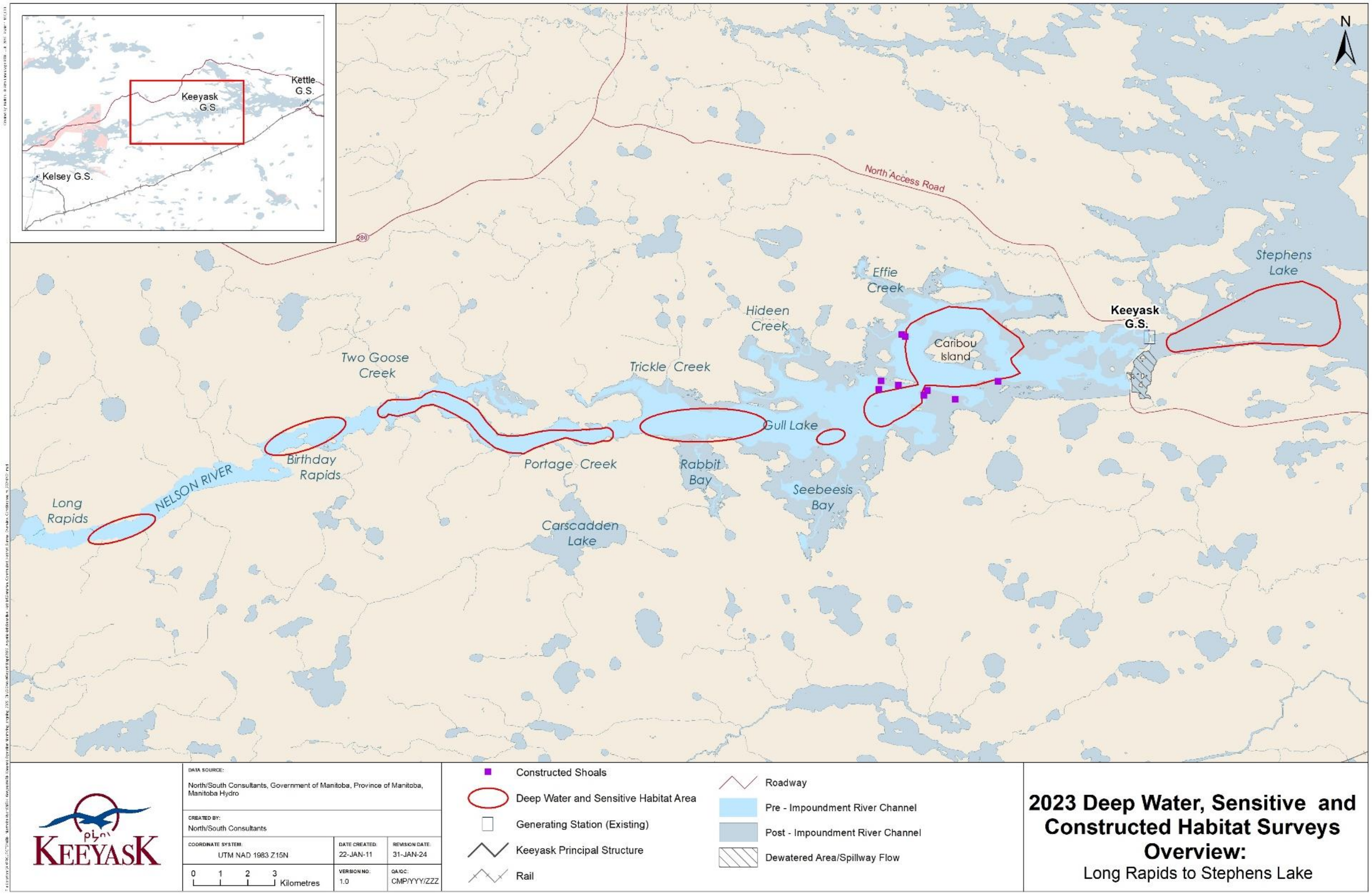
If sand and gravel are no longer present in the areas where they used to be, what are the substrates that develop in their place?

This question is important because it will help us to understand where sand and silt settle on the bottom of the reservoir and downstream of the Keeyask GS. Different fish species use different habitats, and knowing what substrates there are will help determine what types of fish will use these areas.

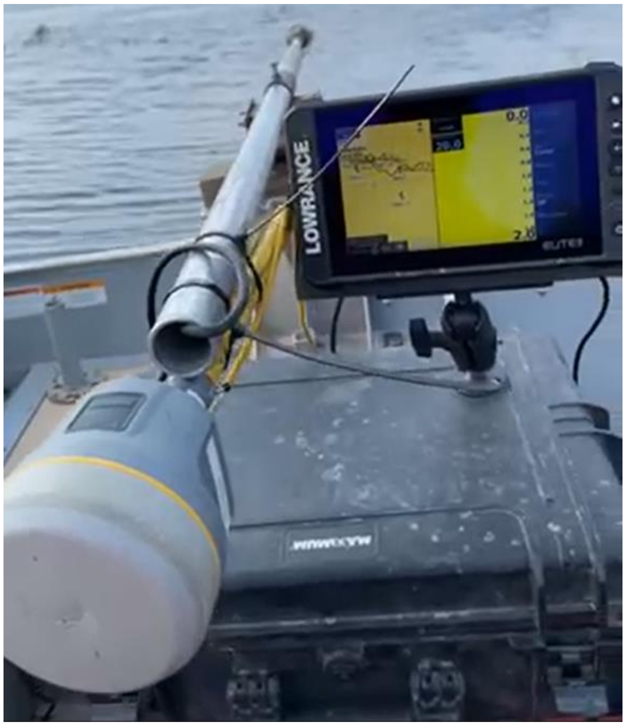
Habitat monitoring at constructed habitat is being done to answer an additional question:

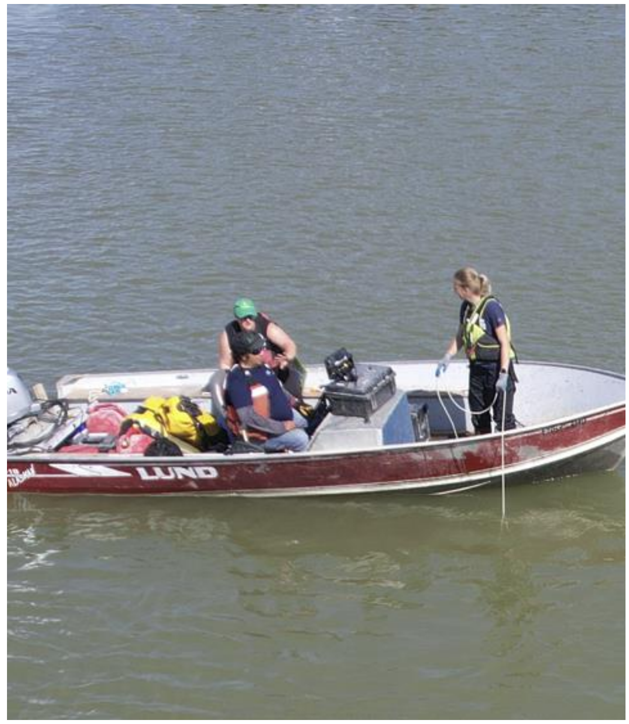
Is the habitat at the constructed areas (i.e., water velocity and depth, and substrate) as it was constructed, or does it change over time?

This question is important to make sure that the shoals continue to provide the types of habitats that fish need to spawn and feed.



Map of the study area for the deep water and constructed habitat monitoring in the Keeyask reservoir and Stephens Lake in 2023.





Setup of acoustic equipment (left) and Ponar dredge substrate sampling (right) used to monitor deep water and constructed habitats in the Keeyask reservoir and Stephens Lake in 2023.

What was done?

Five sensitive Lake Sturgeon habitat areas including four upstream of the Keeyask GS and one downstream were monitored in 2023. These included areas downstream of Long and Birthday rapids, at the entrance to Gull Lake, in lower Gull Lake around Caribou Island, and in the upstream portion of Stephens Lake (see study area map above). Two deep water areas in the fast channel of the middle Keeyask reservoir and in upper Gull Lake were also sampled. Substrate composition (what the bottom is made of) information was collected and measurements of how deep and fast the water were taken in each area. Substrate type was identified in each area by using a Ponar dredge (to grab a sample of the bottom), a sounding line (to hear or feel if the bottom is rocky or soft), and a sonar (to take a picture of the bottom).

Nine constructed spawning shoals in the Keeyask reservoir were also monitored for water velocity and substrate (see map above). These areas were monitored in the same way as sensitive habitat, but because they were constructed in a certain way, a multibeam sonar was used to get a more detailed picture of the shoals to see if they have remained as they were constructed.

What was found?

Sampling in 2023 was the third year of monitoring after the Keeyask reservoir was impounded. Flows (how much water is entering the Keeyask reservoir) were different in all three of these monitoring years. Flows were very low in 2021, measuring near or lower than 5th percentile (meaning less than 5% of flows measured have been below this level). In contrast, near record high flows were seen in 2022, measuring above 95th percentile (meaning these flows were higher than nearly all the flows previously measured). Flows in 2023 were around average. Monitoring over a range of flow conditions show how habitats change in offshore areas depending on different flow conditions.

The areas downstream of Long Rapids and Birthday Rapids as well as the middle of the Keeyask reservoir had mostly hard rocky substrates including bedrock and boulder. Water velocities were medium to high. Although water velocities changed somewhat (based on inflows, *i.e.*, faster in high water years than low water years), the habitat in these areas did not change much between 2021 and 2023.

In 2023, most substrate found within the sampling area at the entrance to Gull Lake were rock, though finer substrates were also present, covering a total of 31% of the area. These finer substrates included a mix of silt, clay, and sand (18% of the area), a mix of gravel and sand (9%) and sand (4%). The area covered by fine substrates has increased from 2021, when no substrates finer than sand were found, and from 2022 when a mix of silt, clay, and sand was found on only 2% of the area.

Substrates in the sampling area of lower Gull Lake around Caribou Island changed little over the three sampling years. An area of sand substrate was still present within the middle of the channel to the north of Caribou Island in 2023, surrounded by mud (*i.e.*, silt and clay) in off-channel areas. Upstream and downstream of this sandy area the channel was generally rocky. Silt was found on the surface over the sand at two of six sites sampled.

Immediately downstream of the Keeyask GS, water velocities were moderate, and substrates were rocky until about 3.5 km downstream where water velocities became lower, and areas of sand and mud were found. Substrates in the area where YOY and juvenile Lake Sturgeon are found 4–7 km downstream of the Keeyask GS were different in the upstream and downstream parts. Hard rocky substrates were found mostly in the upstream portion, where the water velocity was greater. Farther downstream, the substrate largely consisted of a mix of clay, sand, and organic matter (broken down plants). Some silt deposition was found in all sampling years. Habitat in this area did not change much between 2021 and 2023.

Constructed shoals in the Keeyask reservoir are all in areas of low water velocity in the lower reservoir. The constructed shoals were built of rock before the Keeyask reservoir was flooded. In 2023, all nine constructed shoals had areas where organic matter (broken down plants) and silt had deposited over the rocky substrate. Zebra mussels were also present.

What does it mean?

Sampling in 2023 was the third year of monitoring after flooding and is a starting point for studying the changes in substrates in deepwater and constructed habitats in the Keeyask reservoir and Stephens Lake. Water velocities in some parts of the Keeyask reservoir have remained high including at Long Rapids, Birthday Rapids, the middle Keeyask reservoir, and the entrance to Gull Lake. Substrates in these areas were mostly rock, cobble, and gravel. Habitats in these areas have changed little since impoundment. Spawning adult Lake Sturgeon were captured downstream of Birthday Rapids in all years after impoundment, suggesting that the habitat has remained suitable for spawning.

There is evidence that fine substrates such as sand, silt and clay are depositing at the entrance to Gull Lake. In contrast, substrates in the area around Caribou Island (which is used by juvenile sturgeon) have changed little in the first three years after impoundment and sand is still present. It is expected that substrates in the lower reservoir will continue to change as more fine substrates are deposited.

Sand was still present in juvenile and YOY Lake Sturgeon habitat in Stephens Lake, but organic material (broken down plants) was detected, and some silt has been deposited over the sand. Juvenile Lake Sturgeon were caught in the area in 2021, 2022 and 2023, suggesting it still provides rearing habitat.

Habitat characteristics at the Keeyask reservoir spawning shoals have changed over time, and in 2023, silt was found on parts of all the shoals. Mud, organics, and zebra mussels were also found on many of the shoals. Monitoring has indicated that the shoals were used by jackfish and possibly whitefish in the first three years following reservoir impoundment.

What will be done next?

Offshore habitat monitoring at sensitive, deepwater, and constructed shoal sites was done annually in the first three years following reservoir impoundment to document early conditions and changes. Going forward, changes are expected to be slow, and monitoring will be conducted every three years (next in 2026). Surveys will be repeated using the same methods to describe changes to offshore habitats as the Keeyask reservoir ages.

ACKNOWLEDGEMENTS

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

Kelvin Kitchekeesik, Melvin Cook, and Patrick Connell Jr. of Tataskweyak Cree Nation (TCN) are thanked for their local expertise and assistance in conducting the field work. We would also like to thank Douglas Kitchekeesik and Gordon Cook of TCN for arranging logistic support and personnel needed to conduct the fieldwork.

STUDY TEAM

Data Collection

Celina Unrau

Nat Waldner

Melvin Cook

Patrick Connell Jr.

Scott Morrison

Thomas Sutton

Kelvin Kitchekeesik

Data Analysis, Report Preparation, and Report Review

Claire Hrenchuk

Chris Kullman

Friederike Schneider-Vieira

Jarod Larter

Scott Morrison

Thomas Sutton

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF PHOTOS

LIST OF APPENDICES

1.0 INTRODUCTION

The Keeyask Generation Project (the Project) is a 695-megawatt (MW) hydroelectric generating station (GS) 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 by 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 change 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 deep water and constructed habitats.

Data collected in deep water areas (greater than 3 m) will be used to monitor change in substrate composition within offshore areas both upstream and downstream of the GS. Change in the distribution of the substrate in deep water is indicative of an alteration to the hydraulics and the ability of the river to transport materials along the bed. The evolution of substrate composition in deep water within the newly formed reservoir depends mostly on (new) water velocity patterns, and how the processes of erosion, transport, and deposition in the river channel maintain or alter the existing substrate. Potential effects on aquatic habitat downstream of the GS include the deposition of fine sediments over existing substrata. Monitoring areas include both sensitive Lake Sturgeon and constructed habitats.

Lake Sturgeon are a key component of the overall monitoring plan, chosen because they are important to local communities and use a variety of habitats for spawning and foraging that will be substantially altered by the Project. Sensitive Lake Sturgeon habitats (*i.e.*, spawning and rearing habitats) were identified during baseline studies for the Project including areas that were used pre-Project and those predicted to be used post-Project. Sensitive Lake Sturgeon spawning habitats were identified at Long Rapids, Birthday Rapids, and the base of the Keeyask GS spillway. Sensitive Lake Sturgeon young-of-the-year (YOY) and sub-adult habitat was identified at Birthday Rapids, the entrance to Gull Lake, lower Gull Lake in the channel north of Caribou Island, and in Stephens Lake approximately 4–7 km downstream of the GS.

Constructed habitats were developed as an offsetting measure to account for some habitat loss caused by the Project and to increase the certainty that fish spawning habitat was available post-Project. In February and March 2018, three hectares of rocky spawning shoals were constructed in the future Keeyask reservoir to provide Lake Whitefish and Walleye spawning habitat immediately after impoundment (Map 1). Rockfill material was left in place at two temporary causeways (N5 and G3) in Stephens Lake to create shallow rocky habitat for fish and other aquatic species and a means of improving habitat diversity in these areas.

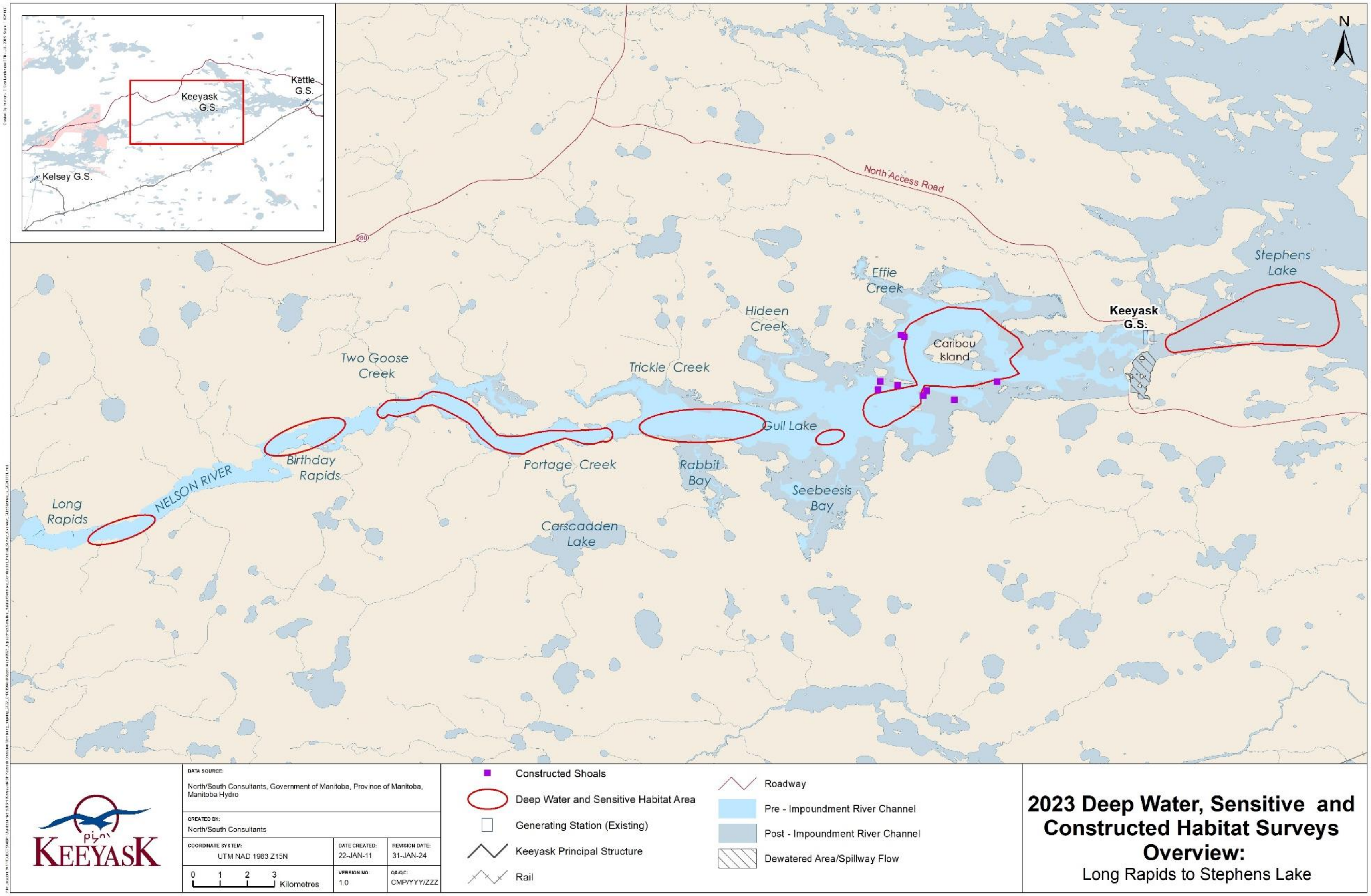
Monitoring of deep water areas is being conducted to address the following key questions, as described in the AEMP:

- *Will Long Rapids and Birthday Rapids and the area below the Keeyask GS continue to provide spawning habitat for Lake Sturgeon?*
- *How many years into the operation period will it take for substrate boundaries to form?*
- *How will substrate composition change over time in deep water areas in the Keeyask reservoir and Stephens Lake (including in the area of existing young-of-the-year [YOY] Lake Sturgeon habitats)?*
- *Will sand and gravel transport through the riverine reach of the reservoir and deposit downstream of Birthday Rapids and/or the entrance to Gull Lake to create suitable YOY Lake Sturgeon habitat?*
- *If sand and gravel do not deposit near the entrance to Gull Lake what are the substrate conditions that develop?*
- *How precise were the post-Project models that predicted the long-term deep water substrate distributions?*

Monitoring of constructed habitats is being conducted to address an additional key question:

- *Will monitoring data collected from the constructed spawning habitat (i.e., water velocity and depth, and substrate) in the reservoir confirm that the extent and surface area continue to meet design criteria over time?*

This report provides results based on data collected in August 2023, three years following impoundment. These results will be used to describe the initial flooded condition within the Keeyask reservoir and early operation within Stephens Lake. Changes to deep water substrates are expected to be slow and may take time to become apparent. Surveys will be repeated over time to describe the development of deep water habitats both upstream and downstream of the Keeyask GS.



Map 1: **Overview map of 2023 deep water and constructed aquatic habitat monitoring areas and sites.**

2.0 STUDY SETTING

The study area encompasses an approximately 110 km long reach of the Nelson River from Clark Lake to the upstream end of the Limestone Reservoir. 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. Clark Lake is located immediately downstream of Split Lake, and approximately 42 km upstream of the Keeyask GS. Current is restricted to the main section of the lake, with off-current bays outside the main channel. The Assean River is the only major tributary to Clark Lake and flows into the north side. Downstream from the outlet of Clark Lake, the Nelson River narrows and water velocity increases for a 3 km stretch, known as Long Rapids. For the next 7 km, the river widens, and water velocity decreases. The area between Clark Lake and Birthday Rapids is referred to herein as the upper Keeyask reservoir.

Birthday Rapids is located approximately 10 km downstream of Clark Lake and 30 km upstream Keeyask GS and marks the upstream end of major water level changes because of impoundment by the Keeyask GS. The drop in elevation from the upstream to downstream side of Birthday Rapids was approximately 2 m prior to impoundment but is now 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, the 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.

3.0 METHODS

Boat-based water velocity monitoring surveys were conducted between August 16 and 20, 2023. Substrate surveys were conducted between August 12 and 23, 2023. Additional habitat mapping and direct substrate sampling to obtain validation data were conducted in Stephens Lake from June 3-10 and on September 23, 2023.

3.1 DEPTH AND VELOCITY

Depth and velocity data were collected by Manitoba Hydro using a SonTek M9 acoustic doppler current profiler (ADCP). Detailed methods can be found in Manitoba Hydro (2024). Data were collected twice at each transect, from start to end bank and end bank to start bank. River Surveyor software was used to display cross sectional water velocities at each transect. Depth-averaged velocity was calculated at each transect using five second intervals (Figure 1).

Mean, minimum, and maximum depth and velocity were calculated for each survey area. ArcGIS mapping software was used to plot each transect and classify each as standing/lentic (<0.2 m/s); and low (0.2–0.5 m/s), moderate (0.5–1.5 m/s), high (1.5–2.5 m/s), and very high (>2.5 m/s) water velocity.

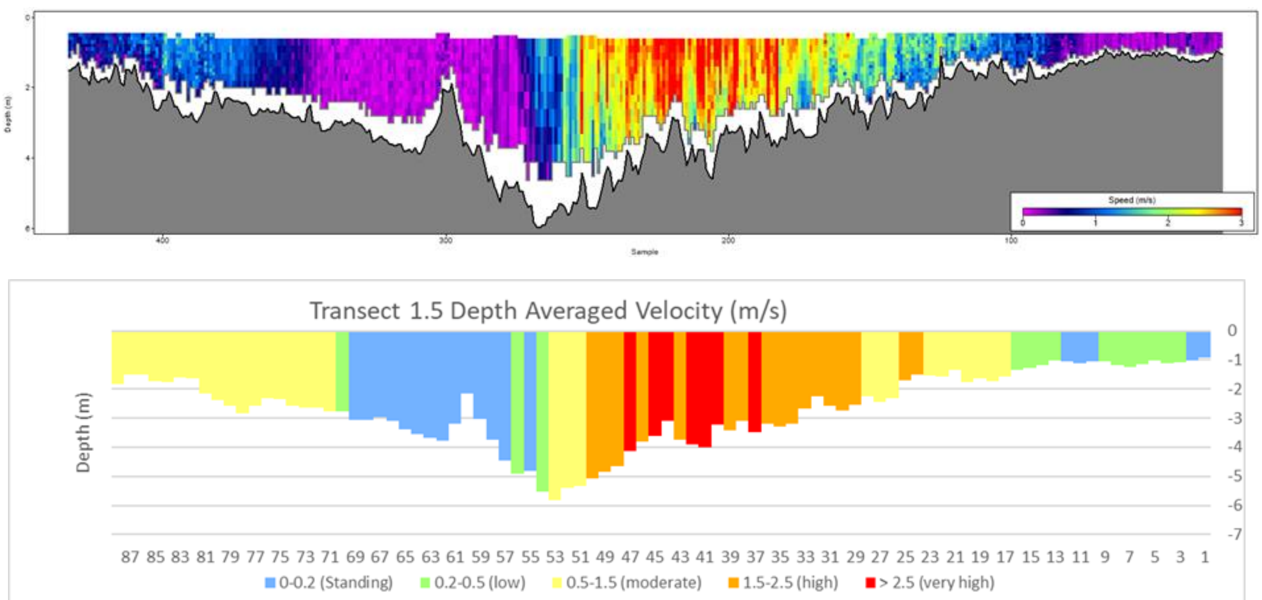


Figure 1: Full ADCP profile (top) sampled with the SonTek M9 ADCP and classified sub-sampled depth averaged velocity representation (bottom). Cross sections are viewed looking upstream (left to right bank).

3.2 SUBSTRATE

3.2.1 SUBSTRATE MAPPING

A Lowrance® Elite FS sonar/GPS echosounder was used to collect depth and bottom composition data as well as sidescan acoustic imagery at all sampling areas. Sidescan sonar image data have been shown to be effective in interpreting and mapping the substrate classes of benthic environments (Lucieer 2008; Kaeser *et al*. 2012; Fakiris *et al*. 2019). The system included a TotalScan™ transducer (83/200 kHz traditional sonar beams, as well as 455/800 kHz sidescan/down scan beams). Data were collected using a 50 m swath. Sidescan image mosaics of each of the survey areas were produced using SonarWiz 7. The raw image data and georeferenced image mosaics will be used to detect substrate boundary differences in future years of monitoring.

Additional transects along the length of the river channel were collected using Ping DSP Inc. 3DSS-IDX-450 combined sidescan sonar and multibeam echosounder to supplement substate data collected with the Biosonics unit.

3.2.1.1 SUBSTRATE MAPPING AT DEEP WATER HABITATS

A BioSonics MX 200 kHz single-beam echosounder (SBES) was used to create substrate maps at each of the deep water habitat areas. A Trimble Pro XRT GNSS receiver using OmniSTAR real-time differential correction was used to provide positions for each sample accurate to less than a metre. Survey transects were navigated bank to bank (cross sections) or upstream to downstream (longitudinal transects) at boat speeds of less than 10 km/hr.

BioSonics Visual Aquatic software was used to calculate depth across each transect. Bottom depth in the field was 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).

3.2.1.2 SUBSTRATE MAPPING AT CONSTRUCTED HABITATS

A Ping DSP Inc. 3DSS-IDX-450 combined sidescan sonar and multibeam echosounder was used to create substrate maps at each of the constructed habitat areas. This system was used to provide higher resolution imagery than at the deep water areas. Data were collected using a 100 m swath. The echosounder was coupled to a Septentrio dual antenna GNSS receiver to provide precise positions. These data were analyzed using SonarWiz software. The data were checked for anomalies and erroneous depth records which were filtered out of each file. Grids (to 0.25 m cell resolution) were created from the multibeam data which were imported into ArcGIS 10.8 software to create detailed maps of substrate and depth at each constructed habitat location.

3.2.2 DIRECT SAMPLING

Substrate grab samples were collected to validate the acoustic bottom typing data using a petite Ponar dredge (0.023 m^2 surface area). Primary, secondary, and tertiary substrate types were identified at each sampling site and classified using modified Wentworth scale 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. The data obtained from Ponar dredge and weighted sounding line sampling is referred to as substrate validation in subsequent sections of this report.

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

4.0 RESULTS

4.1 DEEP WATER AND SENSITIVE HABITATS

Water velocity and substrate surveys were conducted within six areas in the Keeyask reservoir and one area in Stephens Lake in August 2023.

Both water velocity and substrate surveys were conducted within four areas identified in the EIS as habitat important for Lake Sturgeon. These include the areas downstream of Long and Birthday rapids (potential and known spawning habitat, respectively), the entrance to Gull Lake (where YOY sturgeon may settle in slower water post-impoundment), the area north of Caribou Island in lower Gull Lake (existing rearing habitat for YOY and juvenile Lake Sturgeon), and Stephens Lake approximately 5–7 km downstream of the Keeyask GS (existing rearing habitat for YOY and juvenile Lake Sturgeon).

Substrate sampling was conducted in lotic channels in the middle Keeyask reservoir and upper Gull Lake to monitor change in substrate in impounded deep water habitats over time. Substrate surveys in Stephens Lake included the area approximately 1.0–7.5 km downstream of the Keeyask GS to determine whether changes in flow patterns downstream of the GS altered the distribution of coarse and fine substrates in the long-term.

4.1.1 LONG RAPIDS

4.1.1.1 DEPTH, WATER LEVEL, AND VELOCITY

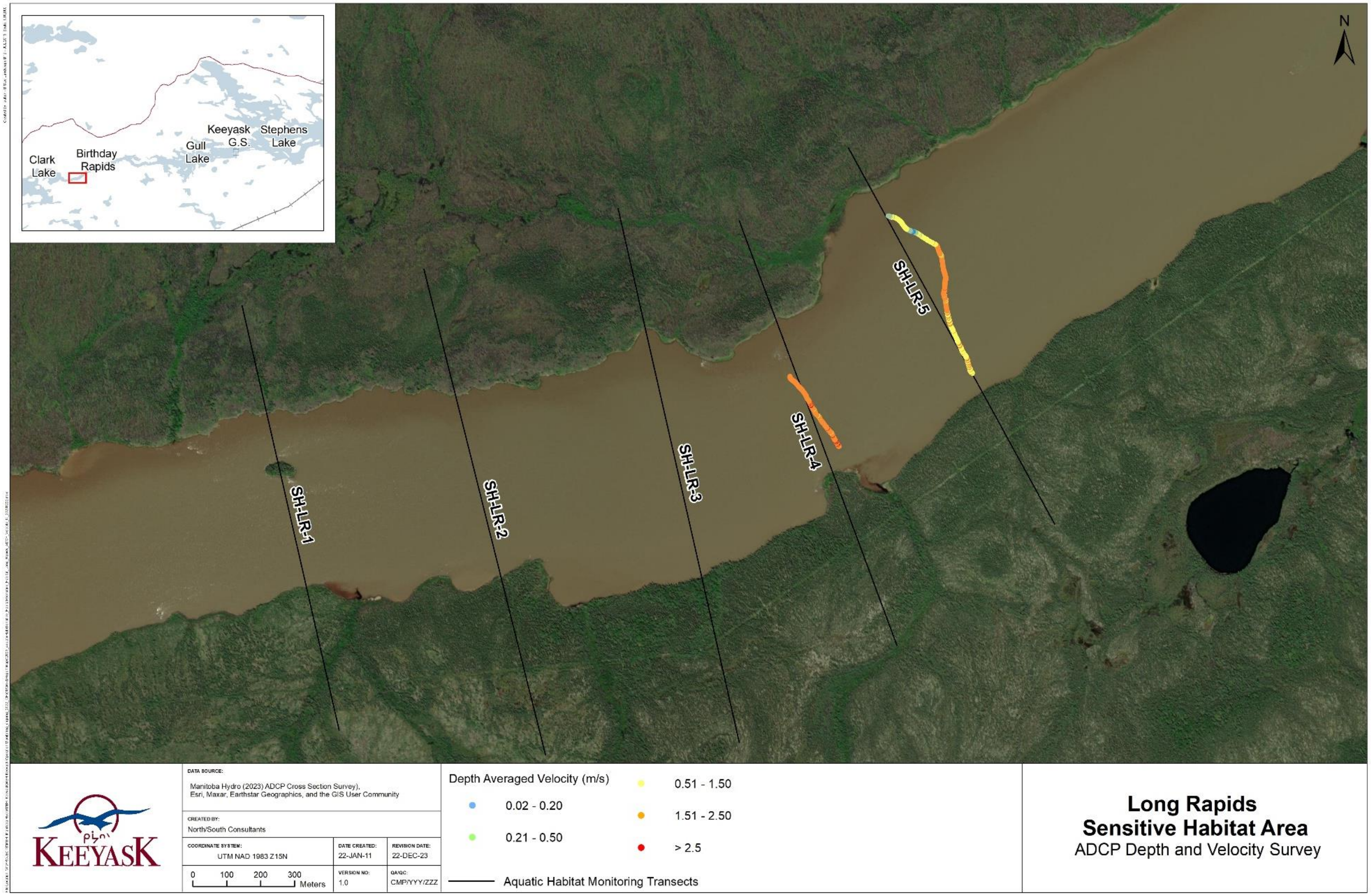
Boat-based ADCP depth and velocity surveys were conducted in the area extending approximately 2 km downstream of Long Rapids on August 20, 2023 by Manitoba Hydro (Manitoba Hydro 2024). Estimated mean Nelson River inflow on this date measured 2,985 m^3/s (Table 2). High flows caused turbulent water and unsafe boating conditions at three of the five transects, therefore, only two transects (*i.e.*, SH-LR-4 and 5) were surveyed (Map 2).

Table 2: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for the two cross sections surveyed at the Long Rapids sensitive habitat area with the SonTek M9 ADCP on August 20, 2023.

Transect ID	Date	Survey Distance (m)	Estimated Inflow (cms)[1]	Estimated WSE (m)[2]	Depth (m)			Velocity (m/s)		
					Min	Max	Mean	Min	Max	Mean
SH-LR-1	-	-	2985	160.2	-	-	-	-	-	-
SH-LR-2	-	-	2985	160.2	-	-	-	-	-	-
SH-LR-3	-	-	2985	160.2	-	-	-	-	-	-
SH-LR-4	20-Aug-23	315	2985	160.2	3.09	6.94	5.06	1.08	2.68	2.16
SH-LR-5	20-Aug-23	516	2985	160.2	2.03	7.20	4.58	0.11	2.59	1.41
Summary					**1.14**	**7.20**	**4.82**	**0.11**	**2.68**	**1.78**

1 - Daily mean virtualized Split Lake outflow data provided by MBH.

2 - Water surface elevation (WSE) estimated from daily averages at MBH Gauging Station 05UF759 (150 m downstream of the Clark Lake Exit) and modelled post-Project water surface elevation data provided by MBH.



Map 2: Depth averaged velocities measured during ADCP transect surveys at the Long Rapids sensitive habitat area, 2023.

Water surface elevation at the time of the survey was estimated at 160.2 m within the Long Rapids reach. Water velocities at Transect 4 (farthest upstream) ranged from 1.08 to 2.68 m/s, with a mean cross section velocity of 2.16 m/s. The mean depth at Transect 4 was 5.06 m with a range of 3.09 to 6.94 m. Water velocities were high across the entire river section in Transect 4, with small areas of very high velocity. Water velocity in Transect 5 was mostly high in the center of the river with moderate to low water velocities along the banks (Figure 2). Velocities ranged from 0.11 to 2.59 m/s with a mean cross section velocity of 1.41 m/s. The depth at Transect 5 ranged from 2.03 to 7.20 m with a mean depth of 4.58 m.

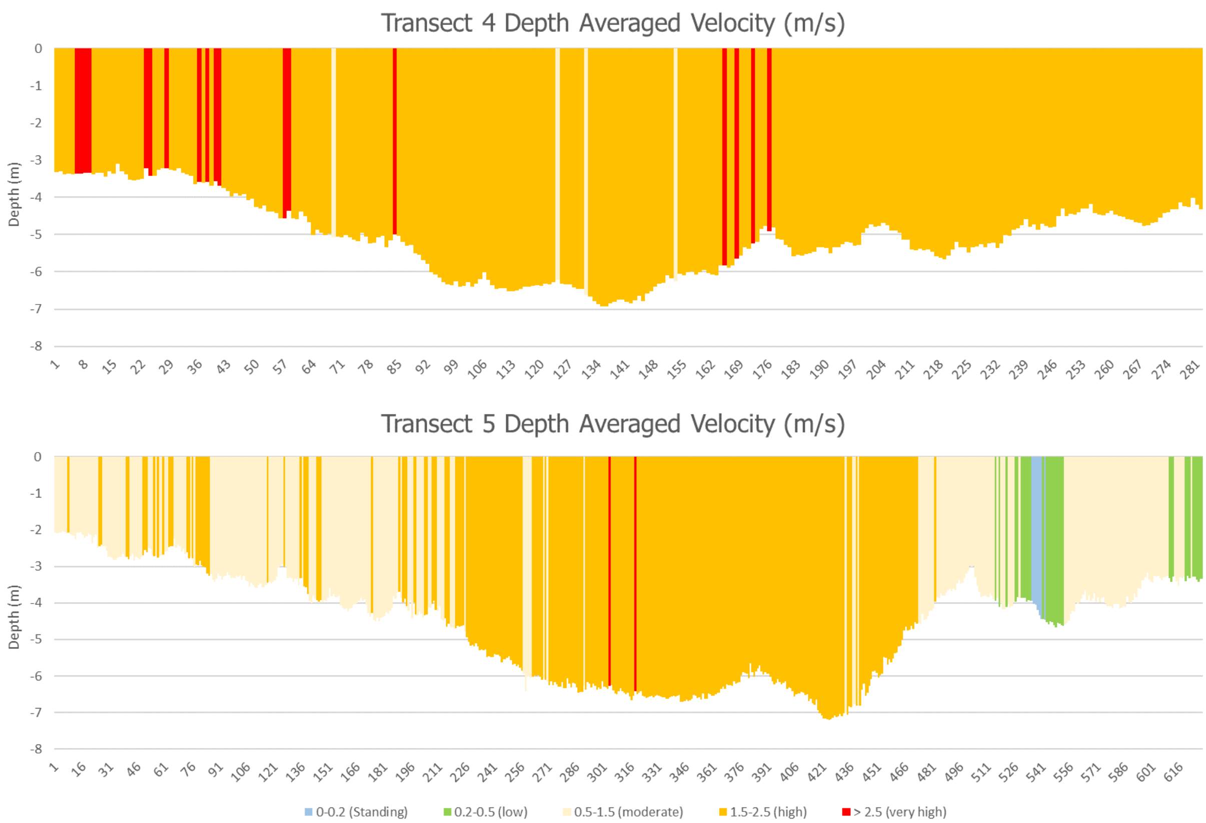


Figure 2: Depth averaged water velocity from two transects sampled using an ADCP at the Long Rapids sensitive habitat area, 2023. Cross sections are viewed looking upstream (left to right bank).

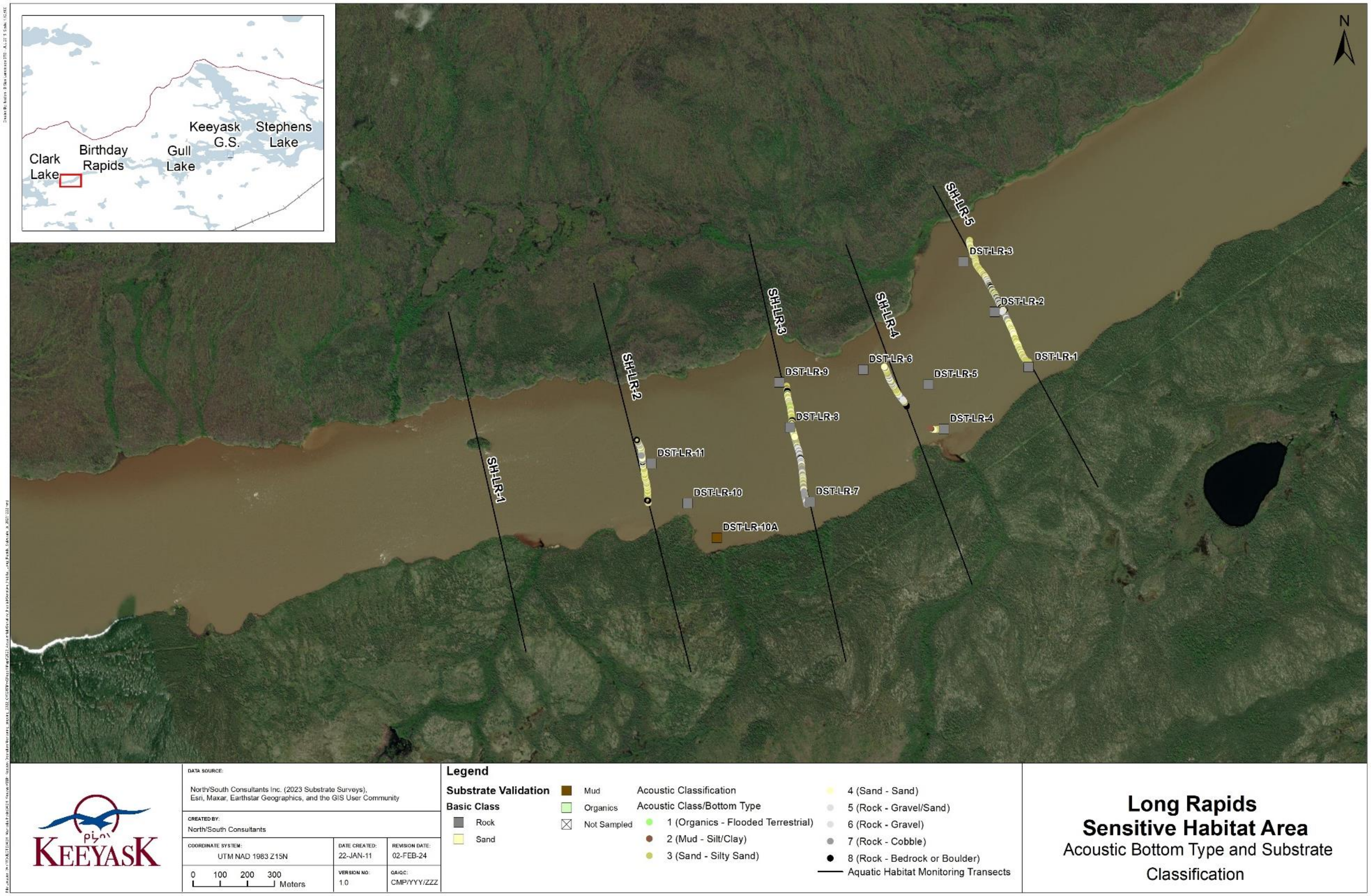
4.1.1.2 SUBSTRATE

Substrate surveys were conducted on August 22, 2023 (Map 3). High velocities throughout the reach prevented the surveying of the farthest upstream transect (Transect 1) and required the use of a weighted sounding line for determination of bottom types at 11 of 12 sites. Substrate was collected using a Ponar dredge at a single site (DST-LR-10A) located along the south bank between transects 2 and 3.

The acoustic substrate classification model indicated the area was comprised of both hard and soft substrates including silt/clay/sand (43%), followed by cobble (18%), and sand (18%; Table 3). Physical sampling confirmed that hard substrates were present throughout much of the reach (Table 4).

Table 3: Substrate composition of each sampling transect collected using a single beam acoustic sonar data at the Long Rapids sensitive habitat area, 2023.

Transect ID	Acoustic Substrate Classification Composition (% Membership)							
	Organics	Mud		Sand	Rock			
	organics/ FT	silt/ clay	silt/ clay/ sand	sand	gravel/ sand	gravel	cobble	bedrock/ boulder
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
1	-	-	-	-	-	-	-	-
2	0	1	49	23	7	9	11	0
3	1	1	36	12	10	14	24	1
4	0	3	40	16	10	9	22	0
5	0	<1	46	23	11	4	12	3
Summary	**<1**	**2**	**43**	**18**	**10**	**9**	**18**	**1**



Map 3: Substrate type measured during acoustic and substrate validation surveys at the Long Rapids sensitive habitat area, 2023.

Table 4: Substrate type observed during direct sampling using a weighted sounding line and petite Ponar dredge at the Long Rapids sensitive habitat area, 2023.

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	%		
DST-LR-1	weighted sounding line	22-Aug-23	327138	6240364	-	hard	boulder	100	-	-	-	-	rock	boulder
DST-LR-2	weighted sounding line	22-Aug-23	327013	6240567	6.5	hard	boulder	100	-	-	-	-	rock	boulder
DST-LR-3	weighted sounding line	22-Aug-23	326898	6240752	-	hard	boulder	100	-	-	-	-	rock	boulder
DST-LR-4	weighted sounding line	22-Aug-23	326826	6240136	-	hard	boulder	100	-	-	-	-	rock	boulder
DST-LR-5	weighted sounding line	22-Aug-23	326768	6240300	4.0	hard	boulder	100	-	-	-	-	rock	boulder
DST-LR-6	weighted sounding line	22-Aug-23	326528	6240355	2.7	hard	boulder	100	-	-	-	-	rock	boulder
DST-LR-7	weighted sounding line	22-Aug-23	326332	6239868	5.2	hard	boulder	100	-	-	-	-	rock	boulder
DST-LR-8	weighted sounding line	22-Aug-23	326258	6240142	3.8	hard	boulder	100	-	-	-	-	rock	boulder
DST-LR-9	weighted sounding line	22-Aug-23	326219	6240308	1.7	hard	boulder	100	-	-	-	-	rock	boulder
DST-LR-10	weighted sounding line	22-Aug-23	325882	6239863	-	hard	boulder	100	-	-	-	-	rock	boulder
DST-LR-10A	petite Ponar	22-Aug-23	325989	6239736	-	soft	clay	85	silt	10	organic	5	mud	clay/silt/organic
DST-LR-11	weighted sounding line	22-Aug-23	325747	6240009	4.7	hard	boulder	100	-	-	-	-	rock	boulder

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

4.1.2 DOWNSTREAM OF BIRTHDAY RAPIDS

4.1.2.1 DEPTH, WATER LEVEL, AND VELOCITY

Boat-based ADCP depth and velocity surveys were conducted in the area extending approximately 3 km downstream of Birthday Rapids on August 20, 2023 (Manitoba Hydro 2024). Estimated mean Nelson River inflow on this date was 2,985 m^3/s (Table 5). High velocities and turbulent water caused unsafe boating conditions close to Birthday Rapids (SH1-1), therefore, surveys were conducted at seven of eight transects (Map 4).

The water surface elevation at the time of the survey was estimated at 159.1 m throughout the reach. The area downstream of Birthday Rapids was characterized by high water velocities, moderating with distance from the rapids. Depth ranged from 3.20 to 11.64 m.

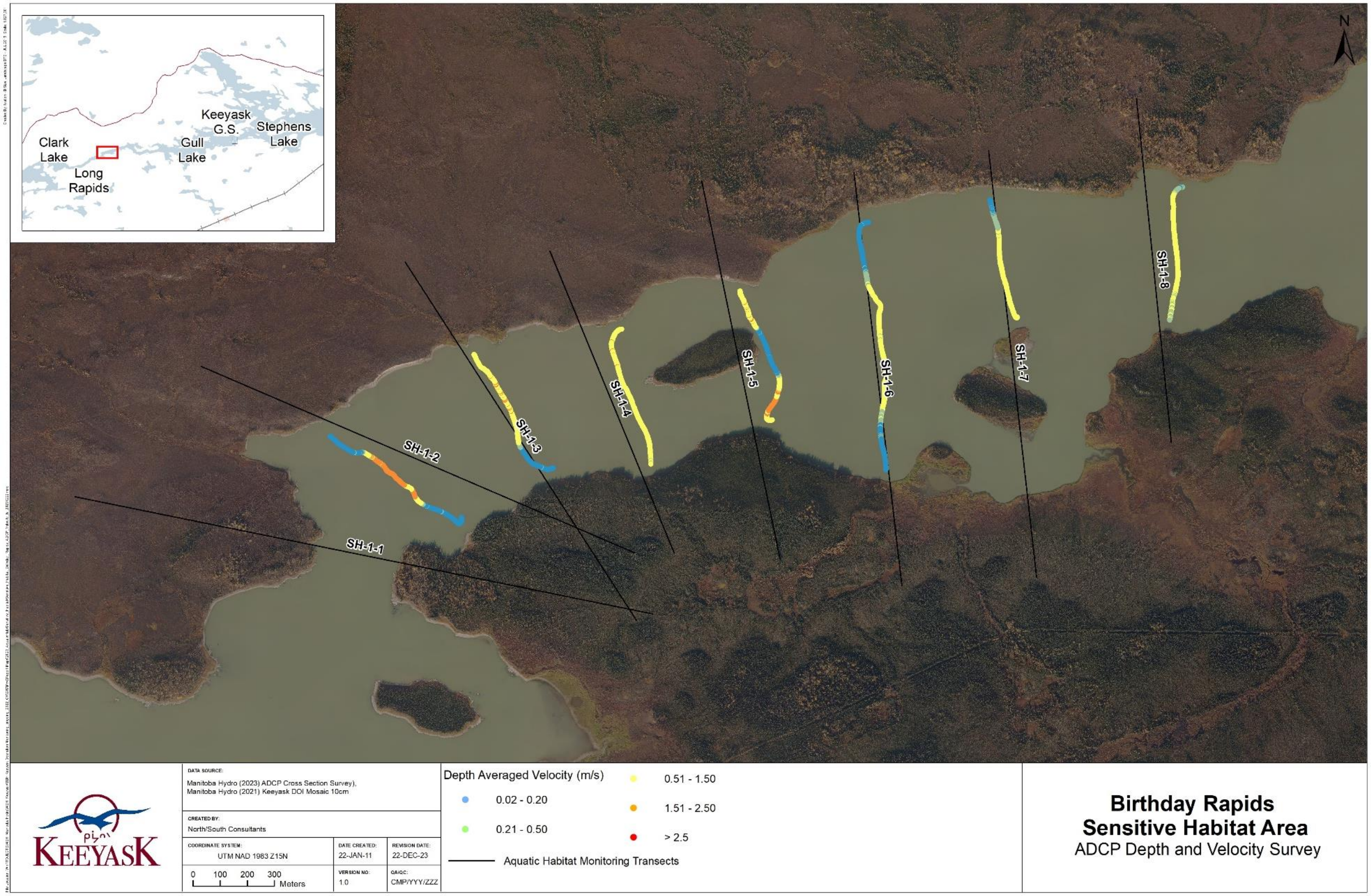
Transect 2 was the farthest upstream transect sampled. This cross section contained moderate to high velocities in the center with areas of standing water along the banks of the river (Figure 3). Mean water velocity was 0.96 m/s, ranging from 0.00 to 2.46 m/s. Transect 5 crosses an island that has deep channels with moderate to high velocities on either side. The remaining transects contained largely moderate velocities with areas of low or standing velocities along both banks (Transect 6), right (north) bank (Transect 7), or left (south) bank (Transect 3).

Table 5: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for the seven cross sections surveyed in the Keeyask reservoir at the Birthday Rapids sensitive habitat area with the SonTek M9 ADCP on August 20, 2023.

Transect ID	Date	Sample Distance (m)	Estimated Inflow[1] (m^3/s)	Estimated WSE[2] (m)	Depth (m)			Velocity (m/s)		
					Min	Max	Mean	Min	Max	Mean
SH1-1	-	-	2985	159.1	-	-	-	-	-	-
SH1-2	20-Aug-23	647	2985	159.1	3.43	9.92	6.67	0.00	2.46	0.96
SH1-3	20-Aug-23	372	2985	159.1	3.20	9.85	7.05	0.01	1.79	0.89
SH1-4	20-Aug-23	535	2985	159.1	3.48	8.29	5.96	0.35	1.58	1.05
SH1-5	20-Aug-23	485	2985	159.1	3.20	11.64	7.03	0.01	1.92	0.96
SH1-6	20-Aug-23	741	2985	159.1	3.78	8.95	6.06	0.01	1.49	0.57
SH1-7	20-Aug-23	1076	2985	159.1	4.48	10.62	7.95	0.03	1.38	0.68
SH1-8	20-Aug-23	494	2985	159.1	3.85	10.52	8.18	0.13	1.14	0.67
Summary					**3.20**	**11.64**	**6.99**	**0.00**	**2.46**	**0.83**

1 - Estimated or virtualized inflow provided by MBH.

2 - Water surface elevation (WSE) estimated from daily averages at MBH Gauging Station 05UF771 (175 m downstream of Birthday Rapids).



Map 4: **Depth averaged velocities measured during ADCP transect surveys in the Keeyask reservoir at the Birthday Rapids sensitive habitat area, 2023.**

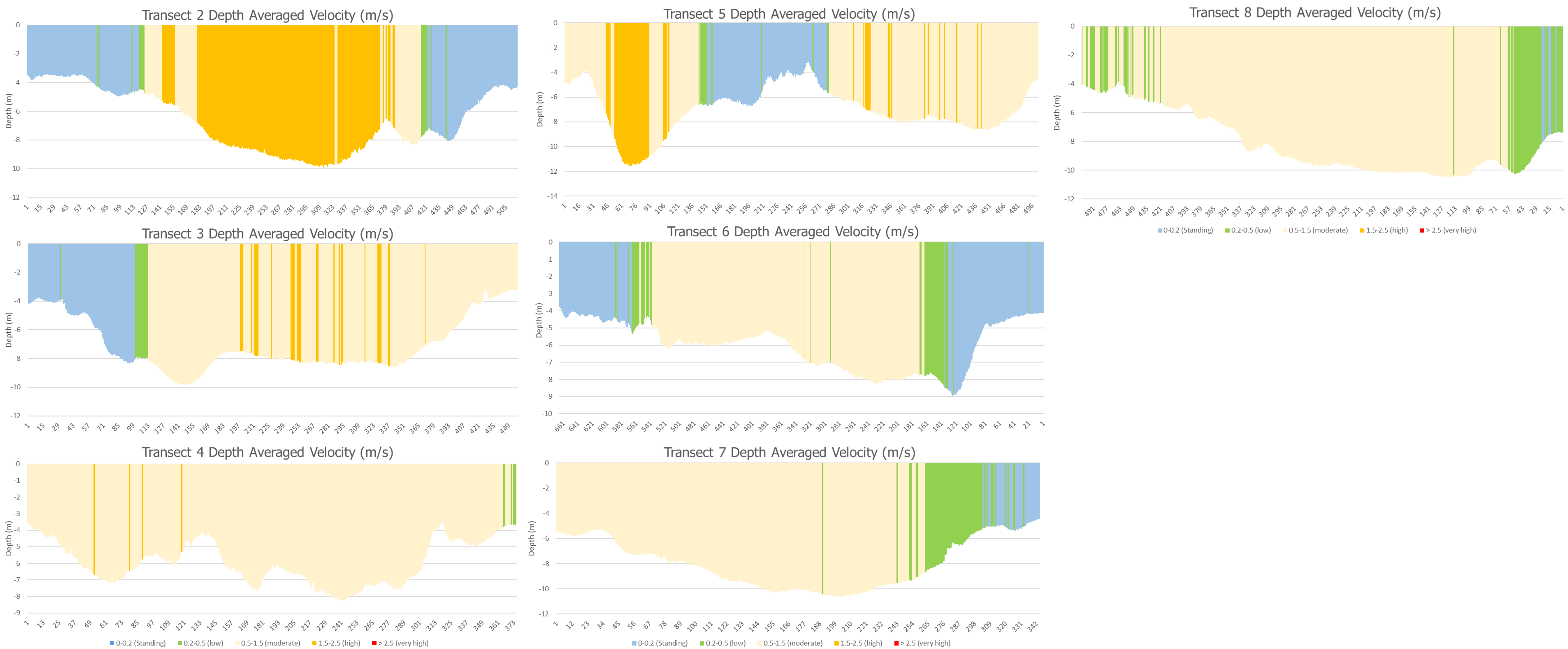


Figure 3: Depth averaged water velocity from seven transects sampled using an ADCP in the sensitive habitat area located downstream of Birthday Rapids, 2023. Cross sections are viewed looking upstream (left to right bank).

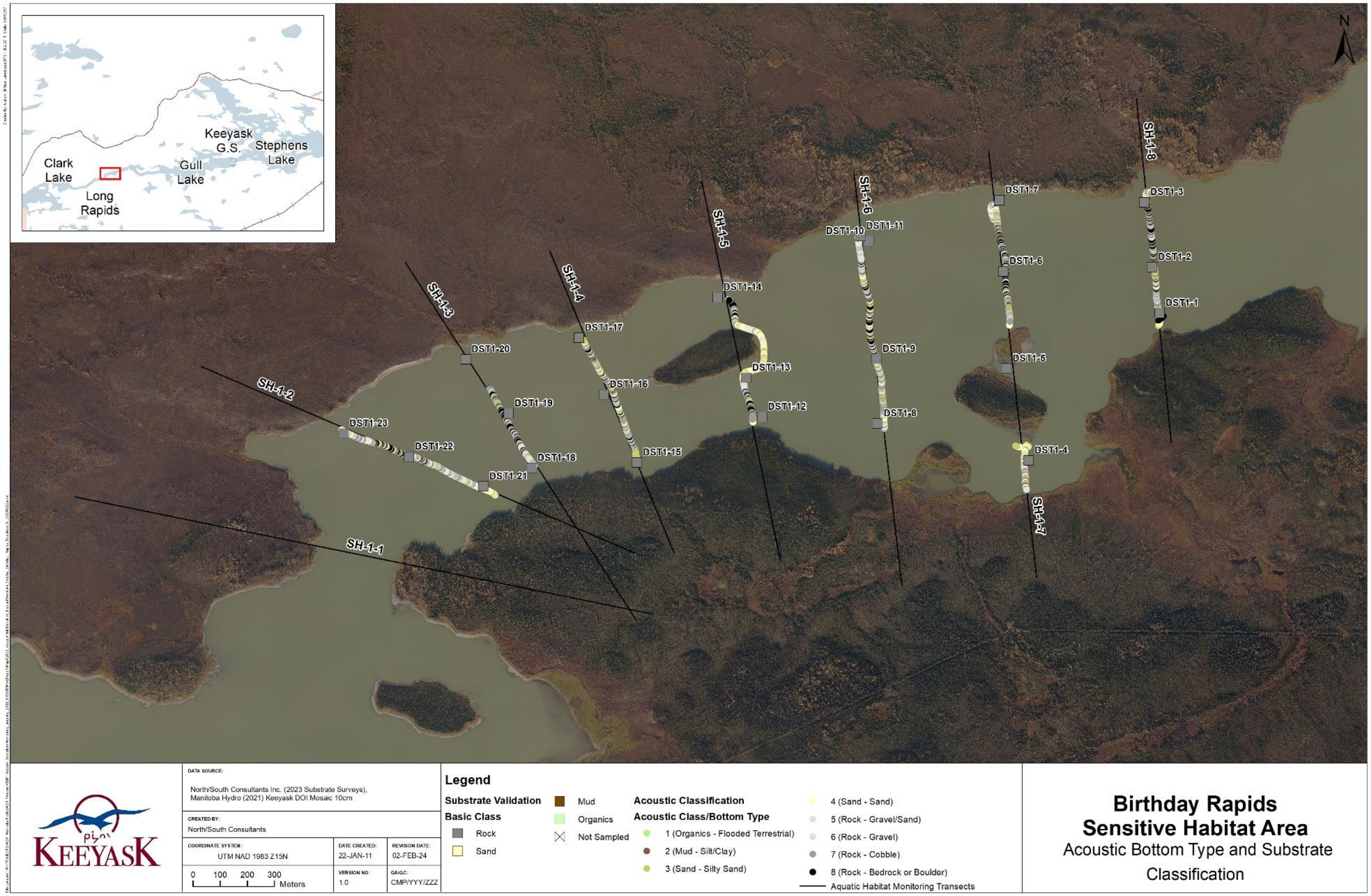
4.1.2.2 SUBSTRATE

Substrate surveys were conducted on August 22, 2023. Due to high water velocities and turbulent water that created unsafe boating conditions, substrate validation was not conducted within Transect 1 (SH-1-1; Map 5).

The acoustic classification model indicated the area was dominated by hard substrates comprised of cobble (30%), silt/clay/sand (16%), bedrock/boulder (15%), and gravel and sand (14% each; Table 6). The presence of mostly hard substrates was confirmed using a weighted sounding line (Table 7).

Table 6: Substrate composition of each sampling transect collected using a single beam acoustic sonar data at the Birthday Rapids sensitive habitat area, 2023.

Transect ID	Acoustic Substrate Classification Composition (% Membership)							
	Organics	Mud		Sand	Rock			
	organics /FT Class 1	silt/ clay Class 2	silt/clay /sand Class 3	sand Class 4	gravel/ sand Class 5	gravel Class 6	cobble Class 7	bedrock /boulder Class 8
1	-	-	-	-	-	-	-	-
2	0	0	12	19	8	24	25	12
3	0	0	11	3	13	10	37	25
4	0	0	21	9	12	10	38	11
5	0	0	17	27	15	10	18	13
6	0	<1	16	12	7	20	33	12
7	0	4	17	19	10	11	26	14
8	0	0	17	7	8	15	33	20
Summary	**0**	**1**	**16**	**14**	**11**	**14**	**30**	**15**



Map 5: Substrate type measured during acoustic and substrate validation surveys in the Keeyask reservoir at the Birthday Rapids sensitive habitat area, 2023.

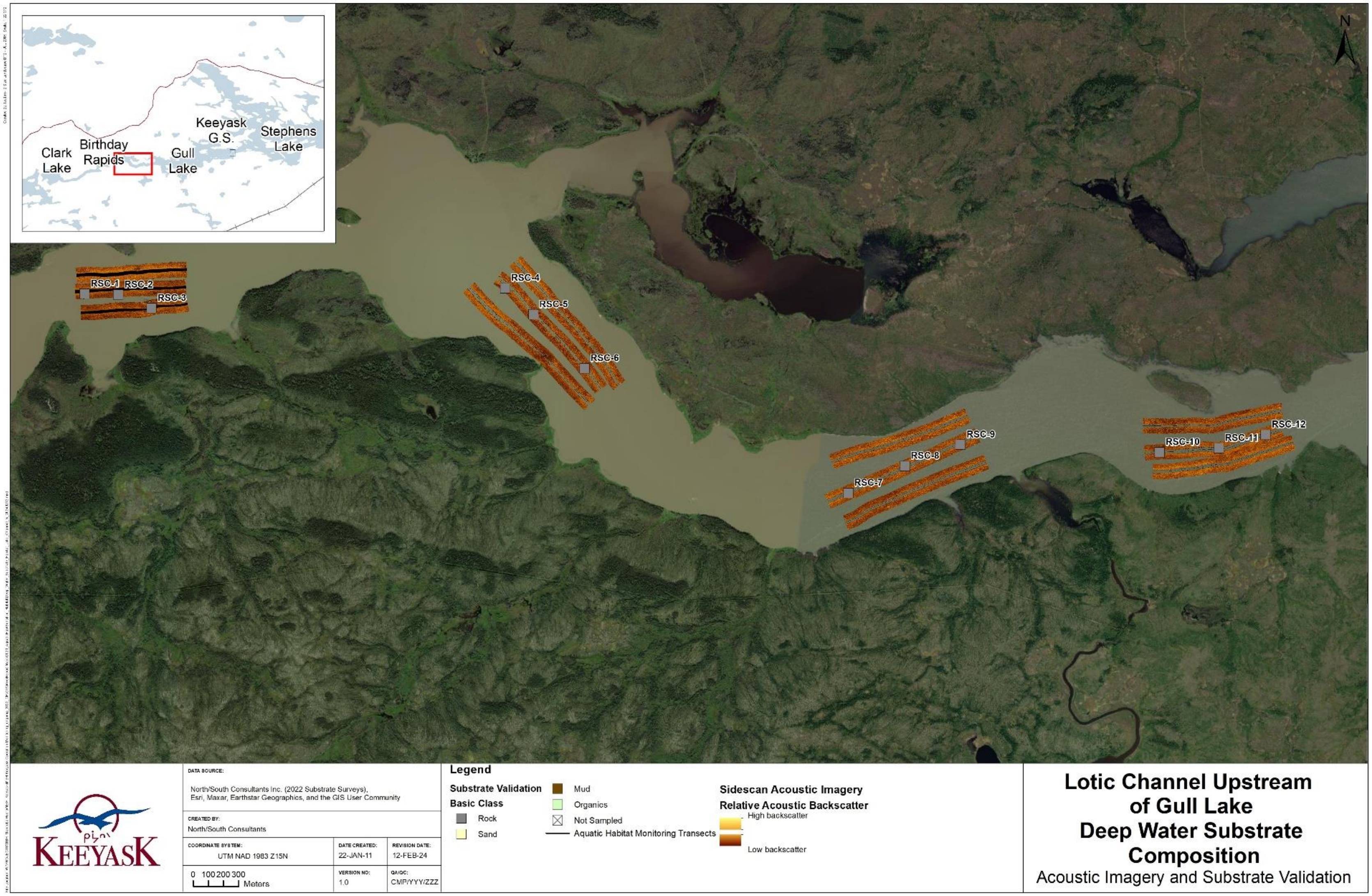
Table 7: Substrate type observed during direct sampling using a weighted sounding line or petite Ponar dredge in the Keeyask reservoir at the Birthday Rapids sensitive habitat area, 2023.

Site ID	Transect ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
								Substrate 1	%	Substrate 2	%	Substrate 3	%		
DST1-1	8	weighted sounding line	22-Aug-23	334385	6243723	4.4	hard	boulder	100	-	-	-	-	rock	boulder
DST1-2	8	weighted sounding line	22-Aug-23	334357	6243892	7.6	hard	boulder	100	-	-	-	-	rock	boulder
DST1-3	8	weighted sounding line	22-Aug-23	334329	6244131	11.2	hard	boulder	100	-	-	-	-	rock	boulder
DST1-4	7	petite Ponar	22-Aug-23	333902	6243180	3.7	hard	boulder	100	-	-	-	-	rock	boulder
DST1-5	7	petite Ponar	22-Aug-23	333821	6243519	2.6	hard	boulder	100	-	-	-	-	rock	boulder
DST1-6	7	weighted sounding line	22-Aug-23	333809	6243877	9.9	hard	boulder	100	-	-	-	-	rock	boulder
DST1-7	7	weighted sounding line	22-Aug-23	333794	6244138	4.3	hard	boulder	100	-	-	-	-	rock	boulder
DST1-8	6	petite Ponar	22-Aug-23	333346	6243317	5.2	hard	boulder	100	-	-	-	-	rock	boulder
DST1-9	6	weighted sounding line	22-Aug-23	333341	6243554	5.3	hard	boulder	100	-	-	-	-	rock	boulder
DST1-10	6	weighted sounding line	22-Aug-23	333313	6243988	7.2	hard	boulder	100	-	-	-	-	rock	boulder
DST1-11	6	weighted sounding line	22-Aug-23	333282	6244007	4.5	hard	boulder	100	-	-	-	-	rock	boulder
DST1-12	5	weighted sounding line	22-Aug-23	332920	6243341	5.2	hard	boulder	100	-	-	-	-	rock	boulder
DST1-13	5	weighted sounding line	22-Aug-23	332862	6243485	3.1	hard	boulder	100	-	-	-	-	rock	boulder
DST1-14	5	weighted sounding line	22-Aug-23	332756	6243781	8.5	hard	boulder	100	-	-	-	-	rock	boulder
DST1-15	4	weighted sounding line	22-Aug-23	332409	6243194	5.9	hard	boulder	100	-	-	-	-	rock	boulder
DST1-16	4	weighted sounding line	22-Aug-23	332337	6243423	7.9	hard	boulder	100	-	-	-	-	rock	boulder
DST1-17	4	weighted sounding line	22-Aug-23	332245	6243632	3.9	hard	boulder	100	-	-	-	-	rock	boulder
DST1-18	3	weighted sounding line	22-Aug-23	332071	6243152	4.5	hard	boulder	100	-	-	-	-	rock	boulder
DST1-19	3	weighted sounding line	22-Aug-23	331986	6243354	7.6	hard	boulder	100	-	-	-	-	rock	boulder
DST1-20	3	petite Ponar	22-Aug-23	331828	6243553	2.9	hard	boulder	100	-	-	-	-	rock	boulder
DST1-21	2	weighted sounding line	22-Aug-23	331893	6243085	3.5	hard	boulder	100	-	-	-	-	rock	boulder
DST1-22	2	weighted sounding line	22-Aug-23	331619	6243194	8.8	hard	boulder	100	-	-	-	-	rock	boulder
DST1-23	2	weighted sounding line	22-Aug-23	331378	6243280	4.6	hard	boulder	100	-	-	-	-	rock	boulder

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

4.1.3 MIDDLE KEEYASK RESERVOIR

The middle Keeyask reservoir was sampled to monitor substrate changes in deep water areas of the reservoir following impoundment. Substrate surveys were conducted within four distinct areas of the middle Keeyask reservoir on August 22, 2023 (Map 6). Twelve substrate validation sites were sampled using a weighted sounding line (Table 8). Hard substrates were found and classified as boulder. Substrate mapping derived from analysis of sidescan image data confirmed boulder was present at each site.



Map 6: **Map illustrating the results of substrate composition sampling sites and acoustic imaging in the lotic portion of the middle Keeyask reservoir, 2023. Lighter colours in the acoustic imagery indicate harder substrates while darker colours indicate softer substrates.**

Table 8: Substrate type observed during direct sampling using a weighted sounding line in the lotic portion of the middle Keeyask reservoir, 2023.

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	%		
RSC-1	weighted sounding line	22-Aug-23	335852	6244517	10.5	hard	boulder	100	-	-	-	-	rock	boulder
RSC-2	weighted sounding line	22-Aug-23	336074	6244512	9.7	hard	boulder	100	-	-	-	-	rock	boulder
RSC-3	weighted sounding line	22-Aug-23	336293	6244423	7.5	hard	boulder	100	-	-	-	-	rock	boulder
RSC-4	weighted sounding line	22-Aug-23	338624	6244554	11.7	hard	boulder	100	-	-	-	-	rock	boulder
RSC-5	weighted sounding line	22-Aug-23	338810	6244381	8.4	hard	boulder	100	-	-	-	-	rock	boulder
RSC-6	weighted sounding line	22-Aug-23	339147	6244026	9.5	hard	boulder	100	-	-	-	-	rock	boulder
RSC-7	weighted sounding line	22-Aug-23	340886	6243204	11.0	hard	boulder	100	-	-	-	-	rock	boulder
RSC-8	weighted sounding line	22-Aug-23	341259	6243382	11.0	hard	boulder	100	-	-	-	-	rock	boulder
RSC-9	weighted sounding line	22-Aug-23	341625	6243523	10.3	hard	boulder	100	-	-	-	-	rock	boulder
RSC-10	weighted sounding line	23-Aug-23	342937	6243473	9.8	hard	boulder	100	-	-	-	-	rock	boulder
RSC-11	weighted sounding line	23-Aug-23	343328	6243499	14.1	hard	boulder	100	-	-	-	-	rock	boulder
RSC-12	weighted sounding line	23-Aug-23	343637	6243588	12.8	hard	boulder	100	-	-	-	-	rock	boulder

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

4.1.4 ENTRANCE TO GULL LAKE

It was predicted in the EIS that following impoundment of the Keeyask reservoir, decreased water velocities would lead to the deposition of sand downstream of the entrance to Gull Lake and that the area may become suitable for YOY Lake Sturgeon.

4.1.4.1 DEPTH, WATER LEVEL, AND VELOCITY

Boat-based ADCP depth and velocity surveys were conducted at nine transects in the area extending approximately 4.5 km downstream of the Gull Lake entrance on August 16, 2023 (Manitoba Hydro 2024; Map 7). Estimated mean Nelson River inflow was 2,883 m^3/s (Table 9). The water surface elevation at the time of survey was estimated as 158.7 m throughout the reach. Average water depths in the reach ranged from 1.27 to 21.21 m with a mean of 12.26 m. Maximum depths ranged from 15.16 m (Transect 1) to 21.21 m (Transect 5), making it one of the deepest areas surveyed.

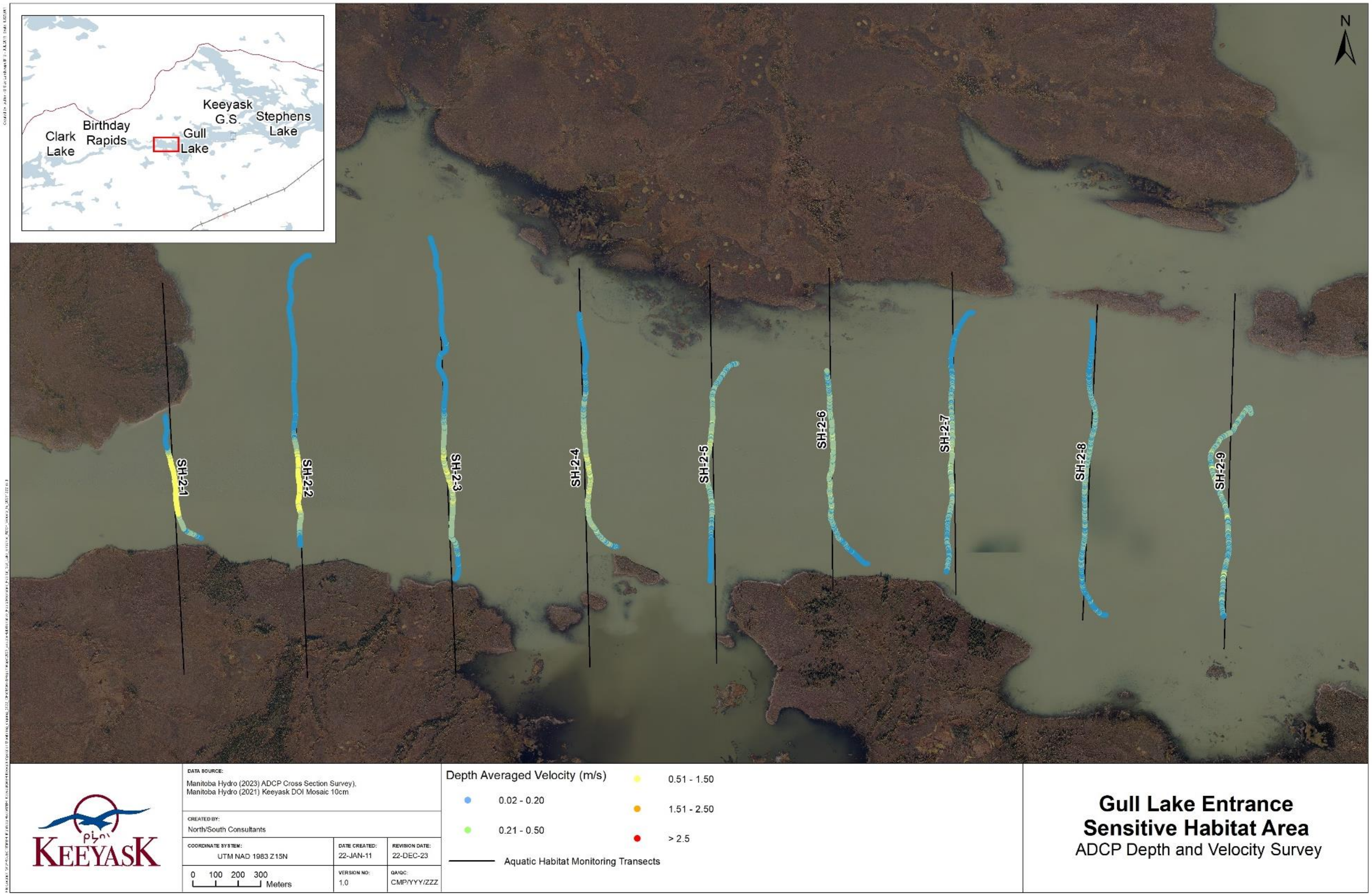
Table 9: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for the nine cross sections surveyed in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area with the SonTek M9 ADCP on August 16, 2023

Transect ID	Date	Sample Distance (m)	Estimated Inflow[1] (m^3/s)	Estimated WSE[2] (m)	Depth (m)			Velocity (m/s)		
					Min	Max	Mean	Min	Max	Mean
SH2-1	16-Aug-23	553	2883	158.7	2.81	15.16	11.08	0.00	0.91	0.42
SH2-2	16-Aug-23	580	2883	158.7	8.61	16.40	12.42	0.00	0.79	0.23
SH2-3	16-Aug-23	1068	2883	158.7	1.27	15.83	10.98	0.00	0.66	0.23
SH2-4	16-Aug-23	929	2883	158.7	5.67	17.11	12.01	0.01	1.13	0.29
SH2-5	16-Aug-23	775	2883	158.7	2.50	21.21	12.54	0.01	0.91	0.24
SH2-6	16-Aug-23	781	2883	158.7	7.57	18.15	13.32	0.02	1.05	0.26
SH2-7	16-Aug-23	946	2883	158.7	6.40	17.82	12.54	0.01	0.99	0.22
SH2-8	16-Aug-23	940	2883	158.7	6.60	17.94	11.88	0.00	0.69	0.19
SH2-9	16-Aug-23	934	2883	158.7	4.56	18.26	13.58	0.01	1.07	0.26
Summary					**1.27**	**21.21**	**12.26**	**0.00**	**1.13**	**0.26**

1 - Estimated or virtualized inflow provided by MBH.

2 - Water surface elevation (WSE) estimated from daily averages at MBH Gauging Station 05UF587 (750 m upstream of the Gull Lake entrance).

Water velocities were similar along each of the transects, with low to moderate water velocities in the middle of the channel (lessening with distance from the inlet) and areas of low and standing water along each shore (Figure 4). Transect 1 is located farthest upstream and had the highest mean water velocity (0.42 m/s). Average water velocities ranged from 0.19 to 0.29 m/s in all other transects (Table 9). Maximum water velocities were found roughly within the middle of the channel throughout the reach.



Map 7: **Depth averaged velocities measured during ADCP transect surveys in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area, 2023.**

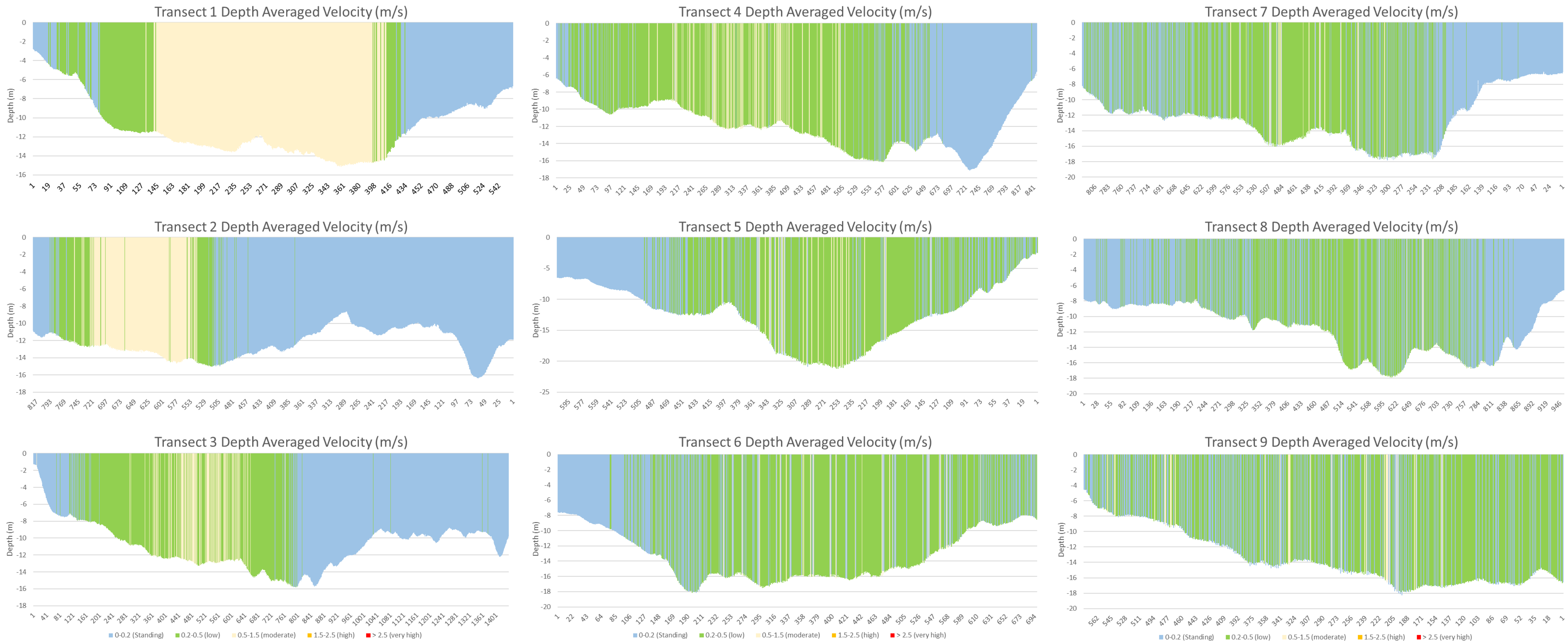


Figure 4: Depth averaged water velocity from nine transects sampled using an ADCP at the entrance to Gull Lake sensitive habitat area, 2023. Cross sections are viewed looking upstream (left to right bank).

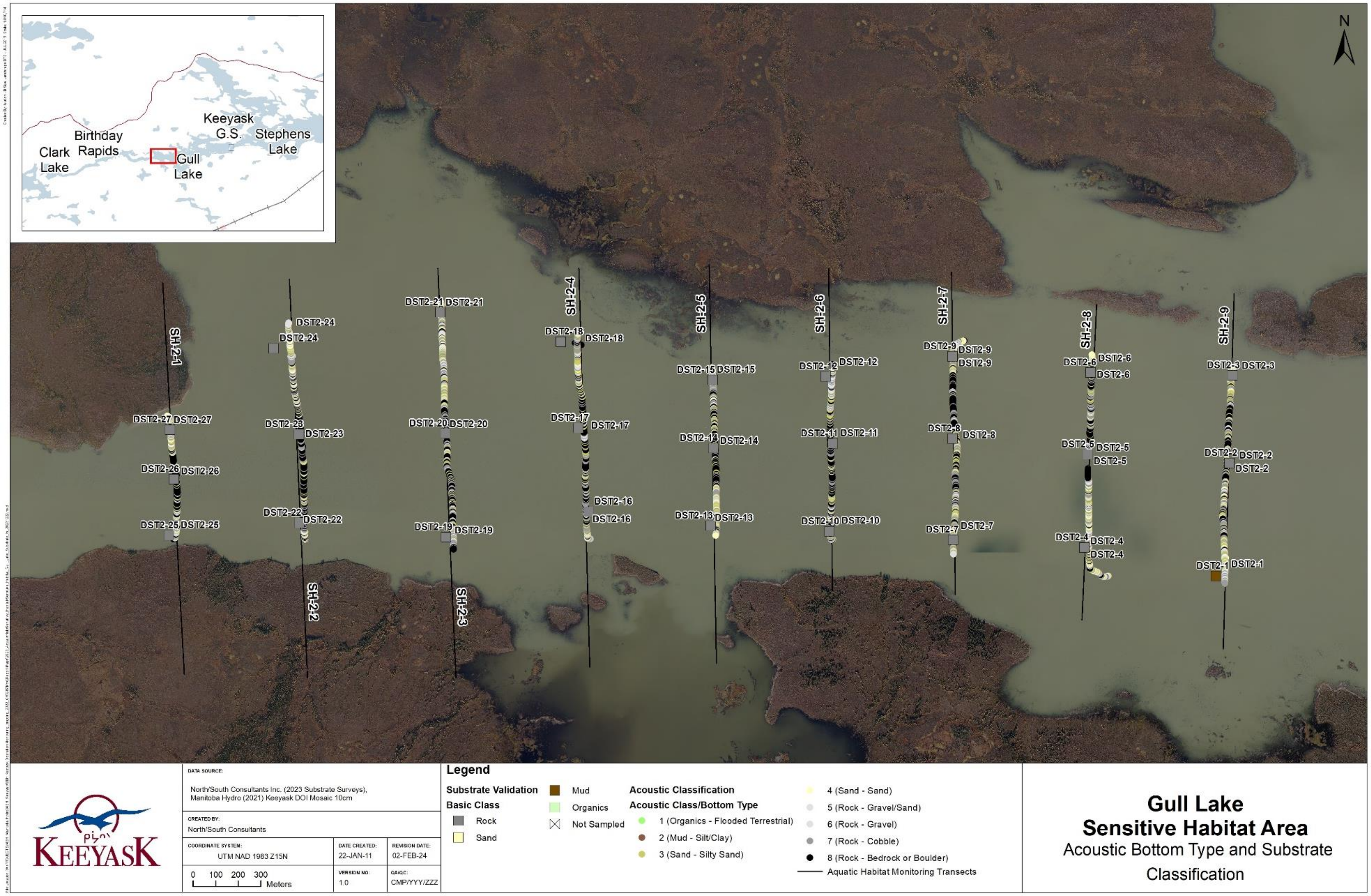
4.1.4.2 SUBSTRATE

Substrate surveys were conducted on August 23, 2023 (Map 8). Twenty-seven substrate validation sites were sampled using either a petite Ponar or a weighted sounding line.

The acoustic classification model indicated the area contained mainly hard substrates including bedrock/boulder (31%) followed by cobble (27%; Table 10). Softer substrates (*i.e.*, silt/clay/sand) were found in 18% of the area. Small areas of sand (4%) and sand/gravel (9%) were also found. The majority of the substrate validation sites were hard, described as boulder (Table 11). However, one site (DST2-1), sampled for PSA, indicated sand (39.7%) and silt (46.4%) were the dominant substrates (Table A1-1).

Table 10: Substrate composition of each sampling transect collected using a single beam acoustic sonar data at the entrance to Gull Lake sensitive habitat area, 2023.

Transect ID	Acoustic Substrate Classification Composition (% Membership)							
	Organics	Mud		Sand	Rock			
	organics/FT	silt/ clay	silt/ clay/ sand	sand	gravel/ sand	gravel	cobble	bedrock/ boulder
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
1	0	0	17	6	8	10	20	39
2	0	0	13	6	9	12	27	33
3	0	0	16	4	10	15	27	28
4	0	0	18	3	8	7	31	34
5	0	0	23	2	11	9	23	32
6	0	0	16	2	7	9	29	37
7	0	0	19	5	8	9	28	31
8	0	0	19	8	12	13	28	20
9	0	0	21	5	10	11	28	25
Summary	**0**	**0**	**18**	**4**	**9**	**11**	**27**	**31**



Map 8: **Substrate type measured during acoustic and substrate validation surveys in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area, 2023.**

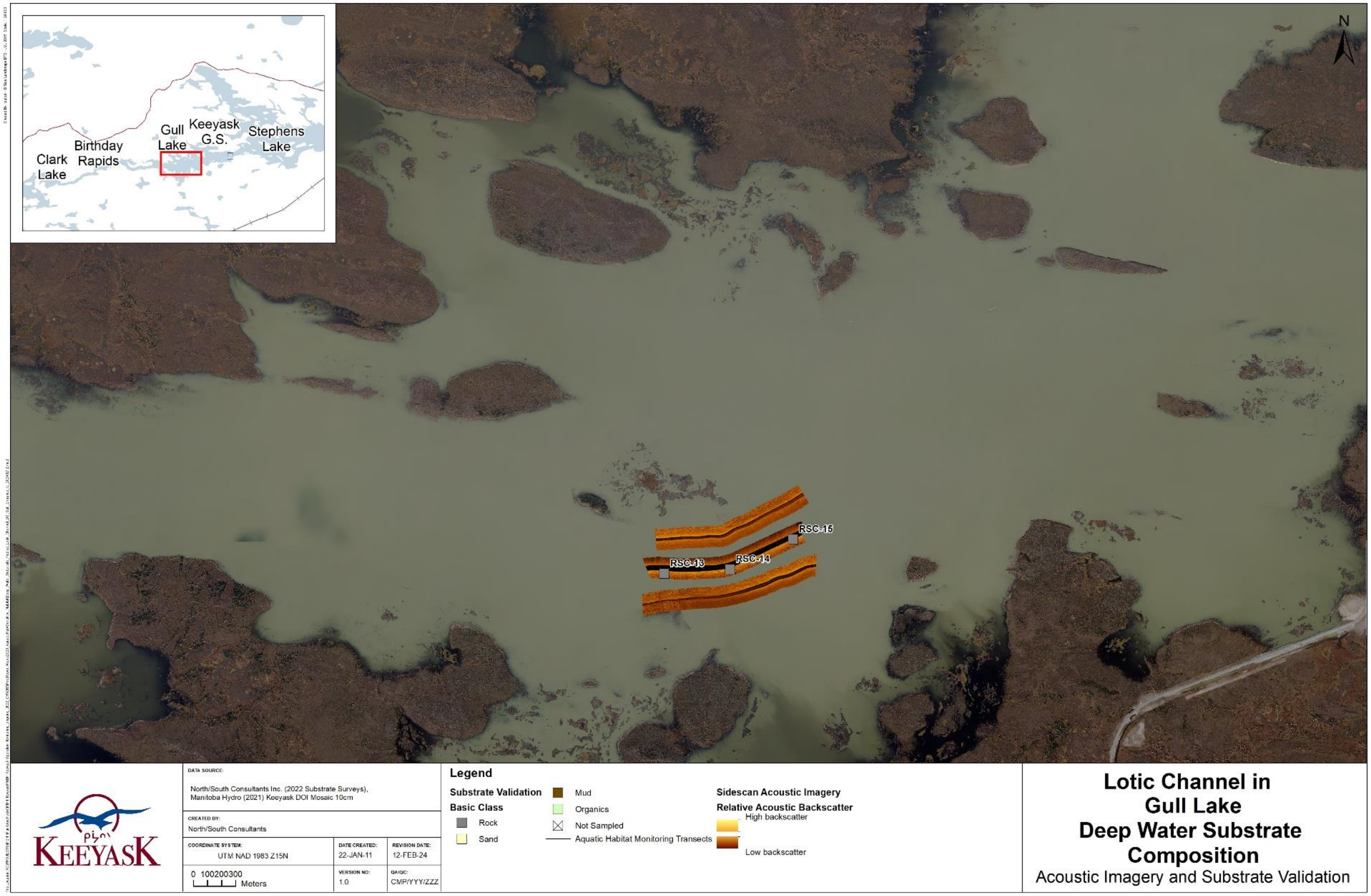
Table 11: Substrate type observed during direct sampling using a weighted sounding line or petite Ponar dredge in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area, 2023.

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	%		
DST2-1	petite Ponar	23-Aug-23	349756	6243512	9.2	soft	clay	85	silt	10	cobble	5	mud	clay/silt/cobble
DST2-2	weighted sounding line	23-Aug-23	349816	6244011	16.2	hard	boulder	100	-	-	-	-	-	boulder
DST2-3	petite Ponar	23-Aug-23	349830	6244399	9.3	hard	boulder	100	-	-	-	-	-	boulder
DST2-4	weighted sounding line	23-Aug-23	349175	6243638	9.2	hard	boulder	100	-	-	-	-	-	boulder
DST2-5	weighted sounding line	23-Aug-23	349189	6244050	15.3	hard	boulder	100	-	-	-	-	-	boulder
DST2-6	weighted sounding line	23-Aug-23	349203	6244412	15.5	hard	boulder	100	-	-	-	-	-	boulder
DST2-7	weighted sounding line	23-Aug-23	348594	6243672	11.5	hard	boulder	100	-	-	-	-	-	boulder
DST2-8	petite Ponar	23-Aug-23	348592	6244120	13.6	hard	boulder	100	-	-	-	-	-	boulder
DST2-9	weighted sounding line	23-Aug-23	348592	6244483	10.9	hard	boulder	100	-	-	-	-	-	boulder
DST2-10	weighted sounding line	23-Aug-23	348047	6243709	14.8	hard	boulder	100	-	-	-	-	-	boulder
DST2-11	weighted sounding line	23-Aug-23	348062	6244098	14.5	hard	boulder	100	-	-	-	-	-	boulder
DST2-12	petite Ponar	23-Aug-23	348030	6244394	11.7	hard	boulder	100	-	-	-	-	-	boulder
DST2-13	weighted sounding line	23-Aug-23	347522	6243735	11.8	hard	boulder	100	-	-	-	-	-	boulder
DST2-14	weighted sounding line	23-Aug-23	347534	6244078	19.9	hard	boulder	100	-	-	-	-	-	boulder
DST2-15	weighted sounding line	23-Aug-23	347531	6244378	9.4	hard	boulder	100	-	-	-	-	-	boulder
DST2-16	weighted sounding line	23-Aug-23	346981	6243797	8.5	hard	boulder	100	-	-	-	-	-	boulder
DST2-17	weighted sounding line	23-Aug-23	346937	6244167	15.0	hard	boulder	100	-	-	-	-	-	boulder
DST2-18	weighted sounding line	23-Aug-23	346859	6244548	14.5	hard	boulder	100	-	-	-	-	-	boulder
DST2-19	weighted sounding line	23-Aug-23	346351	6243684	8.0	hard	boulder	100	-	-	-	-	-	boulder
DST2-20	weighted sounding line	23-Aug-23	346349	6244142	13.2	hard	boulder	100	-	-	-	-	-	boulder
DST2-21	weighted sounding line	23-Aug-23	346326	6244678	9.0	hard	boulder	100	-	-	-	-	-	boulder
DST2-22	weighted sounding line	23-Aug-23	345702	6243748	12.2	hard	boulder	100	-	-	-	-	-	boulder
DST2-23	weighted sounding line	23-Aug-23	345701	6244138	13.6	hard	boulder	100	-	-	-	-	-	boulder
DST2-24	weighted sounding line	23-Aug-23	345589	6244518	8.2	hard	boulder	100	-	-	-	-	-	boulder
DST2-25	petite Ponar	23-Aug-23	345126	6243692	8.4	hard	boulder	100	-	-	-	-	-	boulder
DST2-26	weighted sounding line	23-Aug-23	345149	6243940	13.3	hard	boulder	100	-	-	-	-	-	boulder
DST2-27	weighted sounding line	23-Aug-23	345131	6244159	8.8	hard	boulder	100	-	-	-	-	-	boulder

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

4.1.5 GULL LAKE LOTIC CHANNEL

Substrate surveys were conducted within a lotic channel in upper Gull Lake on August 23, 2023 (Map 9). Three substrate validation sites were sampled using a weighted sounding line. Hard substrates were found, classified as boulder (Table 12). Substrate mapping derived from analysis of sidescan image data confirmed boulder was present at each site.



Map 9: **Map illustrating the results of substrate composition sampling sites and acoustic imaging in the lotic portion of upper Gull Lake, 2023. Lighter colours in the acoustic imagery indicate harder substrates while darker colours indicate softer substrates.**

Table 12: Substrate type observed during direct sampling using a weighted sounding line in a lotic channel within upper Gull Lake, 2023.

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	%		
RSC-13	weighted sounding line	23-Aug-23	351713	6243393	19.2	hard	boulder	100	-	-	-	-	rock	boulder
RSC-14	weighted sounding line	23-Aug-23	352177	6243424	18.8	hard	boulder	100	-	-	-	-	rock	boulder
RSC-15	weighted sounding line	23-Aug-23	352624	6243635	16.9	hard	boulder	100	-	-	-	-	rock	boulder

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

4.1.6 CARIBOU ISLAND

4.1.6.1 DEPTH, WATER LEVEL, AND VELOCITY

Boat-based ADCP depth and velocity surveys were conducted in the area of Gull Lake approaching and surrounding Caribou Island on August 19, 2023 (Manitoba Hydro 2024; Map 10). Estimated mean inflow was 2,939 m^3/s (Table 13). The water surface elevation at the time of the survey was 158.6 m throughout the reach. Water depths ranged from 0.75 to 20.19 m with a mean of 9.04 m.

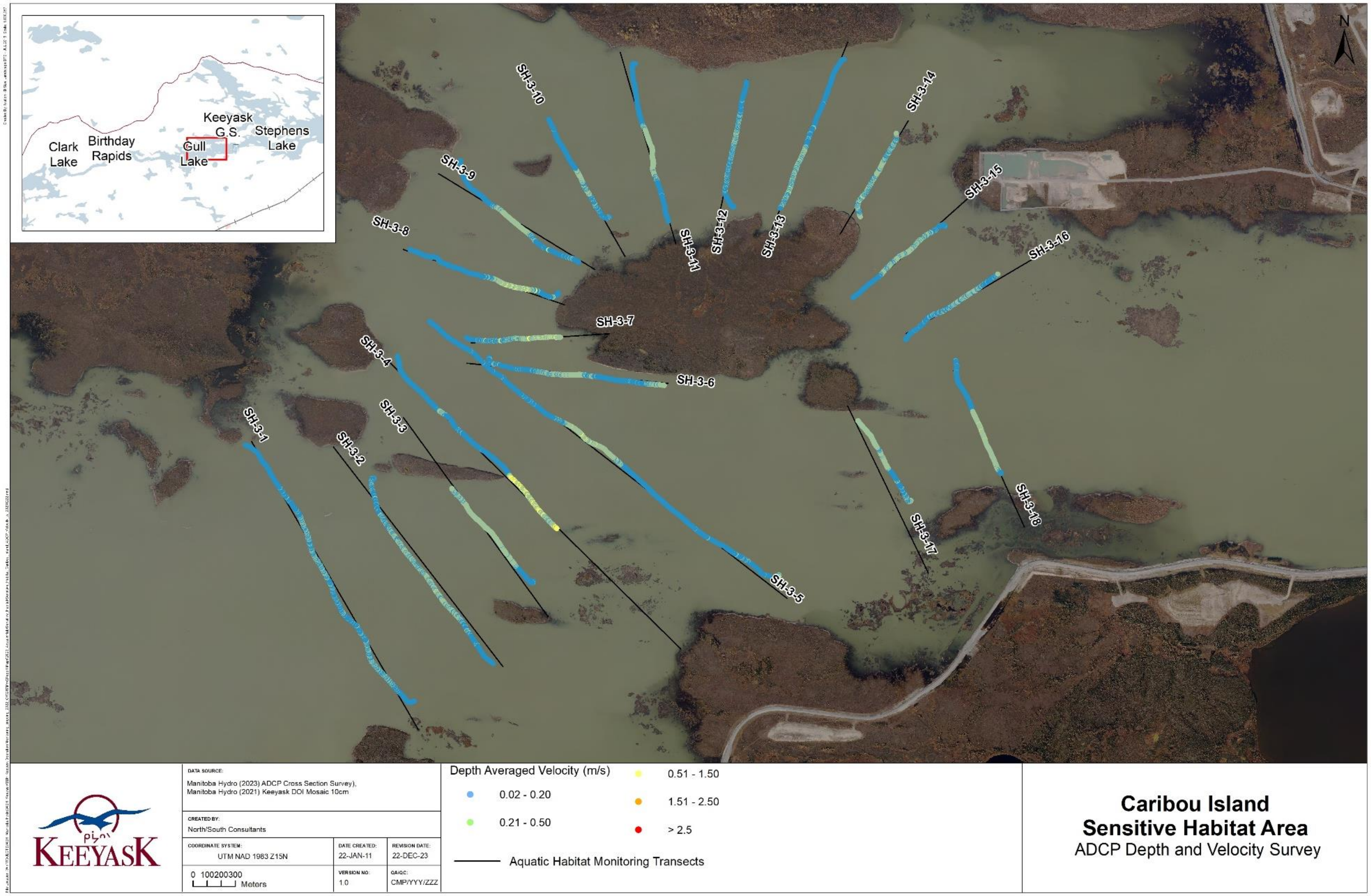
Table 13: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for the 18 cross sections surveyed in the Keeyask reservoir at the Caribou Island sensitive habitat area with the SonTek M9 ADCP on August 19, 2023.

Transect ID	Date	Sample Distance (m)	Estimated Inflow[1] (m^3/s)	Estimated WSE[2] (m)	Depth (m)			Velocity (m/s)		
					Min	Max	Mean	Min	Max	Mean
SH3-1	19-Aug-23	1633	2939	158.6	3.94	19.05	9.49	0.00	0.57	0.15
SH3-2	19-Aug-23	1468	2939	158.6	1.57	19.99	10.07	0.01	0.66	0.18
SH3-3	19-Aug-23	1364	2939	158.6	6.40	18.51	11.06	0.00	0.47	0.24
SH3-4	19-Aug-23	1096	2939	158.6	0.75	20.19	8.08	0.00	2.50	0.19
SH3-5	19-Aug-23	2094	2939	158.6	1.63	18.04	8.46	0.00	0.83	0.13
SH3-6	19-Aug-23	881	2939	158.6	6.77	16.87	9.78	0.00	0.51	0.17
SH3-7	19-Aug-23	472	2939	158.6	3.75	15.11	9.56	0.00	1.15	0.26
SH3-8	19-Aug-23	1173	2939	158.6	5.22	14.15	8.79	0.01	1.03	0.17
SH3-9	19-Aug-23	983	2939	158.6	3.64	13.56	8.12	0.01	0.83	0.16
SH3-10	19-Aug-23	975	2939	158.6	2.57	17.40	8.22	0.01	0.41	0.14
SH3-11	19-Aug-23	1038	2939	158.6	4.74	15.23	8.60	0.01	0.64	0.16
SH3-12	19-Aug-23	872	2939	158.6	4.14	16.36	8.48	0.01	0.51	0.15
SH3-13	19-Aug-23	999	2939	158.6	2.69	14.74	8.23	0.00	0.76	0.15
SH3-14	19-Aug-23	686	2939	158.6	1.15	15.69	8.57	0.03	2.28	0.23
SH3-15	19-Aug-23	741	2939	158.6	3.58	13.88	8.13	0.02	0.42	0.18
SH3-16	19-Aug-23	1075	2939	158.6	3.71	13.64	8.99	0.01	0.41	0.16
SH3-17	19-Aug-23	435	2939	158.6	1.83	17.35	9.16	0.04	0.44	0.25
SH3-18	19-Aug-23	720	2939	158.6	6.23	17.56	10.89	0.04	0.52	0.26
Summary					**0.75**	**20.19**	**9.04**	**0.00**	**2.50**	**0.19**

1 - Estimated or virtualized inflow provided by MBH.

2 - Water levels estimated from daily averages at MBH Gauging Station 05UF596 (175 m downstream of Birthday Rapids).

The entire reach was characterized by areas of low to moderate water velocity surrounded by areas of standing water (Figure 5). Minimum water velocities ranged from 0.00–0.04 m/s and maximum ranged from 0.41–2.50 m/s. Mean cross sectional water velocities ranged from 0.13–0.26 m/s (Transect 5 and Transects 7 and 18, respectively).



Map 10: **Depth averaged velocities measured during ADCP transect surveys in the Keeyask reservoir in the area surrounding Caribou Island, 2023.**

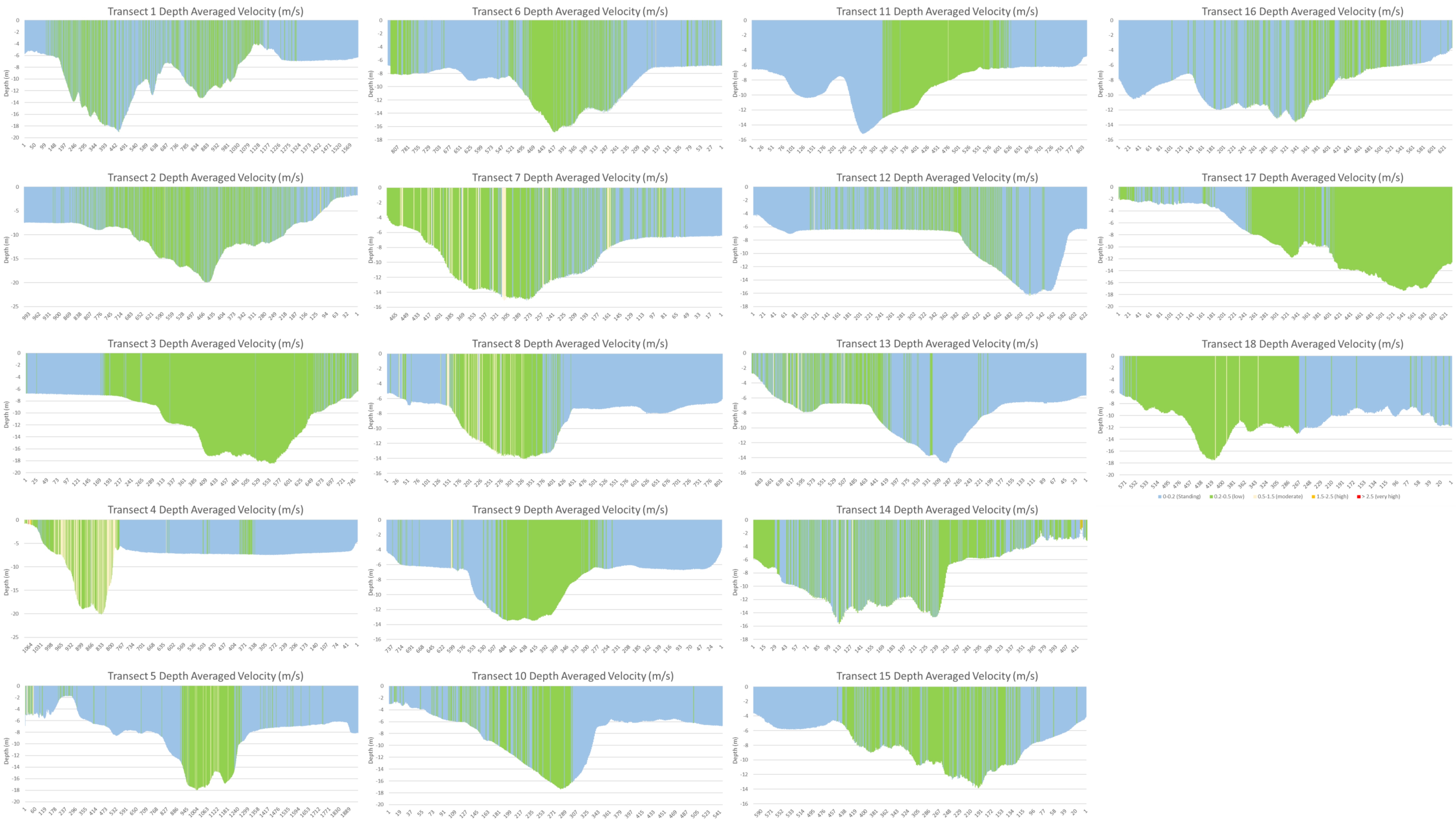


Figure 5: **Depth averaged water velocity from 18 transects sampled using an ADCP at the sensitive habitat area near Caribou Island in Gull Lake, 2023. Cross sections are viewed looking upstream (left to right bank).**

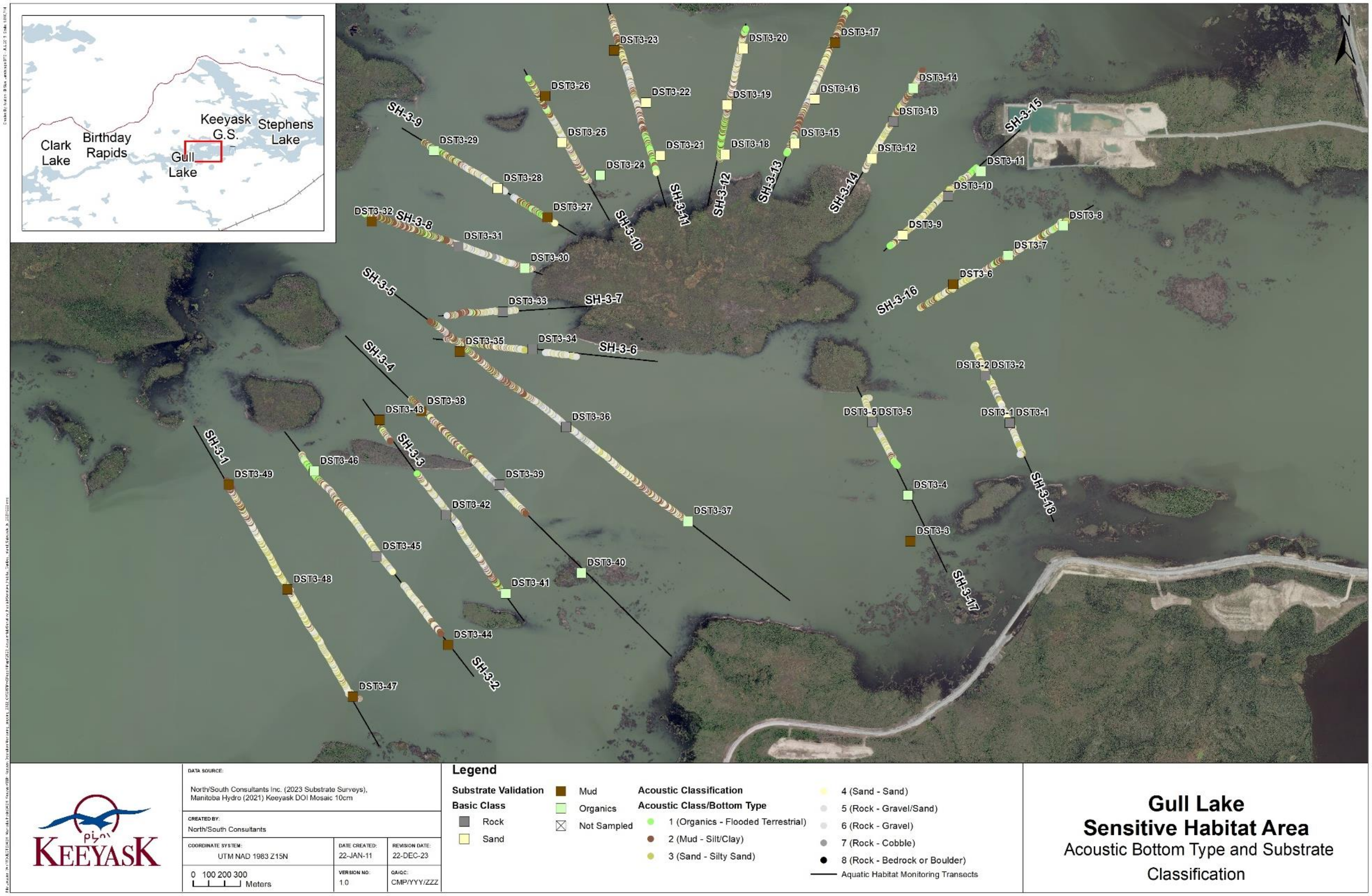
4.1.6.2 SUBSTRATE

Substrate surveys were conducted on August 17 and 18, 2023 (Map 11). Substrate was sampled at 49 sites; a petite Ponar was used at 44 sites, while a weighted sounding line was used at five sites where a grab could not be collected due to rocky substrate. Samples from ten sites were collected for PSA (Table A1-1).

The acoustic classification model indicated the area was dominated by silt/clay (20%), gravel (17%), and cobble (15%; Table 14). Acoustic signatures for sand and silt/clay/sand were each found in 12% of the reach. Organics comprised 5% of the substrate in the reach. Substrates were varied throughout the reach, ranging from hard boulder to areas of soft clay (Table 15). Sand was the dominant substrate type in 11 sites located on the north side of Caribou Island, previously identified as important Lake Sturgeon rearing habitat (Photo 1). Five of these sites were sampled for PSA which confirmed that sand was the predominant substrate (representing 86–97% of each sample) at all five sites (DST3-16, -19, -22, -25, and -28). This area of sand was bordered on the upstream and downstream sides by areas of mud (*i.e.,* silt and clay) and organics (Map 11). Silt deposition was evident at six of the 11 sites.

Table 14: Substrate composition of each sampling transect collected using a single beam acoustic sonar data at the Caribou Island sensitive habitat area, 2023.

Transect ID	Acoustic Substrate Classification Composition (% Membership)							
	Organics	Mud		Sand	Rock			
	organics /FT Class 1	silt/clay Class 2	silt/clay /sand Class 3	sand Class 4	gravel /sand Class 5	gravel Class 6	cobble Class 7	bedrock/ boulder Class 8
1	<1	7	19	17	15	23	15	4
2	7	9	12	13	12	22	17	8
3	2	22	11	8	8	9	20	18
4	2	27	6	9	11	20	7	17
5	1	14	5	21	11	24	8	15
6	3	18	10	13	13	18	14	12
7	2	18	12	12	7	12	23	15
8	3	38	6	10	9	12	13	10
9	11	32	5	10	8	20	10	4
10	3	27	10	13	9	21	10	6
11	9	27	3	19	8	15	12	8
12	12	34	5	11	5	14	15	4
13	3	36	6	14	10	14	12	5
14	2	12	19	13	14	19	15	8
15	13	9	21	11	11	12	15	8
16	3	26	16	14	12	17	9	2
17	12	4	22	4	7	8	28	15
18	0	0	26	10	14	18	20	12
Summary	**5**	**20**	**12**	**12**	**10**	**17**	**15**	**9**



Map 11: **Substrate type measured during acoustic and substrate validation surveys in the Keeyask reservoir in the area surrounding Caribou Island, 2023.**

Photo 1: Substrate collected at site DST3-28 in the area of the Keeyask reservoir surrounding Caribou Island showing sand and shells.

Table 15: Substrate type observed during direct sampling using a weighted sounding line or petite Ponar dredge in the Keeyask reservoir at the Caribou Island sensitive habitat area, 2023.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition								Basic Class	Silt Deposition Evident	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%	Substrate 4	%			
DST3-1	weighted sounding line	17-Aug-23	358678	6245804	13.3	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST3-2	weighted sounding line	17-Aug-23	358521	6246105	9.3	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST3-3	petite Ponar	17-Aug-23	358046	6245051	1.1	hard	clay	85	organic	15	-	-	-	-	mud	no	clay/organic
DST3-4	petite Ponar	17-Aug-23	358030	6245344	2.5	soft	organic	100	-	-	-	-	-	-	organic	no	organic
DST3-5	weighted sounding line	17-Aug-23	357805	6245808	12.7	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST3-6	petite Ponar	18-Aug-23	358267	6246635	11.2	moderate	clay	55	silt	20	organic	15	-	-	mud	yes	clay/silt/organic
DST3-7	petite Ponar	18-Aug-23	358667	6246868	5.9	soft	organic	70	clay	20	silt	10	-	-	organic	yes	organic/clay/silt
DST3-8	petite Ponar	18-Aug-23	359018	6247058	2.7	soft	organic	100	-	-	-	-	-	-	organic	no	organic
DST3-9	petite Ponar	18-Aug-23	357997	6246999	9.9	moderate	sand	70	silt	20	gravel	10	-	-	sand	yes	sand/silt/gravel
DST3-10	petite Ponar	18-Aug-23	358285	6247247	9.4	moderate	gravel	100	-	-	-	-	-	-	rock	no	gravel
DST3-11	petite Ponar	18-Aug-23	358494	6247404	1.6	soft	organic	100	-	-	-	-	-	-	organic	no	organic
DST3-12	petite Ponar	18-Aug-23	357800	6247485	10.4	soft	sand	70	clay	20	silt	10	-	-	sand	yes	sand/clay/silt
DST3-13	petite Ponar	18-Aug-23	357938	6247720	6.3	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST3-14	petite Ponar	18-Aug-23	358064	6247933	1.9	soft	organic	100	-	-	-	-	-	-	organic	no	organic
DST3-15	petite Ponar	18-Aug-23	357311	6247582	7.6	moderate	sand	80	clay	15	silt	5	-	-	sand	yes	sand/clay/silt
DST3-16	petite Ponar	18-Aug-23	357437	6247863	11.0	moderate	sand	95	clay	5	-	-	-	-	sand	no	sand/clay
DST3-17	petite Ponar	18-Aug-23	357567	6248223	7.1	moderate	clay	90	silt	10	-	-	-	-	mud	yes	clay/silt
DST3-18	petite Ponar	18-Aug-23	356867	6247511	6.5	moderate	sand	65	clay	30	silt	5	-	-	sand	yes	sand/clay/silt
DST3-19	petite Ponar	18-Aug-23	356879	6247826	6.3	moderate	sand	85	clay	15	-	-	-	-	sand	no	sand/clay
DST3-20	petite Ponar	18-Aug-23	356982	6248185	15.3	moderate	sand	80	clay	15	silt	5	-	-	sand	yes	sand/clay/silt
DST3-21	petite Ponar	18-Aug-23	356455	6247504	6.0	moderate	sand	70	clay	20	silt	10	-	-	sand	yes	sand/clay/silt
DST3-22	petite Ponar	18-Aug-23	356364	6247842	7.8	moderate	sand	75	clay	20	gravel	5	-	-	sand	no	sand/clay/gravel
DST3-23	petite Ponar	18-Aug-23	356161	6248174	7.2	moderate	clay	85	silt	15	-	-	-	-	mud	yes	clay/silt
DST3-24	petite Ponar	18-Aug-23	356074	6247378	6.7	soft	organic	80	silt	20	-	-	-	-	organic	yes	organic/silt
DST3-25	petite Ponar	18-Aug-23	355829	6247587	13.2	moderate	sand	95	organic	5	-	-	-	-	sand	no	sand/organic
DST3-26	petite Ponar	18-Aug-23	355731	6247661	6.4	moderate	clay	70	silt	30	-	-	-	-	mud	yes	clay/silt
DST3-27	petite Ponar	17-Aug-23	355737	6247111	6.1	moderate	clay	80	silt	10	organic	10	-	-	mud	yes	clay/silt/organic
DST3-28	petite Ponar	17-Aug-23	355421	6247295	12.7	moderate	sand	90	organic	10	-	-	-	-	sand	no	sand/organic
DST3-29	petite Ponar	17-Aug-23	355015	6247535	6.3	moderate	organic	85	silt	15	-	-	-	-	organic	yes	organic/silt
DST3-30	petite Ponar	17-Aug-23	355592	6246788	6.2	soft	organic	60	clay	20	silt	20	-	-	organic	yes	organic/clay/silt
DST3-31	petite Ponar	17-Aug-23	355170	6246926	12.4	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST3-32	petite Ponar	17-Aug-23	354619	6247085	6.6	moderate	clay	70	silt	25	organic	5	-	-	mud	yes	clay/silt/organic
DST3-33	petite Ponar	17-Aug-23	355453	6246511	13.8	hard	gravel	75	sand	25	-	-	-	-	rock	no	gravel/sand
DST3-34	petite Ponar	17-Aug-23	355642	6246272	14.3	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST3-35	petite Ponar	17-Aug-23	355306	6246155	6.8	moderate	clay	50	sand	45	gravel	5	-	-	mud	no	clay/sand/gravel
DST3-36	petite Ponar	17-Aug-23	355855	6245777	14.3	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST3-37	petite Ponar	17-Aug-23	356631	6245178	6.8	soft	organic	100	-	-	-	-	-	-	organic	no	organic
DST3-38	petite Ponar	17-Aug-23	354934	6245878	6.9	moderate	clay	80	silt	15	organic	5	-	-	mud	yes	clay/silt/organic

Table 15: Continued.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition								Basic Class	Silt Deposition Evident	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%	Substrate 4	%			
DST3-39	petite Ponar	17-Aug-23	355432	6245410	18.3	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST3-40	petite Ponar	17-Aug-23	355952	6244849	2.3	soft	organic	100	-	-	-	-	-	-	organic	no	organic
DST3-41	petite Ponar	17-Aug-23	355471	6244719	6.1	soft	organic	100	-	-	-	-	-	-	organic	no	organic
DST3-42	weighted sounding line	17-Aug-23	355092	6245217	16.1	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST3-43	petite Ponar	17-Aug-23	354669	6245823	6.5	moderate	clay	70	sand	20	silt	10	-	-	mud	yes	clay/sand/silt
DST3-44	petite Ponar	17-Aug-23	355104	6244391	7.4	moderate	clay	80	silt	10	organic	10	-	-	mud	yes	clay/silt/organic
DST3-45	weighted sounding line	17-Aug-23	354651	6244954	17.2	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST3-46	petite Ponar	17-Aug-23	354254	6245497	2.5	moderate	organic	100	-	-	-	-	-	-	organic	no	organic
DST3-47	petite Ponar	17-Aug-23	354500	6244063	6.8	soft	clay	60	silt	35	organic	5	-	-	mud	yes	clay/silt/organic
DST3-48	petite Ponar	17-Aug-23	354083	6244745	7.1	moderate	clay	70	silt	20	organic	10	-	-	mud	yes	clay/silt/organic
DST3-49	petite Ponar	17-Aug-23	353709	6245412	6.5	moderate	clay	80	silt	10	organic	10	-	-	mud	yes	clay/silt/organic

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

4.1.7 STEPHENS LAKE

4.1.7.1 DEPTH, WATER LEVEL, AND VELOCITY

Boat-based ADCP depth and velocity surveys were conducted in the area extending from approximately 1.0–7.5 km downstream of the Keeyask GS on August 17, 2023 (Manitoba Hydro 2024; Map 12). Estimated mean inflow was 3,077 m^3/s (Table 16). The water surface elevation at the time of the survey was 140.6 m throughout the reach. Average water depths ranged from 0.80 to 20.87 m with a mean of 10.52 m.

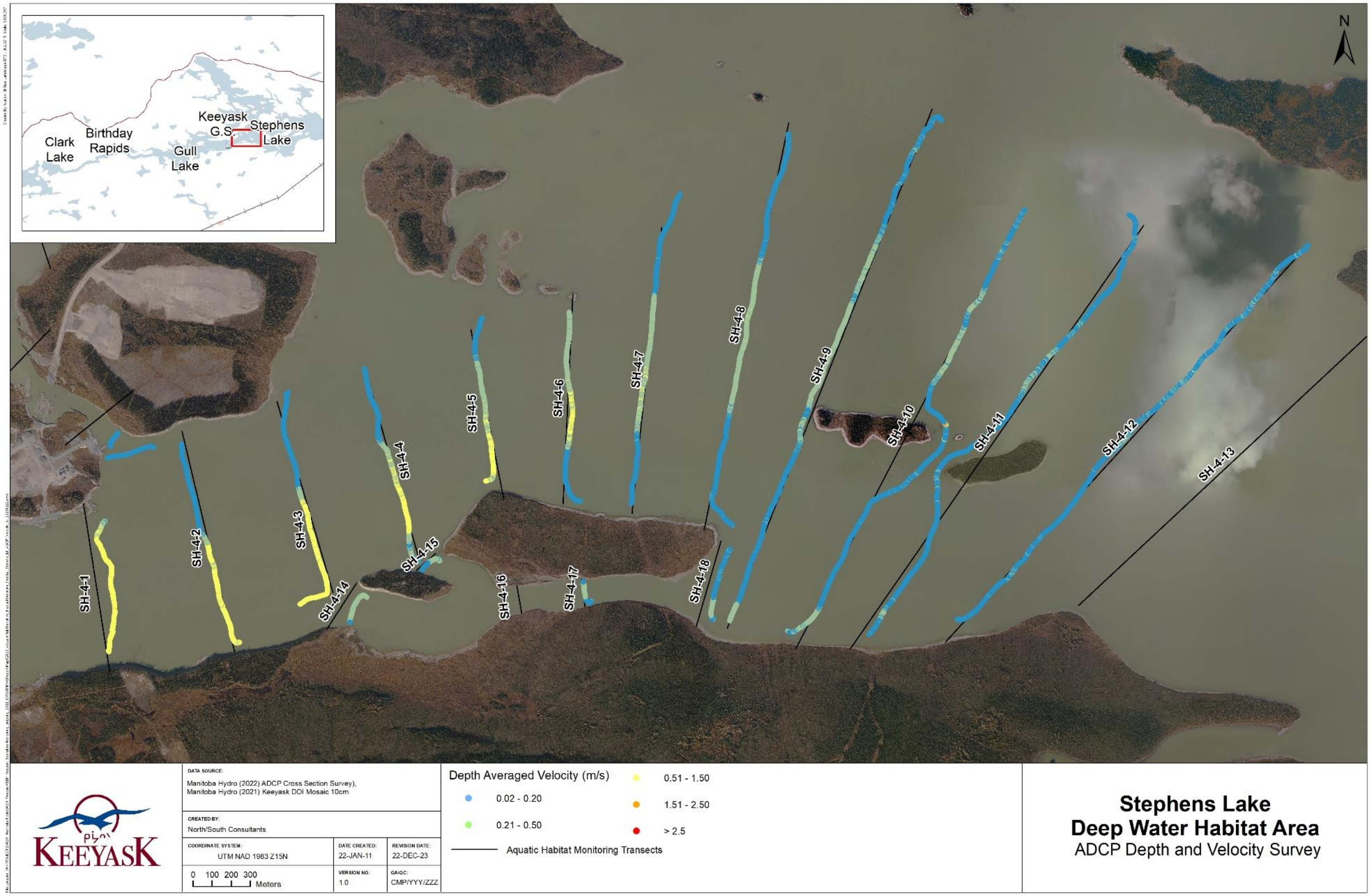
Transect 1 was the farthest upstream transect sampled in Stephens Lake, located approximately 1 km downstream of the Keeyask GS and comprised of moderate to high velocities throughout (Figure 6). Mean water velocity was 0.97 m/s, ranging from 0.11 to 1.79 m/s (SH4-1). A channel of moderate water velocity extended to approximately 3 km downstream (SH4-6), after which mean velocities became low (SH4-7 to SH4-8; Map 12).

Table 16: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for the 18 cross sections surveyed in the Stephens Lake sensitive habitat area with the SonTek M9 ADCP on August 17, 2023.

Transect ID	Date	Sample Distance (m)	Estimated Inflow[1] (m^3/s)	Estimated WSE[2] (m)	Depth (m)			Velocity (m/s)		
					Min	Max	Mean	Min	Max	Mean
SH4-1	17-Aug-23	713	3077	140.6	1.80	10.41	5.86	0.11	1.79	0.97
SH4-2	17-Aug-23	1069	3077	140.6	3.96	13.24	10.25	0.00	0.98	0.39
SH4-3	17-Aug-23	1015	3077	140.6	4.77	14.61	11.22	0.00	0.97	0.41
SH4-4	17-Aug-23	1013	3077	140.6	9.05	15.64	14.03	0.00	0.80	0.31
SH4-5	17-Aug-23	815	3077	140.6	6.93	16.20	13.10	0.00	0.66	0.37
SH4-6	17-Aug-23	946	3077	140.6	4.77	17.74	13.62	0.01	0.65	0.30
SH4-7	17-Aug-23	1487	3077	140.6	4.81	16.40	13.27	0.01	1.15	0.22
SH4-8	17-Aug-23	1577	3077	140.6	3.47	16.76	12.86	0.00	0.55	0.19
SH4-9	17-Aug-23	2719	3077	140.6	1.14	18.10	11.57	0.01	0.68	0.20
SH4-10	17-Aug-23	2403	3077	140.6	0.80	20.54	11.72	0.00	2.34	0.15
SH4-11	17-Aug-23	2535	3077	140.6	1.18	19.02	13.16	0.00	0.55	0.12
SH4-12	17-Aug-23	2685	3077	140.6	3.62	18.25	13.61	0.00	0.50	0.12
SH4-13	17-Aug-23	2049	3077	140.6	1.53	20.87	12.92	-	-	-
SH4-14	17-Aug-23	167	3077	140.6	4.10	7.35	6.10	0.11	0.48	0.36
SH4-15	17-Aug-23	239	3077	140.6	2.18	7.90	4.62	0.01	0.39	0.19
SH4-16	17-Aug-23	179	3077	140.6	2.44	9.70	6.81	-	-	-
SH4-17	17-Aug-23	115	3077	140.6	8.29	11.32	9.84	0.01	0.41	0.22
SH4-18	17-Aug-23	201	3077	140.6	1.48	10.66	4.90	0.01	0.48	0.16
Summary					**0.80**	**20.87**	**10.52**	**0.00**	**2.34**	**0.29**

1 - Estimated or virtualized inflow provided by MBH.

2 - Water levels estimated from daily averages at MBH Gauging Station 05UF709 (Stephens Lake).



Map 12: Depth averaged velocities measured during ADCP transect surveys in the upstream portion of Stephens Lake, 2023.

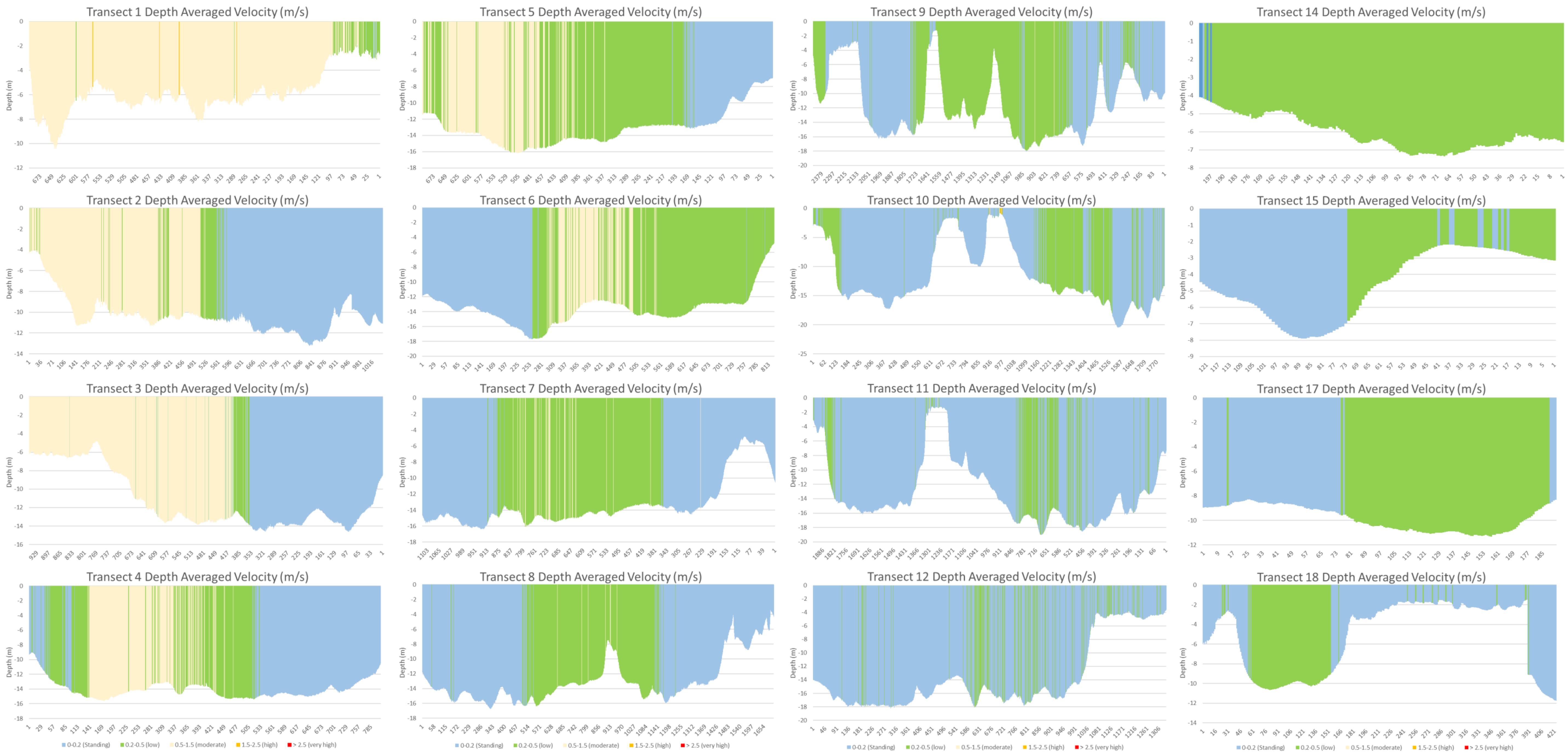


Figure 6: Depth averaged water velocity from 18 transects sampled using an ADCP in Stephens Lake downstream of the Keeyask GS, 2023. Cross sections are viewed looking upstream (left to right bank).

4.1.7.2 SUBSTRATE

Substrate surveys were conducted in the area extending from approximately 1.0–7.5 km downstream of the Keeyask GS during August (summer). A portion of this area, approximately 5–7 km downstream of the Keeyask GS, was identified in the EIS as Lake Sturgeon YOY and rearing habitat. To assess whether there were seasonal changes in substrate type that could affect its use by YOY sturgeon, substrate surveys were also conducted in this area in June (spring) and September (fall).

Spring substrate surveys were conducted on June 3, 8, and 10, 2023 (Map 13). Twenty sites were sampled using a petite Ponar. Sandy substrates were predominant (50–90%) at four sites while silt deposition was evident at eight (Table 17). Organics, consisting of detritus and loose, broken-down plant matter (Photo 2), were evident at 19 sampling sites, and were the dominant substrate at three.

Photo 2: Substrate collected at site T1-3 in the upper Stephens Lake sensitive habitat area in June showing organics, clay, and silt.

Map 13: **Map illustrating the results of substrate composition sampling sites and acoustic imaging for the Stephens Lake sensitive habitat area, June 2023. Lighter colours in the acoustic imagery indicate harder substrates while darker colours indicate softer substrates.**

Table 17: Substrate type observed during direct sampling using a petite Ponar dredge in the in the Stephens Lake sensitive habitat area, June 2023.

Site ID	Transect ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition								Basic Class	Silt Deposition Evident	Class Verification[1]
								Substrate 1	%	Substrate 2	%	Substrate 3	%	Substrate 4	%			
T1-1	T1	petite Ponar	3-Jun-23	368449	6248902	13.7	soft	clay	90	silt	9	organic	1	-	-	mud	yes	clay/silt/organic
T1-2	T1	petite Ponar	3-Jun-23	368675	6248996	13.5	soft	clay	80	silt	20	-	-	-	-	mud	yes	clay/silt
T1-3	T1	petite Ponar	3-Jun-23	368937	6249113	14.1	soft	organic	50	clay	40	silt	10	-	-	organic	yes	organic/clay/silt
T2-1	T2	petite Ponar	3-Jun-23	368245	6248521	14.1	hard	sand	90	gravel	5	organic	5	-	-	sand	no	sand/gravel/organic
T2-2	T2	petite Ponar	3-Jun-23	368542	6248651	14.5	moderate	sand	50	organic	30	clay	10	silt	10	sand	yes	sand/organic/clay/silt
T2-3	T2	petite Ponar	8-Jun-23	368863	6248767	16.2	soft	clay	80	sand	15	organic	5	-	-	mud	no	clay/sand/organic
T2-4	T2	petite Ponar	8-Jun-23	369015	6248881	13.7	soft	organic	80	clay	15	sand	5	-	-	organic	no	organic/clay/sand
T2-5	T2	petite Ponar	8-Jun-23	369273	6249007	13.3	soft	clay	60	organic	35	sand	5	-	-	mud	no	clay/organic/sand
T3-1	T3	petite Ponar	8-Jun-23	368368	6248287	13.1	hard	cobble	99	organic	1	-	-	-	-	rock	no	cobble/organic
T3-2	T3	petite Ponar	8-Jun-23	368646	6248412	-	hard	sand	60	organic	40	-	-	-	-	sand	no	sand/organic
T3-3	T3	petite Ponar	3-Jun-23	368837	6248530	17.5	soft	clay	80	sand	10	organic	10	-	-	mud	no	clay/sand/organic
T3-4	T3	petite Ponar	3-Jun-23	369093	6248659	14.9	soft	clay	85	sand	10	organic	5	-	-	mud	no	clay/sand/organic
T3-5	T3	petite Ponar	3-Jun-23	369352	6248801	16.1	soft	clay	75	organic	15	sand	10	-	-	mud	no	clay/organic/sand
T4-1	T4	petite Ponar	8-Jun-23	368507	6248040	12.9	moderate	organic	50	silt	50	-	-	-	-	organic	yes	organic/silt
T4-2	T4	petite Ponar	8-Jun-23	368795	6248183	13.2	soft	sand	75	clay	20	organic	5	-	-	sand	no	sand/clay/organic
T4-3	T4	petite Ponar	3-Jun-23	369086	6248375	13.4	soft	clay	80	sand	15	organic	5	-	-	mud	no	clay/sand/organic
T4-4	T4	petite Ponar	10-Jun-23	369353	6248502	15.4	soft	clay	40	silt	40	organic	20	-	-	mud	yes	clay/silt/organic
T5-1	T5	petite Ponar	10-Jun-23	368813	6247984	9.3	soft	clay	70	organic	15	silt	15	-	-	mud	yes	clay/organic/silt
T5-2	T5	petite Ponar	10-Jun-23	369092	6248146	13.4	soft	clay	90	organic	5	silt	5	-	-	mud	yes	clay/organic/silt
T5-3	T5	petite Ponar	3-Jun-23	369418	6248312	15.3	soft	clay	70	sand	20	organic	10	-	-	mud	no	clay/sand/organic

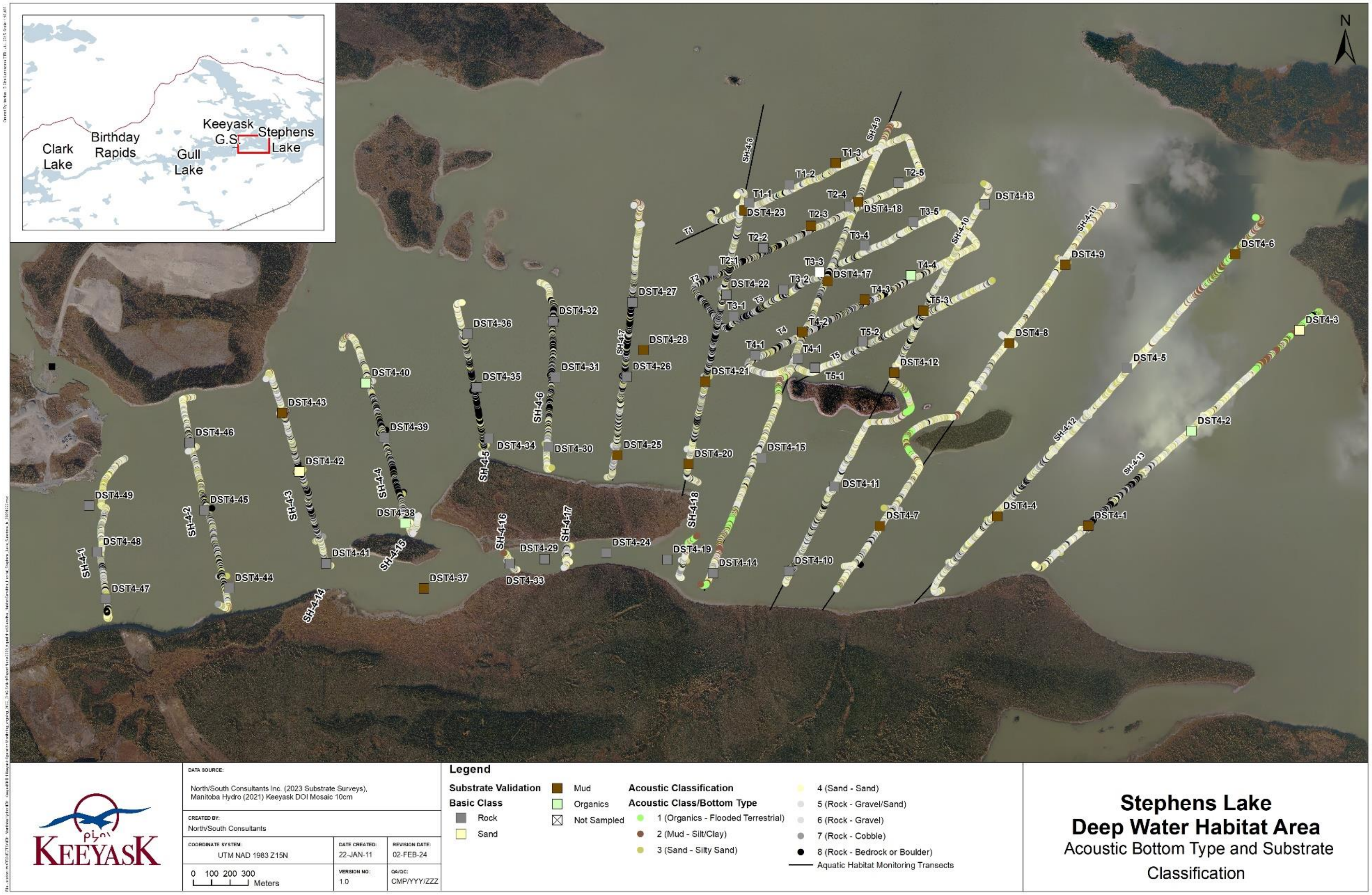
Summer substrate validation and single-beam acoustic surveys were conducted from August 12-14, 2023 (Map 14). Sixty-nine sites were sampled, using a petite Ponar (at 45 sites) and a weighted sounding line (at 24 sites). Samples from nine sites were collected for PSA (Table A1-1).

Acoustic classification was conducted on August 13 and 14, 2023 (Table 18). The acoustic classification model indicated that cobble and gravel comprised the largest single type (19% each) of the substrate type in the area, followed by silt/clay/sand, sand, and bedrock/boulder, each comprising 14% of the reach. Silt/clay comprised 5% of the substrate and organics were found in 4% of the reach. Hard rocky substrates (*e.g.,* boulder) were predominant (90–100%) within the upstream portion of the reach and along the south shore (Map 14; Table 19). Sand was the predominant (60–95%) substrate at two sites (Photo 3). PSA indicated that sand was dominant at five of nine representative sites sampled (representing 48.1–65.7% of each sample), silt being the dominate substrate at the four remaining sites. Silt deposition was evident at 20 sites during the summer sampling period, four of which were within the area 5 to 7 km downstream of the GS where juvenile Lake Sturgeon are found.

Table 18: Substrate composition of each sampling transect collected using a single beam acoustic sonar data at the Stephens Lake sensitive habitat area, 2023.

Transect ID	Acoustic Substrate Classification Composition (% Membership)							
	Organics	Mud		Sand		Rock		
	organics /FT	silt/clay	silt/clay /sand	sand	gravel/ sand	gravel	cobble	bedrock/ boulder
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
1	1	3	32	23	11	11	16	3
2	0	2	20	10	12	13	26	18
3	0	1	14	9	10	15	30	21
4	1	5	13	9	9	13	23	27
5	0	1	13	7	7	11	19	43
6	0	0	15	9	9	10	25	32
7	0	3	16	6	10	14	25	25
8	0	0	14	6	10	18	29	22
9	7	11	15	12	14	19	16	5
10	6	3	16	16	14	26	14	5
11	6	6	16	21	14	27	9	1
12	5	12	12	18	13	27	9	3
13	13	11	12	15	11	19	10	9
14	-	-	-	-	-	-	-	-
15	0	7	5	21	19	36	7	5
16	4	5	9	21	19	14	26	2
17	0	3	14	20	5	27	23	8
18	20	13	5	11	9	25	13	3
Summary	**4**	**5**	**14**	**14**	**11**	**19**	**19**	**14**

Photo 3: Substrate collected at site DST4-3 in the upper Stephens Lake sensitive habitat area in August showing sand and clay.



Map 14: **Substrate type measured during acoustic and substrate validation surveys at the upstream portion and sensitive habitat area of Stephens Lake, August 2023.**

Table 19: Substrate type observed during direct sampling using a weighted sounding line or petite Ponar dredge in the upstream portion of Stephens Lake, August 2023.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition								Basic Class	Silt Deposition Evident	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%	Substrate 4	%			
DST4-01	petite Ponar	12-Aug-23	370305	6247136	16.9	moderate	clay	80	silt	10	organic	10	-	-	mud	yes	clay/silt/organic
DST4-02	petite Ponar	13-Aug-23	370868	6247652	19.8	soft	silt	50	organic	50	-	-	-	-	organic	yes	silt/organic
DST4-03	petite Ponar	13-Aug-23	371456	6248202	2.4	moderate	sand	60	clay	40	-	-	-	-	sand	no	sand/clay
DST4-04	petite Ponar	12-Aug-23	369810	6247188	18.2	moderate	clay	80	silt	10	organic	10	-	-	mud	yes	clay/silt/organic
DST4-05	petite Ponar	13-Aug-23	370517	6247995	17.7	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-06	petite Ponar	13-Aug-23	371105	6248616	3.0	soft	clay	70	sand	15	gravel	15	-	-	mud	no	clay/sand/gravel
DST4-07	petite Ponar	12-Aug-23	369171	6247135	15.3	moderate	clay	80	silt	10	organic	10	-	-	mud	yes	clay/silt/organic
DST4-08	petite Ponar	13-Aug-23	369875	6248131	18.4	soft	clay	80	silt	10	organic	10	-	-	mud	yes	clay/silt/organic
DST4-09	petite Ponar	13-Aug-23	370181	6248558	17.0	soft	clay	80	silt	15	organic	5	-	-	mud	yes	clay/silt/organic
DST4-10	weighted sounding line	12-Aug-23	368675	6246889	13.8	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-11	weighted sounding line	12-Aug-23	368923	6247350	14.5	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-12	petite Ponar	13-Aug-23	369249	6247970	10.0	moderate	clay	80	silt	10	sand	10	-	-	mud	yes	clay/silt/sand
DST4-13	petite Ponar	13-Aug-23	369742	6248889	15.7	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-14	weighted sounding line	12-Aug-23	368261	6246877	10.6	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-15	weighted sounding line	13-Aug-23	368526	6247506	14.6	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-16	weighted sounding line	13-Aug-23	368723	6248047	11	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-17	petite Ponar	13-Aug-23	368886	6248469	17.0	soft	clay	70	organic	20	silt	10	-	-	mud	yes	clay/organic/silt
DST4-18	petite Ponar	12-Aug-23	369052	6248902	14.9	soft	clay	80	silt	10	organic	10	-	-	mud	yes	clay/silt/organic
DST4-19	weighted sounding line	12-Aug-23	368012	6246951	7.7	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-20	petite Ponar	13-Aug-23	368129	6247472	14.5	moderate	clay	80	gravel	10	silt	10	-	-	mud	yes	clay/gravel/silt
DST4-21	petite Ponar	13-Aug-23	368220	6247921	15.3	moderate	clay	90	silt	5	organic	5	-	-	mud	yes	clay/silt/organic
DST4-22	weighted sounding line	13-Aug-23	368335	6248394	8.1	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-23	petite Ponar	12-Aug-23	368933	6248854	13.6	moderate	clay	60	cobble	20	silt	20	-	-	mud	yes	clay/cobble/silt
DST4-24	weighted sounding line	12-Aug-23	367681	6246989	8.5	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-25	petite Ponar	13-Aug-23	367741	6247521	14.1	moderate	clay	95	gravel	5	-	-	-	-	mud	no	clay/gravel
DST4-26	petite Ponar	13-Aug-23	367792	6247948	14	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-27	petite Ponar	13-Aug-23	367824	6248354	13.5	hard	boulder	95	cobble	5	-	-	-	-	rock	no	boulder/cobble
DST4-28	petite Ponar	12-Aug-23	367883	6248094	12.6	hard	clay	95	silt	5	-	-	-	-	mud	yes	clay/silt
DST4-29	weighted sounding line	12-Aug-23	367345	6246954	9.4	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-30	weighted sounding line	13-Aug-23	367366	6247567	12.8	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-31	petite Ponar	13-Aug-23	367404	6247945	12.0	hard	boulder	95	cobble	5	-	-	-	-	rock	no	boulder/cobble
DST4-32	petite Ponar	12-Aug-23	367391	6248251	12.5	hard	boulder	95	cobble	5	-	-	-	-	rock	no	boulder/cobble
DST4-33	weighted sounding line	13-Aug-23	367155	6246929	7.9	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-34	weighted sounding line	13-Aug-23	367041	6247611	13.0	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-35	petite Ponar	13-Aug-23	366975	6247891	14.5	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-36	weighted sounding line	12-Aug-23	366925	6248181	12.5	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-37	petite Ponar	13-Aug-23	366687	6246795	8.8	moderate	clay	80	silt	10	organic	10	-	-	mud	yes	clay/silt/organic
DST4-38	petite Ponar	13-Aug-23	366586	6247150	10.5	hard	organic	80	silt	10	gravel	10	-	-	organic	yes	organic/silt/gravel

Table 19: Continued.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition								Basic Class	Silt Deposition Evident	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%	Substrate 4	%			
DST4-39	petite Ponar	13-Aug-23	366471	6247617	13.5	hard	boulder	90	sand	10	-	-	-	-	rock	no	boulder/sand
DST4-40	petite Ponar	12-Aug-23	366371	6247914	19.8	moderate	organic	50	gravel	40	clay	10	-	-	organic	no	organic/gravel/clay
DST4-41	petite Ponar	12-Aug-23	366155	6246931	6.0	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-42	petite Ponar	12-Aug-23	366010	6247432	13.0	moderate	sand	95	gravel	5	-	-	-	-	sand	no	sand/gravel
DST4-43	petite Ponar	12-Aug-23	365915	6247751	13.0	moderate	clay	80	silt	10	organic	10	-	-	mud	yes	clay/silt/organic
DST4-44	weighted sounding line	12-Aug-23	365676	6246796	6.8	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-45	weighted sounding line	12-Aug-23	365491	6247221	9.6	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-46	weighted sounding line	12-Aug-23	365411	6247588	11.7	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-47	weighted sounding line	12-Aug-23	364955	6246737	8.9	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-48	petite Ponar	12-Aug-23	364907	6246993	6.2	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-49	petite Ponar	12-Aug-23	364863	6247245	-	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
T1-1	petite Ponar	13-Aug-23	368459	6248896	13.7	hard	-	-	-	-	-	-	-	-	rock	no	unknown
T1-2	weighted sounding line	13-Aug-23	368678	6248996	12.9	hard	-	-	-	-	-	-	-	-	rock	no	unknown
T1-3	petite Ponar	13-Aug-23	368930	6249112	13.8	moderate	clay	70	silt	15	organic	15	-	-	mud	yes	clay/silt/organic
T2-1	petite Ponar	13-Aug-23	368264	6248525	12.9	hard	-	-	-	-	-	-	-	-	rock	no	unknown
T2-2	weighted sounding line	13-Aug-23	368535	6248650	14.5	hard	-	-	-	-	-	-	-	-	rock	no	unknown
T2-3	petite Ponar	13-Aug-23	368795	6248770	16.4	moderate	organic	80	silt	10	sand	10	-	-	mud	yes	organic/silt/sand
T2-4	weighted sounding line	13-Aug-23	369005	6248875	13.4	hard	-	-	-	-	-	-	-	-	rock	no	unknown
T2-5	petite Ponar	13-Aug-23	369273	6249004	13.2	hard	-	-	-	-	-	-	-	-	rock	no	unknown
T3-1	petite Ponar	13-Aug-23	368374	6248278	13.1	hard	-	-	-	-	-	-	-	-	rock	no	unknown
T3-2	petite Ponar	13-Aug-23	368646	6248423	12.4	hard	-	-	-	-	-	-	-	-	rock	no	unknown
T3-3	weighted sounding line	13-Aug-23	368842	6248518	17.3	-	-	-	-	-	-	-	-	-	-	-	-
T3-4	weighted sounding line	13-Aug-23	369088	6248662	14.9	hard	-	-	-	-	-	-	-	-	rock	no	unknown
T3-5	petite Ponar	13-Aug-23	369353	6248792	16.3	hard	-	-	-	-	-	-	-	-	rock	no	unknown
T4-1	weighted sounding line	13-Aug-23	368491	6248065	13.1	hard	-	-	-	-	-	-	-	-	rock	no	unknown
T4-2	petite Ponar	13-Aug-23	368748	6248192	14.4	moderate	clay	60	organic	30	silt	10	-	-	mud	yes	clay/organic/silt
T4-3	petite Ponar	13-Aug-23	369088	6248367	12.9	moderate	clay	80	organic	10	gravel	10	-	-	mud	no	clay/organic/gravel
T4-4	petite Ponar	13-Aug-23	369340	6248500	14.0	moderate	organic	90	silt	10	-	-	-	-	organic	yes	organic/silt
T5-1	weighted sounding line	13-Aug-23	368817	6247996	10.0	hard	-	-	-	-	-	-	-	-	rock	no	unknown
T5-2	petite Ponar	13-Aug-23	369078	6248139	12.9	hard	-	-	-	-	-	-	-	-	rock	no	unknown
T5-3	petite Ponar	13-Aug-23	369407	6248308	13.4	moderate	clay	70	sand	20	organic	10	-	-	mud	no	clay/sand/organic

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

Fall substrate surveys were conducted within the Stephens Lake sensitive habitat area on September 23, 2023 (Map 15). Eighteen sites were sampled using a petite Ponar (Table 20). Sandy substrates (Photo 4) were predominant (70–95%) at two sites within the reach. Organics, consisting of detritus and loose, broken-down plant matter, and silt deposition were evident at all 18 sites.

Photo 4: Substrate collected at site T3-2 in the upper Stephens Lake sensitive habitat area in September showing sand, silt, and shells.

Map 15: **Map illustrating the results of substrate composition sampling sites and acoustic imaging for the Stephens Lake sensitive habitat area, September 2023. Lighter colours in the acoustic imagery indicate harder substrates while darker colours indicate softer substrates.**

Table 20: Substrate type observed during direct sampling using a petite Ponar dredge in the Stephens Lake sensitive habitat area, September 2023.

Site ID	Transect ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition								Basic Class	Silt Deposition Evident	Class Verification[1]
								Substrate 1	%	Substrate 2	%	Substrate 3	%	Substrate 4	%			
T1-1	T1	petite Ponar	23-Sep-23	368435	6248910	12.9	soft	organic	60	silt	20	clay	20	-	-	organic	yes	organic/silt/clay
T1-2	T1	petite Ponar	23-Sep-23	368679	6248993	13	soft	silt	60	clay	30	organic	10	-	-	mud	yes	silt/clay/organic
T1-3	T1	petite Ponar	23-Sep-23	368930	6249103	14.8	soft	organic	50	clay	40	silt	10	-	-	organic	yes	organic/clay/silt
T2-1	T2	petite Ponar	23-Sep-23	368261	6248528	12.8	hard	-	-	-	-	-	-	-	-	-	-	-
T2-2	T2	petite Ponar	23-Sep-23	368536	6248651	14.2	moderate	sand	70	gravel	15	organic	10	silt	5	sand	yes	sand/gravel/organic/silt
T2-3	T2	petite Ponar	23-Sep-23	368803	6248772	16	soft	organic	40	silt	40	clay	20	-	-	organic	yes	organic/silt/clay
T2-4	T2	petite Ponar	23-Sep-23	369007	6248880	13.2	soft	organic	60	silt	40	-	-	-	-	organic	yes	organic/silt
T2-5	T2	petite Ponar	23-Sep-23	369267	6249004	12.8	soft	silt	40	organic	30	clay	30	-	-	mud	yes	silt/organic/clay
T3-1	T3	petite Ponar	23-Sep-23	368375	6248270	13.1	hard	-	-	-	-	-	-	-	-	-	-	-
T3-2	T3	petite Ponar	23-Sep-23	-	-	12.2	soft	sand	95	silt	4	organic	1	-	-	sand	yes	sand/silt/organic
T3-3	T3	petite Ponar	23-Sep-23	368846	6248526	17.4	soft	clay	40	silt	40	organic	20	-	-	mud	yes	clay/silt/organic
T3-4	T3	petite Ponar	23-Sep-23	369085	6248653	14.2	soft	organic	60	clay	25	silt	15	-	-	organic	yes	organic/clay/silt
T3-5	T3	petite Ponar	23-Sep-23	369350	6248795	16.1	soft	organic	50	silt	40	clay	10	-	-	organic	yes	organic/silt/clay
T4-1	T4	petite Ponar	23-Sep-23	368487	6248066	13	hard	cobble	85	silt	10	organic	5	-	-	rock	yes	cobble/silt/organic
T4-2	T4	petite Ponar	23-Sep-23	368775	6248210	13	moderate	cobble	50	organic	30	silt	20	-	-	rock	yes	cobble/organic/silt
T4-3	T4	petite Ponar	23-Sep-23	369076	6248365	12.7	soft	organic	50	silt	25	clay	20	sand	5	organic	yes	organic/silt/clay/sand
T4-4	T4	petite Ponar	23-Sep-23	369338	6248502	14.1	soft	organic	90	silt	10	-	-	-	-	organic	yes	organic/silt
T5-1	T5	petite Ponar	23-Sep-23	368819	6247989	9.1	soft	organic	80	silt	13	clay	7	-	-	organic	yes	organic/silt/clay
T5-2	T5	petite Ponar	23-Sep-23	369089	6248142	12.7	soft	silt	60	organic	30	clay	10	-	-	mud	yes	silt/organic/clay
T5-3	T5	petite Ponar	23-Sep-23	369422	6248316	13.3	soft	silt	60	clay	30	organic	10	-	-	mud	yes	silt/clay/organic

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

4.2 CONSTRUCTED HABITATS

Nine constructed shoal habitats were surveyed in the Keeyask reservoir on August 19, 2023 (Map 16). Water surface elevation was 158.6 m in the lower Keeyask reservoir at the time each shoal was surveyed (Table 21). Boat-based ADCP depth and velocity surveys were not conducted directly on each shoal and water velocity was calculated as the depth averaged ADCP velocity taken from the closest transect. Water velocity was generally low, ranging from 0.00 to 1.26 m/s near each of the nine shoal habitats. Mean velocity was lowest near shoals G-South and G-North (0.06 m/s) and highest near shoals H-North (0.31 m/s).

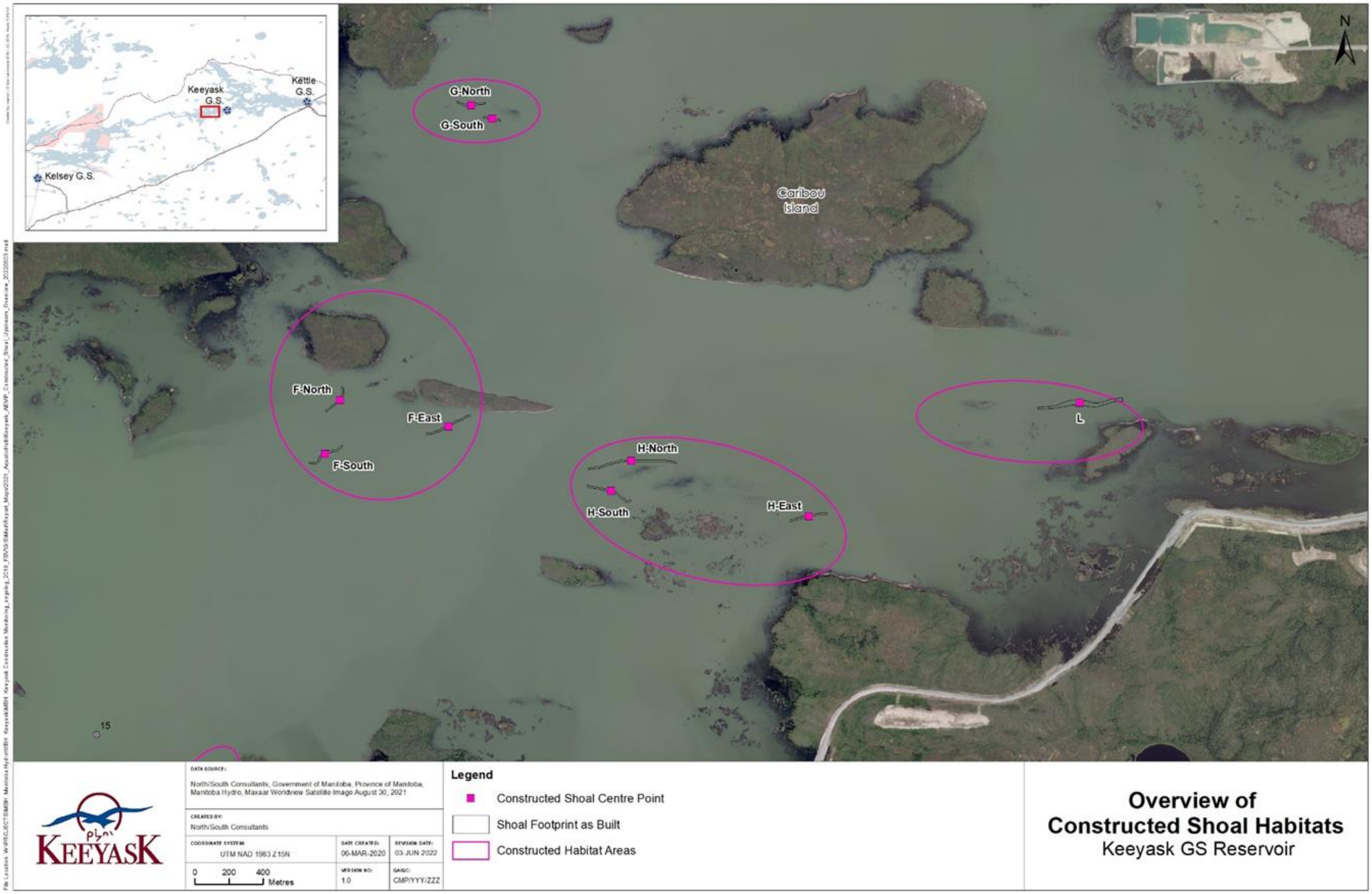
Table 21: Minimum, maximum, and averaged velocity (m/s) for cross sections surveyed at constructed shoal habitats in the Keeyask reservoir, August 19, 2023.

Area	Shoal	Date Surveyed	Water Surface Elevation[2] (m)	Velocity[1] (m/s)		
				Min	Max	Mean
Keeyask reservoir	G-South	19-Aug-23	158.6	0.01	0.12	0.06
Keeyask reservoir	G-North	19-Aug-23	158.6	0.01	0.17	0.06
Keeyask reservoir	F-North	19-Aug-23	158.6	0.00	0.30	0.12
Keeyask reservoir	F-South	19-Aug-23	158.6	0.07	0.39	0.19
Keeyask reservoir	F-East	19-Aug-23	158.6	0.02	0.30	0.14
Keeyask reservoir	H-North	19-Aug-23	158.6	0.07	1.26	0.31
Keeyask reservoir	H-South	19-Aug-23	158.6	0.01	0.47	0.18
Keeyask reservoir	H-East	19-Aug-23	158.6	0.00	0.39	0.12
Keeyask reservoir	L	19-Aug-23	158.6	0.04	0.29	0.14

1 - Velocity samples are averaged subsets of depth averaged ADCP velocity taken from the closest transect to each constructed shoal.

2 - Daily mean water surface elevation from MBH gauge station Gull Lake (05UF596).

Substrate surveys were conducted on August 16 and 17, 2023. Seven bottom type validation sites were sampled at each constructed spawning shoal for a total of 63 sites using either a petite Ponar or a weighted sounding line (Table 22). Silt deposition was evident at 33 of 63 sites and was present on all nine shoal habitats.



Map 16: **Map of 2023 Keeyask GS reservoir constructed habitat aquatic habitat monitoring sampling areas showing their locations following reservoir impoundment.**

Table 22: Substrate type observed during direct sampling using a weighted sounding line or petite Ponar dredge at the constructed habitats in the Keeyask reservoir, 2023.

Waterbody	Shoal	Date	Site ID	Gear	Location		Depth (m)	Compaction	Estimated Sample Composition						Basic Class	Substrate Class Verification[1]
					Easting	Northing			Substrate 1	%	Substrate 2	%	Substrate 3	%		
Keeyask Reservoir	F-East	17-Aug-23	F-East-1	petite Ponar	354759	6245474	4.0	soft	organic	95	silt	5	-	-	organic	organic/silt
Keeyask Reservoir	F-East	17-Aug-23	F-East-2	petite Ponar	354666	6245434	3.6	moderate	clay	50	silt	40	organic	10	mud	clay/silt/organic
Keeyask Reservoir	F-East	17-Aug-23	F-East-3	petite Ponar	354548	6245379	4.0	soft	organic	100	-	-	-	-	organic	organic
Keeyask Reservoir	F-East	17-Aug-23	F-East-4	petite Ponar	354718	6245466	3.2	soft	organic	100	-	-	-	-	organic	organic
Keeyask Reservoir	F-East	17-Aug-23	F-East-5	petite Ponar	354755	6245461	4.4	soft	organic	100	-	-	-	-	organic	organic
Keeyask Reservoir	F-East	17-Aug-23	F-East-6	petite Ponar	354616	6245412	2.7	moderate	clay	55	organic	30	silt	15	mud	clay/organic/silt
Keeyask Reservoir	F-East	17-Aug-23	F-East-7	petite Ponar	354616	6245390	4.2	moderate	clay	90	silt	10	-	-	mud	clay/silt
Keeyask Reservoir	F-North	17-Aug-23	F-North-1	petite Ponar	353969	6245523	2.8	soft	organic	95	silt	5	-	-	organic	organic/silt
Keeyask Reservoir	F-North	17-Aug-23	F-North-2	petite Ponar	354036	6245581	3.5	soft	clay	40	silt	30	organic	30	mud	clay/silt/organic
Keeyask Reservoir	F-North	17-Aug-23	F-North-3	petite Ponar	354044	6245646	3.4	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	F-North	17-Aug-23	F-North-4	weighted sounding line	353992	6245545	3.6	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	F-North	17-Aug-23	F-North-5	petite Ponar	354039	6245609	2.6	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	F-North	17-Aug-23	F-North-6	petite Ponar	353966	6245543	3.6	soft	organic	95	silt	5	-	-	organic	organic/silt
Keeyask Reservoir	F-North	17-Aug-23	F-North-7	petite Ponar	354053	6245633	3.9	hard	organic	100	-	-	-	-	organic	organic
Keeyask Reservoir	F-South	17-Aug-23	F-South-1	petite Ponar	354029	6245291	3.2	soft	organic	80	silt	20	-	-	organic	organic/silt
Keeyask Reservoir	F-South	17-Aug-23	F-South-2	weighted sounding line	353945	6245264	3.9	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	F-South	17-Aug-23	F-South-3	petite Ponar	353865	6245210	3.3	moderate	clay	70	silt	30	-	-	mud	clay/silt
Keeyask Reservoir	F-South	17-Aug-23	F-South-4	weighted sounding line	354006	6245286	3.3	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	F-South	17-Aug-23	F-South-5	petite Ponar	353896	6245218	3.1	moderate	clay	90	silt	10	-	-	mud	clay/silt
Keeyask Reservoir	F-South	17-Aug-23	F-South-6	petite Ponar	353918	6245237	4.2	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	F-South	17-Aug-23	F-South-7	petite Ponar	353979	6245266	4.2	soft	organic	70	clay	20	silt	10	organic	organic/clay/silt
Keeyask Reservoir	G-North	17-Aug-23	G-North-1	petite Ponar	354860	6247299	3.2	soft	organic	90	silt	10	-	-	organic	organic/silt
Keeyask Reservoir	G-North	17-Aug-23	G-North-2	petite Ponar	354785	6247296	2.1	soft	clay	50	silt	40	organic	10	mud	clay/silt/organic
Keeyask Reservoir	G-North	17-Aug-23	G-North-3	petite Ponar	354717	6247308	3.1	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	G-North	17-Aug-23	G-North-4	petite Ponar	354865	6247314	3.4	soft	clay	50	organic	35	silt	15	mud	clay/organic/silt
Keeyask Reservoir	G-North	17-Aug-23	G-North-5	petite Ponar	354833	6247297	3.2	soft	organic	90	silt	10	-	-	organic	organic/silt
Keeyask Reservoir	G-North	17-Aug-23	G-North-6	petite Ponar	354756	6247298	4.1	hard	cobble	100	-	-	-	-	rock	cobble
Keeyask Reservoir	G-North	17-Aug-23	G-North-7	petite Ponar	354722	6247303	3.0	soft	organic	95	silt	5	-	-	organic	organic/silt
Keeyask Reservoir	G-South	17-Aug-23	G-South-1	petite Ponar	354872	6247224	1.6	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	G-South	17-Aug-23	G-South-2	petite Ponar	354910	6247216	4.0	moderate	clay	70	sand	20	silt	10	mud	clay/sand/silt
Keeyask Reservoir	G-South	17-Aug-23	G-South-3	petite Ponar	354959	6247212	3.1	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	G-South	17-Aug-23	G-South-4	petite Ponar	354939	6247206	4.5	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	G-South	17-Aug-23	G-South-5	petite Ponar	354916	6247226	2.6	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	G-South	17-Aug-23	G-South-6	weighted sounding line	354888	6247232	2.8	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	G-South	17-Aug-23	G-South-7	petite Ponar	354872	6247217	1.5	soft	clay	50	silt	35	organic	15	mud	clay/silt/organic
Keeyask Reservoir	H-East	16-Aug-23	H-East-1	petite Ponar	356647	6244871	2.9	moderate	organic	90	silt	10	-	-	organic	organic/silt
Keeyask Reservoir	H-East	16-Aug-23	H-East-2	petite Ponar	356761	6244910	3.0	moderate	organic	50	clay	50	-	-	mud	organic/clay

Table 22: Continued.

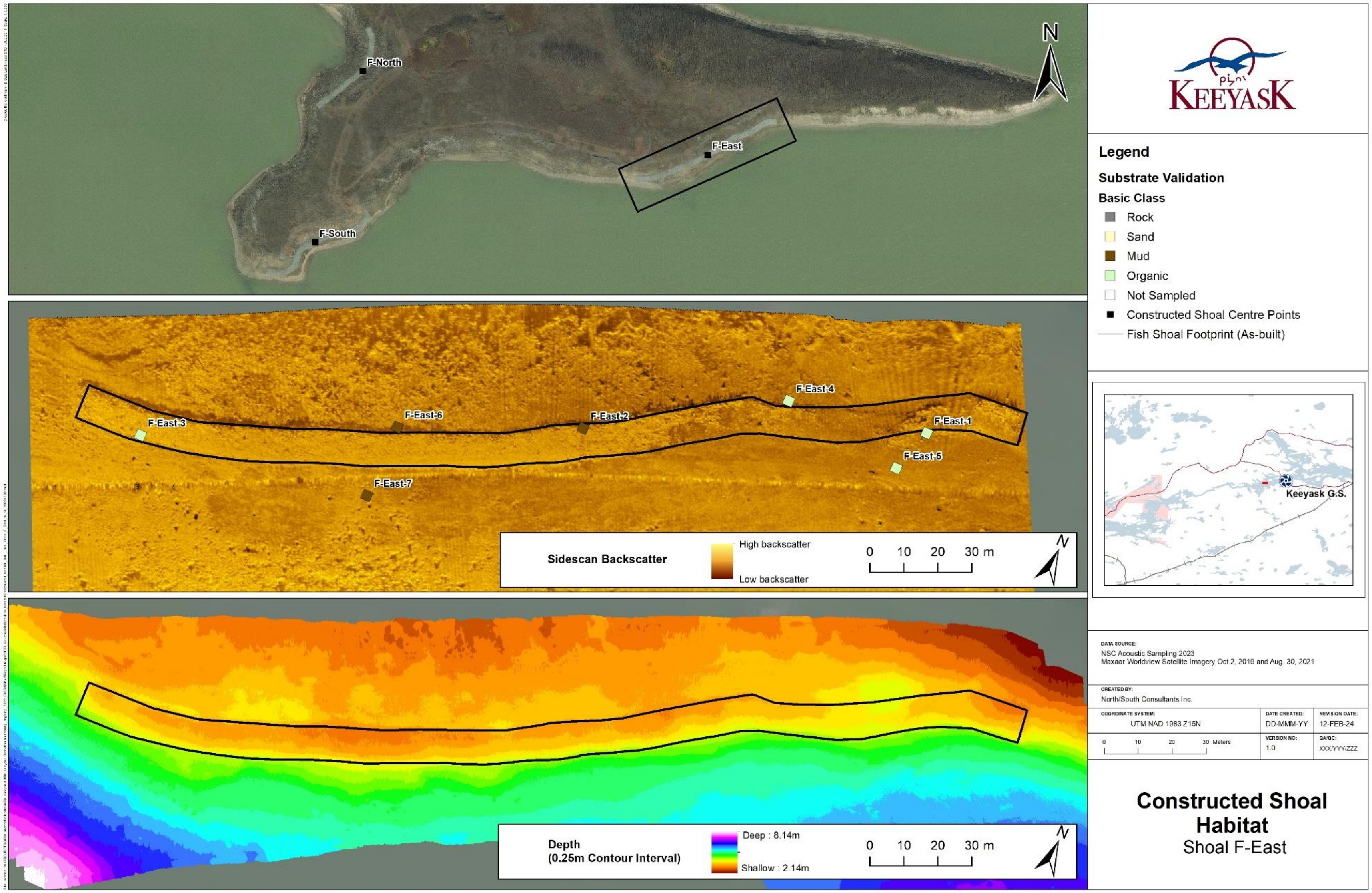
Waterbody	Shoal	Date	Site ID	Gear	Location		Depth (m)	Compaction	Estimated Sample Composition						Basic Class	Substrate Class Verification[1]
					Easting	Northing			Substrate 1	%	Substrate 2	%	Substrate 3	%		
Keeyask Reservoir	H-East	16-Aug-23	H-East-3	petite Ponar	356856	6244910	3.5	moderate	organic	100	-	-	-	-	organic	organic
Keeyask Reservoir	H-East	16-Aug-23	H-East-4	petite Ponar	356683	6244894	3.0	moderate	organic	90	silt	10	-	-	organic	organic/silt
Keeyask Reservoir	H-East	16-Aug-23	H-East-5	petite Ponar	356719	6244889	3.0	moderate	organic	100	-	-	-	-	organic	organic
Keeyask Reservoir	H-East	16-Aug-23	H-East-6	petite Ponar	356796	6244911	3.5	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	H-East	16-Aug-23	H-East-7	petite Ponar	356823	6244894	3.4	soft	organic	90	silt	10	-	-	organic	organic/silt
Keeyask Reservoir	H-North	17-Aug-23	H-North-1	petite Ponar	355495	6245179	2.7	soft	clay	100	-	-	-	-	mud	clay
Keeyask Reservoir	H-North	17-Aug-23	H-North-2	petite Ponar	355719	6245220	2.4	moderate	organic	100	-	-	-	-	organic	organic
Keeyask Reservoir	H-North	17-Aug-23	H-North-3	petite Ponar	355982	6245211	3.0	soft	organic	70	silt	30	-	-	organic	organic/silt
Keeyask Reservoir	H-North	17-Aug-23	H-North-4	petite Ponar	355953	6245215	2.4	soft	organic	95	silt	5	-	-	organic	organic/silt
Keeyask Reservoir	H-North	17-Aug-23	H-North-5	petite Ponar	355891	6245227	2.5	soft	organic	95	silt	5	-	-	organic	organic/silt
Keeyask Reservoir	H-North	17-Aug-23	H-North-6	petite Ponar	355587	6245191	2.5	soft	organic	100	-	-	-	-	organic	organic
Keeyask Reservoir	H-North	17-Aug-23	H-North-7	petite Ponar	355521	6245181	2.8	soft	organic	95	silt	5	-	-	organic	organic/silt
Keeyask Reservoir	H-South	17-Aug-23	H-South-1	petite Ponar	355482	6245062	4.4	soft	silt	70	clay	20	organic	10	organic	silt/clay/organic
Keeyask Reservoir	H-South	17-Aug-23	H-South-2	petite Ponar	355599	6245052	3.2	soft	organic	95	silt	5	-	-	organic	organic/silt
Keeyask Reservoir	H-South	17-Aug-23	H-South-3	petite Ponar	355711	6244982	4.0	soft	organic	95	silt	5	-	-	organic	organic/silt
Keeyask Reservoir	H-South	17-Aug-23	H-South-4	petite Ponar	355505	6245097	2.4	moderate	clay	95	silt	5	-	-	mud	clay/silt
Keeyask Reservoir	H-South	17-Aug-23	H-South-5	petite Ponar	355523	6245063	4.4	hard	cobble	95	organic	5	-	-	rock	cobble/organic
Keeyask Reservoir	H-South	17-Aug-23	H-South-6	petite Ponar	355677	6245007	3.9	hard	cobble	100	-	-	-	-	rock	cobble
Keeyask Reservoir	H-South	17-Aug-23	H-South-7	petite Ponar	355650	6245012	4.2	soft	organic	95	silt	5	-	-	organic	organic/silt
Keeyask Reservoir	L	16-Aug-23	L-1	petite Ponar	358108	6245529	2.0	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	L	16-Aug-23	L-2	weighted sounding line	358340	6245564	3.0	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	L	16-Aug-23	L-3	petite Ponar	358544	6245578	2.0	soft	organic	90	silt	10	-	-	organic	organic/silt
Keeyask Reservoir	L	16-Aug-23	L-4	weighted sounding line	358152	6245538	3.0	hard	boulder	100	-	-	-	-	rock	boulder
Keeyask Reservoir	L	16-Aug-23	L-5	petite Ponar	358226	6245539	2.9	soft	organic	80	clay	20	-	-	organic	organic/clay
Keeyask Reservoir	L	16-Aug-23	L-6	petite Ponar	358415	6245567	4.3	soft	organic	95	silt	5	-	-	organic	organic/silt
Keeyask Reservoir	L	16-Aug-23	L-7	petite Ponar	358543	6245565	2.7	soft	organic	90	silt	10	-	-	organic	organic/silt

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

4.2.1 CONSTRUCTED SHOAL F-EAST

Three years after reservoir impoundment, portions of the spawning shoal F-East were still comprised of rocky substrates, although mud (*i.e.,* silt and clay) and organic substrates covered approximately a third of the area. A section of the shoal approximately 80 m long on the northeast end has changed from rock shoal to soft fine substrate material. A deeper depression is noticeable within the shoal and directly to the northeast of the shoal (Map 17; Figure 7). Petite Ponar dredges from seven sites confirmed soft or organic substrates were present (Table 22), although five samples were taken outside of the original footprint of the spawning shoal. Zebra mussels were observed in one of the substrate grabs taken in the middle of the shoal (site F-East-2; Photo 5). Acoustic surveys indicated that rocky substrates still comprised much of the spawning shoal, although mud and organic substrates were dominant along the north-eastern border (Map 18).

Photo 5: Substrates collected from constructed shoal F-East-2 in the Keeyask reservoir, showing clay and silt.



Map 17: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the F-East shoal.**

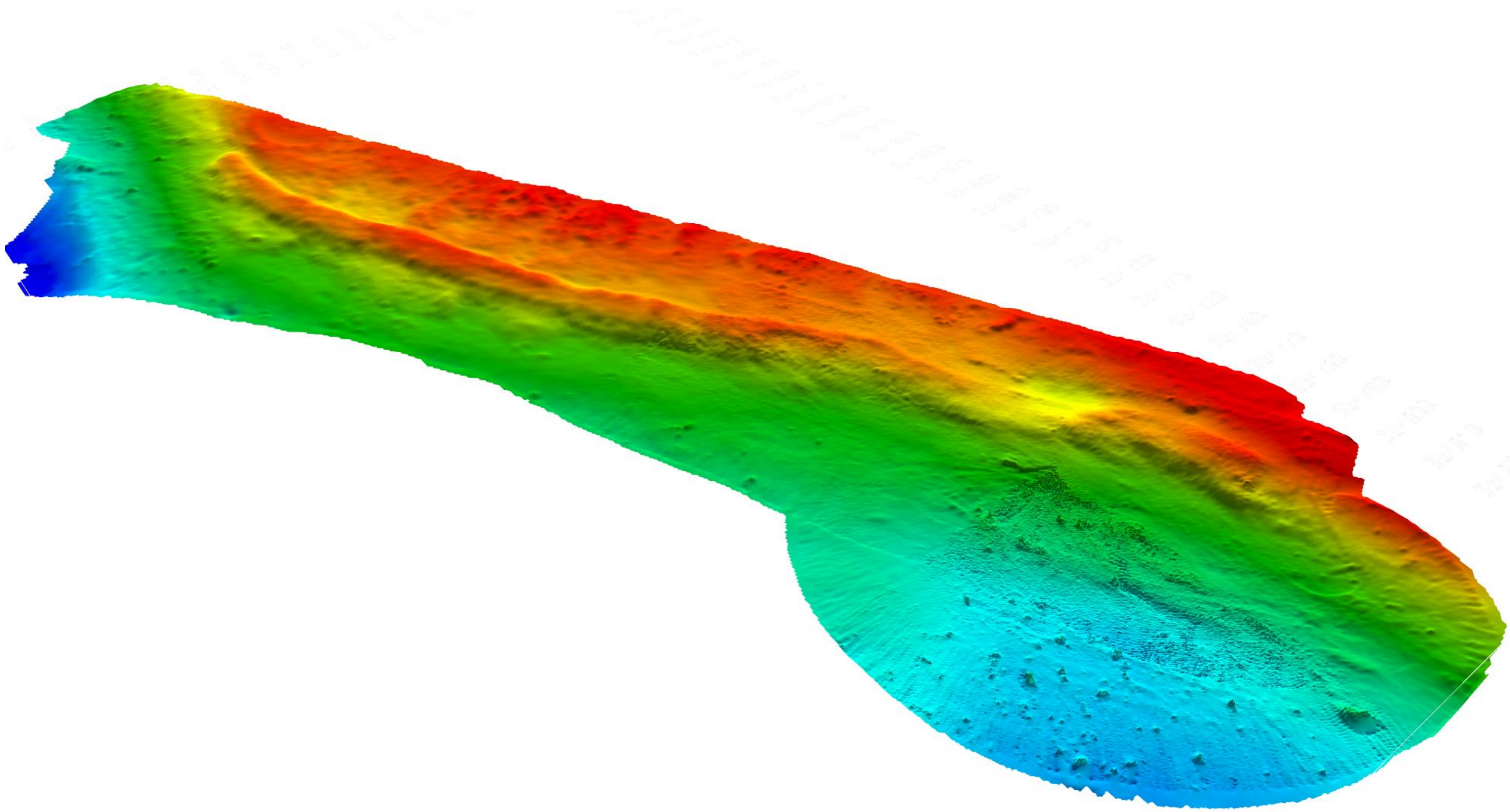
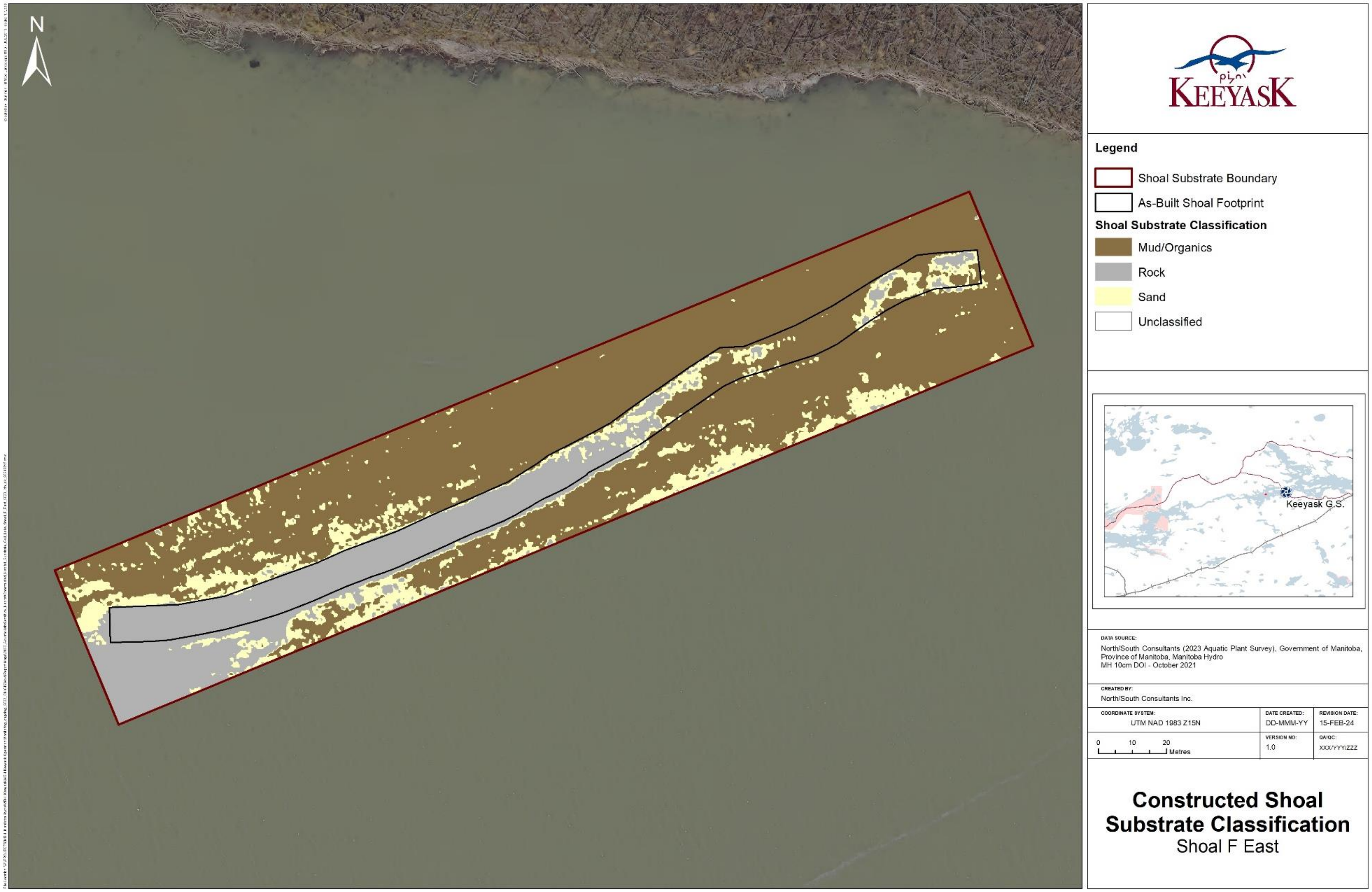


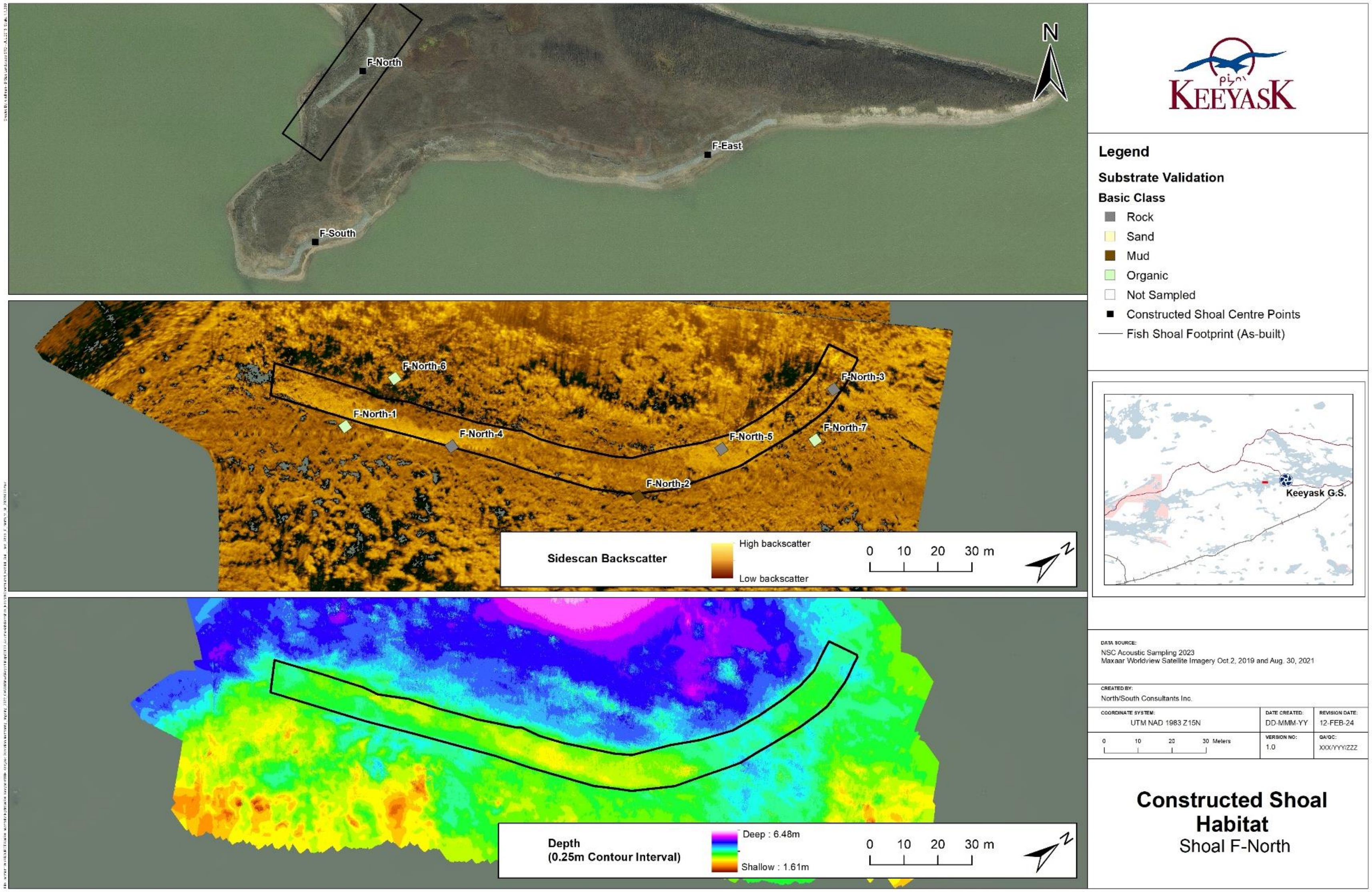
Figure 7: Detailed perspective view of Keeyask reservoir spawning shoal F-East looking northwest, August 2023. Colours follow depth contours outlined in Map 17.



Map 18: Basic substrate type (*i.e.*, mud/organics, rock, or sand) found on the constructed spawning shoal F-East during surveys conducted in August 2023.

4.2.2 CONSTRUCTED SHOAL F-NORTH

Three years after impoundment, spawning shoal F-North was comprised largely of hard boulder substrates although some deposits of mud (*i.e.,* silt and clay) and sand were present. Soft clay and organic substrates were found at four of seven sites sampled with a ponar dredge (Table 22), although the three samples containing organics were taken outside of the original footprint of the spawning shoal (Map 19). Zebra mussels were also present in grabs at two of the sites (F-North-2 and -6). Acoustic surveys indicated that rocky substrates still comprised much of the spawning shoal, although portions of the shoal (~100m in length) appear to be covered with flooded organic debris or deposition (Figure 8; Map 20).



Map 19: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the F-North shoal.**

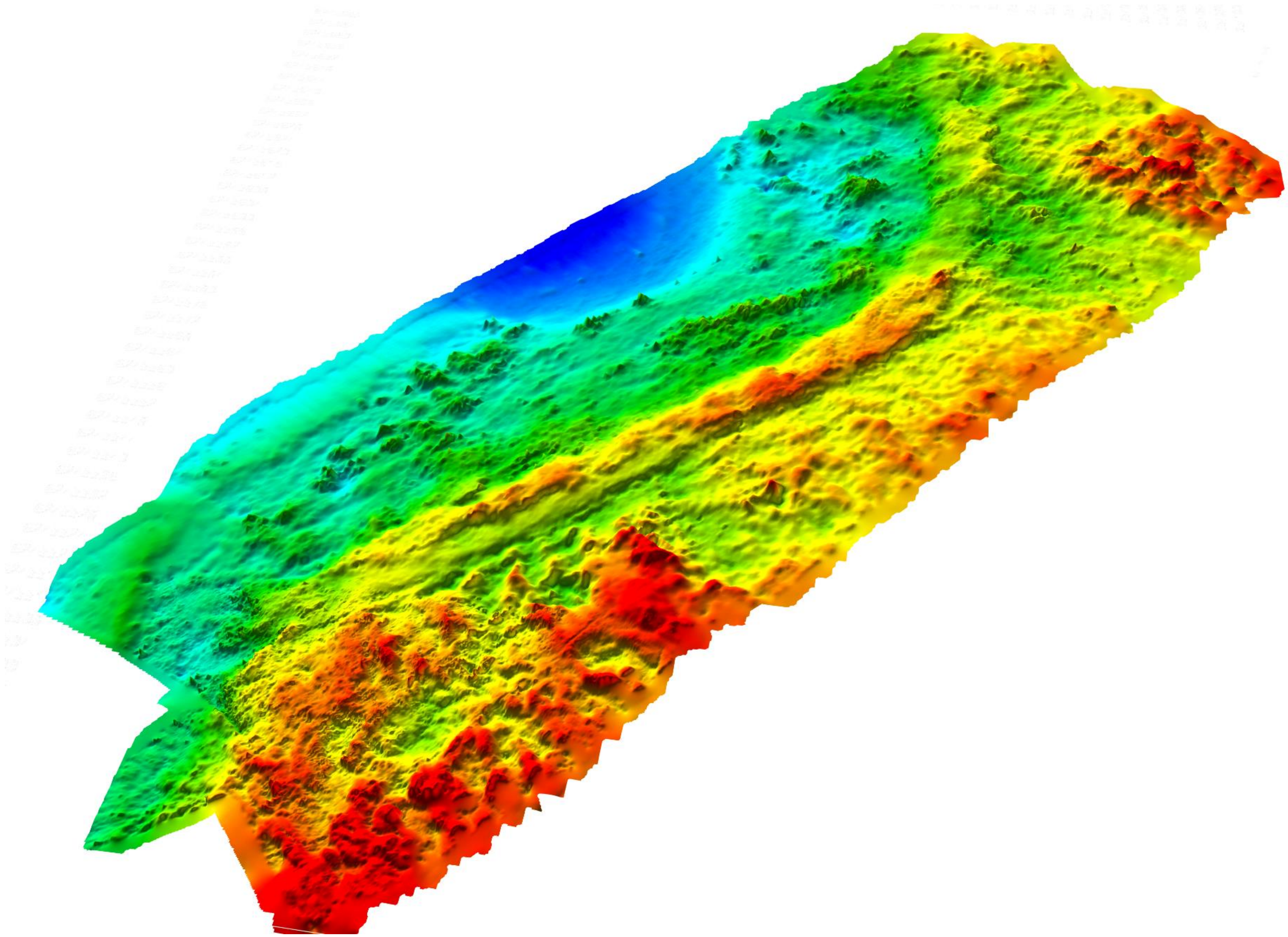
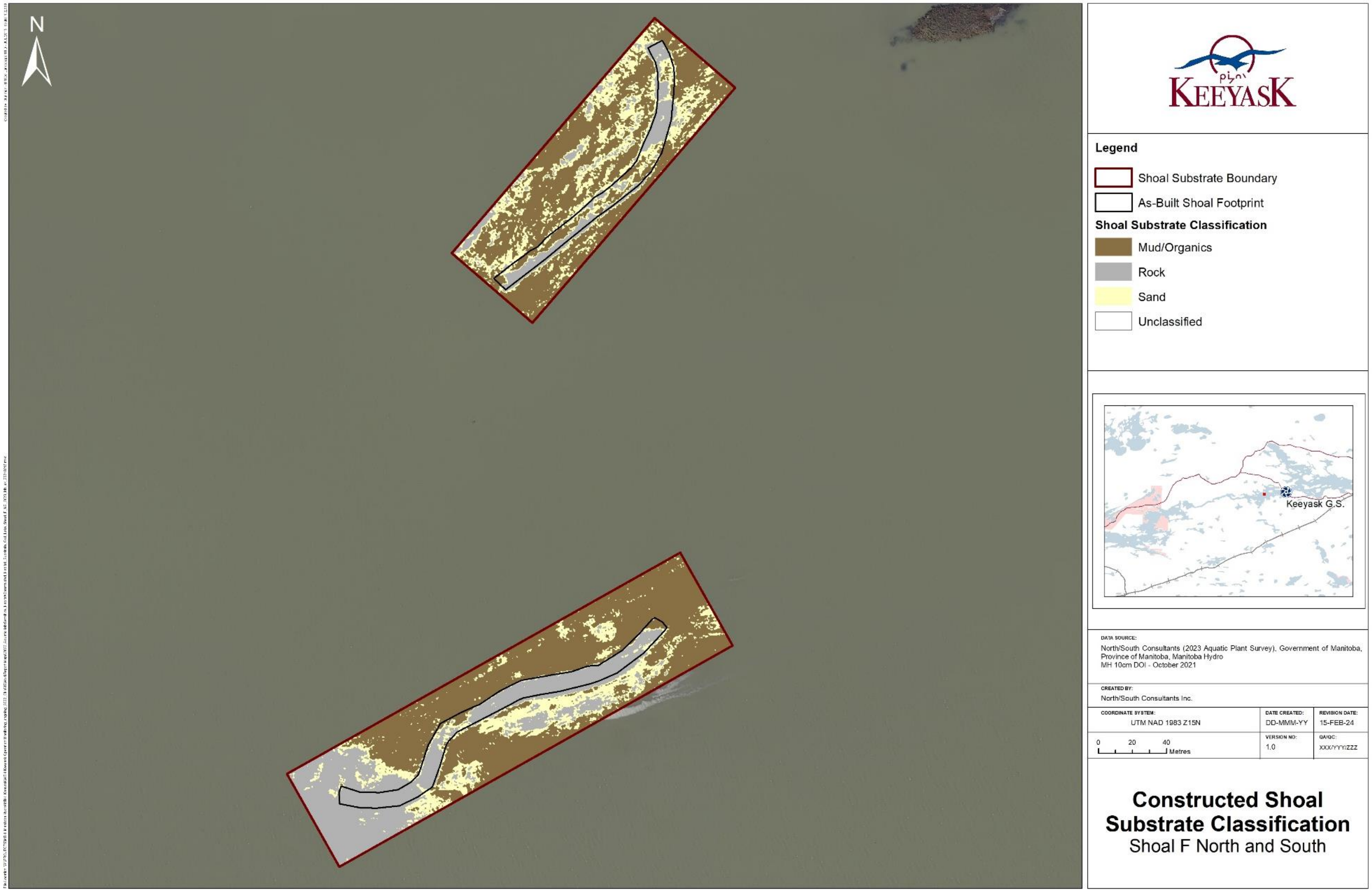


Figure 8: Detailed perspective view of Keeyask reservoir spawning shoal F-North looking north, August 2023. Colours follow depth contours outlined in Map 19.

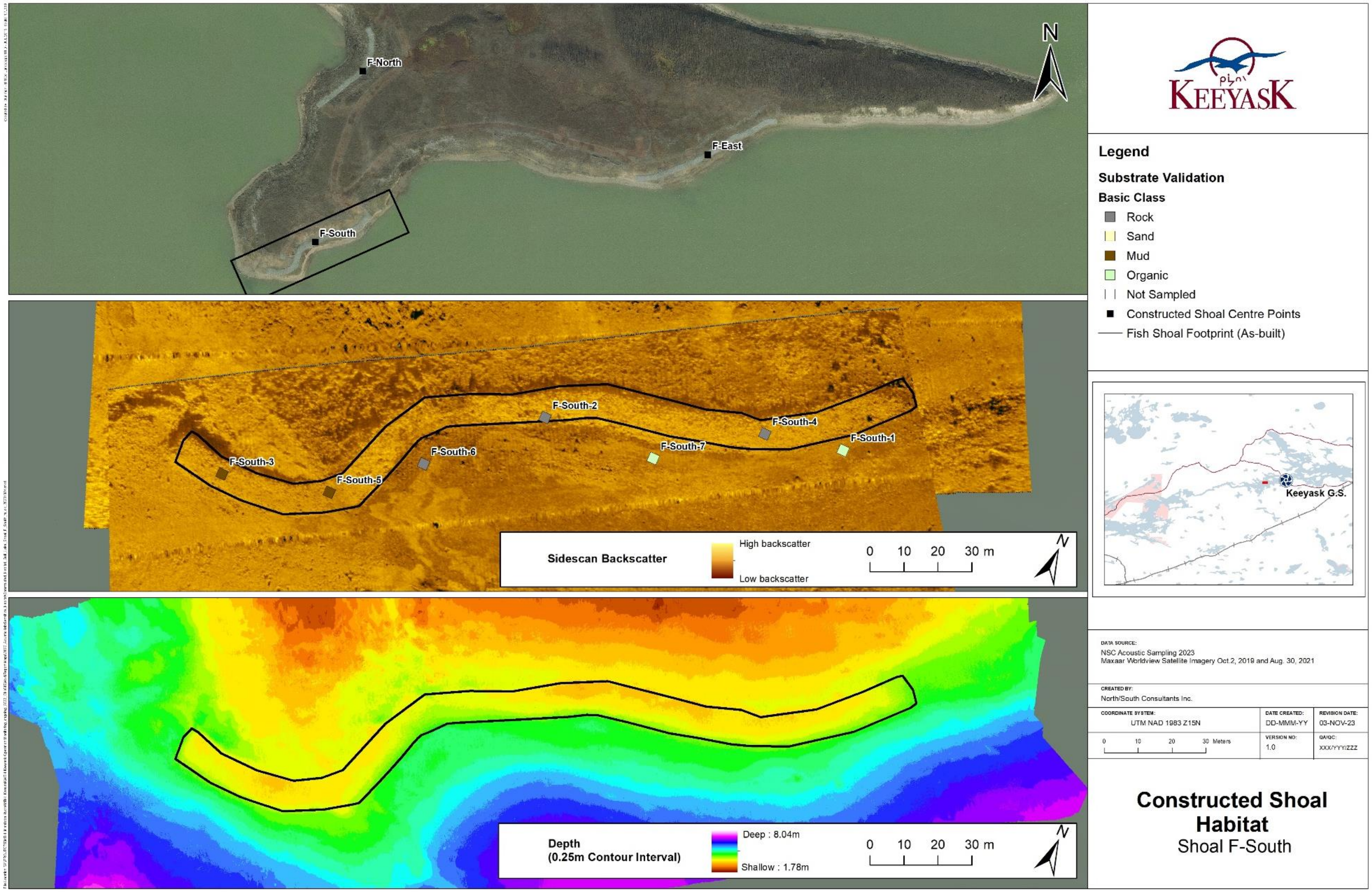


Map 20: **Basic substrate type (*i.e.*, mud/organics, rock, or sand) found on the constructed spawning shoals F-North and F-South during surveys conducted in August 2023.**

4.2.3 CONSTRUCTED SHOAL F-SOUTH

Three years after impoundment, spawning shoal F-South was comprised largely of hard boulder substrates as when it was built. Soft clay and silt substrates were collected from the eastern extent of the shoal at two sites using a petite Ponar dredge (Table 22; Map 21; Photo 6). Organics were collected at two sites, although these areas were located outside of the original footprint of the shoal. Acoustic surveys indicated that rocky substrates still comprised the majority of the spawning shoal, with little structural change since construction (Figure 9; Map 20).

Photo 6: Substrates collected from constructed shoal F-South-3 in the Keeyask reservoir, showing clay and silt, 2023.



Map 21: Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the F-South shoal.

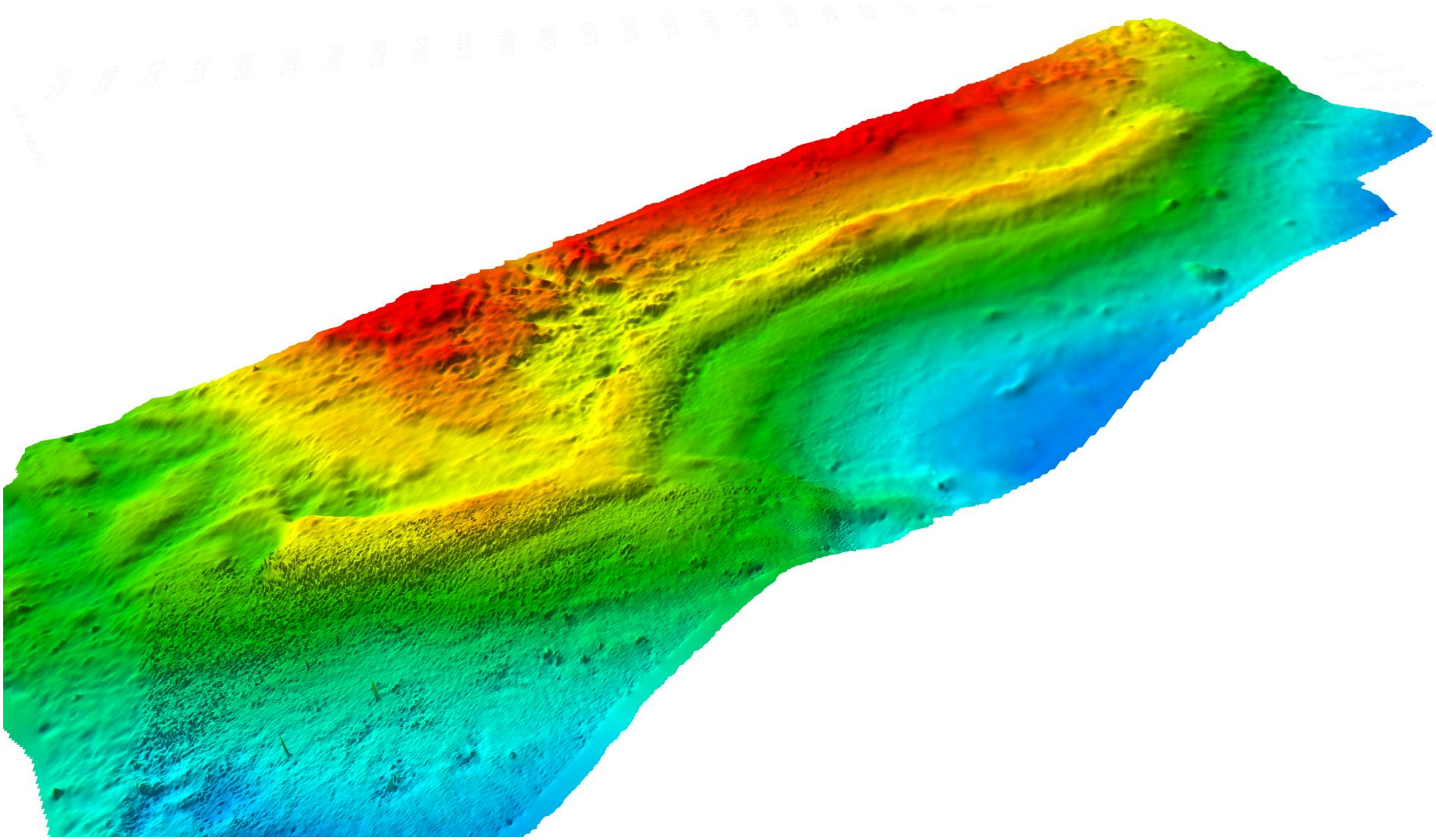
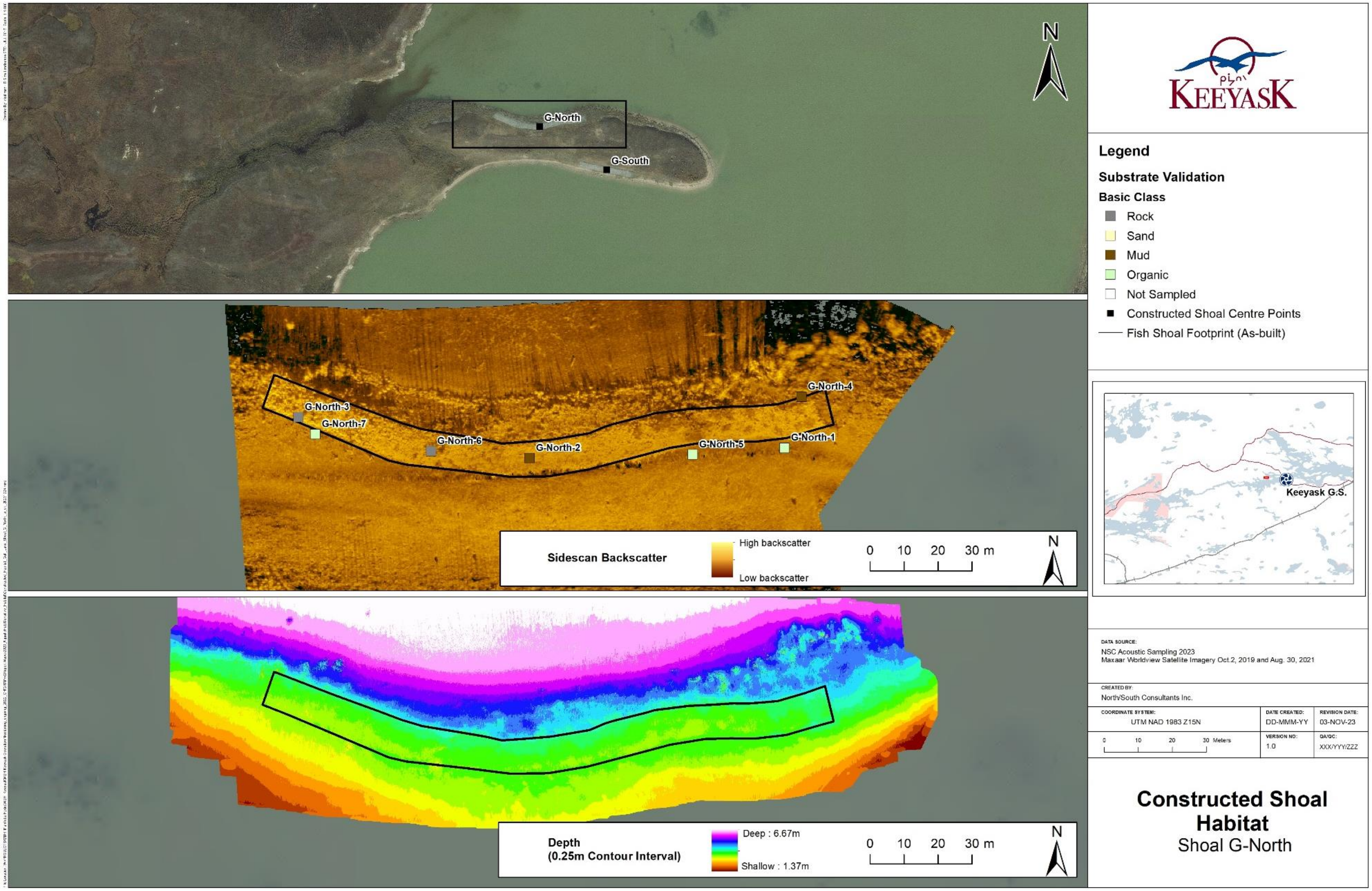


Figure 9: Detailed perspective view of Keeyask reservoir spawning shoal F-South looking north, August 2023. Colours follow depth contours outlined in Map 21.

4.2.4 CONSTRUCTED SHOAL G-NORTH

After the third year following reservoir impoundment, spawning shoal G-North was comprised largely of hard boulder substrates as when it was built. Soft mud (*i.e.*, silt and clay) was collected from the middle of the shoal (site G-North-2) using a petite Ponar dredge (Table 22; Map 22; Photo 7). Zebra mussels were also present at two of the grab sites (G-North-5 and -6), although were not observed in large numbers on the shoal when viewed with an underwater camera. Organics were found at three sites, although these were collected from areas outside of the original footprint of the shoal. Acoustic surveys indicated that rocky substrates still comprised the majority of the spawning shoal although deposits of mud/organics and sand were evident (Figure 10; Map 23). The overall structure of G-North appears to be intact with limited change since construction.

Photo 7: Substrates collected from constructed shoal G-North-2 in the Keeyask reservoir, showing clay and silt and collected zebra mussels, 2023.



Map 22: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the G-North shoal.**

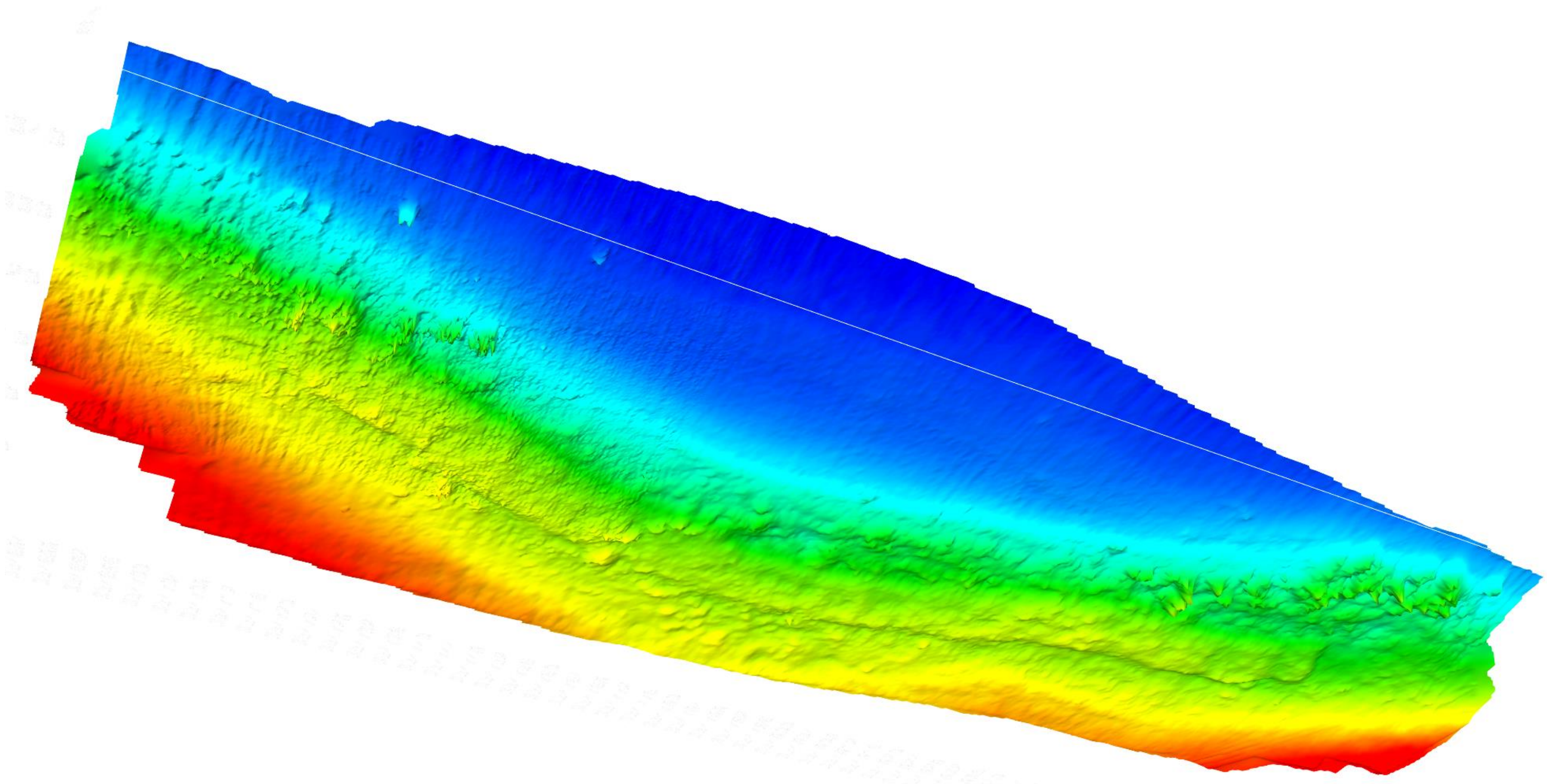
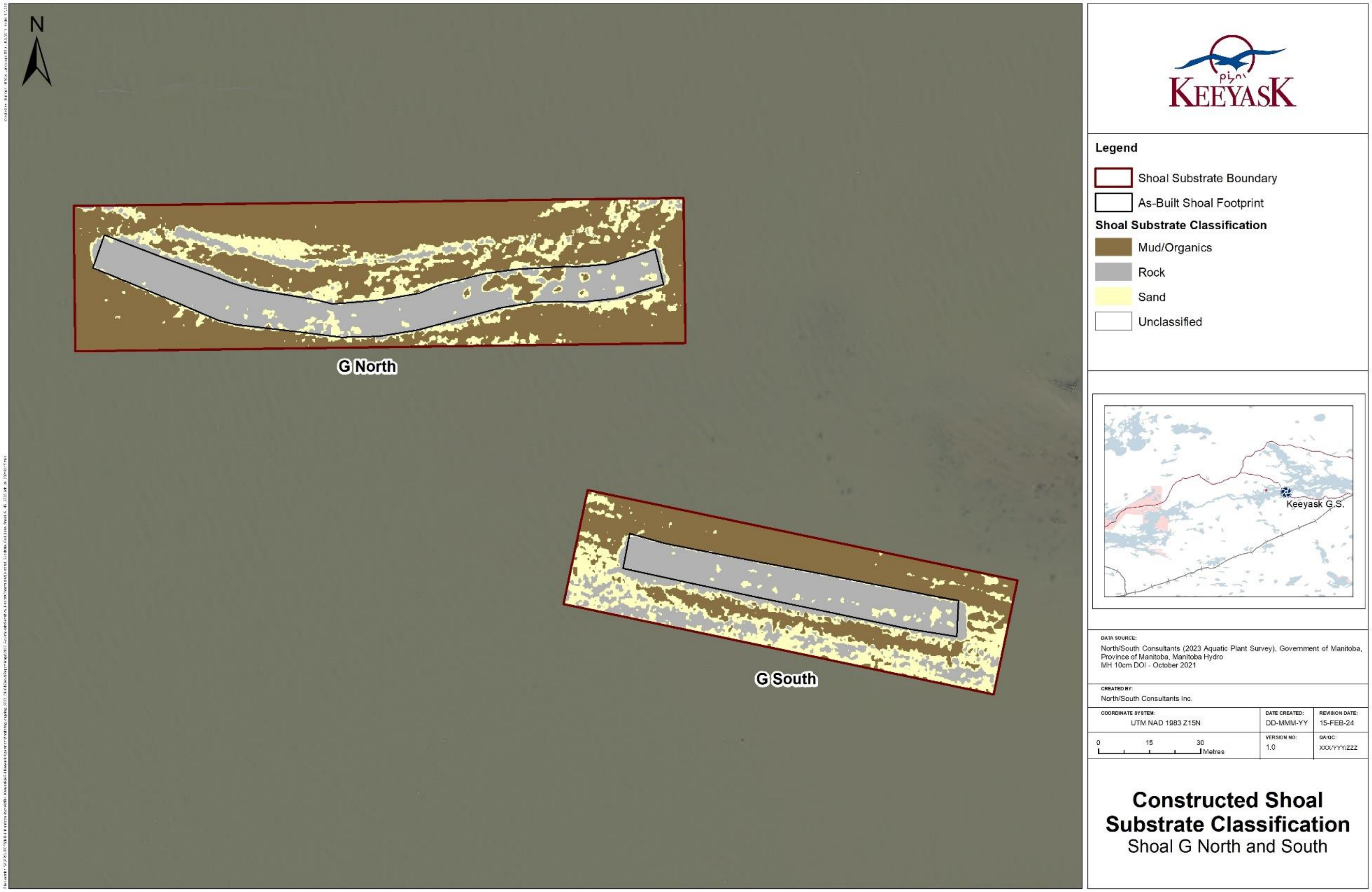


Figure 10: Detailed perspective view of Keeyask reservoir spawning shoal G-North looking south, August 2023. Colours follow depth contours outlined in Map 22.

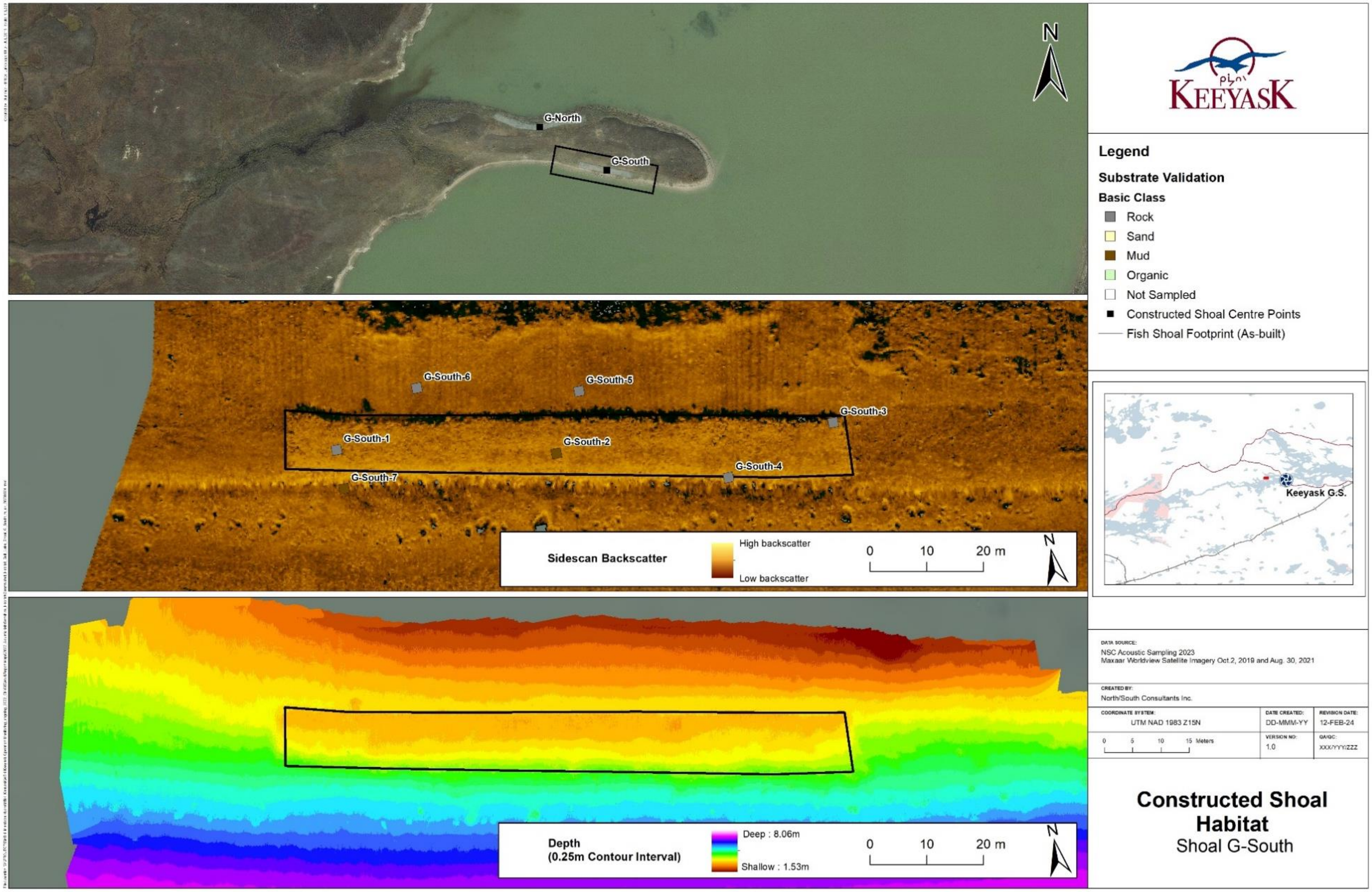


Map 23: **Basic substrate type (*i.e.*, mud/organics, rock, or sand) found on the constructed spawning shoals G-North and G-South during surveys conducted in August 2023.**

4.2.5 CONSTRUCTED SHOAL G-SOUTH

Three years after impoundment, spawning shoal G-North was comprised largely of hard boulder substrates as when it was built. Soft clay and silt substrates were collected from the middle of the shoal (site G-South-2) using a petite Ponar dredge (Table 22; Map 24). Zebra mussels were evident on the shoal (Photo 8). Acoustic surveys indicated that rocky substrates still comprised the majority of the spawning shoal although deposits of sand were evident (Figure 11; Map 23). The overall structure of G-South appears to be intact with limited change since construction.

Photo 8: Zebra mussels present on constructed shoal G-South in the Keeyask reservoir (photographed *in situ* using an underwater camera), 2023.



Map 24: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the G-South shoal.**

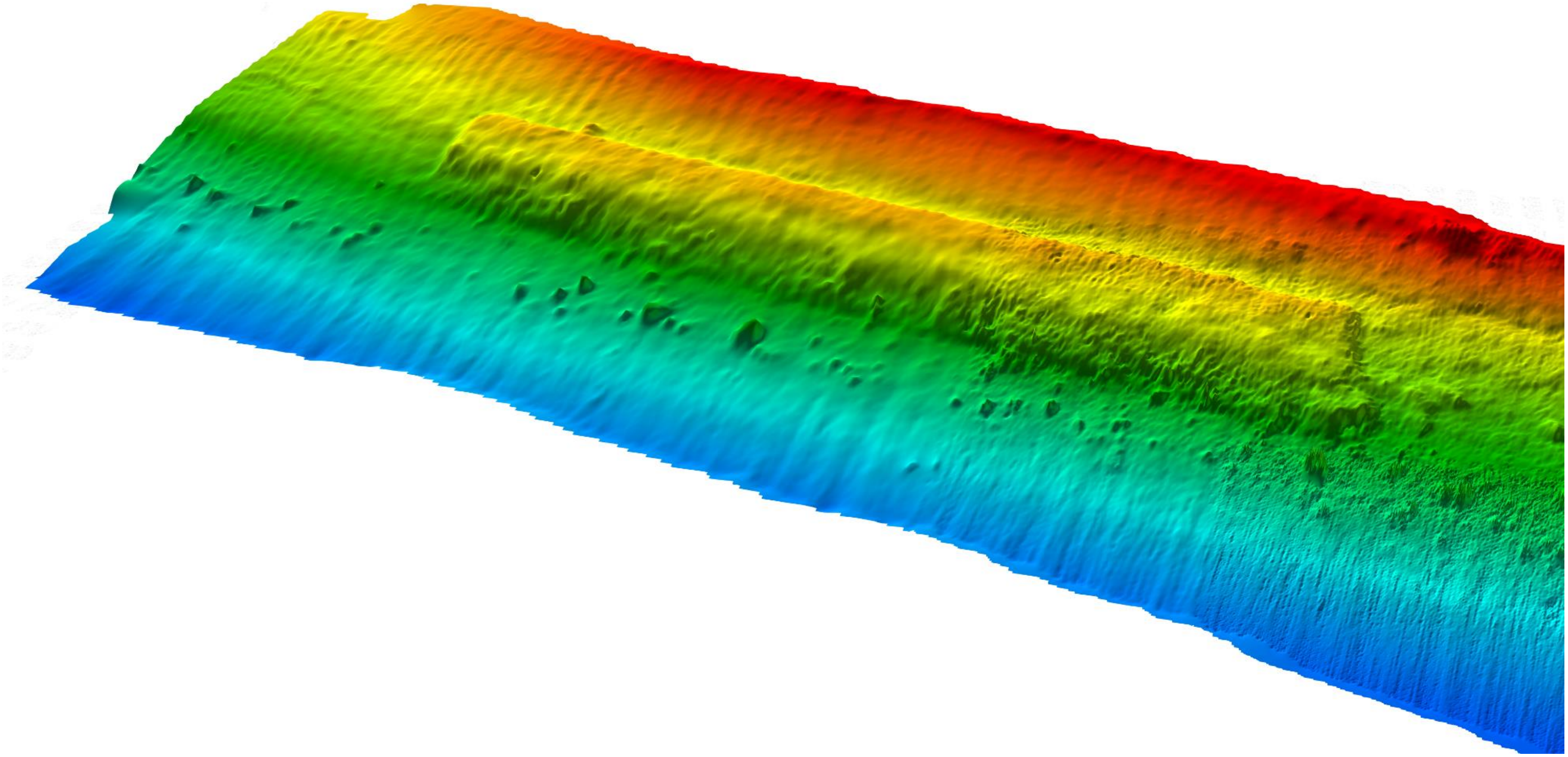
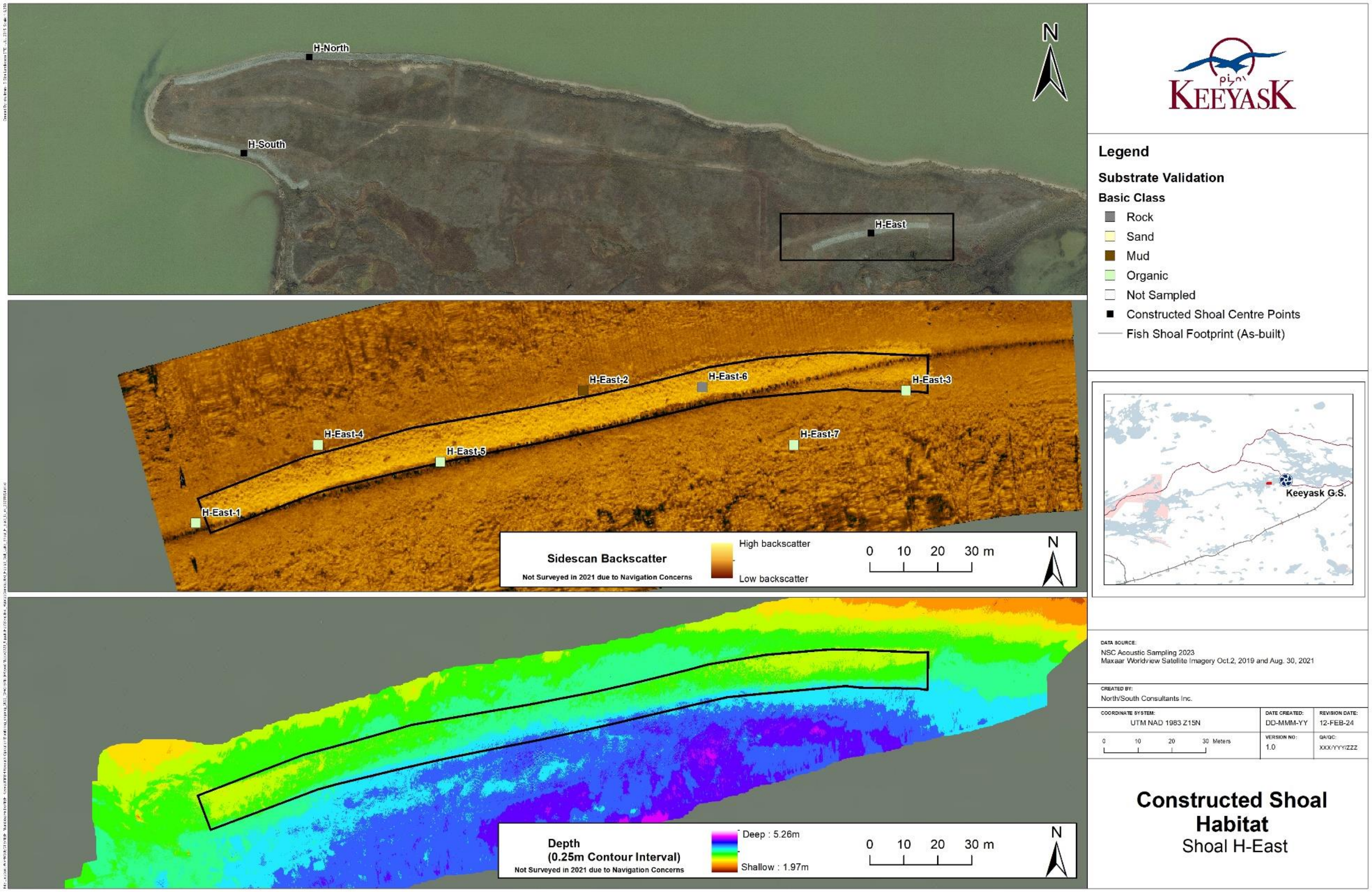


Figure 11: Detailed perspective view of Keeyask reservoir spawning shoal G-South looking north, August 2023. Colours follow depth contours outlined in Map 24.

4.2.6 CONSTRUCTED SHOAL H-EAST

After the third year following reservoir impoundment, spawning shoal H-East was comprised largely of hard boulder substrates as when it was built. Organic substrates collected using a petite Ponar dredge were from areas outside the original footprint of the spawning shoal (Table 22; Map 25). Acoustic surveys indicated that the majority of the spawning shoal was still comprised of rocky substrates (Figure 12; Map 26). The overall structure of H-East appears to be intact with limited change since construction.



Map 25: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the H-East shoal.**

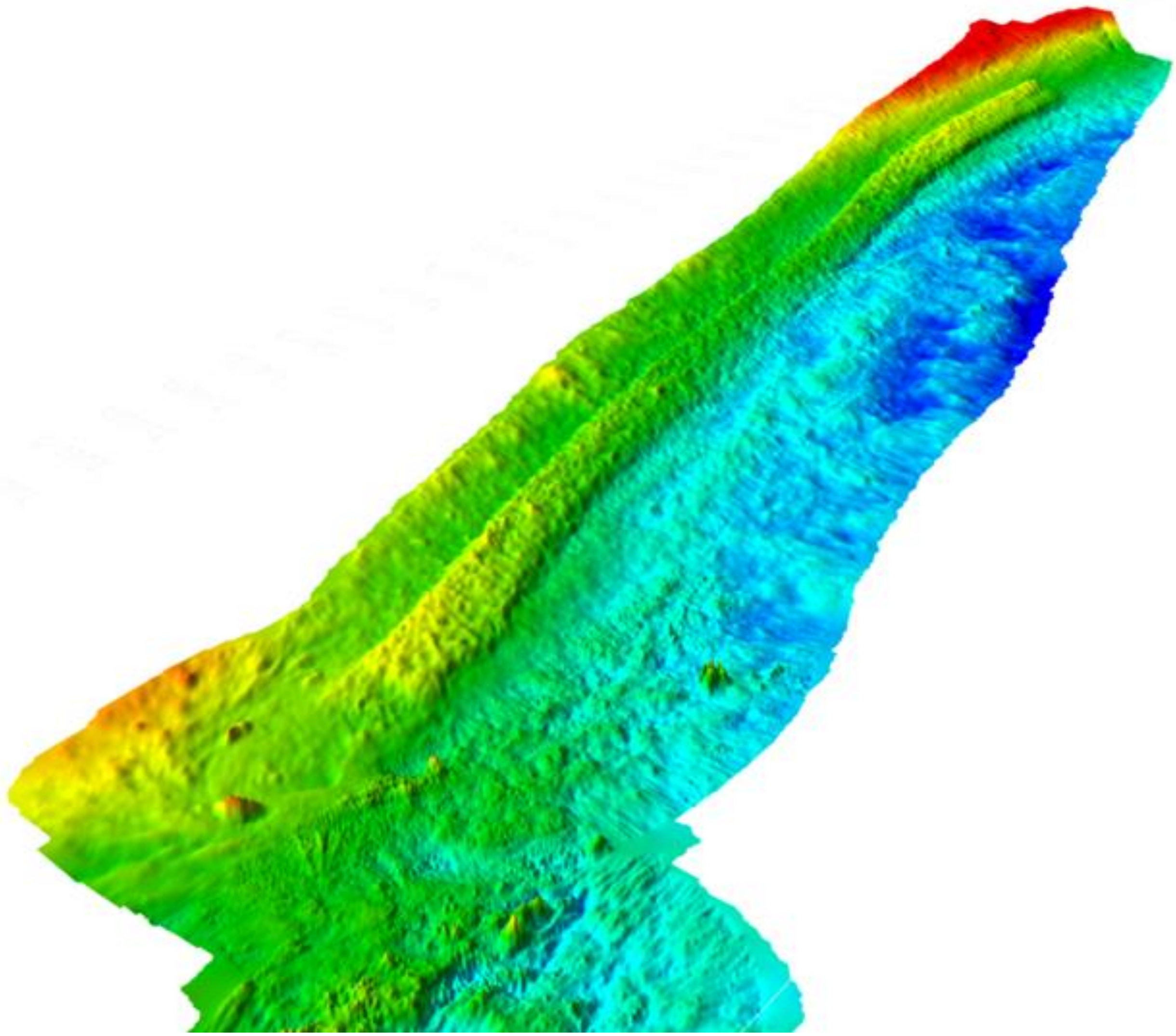
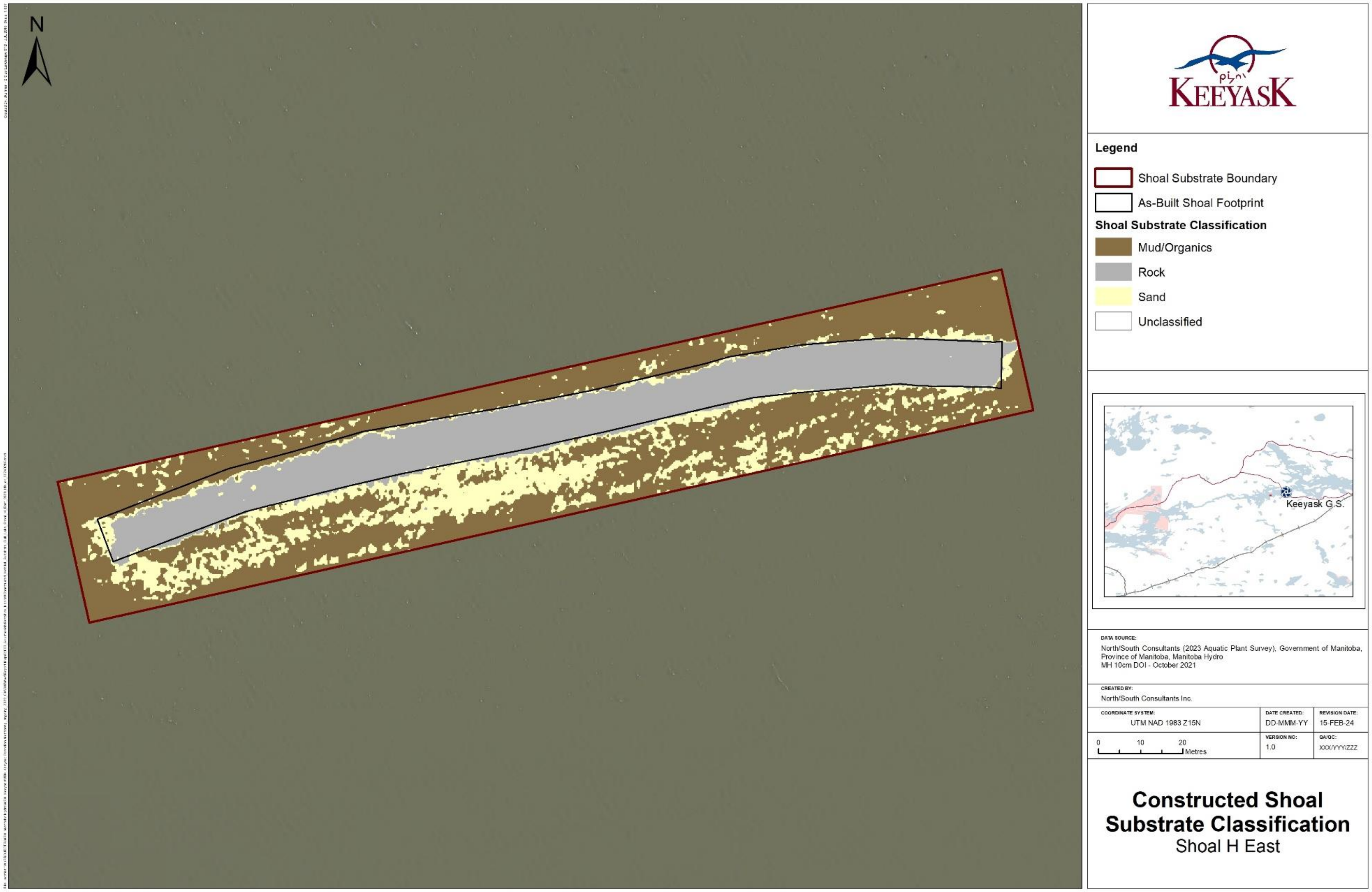


Figure 12: Detailed perspective view of Keeyask reservoir spawning shoal H-East looking east, August 2023. Colours follow depth contours outlined in Map 25.

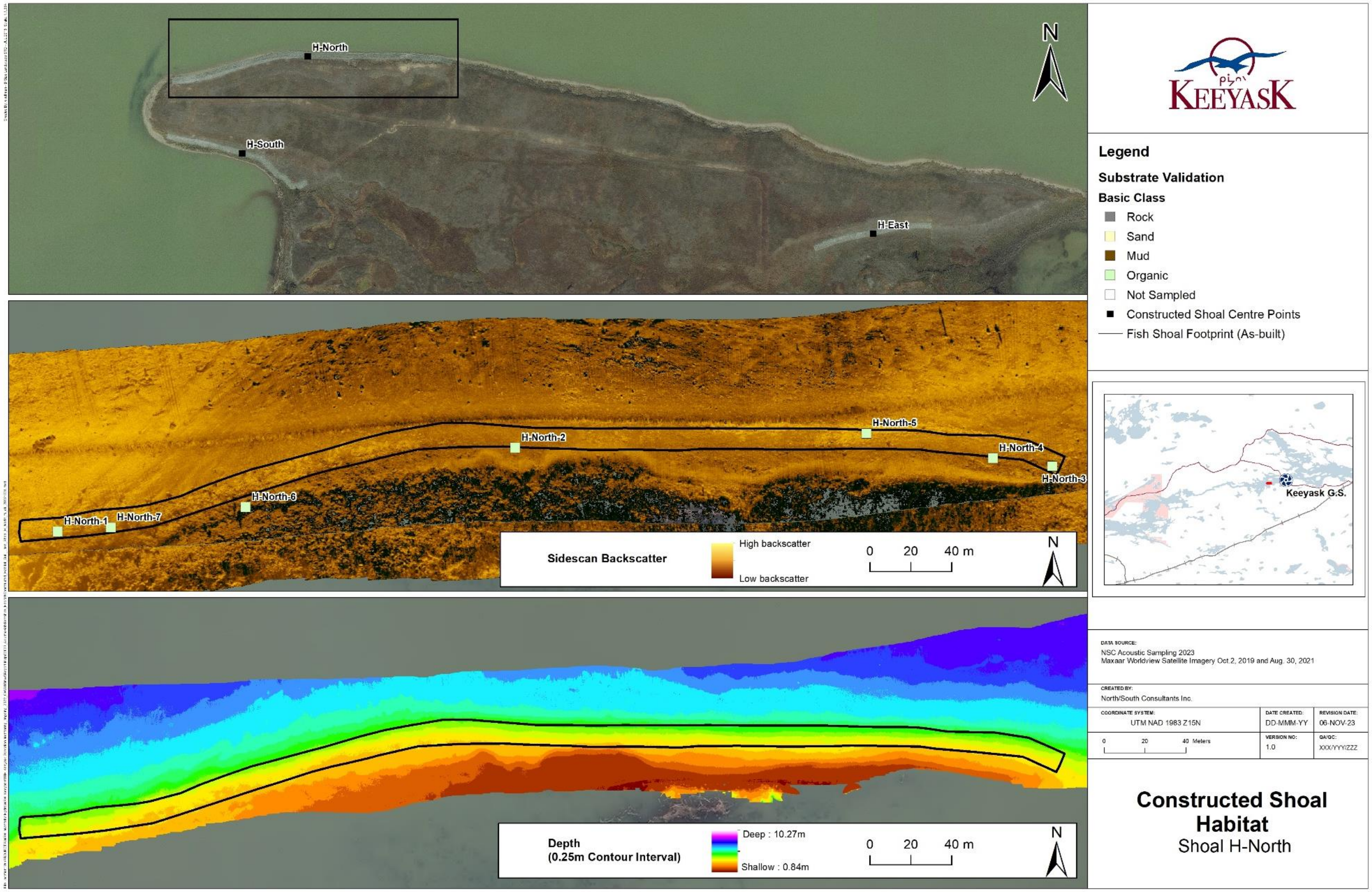


Map 26: Map showing the constructed habitat substrate composition at the H-East shoal.

4.2.7 CONSTRUCTED SHOAL H-NORTH

After the third year following reservoir impoundment, much of the spawning shoal H-North has been covered with soft mud (*i.e.,* silt and clay) and organic substrates. Organic substrates were collected using a petite Ponar dredge along the length of the spawning shoal (Table 22; Map 27; Photo 9). Acoustic surveys confirmed that much of the spawning shoal has been covered by soft mud and organic substrates with little rocky shoal materials visible at the surface (Figure 13; Map 28).

Photo 9: Substrates collected from constructed shoal H-North-4 in the Keeyask reservoir, showing organics and silt.



Map 27: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the H-North shoal.**

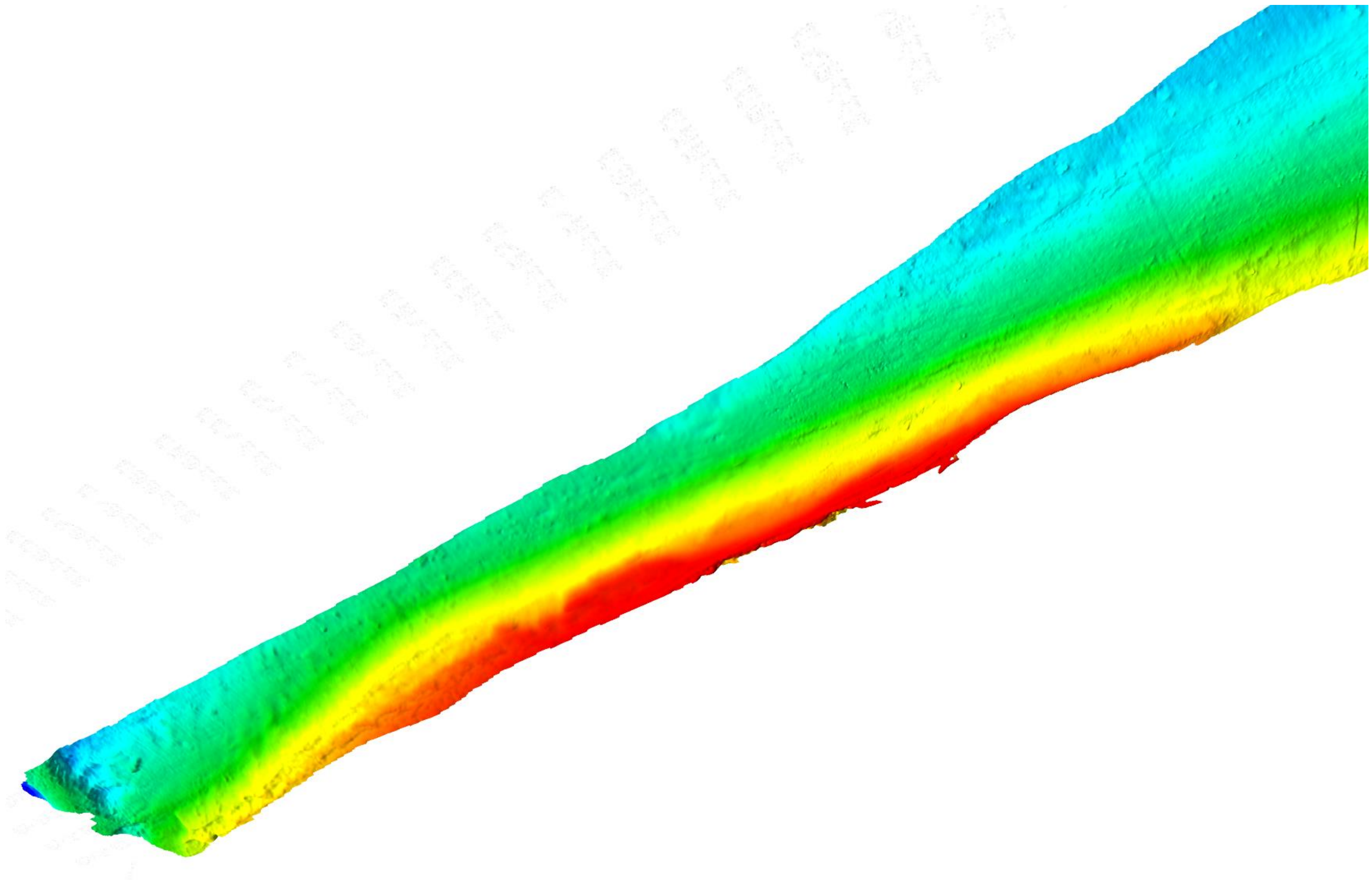
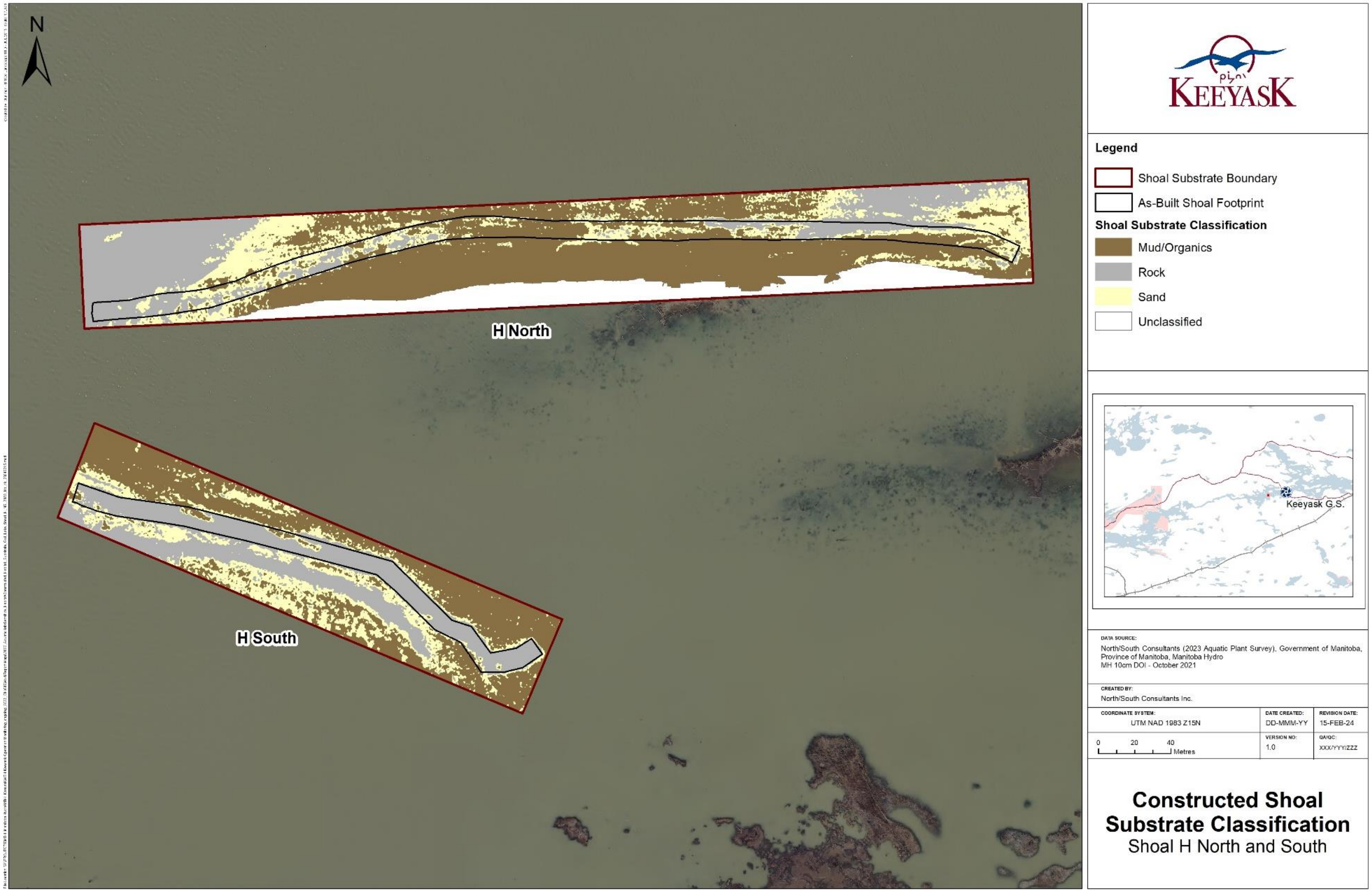


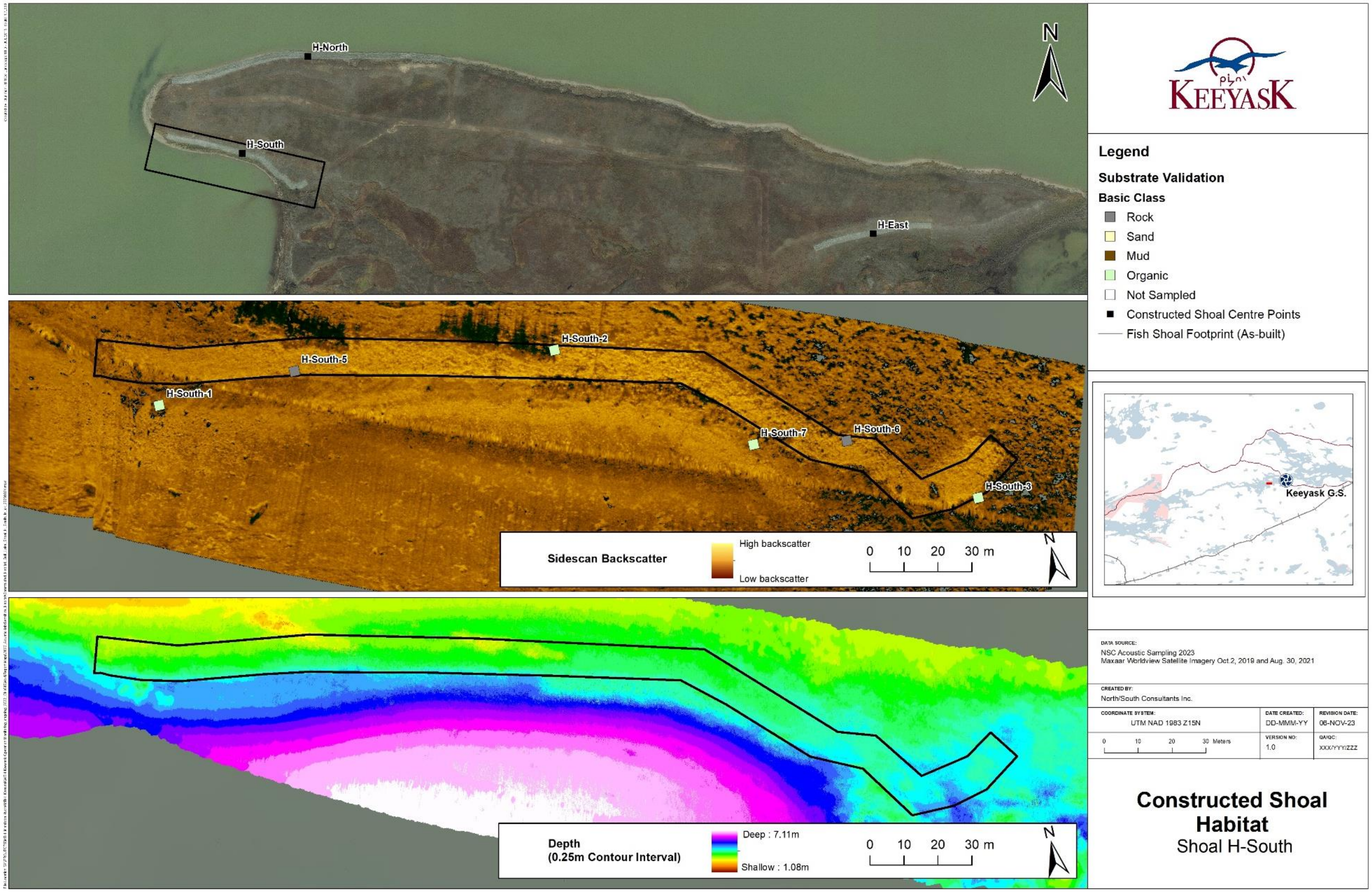
Figure 13: Detailed perspective view of Keeyask reservoir spawning shoal H-North looking southwest, August 2023. Colours follow depth contours outlined in Map 27.



Map 28: **Basic substrate type (*i.e.*, mud/organics, rock, or sand) found on the constructed spawning shoals H-North and H-South during surveys conducted in August 2023.**

4.2.8 CONSTRUCTED SHOAL H-SOUTH

Three years after impoundment, spawning shoal H-South was comprised largely of hard boulder substrates as when it was built, although large areas of organic overlay were observed. Organic substrates were collected using a petite Ponar dredge from four substrate validation sites; however, three sites were located outside the original footprint of the spawning shoal (Table 22; Map 29). Acoustic surveys indicated that rocky substrates still comprised the majority of the spawning shoal; however, two larger (>25m long) raised masses of organic material appear to be draped over the north edge of the shoal in addition to small patches of mud/organics and sand (Figure 14; Map 28). Organic debris (woody branches etc.) was also present on top of shoal adjacent to large peat mass on shoal.



Map 29: Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the H-South shoal.

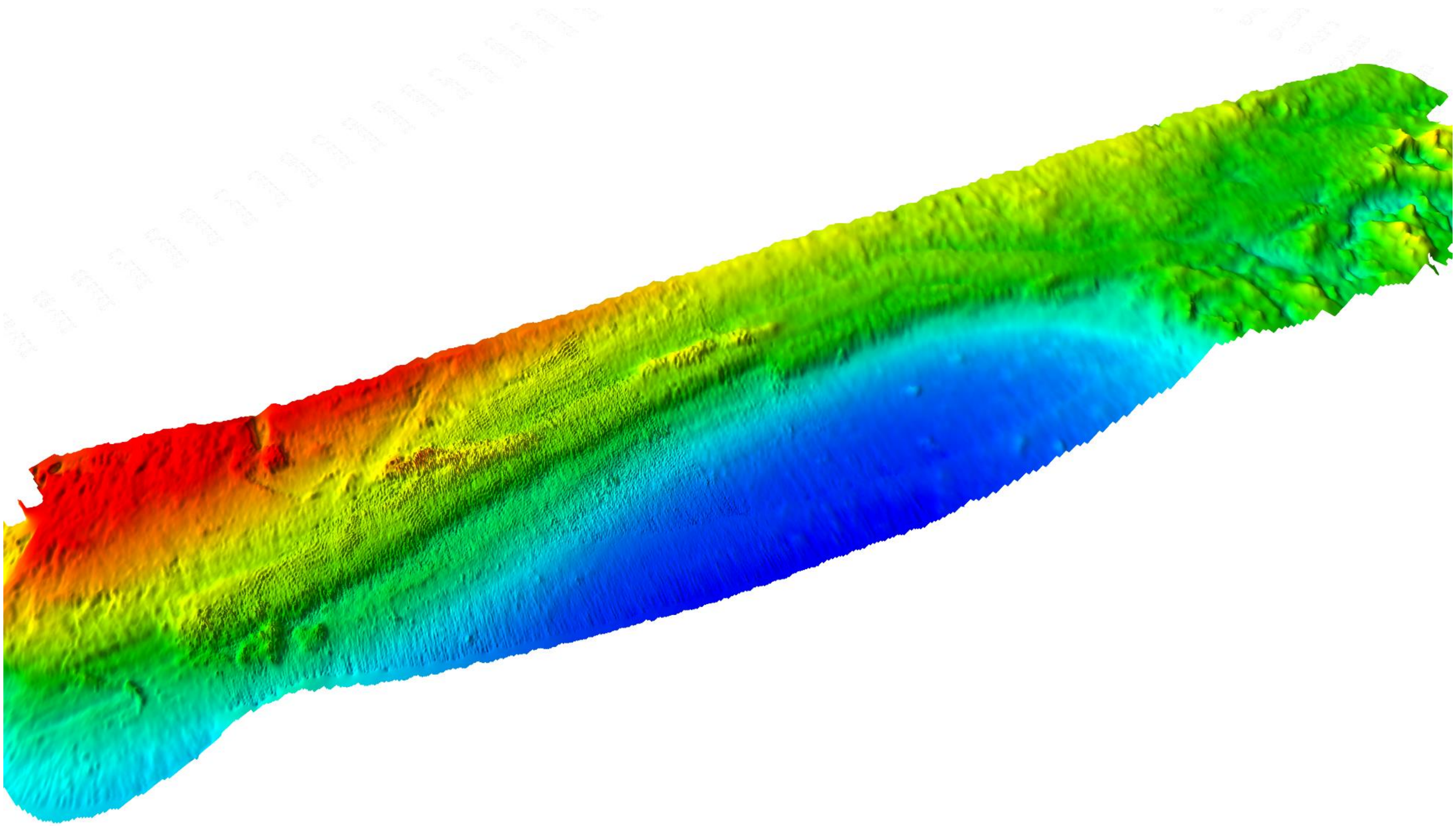
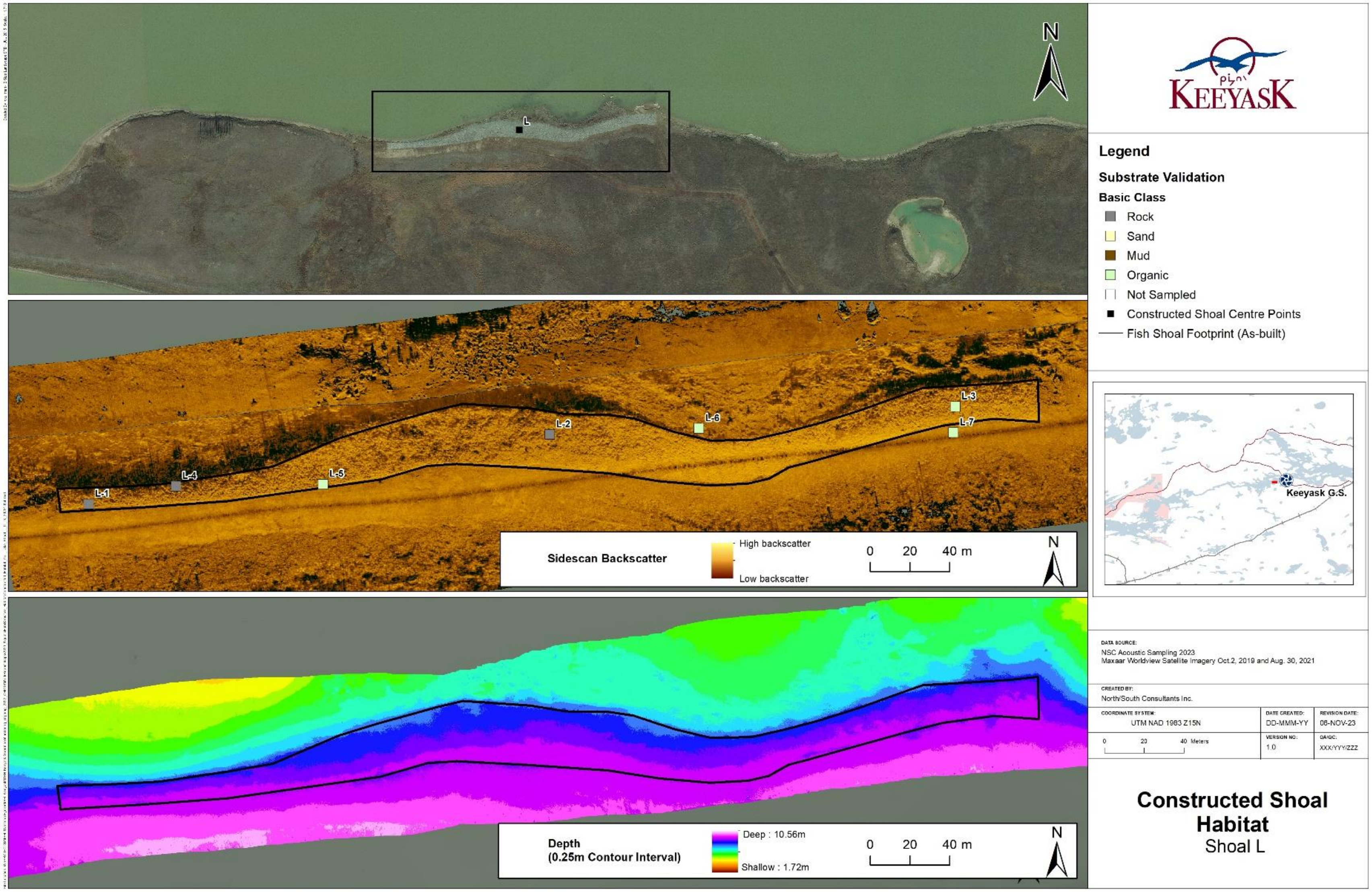


Figure 14: Detailed perspective view of Keeyask reservoir spawning shoal H-South looking northeast, August 2023. Colours follow depth contours outlined in Map 29.

4.2.9 CONSTRUCTED SHOAL L

Three years after impoundment, spawning shoal L was comprised largely of hard boulder substrates as when it was built, although some soft organic substrates were present (Table 22; Map 30). Acoustic surveys indicated that rocky substrates still comprised the majority of the spawning shoal although deposits of sand were evident (Map 31). However, the overall structure of shoal L appears to be intact with limited change since construction (Figure 15). Underwater cameras revealed that much of the spawning shoal is covered by zebra mussels (Photo 10).

Photo 10: Zebra mussels observed on the constructed spawning shoal L using an underwater camera, 2023.



Map 30: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the L shoal.**

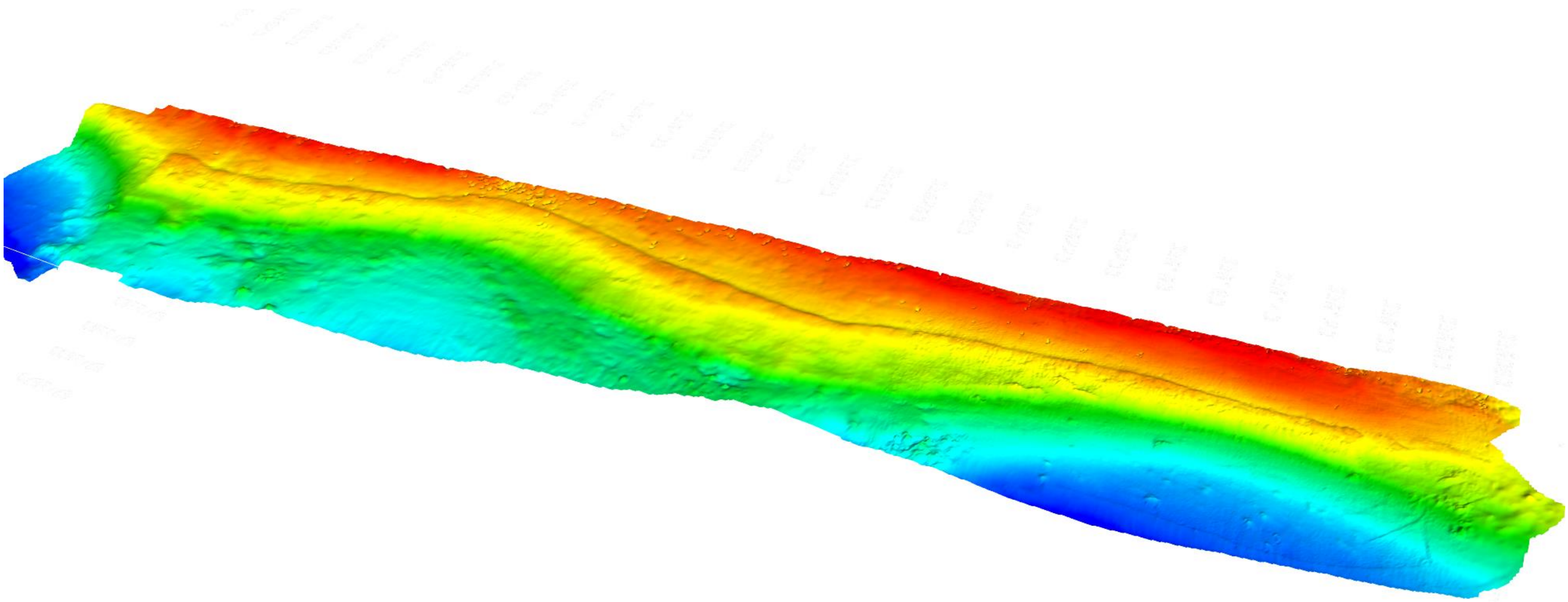
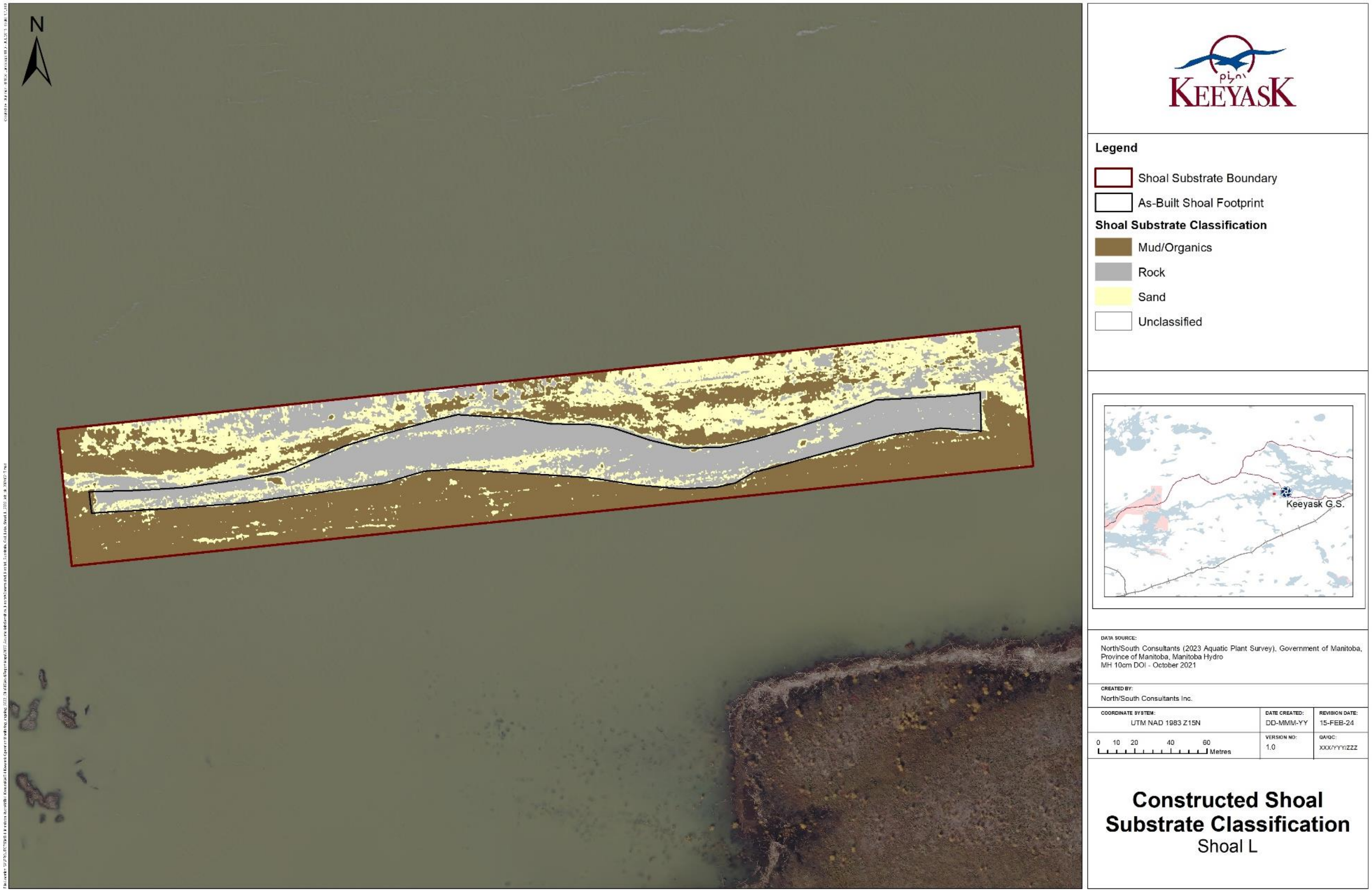


Figure 15: Detailed perspective view of Keeyask reservoir spawning shoal L looking northwest, August 2023. Colours follow depth contours outlined in Map 30.



Map 31: **Basic substrate type (*i.e.*, mud/organics, rock, or sand) found on the constructed spawning shoal L during surveys conducted in August 2023.**

5.0 DISCUSSION

The primary objective of monitoring deep water and constructed habitats is to assess change in substrate composition in deep water areas (greater than 3 m) both in the Keeyask reservoir and Stephens Lake following GS construction and reservoir impoundment. Monitoring focussed on sites identified in the EIS as sensitive habitats for Lake Sturgeon (both spawning and rearing) and constructed habitats that were developed as an offsetting measure. It was predicted in the EIS that substrate and habitat characteristics (such as depth and velocity) would change in these deep water areas following reservoir impoundment and GS operation due to alteration in hydraulics and the ability of the river to transport materials along the riverbed. The evolution of substrate composition within the Keeyask reservoir and immediately downstream of the GS in Stephens Lake depends mostly on water velocity patterns and how the processes of erosion, transport, and deposition maintain or alter existing substrates.

Sensitive Lake Sturgeon habitats (*i.e.*, spawning and rearing habitats) identified during baseline studies for the Project were surveyed annually from 2021 to 2023. These included spawning habitats at Long Rapids and Birthday Rapids, and juvenile habitat in Gull Lake, lower Gull Lake in the area north of Caribou Island, and in Stephens Lake approximately 4–7 km downstream of the GS. Additional deep water habitats were monitored for substrate composition in lotic areas in the middle Keeyask reservoir, and the area of Stephens Lake between 1–4 km downstream of the GS. Constructed habitats in the Keeyask reservoir were also sampled between 2021 and 2023.

Sampling over the first three years of impoundment occurred during a range of flow conditions. In August 2021, river discharge (as measured at the outflow from Split Lake) was near or lower than 5^{th} percentile flows (Manitoba Hydro 2022). In contrast, near record high flows were observed in August 2022, measuring between 95^{th} and 100^{th} percentile (Manitoba Hydro 2023). Near median flows were observed during August 2023 (Manitoba Hydro 2024). Monitoring over a range of flow conditions allows comparisons to be made between years to determine how water velocities and substrate characteristics in offshore habitat monitoring areas may change as a result.

Monitoring was conducted to address the following key question outlined in the AEMP:

Will Long Rapids, Birthday Rapids, and the area below the Keeyask GS continue to provide spawning habitat for Lake Sturgeon?

It was predicted in the EIS that habitat characteristics at Birthday Rapids would change following reservoir impoundment (*e.g.*, slower water velocities and silt deposition) and the area may become unsuitable for Lake Sturgeon spawning. It was also predicted that Lake Sturgeon would then move upstream to Long Rapids to spawn. However, habitat characteristics remained similar between the two sampling areas. In all three sampling years following reservoir impoundment, hard substrates were predominant downstream of both Long and Birthday rapids, generally consisting of bedrock/boulders, with finer substrates present in off-current areas along the shorelines. Water velocities were generally fast in both areas but changed between years depending on inflows. Inflows were low in 2021 (2,069 m^3/s) and maximum water velocities measured 2.92 m/s at Long Rapids and 1.93 m/s at Birthday Rapids. In 2022, inflows were very high (6,366 m^3/s) and higher water velocities were observed in both areas (a maximum of 3.22 m/s at Long Rapids and 3.15 m/s at Birthday Rapids). Moderate inflows were observed in 2023 (2,985 m^3/s) and maximum water velocities (2.68 m/s at Long Rapids and 2.46 m/s at Birthday Rapids) measured between the two previous sampling years.

Spawning adult Lake Sturgeon captured downstream of Birthday Rapids suggests that spawning has continued in this area following reservoir impoundment. No evidence of spawning at Long Rapids has been observed as no adult Lake Sturgeon have been captured between Long Rapids and Birthday Rapids in all three years following reservoir impoundment (Dowd and Hrenchuk 2024b). Further, movement monitoring studies using acoustic telemetry did not observe any Lake Sturgeon moving upstream to Long Rapids during the spawning period (Hrenchuk 2024). Together this suggests that habitat characteristics at Birthday Rapids have remained suitable for Lake Sturgeon spawning following reservoir impoundment and adult Lake Sturgeon do not appear to move upstream to spawn at Long Rapids.

Will sand and gravel transport through the riverine reach of the reservoir and deposit downstream of Birthday Rapids and/or the entrance to Gull Lake to create suitable YOY Lake Sturgeon habitat? If sand and gravel do not deposit near the entrance to Gull Lake what are the substrate conditions that develop?

It was predicted in the EIS that sand and gravel may deposit downstream of Birthday Rapids and/or at the entrance to Gull Lake following reservoir impoundment due to decreases in water velocities and this may create YOY Lake Sturgeon habitat. As discussed above, habitat characteristics downstream of Birthday Rapids remained similar to pre-impoundment, with high water velocities and hard substrates. Some areas of sand were observed in off-current areas in 2023, however, the majority of substrates were rock. Similar to observations at Long and Birthday rapids, water velocity characteristics at the entrance to Gull Lake changed over the three sampling years due to differences in inflows. In both 2021 and 2023 (when inflows were low and moderate, respectively), water velocities in the area downstream of the entrance to Gull Lake were generally low (*i.e.*, 0.2–0.5 m/s) in the middle of the channel with areas of standing water (*i.e.*, 0–0.2 m/s) on the edges. In 2022 (when inflows were high), water velocities were generally moderate (0.5–1.5 m/s) in the middle of the channel, although areas of high velocity (1.5–2.5 m/s) were also observed.

In the third year following reservoir impoundment, small areas of sand were evident at the entrance to Gull Lake. Although the majority of substrates in the middle of the channel were rock, (with cobble, boulder, and bedrock comprising 58% of the sampling area), finer substrates were also present. A mix of silt, clay, and sand comprised 18% of the sampling area, a mix of gravel and sand made up 9%, while sand was found in 4% of the area. This has changed from 2021, when no substrates finer than sand were observed, and from 2022 when a mix of silt, clay, and sand comprised only 2% of the sampling area.

Juvenile Lake Sturgeon were captured at the downstream end of this sampling area (*i.e.*, downstream of SH2-7) both before and after impoundment, although the number of fish captured has increased. In the six sampling years between 2014 and 2019 (before impoundment), thirteen juvenile Lake Sturgeon were captured in this area, while 11 were captured in 2022 and 2023 (post-impoundment; Henderson *et al.* 2015; Burnett *et al*. 2016, 2017, 2018, 2023; Burnett and Hrenchuk 2019, 2020; Dowd and Hrenchuk 2024a). It is expected that substrates in this area will continue to change over time as the reservoir ages and more fine substrates are deposited.

How will substrate composition change over time in deep water areas in the Keeyask reservoir and Stephens Lake (including in existing young-of-the-year [YOY] Lake Sturgeon habitats)?

The lower portion of Gull Lake (*i.e.*, the area around Caribou Island) provides Lake Sturgeon YOY and juvenile rearing habitat. The EIS predicted that fine substrates may deposit on top of existing sand and gravel following impoundment, decreasing suitability for juvenile Lake Sturgeon. Despite differences in inflows between the three post-impoundment sampling years, water velocities within this sampling area remained fairly consistent. In all years, there were areas of low to moderate water velocity surrounded by standing water with minimal velocity. Substrates changed little over the three years of sampling. An area of sand remained within the middle of the channel to the north of Caribou Island three years after impoundment, surrounded by mud (*i.e.*, silt and clay) in off-channel areas. Upstream and downstream of this sandy area the channel was generally rocky. Some evidence of silt deposition was observed within this sandy area, although only at two of six sites sampled. Juvenile Lake Sturgeon continue to be captured in this area following impoundment, further suggesting that habitat has remained suitable (Burnett *et al*. 2022, 2023, Dowd and Hrenchuk 2024a). It is expected that it may take time for sufficient silt to deposit to affect habitat use and surficial substrates may change over time.

Operation of the Keeyask GS varied over the three years of sampling, and differences in water velocity patterns downstream of the GS were observed. In 2021, the Keeyask GS powerhouse was still under construction (commissioning was completed in March 2022), with only a subset of the turbines in use. Because this year did not represent operation conditions, ADCP depth and velocity data were not acquired. In 2022, all powerhouse turbines were in use and high water levels necessitated the use of the spillway for the entire sampling period (Manitoba Hydro 2023). The area immediately downstream of the Keeyask GS was characterized by high to very high water velocity across the channel. Water velocities became low approximately 5 km downstream of the GS. In 2023, inflows were moderate, and the spillway was closed for the entire sampling period. Few areas of high water velocity were observed, and low water velocity began approximately 3 km downstream of the GS.

Prior to the Project, YOY and juvenile Lake Sturgeon habitat with a sand substrate was identified approximately 4–7 km downstream of the GS site. It was predicted in the EIS that fine sediments may deposit over sand, decreasing habitat suitability for juvenile Lake Sturgeon. Substrates were monitored three times each year (spring, summer, and fall), and differed somewhat between each sampling period. However, areas of hard substrates (*i.e.*, rock, cobble, and gravel) were consistently found within the upstream portions of the reach. Farther downstream, sites largely consisted of a mix of clay and organic matter, composed of detritus and broken-down plant material. Sand was present in all sampling years. Silt deposition was evident in each sampling year but varied by year and by season. Silt deposition was evident at 56 to 84% of sites in 2021 (sampled in summer and fall, respectively), 77 to 83% of sites in 2022 (sampled in summer and spring, respectively), and 32 to 100% of sites in 2023 (sampled in summer and fall, respectively). Despite this, juvenile Lake Sturgeon were captured in large numbers in the fall of each sampling year between 2021 and 2023 suggesting that habitat within this area has remained suitable (Dowd and Hrenchuk 2024a).

Will monitoring data collected from the constructed spawning habitat (i.e., water velocity and depth, and substrate) in the reservoir confirm that the extent and surface area continue to meet design criteria over time?

In the third year following reservoir impoundment, habitat characteristics at the constructed reservoir spawning shoals (Map 16) varied between sites, but some silt deposition was observed on all of the nine shoals. Five of the nine spawning shoals were still largely composed of rock (*i.e.*, boulder and cobble), with few areas of mud or organic substrates (F-South, G-North, G-South, H-East, and L). The overall structure of these five shoals appears to be intact with limited change since construction. The remaining four shoals have undergone structural changes and/or sedimentation since impoundment. In 2023, both shoals F-North and H-South were still comprised of rocky substrates, but also contained large areas of organic matter. Shoal F-East has undergone notable changes since construction, and a section of the shoal approximately 80 m long has changed from rock shoal to soft fine substrate material. The area is suspected to have been affected by ice breakup/scour action and sedimentation and a deeper depression is noticeable within the shoal. Shoal H-North differed most from when it was built and, in 2023, was largely comprised of mud and organic substrates with little rock material visible at the surface. The shoal is located on the downstream side of a pre-flood land outcrop. The area appears to form a current shadow towards the middle of the shoal, which may account for the increased deposition of fine sediments.

Water velocities differed at each the shoals, ranging from an average of 0.06 m/s (at both G-North and G-South) to 0.31 m/s (at H-North) in 2023. The majority of shoals contained areas of both standing (*i.e.*, 0.0–0.2 m/s) and low (*i.e.*, 0.2–0.5 m/s) water velocities, although two shoals (G-North and G-South) contained only standing water, while shoal H-North contained areas of moderate (*i.e.*, 0.5 – 1.5 m/s) water velocity. Water velocities differed at each the shoals, ranging from an average of 0.06 m/s (at both G-North and G-South) to 0.31 m/s (at H-North) in 2023.

Zebra mussels were observed on four of the spawning shoals (F-North, G-North, G-South, and L), and were observed in large numbers on two (G-South and L). Zebra mussel veligers were first found in Gull Lake in 2019 and adults have since become established. Although the presence of zebra mussels is not Project-related, it is not clear how they may impact fish use of the spawning shoals.

In the first three years following reservoir impoundment, there is evidence that Northern Pike and possibly Lake Whitefish have used the spawning shoals (Morrison and Hrenchuk 2024). Spawning Northern Pike have been captured on seven of the nine spawning shoals including those with high levels of debris (F-North, F-East, H-North) and zebra mussels (F-North, G-North, and L).Two Lake Whitefish larvae were captured on shoal F-East and L and, although they may have drifted from an alternate spawning location, it is possible that Lake Whiteish spawned on these two shoals. No Walleye were observed using the shoals in any of the three sampling years.

5.1 NEXT STEPS

Offshore habitat monitoring at sensitive, deep water, and constructed sites was conducted annually in the first three years following reservoir impoundment to document early conditions and changes. Going forward, changes are expected to be slow, thus monitoring will be conducted every three years (next in 2026). Surveys will be repeated using the same measures to describe changes to offshore habitats as the Keeyask reservoir ages over the long-term.

6.0 SUMMARY AND CONCLUSIONS

- Deep water and constructed habitats were sampled in 2023 to monitor change in substrate composition in deep water areas (greater than 3 m) both upstream and downstream of the GS.
- Sampling over the first three years of impoundment occurred during differing flow conditions including near or lower than 5th percentile flows in 2021, near record high flows in August 2022, measuring over 95th percentile, and near median flows in 2023. Monitoring over a range of flow conditions demonstrates how velocities and substrate characteristics in offshore habitat monitoring areas change depending on discharge.
- Monitoring was conducted to address the following key questions outlined in the AEMP:
  - *Will Long Rapids, Birthday Rapids, and the area below the Keeyask GS continue to provide spawning habitat for Lake Sturgeon?*

    It was predicted in the EIS that habitat at Birthday Rapids would change following reservoir impoundment and the area may become unsuitable for Lake Sturgeon spawning. It was also predicted that Lake Sturgeon would then move upstream to Long Rapids to spawn. However, in all three sampling years following Keeyask reservoir impoundment, hard substrates remained predominant downstream of both Long and Birthday rapids, generally consisting of bedrock/boulders, with finer substrates present in off-current areas along the shorelines. Water velocities were generally fast in both areas but changed between years depending on inflows. Monitoring suggests that adult Lake Sturgeon have continued to spawn at Birthday Rapids following reservoir impoundment, while no evidence of spawning at Long Rapids has been observed. This suggests that habitat characteristics at Birthday Rapids have remained suitable for Lake Sturgeon spawning.
  - *Will sand and gravel transport through the riverine reach of the reservoir and deposit downstream of Birthday Rapids and/or the entrance to Gull Lake to create suitable YOY Lake Sturgeon habitat? If sand and gravel do not deposit near the entrance to Gull Lake what are the substrate conditions that develop?*

    The EIS predicted that sand and gravel may deposit downstream of Birthday Rapids and/or the entrance to Gull Lake following reservoir impoundment due to reduced water velocity and this may provide YOY Lake Sturgeon habitat. As discussed above, habitat characteristics downstream of Birthday Rapids remained similar to pre-impoundment, with high water velocities and hard substrates. Some areas of sand were observed in off-current areas in 2023, however, the majority of substrates were rock.

    Three years after impoundment, small areas of sand were evident at the entrance to Gull Lake. Although the majority of substrates in the middle of the channel were rock, finer substrates were also present including a mix of silt, clay, and sand (18% of the sampling area), a mix of gravel and sand (9%), and sand (4%). This has changed from

2021, when no substrates finer than sand were observed, and from 2022 when a mix of silt, clay, and sand comprised only 2% of the sampling area. Juvenile Lake Sturgeon were captured at the downstream end of this sampling area both before and after impoundment, although the number of fish captured has increased since reservoir impoundment. It is expected that substrates in this area will continue to change over time as the reservoir ages and more fine substrates are deposited.

- *How will substrate composition change over time in deep water areas in the Keeyask reservoir and Stephens Lake (including in the area of existing young-of-the-year [YOY] Lake Sturgeon habitats)?*

  The lower portion of Gull Lake (*i.e.,* the area around Caribou Island) provides Lake Sturgeon YOY and juvenile rearing habitat. It was predicted in the EIS that silt may deposit on top of existing sand and gravel following impoundment, decreasing suitability for juvenile Lake Sturgeon. In all years, this area was characterized by low to moderate water velocity surrounded by areas of standing water with minimal velocity. Substrates changed little over the three years of sampling. An area of sand substrate was still present within the middle of the channel to the north of Caribou Island in the third year following reservoir impoundment, surrounded by mud *(i.e.,* silt and clay) in off-channel areas. Some evidence of silt deposition was observed within this sandy area, although only at two of six sites sampled. Juvenile Lake Sturgeon continue to be captured in this area following impoundment, suggesting that habitat has remained suitable. It is expected that silt may take time to deposit and substrates in this area may change over time.

  Prior to the Project, YOY and juvenile Lake Sturgeon habitat was identified approximately 4–7 km downstream of the GS site. This area contained sand substrate. It was predicted in the EIS that silt may be deposited in this area, decreasing its suitability for juvenile Lake Sturgeon. Substrates were monitored three times each year (spring, summer, and fall), and differed somewhat between each sampling period. However, areas of hard substrates (*i.e.,* rock, cobble, and gravel) were consistently found within the upstream portions of the reach. Farther downstream, sites largely consisted of a mix of clay and organic matter, composed of detritus and broken-down plant material. Sand was present in all sampling years. Silt deposition was evident in each year but varied by year and by season. Despite this, juvenile Lake Sturgeon were captured in large numbers in the fall of each year between 2021 and 2023, suggesting that habitat has remained suitable.

- *Will monitoring data collected from the constructed spawning habitat (i.e., water velocity and depth, and substrate) in the reservoir confirm that the extent and surface area continue to meet design criteria over time?*

  Three years after impoundment, habitat characteristics at the constructed reservoir spawning shoals varied between sites, but some silt deposition was observed on all nine shoals. Five shoals were still largely composed of rock (*i.e.,* boulder and cobble), with few areas of mud or organic substrates (F-South, G-North, G-South, H-East, and

L). Both shoals Shoal F-North and H-South contained moderate amounts of soft substrates with patches of mud/organics and sand substrates present along their lengths. Shoal F-East was comprised of mud and organic substrates along approximately a third of its length. Shoal H-North differed most from when it was built and, in 2023, was largely comprised of mud and organic substrates. Zebra mussels were observed on four of the spawning shoals (F-North, G-North, G-South, and L), and were observed in large numbers on two (G-South and L). Zebra mussel veligers were first found in Gull Lake in 2019 and adults have since become established. Although the presence of zebra mussels is not Project-related, it is not clear how they may impact fish use of the spawning shoals. Despite these changes to the spawning shoals, monitoring has indicated that the shoals were used by Northern Pike and possibly Lake Whitefish in the first three years following reservoir impoundment.

- Offshore habitat monitoring at sensitive, deep water, and constructed sites was conducted annually in the first three years following reservoir impoundment to document early conditions and changes. Going forward, changes are expected to be slow, thus monitoring will be conducted every three years (next in 2026). Surveys will be repeated using the same measures to describe changes to offshore habitats as the Keeyask reservoir ages.

7.0 LITERATURE CITED

Burnett, D.C. and C.L. Hrenchuk. 2019. Juvenile Lake Sturgeon population monitoring, fall 2018: Year 5 Construction. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2019-06. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2019. xvii + 116 pp.

Burnett, D.C. and C.L. Hrenchuk. 2020. Juvenile Lake Sturgeon population monitoring, fall 2019: Year 6 Construction. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2020-06. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2020. xvi + 151 pp.

Burnett, D.C., L.M. Henderson, C.C. Barth, and C.L. Hrenchuk. 2016. Juvenile Lake Sturgeon population monitoring, fall 2015: Year 2 Construction. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2016-02. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2016. 84 pp.

Burnett, D.C., C.D. Lacho, and C.L. Hrenchuk. 2017. Juvenile Lake Sturgeon population monitoring, fall 2016: Year 3 Construction. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2017-06. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2017. xv + 86 pp.

Burnett, D.C., C.L. Hrenchuk, and C.C. Barth. 2018. Juvenile Lake Sturgeon population monitoring, fall 2017: Year 4 Construction. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2018-02. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2018. xv + 120 pp.

Burnett, D.C., Hrenchuk, C.L., and P. Nelson. 2022. Juvenile Lake Sturgeon population monitoring, fall 2021: Year 8 Construction. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2022-06. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2022. xvii + 119 pp.

Burnett, D.C., Hrenchuk, C.L., and P. Nelson. 2023. Juvenile Lake Sturgeon population monitoring, fall 2022: Year 1 Operation. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2023-06. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2023. xix + 147 pp.

Dowd, M.B. and C.L. Hrenchuk. 2024a. Juvenile Lake Sturgeon population monitoring, fall 2023: Year 2 Operation. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2024-05. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2024. xv + 131 pp.

Dowd, M.B. and C.L. Hrenchuk. 2024b. Adult Lake Sturgeon population monitoring in the Keeyask reservoir and Stephens Lake, 2023. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2024-05. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2024. xv + 79 pp.

Fakiris, E., Blondel, P., Papatheodorou, G., Christodoulou, D., Dimas, X., Georgiou, N., Kordella, S., Dimitriadis, C., Rzhanov, Y., Geraga, M., and G. Ferentinos. 2019. Multi-frequency, multi-sonar mapping of shallow habitats—efficacy and management implications in the national marine park of Zakynthos, Greece. Remote Sensing 11: 461. https://doi.org/10.3390/rs11040461

Henderson, L.M., C.C. Barth, and C.L. Hrenchuk. 2015. Juvenile Lake Sturgeon population monitoring, fall 2014: Year 1 Construction. Keeyask Generation Project Aquatic Effects Monitoring Report #AEMP-2015-03. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2015, 66 pp.

Hrenchuk, C.L. 2024. Adult Lake Sturgeon acoustic tracking in the Nelson River between Clark Lake and the Limestone Generating Station, October 2022 to August 2023: Year 2 Operation. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2024-01. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2024. xx + 279 pp.

Kaeser, A., Litts, T., and T. Tracy. 2012. Using low-cost side-scan sonar for benthic mapping throughout the lower Flint River, Georgia, USA. River Research and Applications: https://doi.org/10.1002/rra.2556

Lucieer, V. 2008. Object-oriented classification of sidescan sonar data for mapping benthic marine habitats. International Journal of Remote Sensing 29: 905–921. https://doi.org/10.1080/01431160701311309

Manitoba Hydro. 2022. 2021-2022 Physical Environment Monitoring Report: Year 1 Operation. Keeyask Generation Project Physical Environment Monitoring Plan Report #PEMP-2022-01. June 2022.

Manitoba Hydro. 2023. 2022-2023 Physical Environment Monitoring Report: Year 2 Operation. Keeyask Generation Project Physical Environment Monitoring Plan Report #PEMP-2023-01. June 2023.

Manitoba Hydro. 2024. 2023-2024 Physical Environment Monitoring Report: Year 3 Operation. Keeyask Generation Project Physical Environment Monitoring Plan Report #PEMP-2024-01. June 2024.

Morrison, S.M. and C.L. Hrenchuk. 2024. Fish use of existing and created spawning habitat: Year 3 impoundment. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2024-07. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2024. xvi + 123 pp.

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

APPENDICES

APPENDIX 1: RESULTS OF PARTICLE SIZE ANALYSIS FROM SAMPLES COLLECTED IN DEEP WATER AREAS OF THE KEEYASK RESERVOIR AND STEPHENS LAKE, 2023.

Table A1-1: Results of particle size analysis (conducted at ALS Laboratories) from samples collected at selected sites in the Keeyask reservoir at Gull Lake and Caribou Island sensitive habitat areas and in the Stephens Lake sensitive habitat area in August, 2023.

Date	Area Code	Area Name	Site ID	Inorganic Carbon (%)	$CaCO_3$ Equivalent	Total Carbon by Combustion (%)	Total Organic Carbon (%)	% Sand (2.0-0.05 mm)	% Silt (0.05-2 µm)	% Clay (<2 µm)	Texture
23-Aug-23	DST2	Gull Lake	DST2-1	2.32	19.3	4.65	2.33	39.7	46.4	13.9	Loam
18-Aug-23	DST3	Caribou Island	DST3-16	0.865	7.21	1.46	0.595	87.6	8.9	3.5	Sand
18-Aug-23	DST3	Caribou Island	DST3-17	1.95	16.2	4.31	2.36	9.1	77.7	13.2	Silt Loam
18-Aug-23	DST3	Caribou Island	DST3-19	1.06	8.83	1.7	0.64	86.6	10.4	2.9	Sand
18-Aug-23	DST3	Caribou Island	DST3-22	1.11	9.27	1.98	0.87	85.6	11.7	2.7	Loamy Sand
18-Aug-23	DST3	Caribou Island	DST3-25	1.47	12.2	2.05	0.58	94.2	4.4	1.4	Sand
17-Aug-23	DST3	Caribou Island	DST3-28	1.68	14	2.31	0.63	97	2	<1.0	Sand
17-Aug-23	DST3	Caribou Island	DST3-32	2.04	17	4.55	2.51	6.6	83	10.4	Silt
17-Aug-23	DST3	Caribou Island	DST3-33	2.28	19	3.36	1.08	92.4	7.2	<1.0	Sand
17-Aug-23	DST3	Caribou Island	DST3-37	1.12	9.3	9.53	8.41	18.8	58	23.2	Silt Loam
17-Aug-23	DST3	Caribou Island	DST3-48	2.5	20.9	4.07	1.57	23.8	32.8	43.4	Clay
12-Aug-23	DST4	Stephens Lake	DST4-4	1.85	15.4	4.92	3.07	21.1	65.8	13.2	Silt Loam
13-Aug-23	DST4	Stephens Lake	DST4-17	1.26	10.5	8.45	7.19	60.6	27.6	11.8	Sandy Loam
13-Aug-23	DST4	Stephens Lake	DST4-18	1.57	13.1	5.32	3.75	38.2	49.6	12.2	Silt Loam
13-Aug-23	DST4	Stephens Lake	DST4-23	2.19	18.3	5.06	2.87	20.3	60	19.8	Silt Loam
13-Aug-23	SH4	Stephens Lake	T1-1	1.9	15.9	5.13	3.23	33	57	10.1	Silt Loam
13-Aug-23	SH4	Stephens Lake	T2-3	1.18	9.82	8.44	7.26	50.4	42.2	7.4	Loam
13-Aug-23	SH4	Stephens Lake	T2-5	1.65	13.8	3.81	2.16	48.1	43.8	8.1	Loam
13-Aug-23	SH4	Stephens Lake	T4-3	1.7	14.2	4.23	2.53	57.7	30.2	12.1	Sandy Loam
13-Aug-23	SH4	Stephens Lake	T5-3	1.56	13	3.94	2.38	65.7	22.3	12	Sandy Loam