Keeyask Generation Project

Aquatic Effects Monitoring Plan

Sensitive and Constructed Habitat Monitoring Report

AEMP-2022-15

KEEYASK

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KEEYASK GENERATION PROJECT

AQUATIC EFFECTS MONITORING PLAN

REPORT #AEMP-2022-15

SENSITIVE AND CONSTRUCTED HABITAT MONITORING IN THE KEEYASK STUDY AREA, 2021

Prepared for

Manitoba Hydro

By

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SUMMARY

Background

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

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

Aquatic habitat provides the environment in which aquatic 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 construction of the generating station and reservoir impoundment.

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 the lower portion of the reservoir) and areas where Lake Sturgeon spawn (such as at Long Rapids, Birthday Rapids, and the base of what was Gull Rapids that is now the Keeyask GS) (see map below). Impoundment of the Keeyask reservoir in fall 2020 changed water depth and flows at Birthday Rapids and along the mainstem where Lake Sturgeon spawned. Flooding also changed depths and flows in areas important for YOY Lake Sturgeon to grow. Construction of the GS also eliminated Gull Rapids and changed flows downstream, which was also Lake Sturgeon spawning habitat.

Construction of the Keeyask GS also changed spawning habitats used by other fish species including Walleye (pickerel) and Lake 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). Several rocky areas were also created downstream of the GS to create

some diversity in habitat in areas where the substrate (what the bottom is made of) is all the same. These will create feeding areas for pickerel and other types of fish.

This report presents the results of habitat monitoring conducted at these created shoals as well as areas identified as sensitive Lake Sturgeon habitats in Nelson River from downstream of Long Rapids to the Keeyask GS and in Stephens Lake downstream of the GS during the first year post-impoundment.

Why is the study being done?

Habitat monitoring at sensitive Lake Sturgeon 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, 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 like to live 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 are present in the riverbed both upstream and downstream of the GS. It is important to find out where these habitats are located. This will help to make sure that YOY Lake Sturgeon have enough of the habitat that they need to survive and grow.

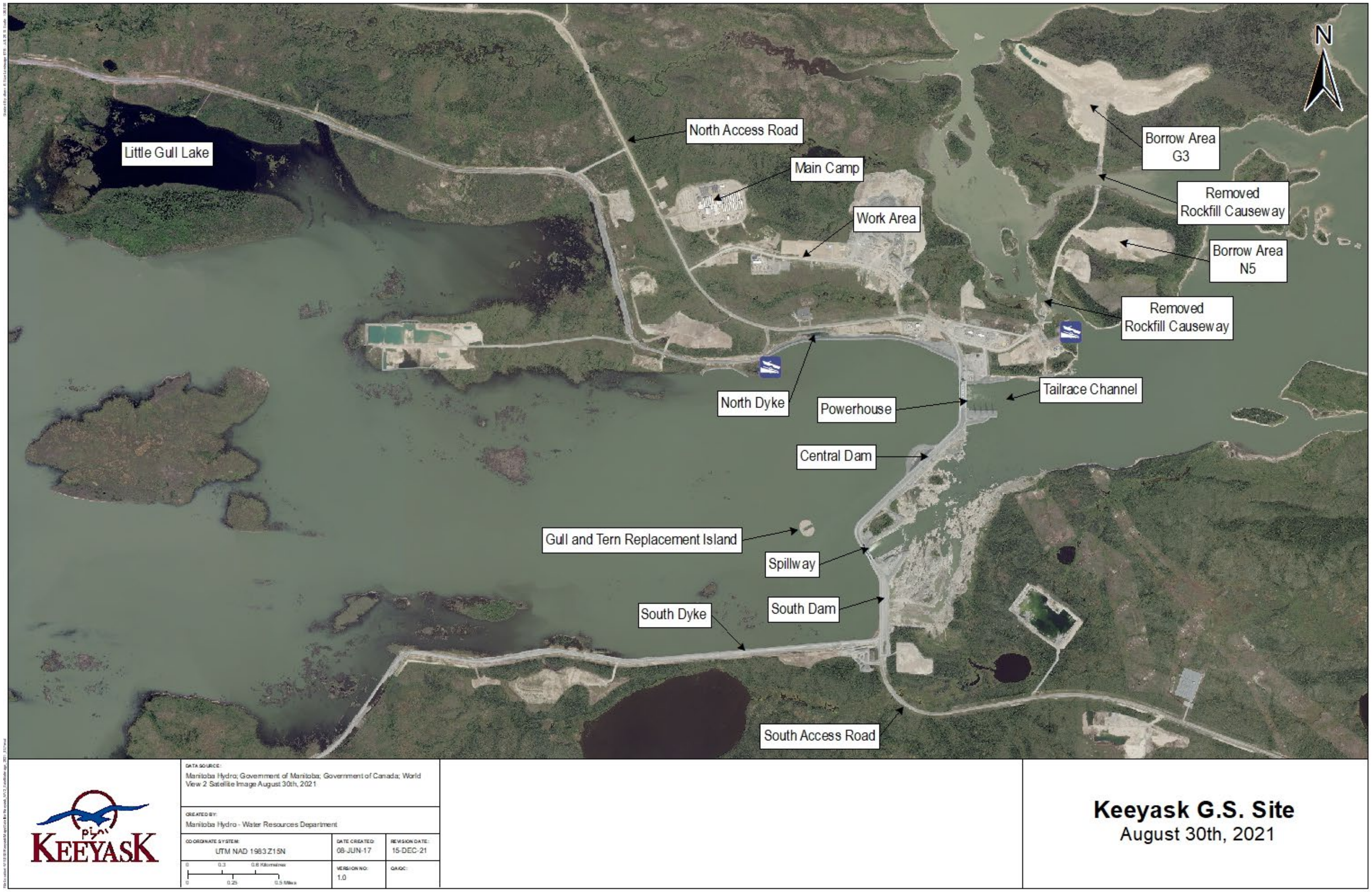
If sand and gravel are no longer present in the areas where they used to be, what are the substrates that develop in their place?

This question is important because it will help us to understand how rock, gravel, sand, and silt are settling on the bottom of the reservoir and downstream of Keeyask. Fish prefer some types of substrates over others and knowing what substrates are there will help determine what types of fish will use these areas.

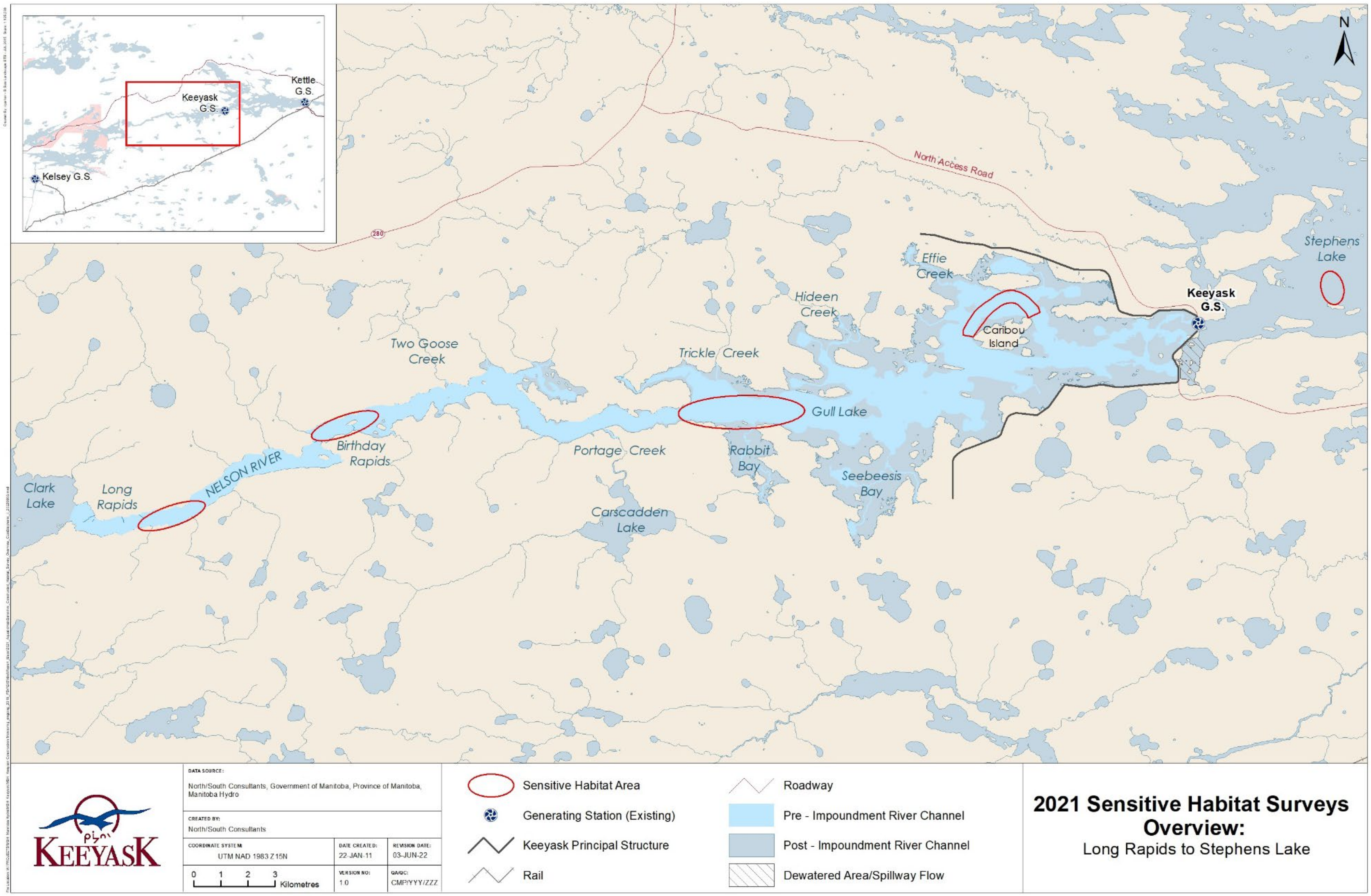
Habitat monitoring at constructed habitat is being done to answer an additional question:

Is the habitat at the constructed habitats (i.e., water velocity and depth, and substrate) the same as how they were designed, or does it change over time?

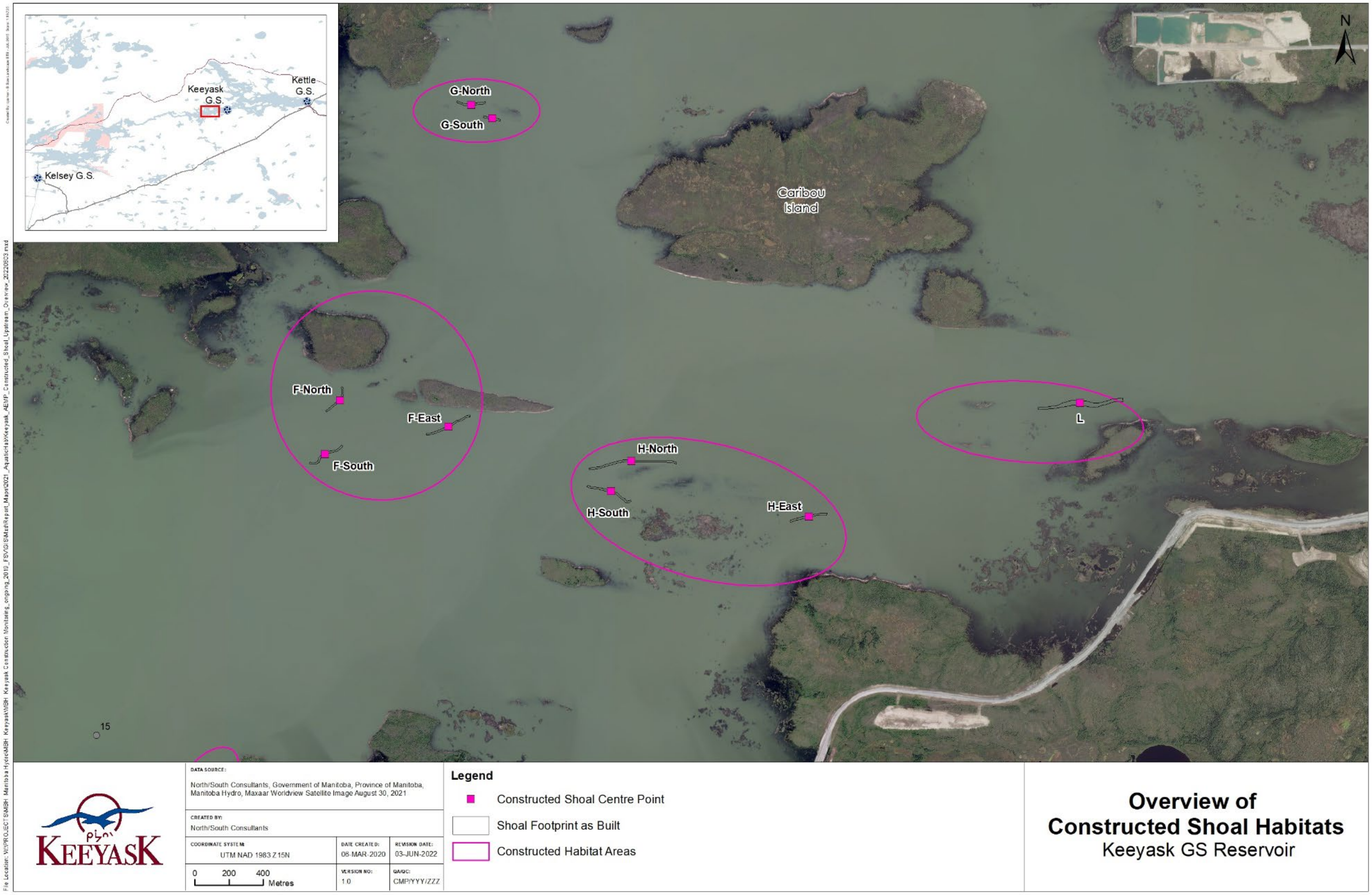
This question is important to make sure that the shoals continue to provide the types of habitats that fish need to spawn and feed.



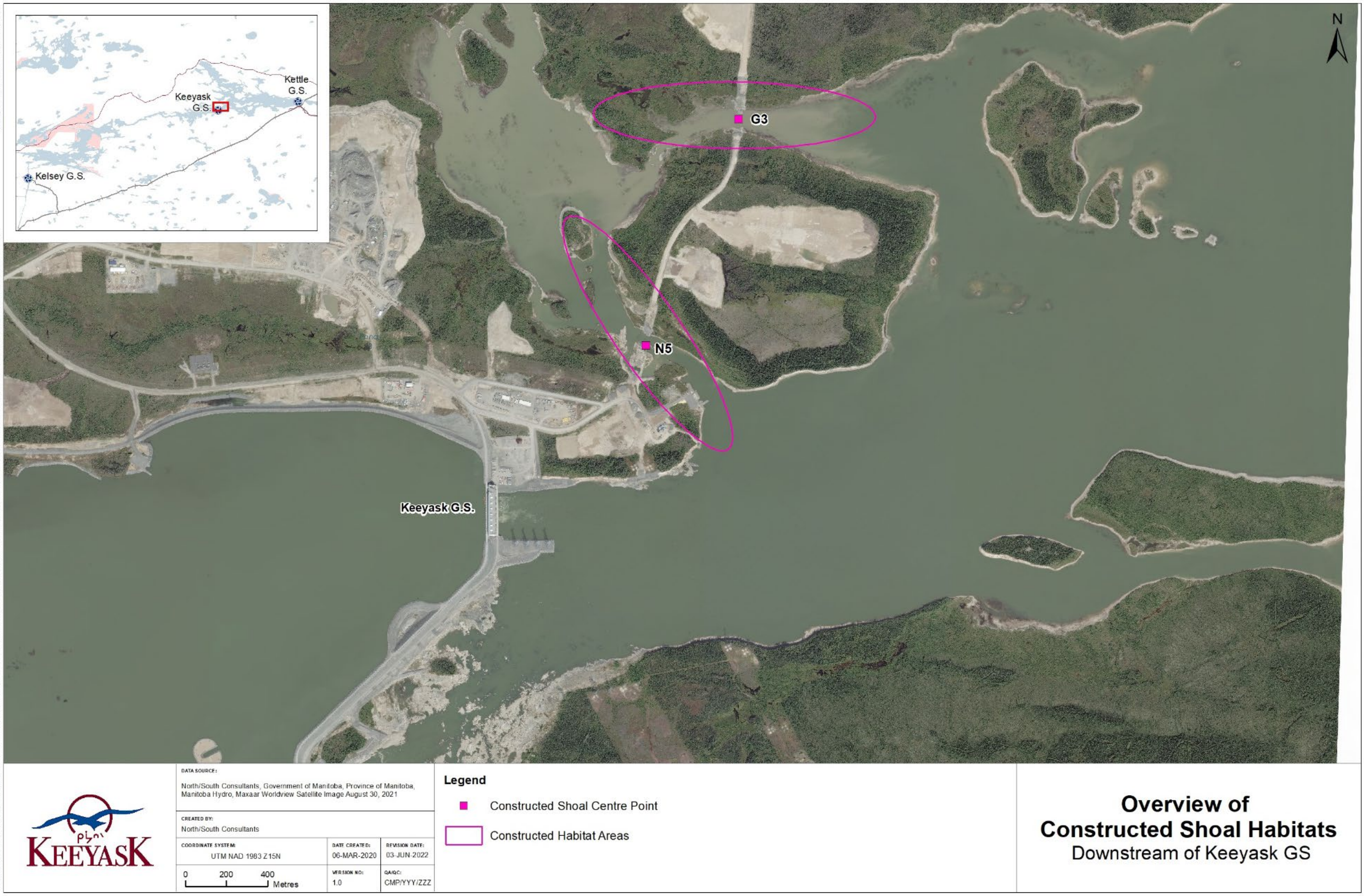
Map illustrating instream structures at the Keeyask Generating Station site, August 2021.



Map of the study area for the sensitive and constructed habitat monitoring in the Keeyask reservoir and Stephens Lake in 2021 including Long Rapids, Birthday Rapids, the entrance to Gull Lake, Caribou Island, and downstream of the Keeyask GS.



Map showing the locations of the constructed spawning shoals in the Keeyask reservoir.



Map showing the locations of the constructed rocky shoal habitat in Stephens Lake.

Setup of acoustic equipment (left) and Ponar dredge substrate sampler (right) used to monitor sensitive and constructed habitats in the Keeyask reservoir and Stephens Lake in 2021.

What was done?

Five sensitive habitat areas including four upstream of the Keeyask GS and one downstream were monitored in 2021. These included areas downstream of Long Rapids, Birthday Rapids, and the Gull Lake entrance, around Caribou Island, and in the upstream portion of Stephens Lake (see study area map above). Substrate composition (what the bottom is made of) information was collected and measurements of how deep and fast the water is were taken at 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 make a picture of the bottom).

Constructed habitats including nine spawning shoals in the Keeyask reservoir and two rocky habitats in Stephens Lake were monitored in 2021 (see maps 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 also used to get a more detailed picture of each shoal.

What was found?

The sensitive habitats at Long Rapids, Birthday Rapids, and the entrance to Gull Lake had mostly hard substrates including bedrock, boulder, cobble, and some areas of gravel. Water velocity was high throughout the Long Rapids reach. Birthday Rapids and the entrance to Gull Lake had high water velocities with areas of low velocity and standing water along the shores.

The area around Caribou Island had more of a mix of substrates ranging from hard rock to soft mud. An area of sand was present in the middle of the channel to the east and north of Caribou Island, surrounded by mud (*i.e.*, silt and clay) in off-channel areas. Upstream and downstream of this sandy area the channel is generally rocky. Some silt was deposited near the downstream end of the sand.

Substrates in the sensitive Lake Sturgeon habitat in the upstream portion of Stephens Lake were sampled three times in 2021 in spring, summer, and fall. Substrate also varied within this area.

Areas of sand were found, mostly in the upstream part of the study area. Farther downstream sites largely consisted of a mix of silt, sand, and clay. Some silt was deposited on top of the substrates towards the downstream end of the reach in spring and throughout the reach in summer and fall.

Constructed habitat in the Keeyask reservoir and Stephens Lake were all found in areas of low water velocity. Each shoal was made of boulder with no obvious areas of silt deposition.

What does it mean?

It is still too early to see in there are any changes to sensitive and constructed habitat areas upstream and downstream of the Keeyask GS as the result of the Project. The habitat downstream of Birthday Rapids was found to be fast water with hard substrates. This combined with the capture of spawning Lake Sturgeon in the area in spring 2021 suggests that this is still a spawning area. Further monitoring will help us see if this habitat changes over time.

What will be done next?

The program will be repeated yearly until 2023. Data will be collected in the same areas and the same sites to see if anything has changed (*e.g.*, if fine sediments deposit over areas that are currently coarse sand, gravel, or cobble).

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1.0 INTRODUCTION

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

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

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

Lake Sturgeon are a key component of the overall monitoring plan, chosen because they are important to local communities, are sensitive to environmental change, 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 YOY and sub-adult habitat was identified at Birthday Rapids, the entrance to Gull Lake, lower Gull Lake, the channel north of Caribou Island, and in Stephens Lake approximated 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 2). Rockfill material was left in place at two temporary causeways (N-5 and G-3) in Stephens Lake to create shallow rocky habitat for fish and other aquatic species and a means of improving diversity at these areas (Map 2). A tailrace spawning shoal was constructed immediately downstream of the Keeyask GS powerhouse to provide Lake Sturgeon spawning habitat downstream of the GS. This shoal is not expected to be used until the powerhouse is fully commissioned. A Lake Whitefish spawning reef will be constructed along the South shore of Stephens Lake after construction of the GS is complete.

Impoundment of the Keeyask reservoir was completed on September 5, 2020. Sampling in the Keeyask reservoir in 2021 represented the first year of sampling under operating conditions (water levels and flows). Monitoring in Stephens Lake, however, represented a transition between construction and operation as a considerable portion of the flow was still being passed through the spillway. in the spring and early summer, but by fall the spillway was closed and all water was flowing through the powerhouse as more units came into service. Fish use of sensitive and constructed habitats in the first year after reservoir impoundment was investigated during several studies conducted in 2021. Lake Sturgeon spawning locations are described in Loeppky and Hrenchuk (2022) and Hrenchuk and Small (2022). Juvenile Lake Sturgeon rearing locations are discussed in Burnett et al. (2022) and Funk and Hrenchuk (2022). Fish use of the reservoir spawning shoals is described in Hrenchuk and Loeppky (2022). This report presents results from sensitive and constructed habitat monitoring conducted in the Keeyask reservoir and Stephens Lake in summer, 2021.

Monitoring of sensitive Lake Sturgeon habitats 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 spillway (when it is in operation) continue to provide spawning habitat for Lake Sturgeon?*
- *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?*

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, near the tailrace, and along the south and north shore downstream of the GS confirm that the extent and surface area continue to meet design criteria over time?*

It should be noted that some of the transects included in the sensitive habitat monitoring are also included in the deep water habitat study (Larter and Hrenchuk 2022) where YOY Lake Sturgeon habitat occurs in deep water areas. Monitoring of sensitive and constructed habitats will be conducted in 2022 and 2023, and the results will be assessed to determine if additional monitoring is required.

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 (Map 1). This section of river offers a diversity of physical habitat conditions, including a variety of substrate types, and variable water depths (range 0–30 m) and velocities. Clark Lake is located immediately downstream of Split Lake, and approximately 42 km upstream of the Keeyask GS (formerly Gull Rapids). 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 the Keeyask GS is considered the Keeyask reservoir.

Birthday Rapids is located approximately 10 km downstream of Clark Lake and 30 km upstream of Gull Rapids/the Keeyask GS and marks the upstream end of major water level changes 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 a near level, albeit fast-flowing section of river. The 14 km reach of the Nelson River between Birthday Rapids and Gull Lake was characterized as a large and somewhat uniform channel with medium to high water velocities and a few large bays. This area is now within the Keeyask reservoir, though flooding was limited to mainly shoreline areas.

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

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

Kettle GS is located approximately 40 km downstream of the Keeyask GS.

2.1 FLOWS, WATER LEVELS, AND KEEYASK OPERATIONS

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

Water levels on Gull Lake have been held steady between about 158.8–159 m since reservoir impoundment in September 2020. Upstream of Gull Lake at gauges below and above Birthday Rapids the levels were about 0.5 m and 2 m higher than on Gull Lake, a smaller difference than would have occurred prior to the Project. Upstream levels increased about 3–4 m at these sites in winter due to ice effects as in previous years. Due to low flows in summer 2021 the water surface was relatively flat from Gull Lake to the gauge just upstream of Birthday Rapids, with a difference of only about 0.8–0.9 m between the two.

Keeyask is transitioning from a construction project to an operating station (Map 3). In 2021, the work at site has been focused on bringing units into service. By the end of April 2021, prior to the start of aquatic monitoring, Unit 1 and Unit 2 were in service. Throughout the open-water period more units were being tested and brought into service one at a time. As units came into service, the distribution of flow between the spillway and powerhouse has gradually shifted, as summarized in the table below. By the end of October 2021 five units were fully in service.

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

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

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

3.0 METHODS

Boat-based habitat surveys were conducted between July 20 and August 23, 2021. Additional data were collected at the sensitive Lake Sturgeon habitat in the upstream portion of Stephens Lake on June 3 and September 22 as part of the deep water habitat monitoring study (see Larter and Hrenchuk 2022) and are used in the current report.

Data was collected differently at the sensitive and constructed sampling areas. Sonar remote sensing technologies were used to collect depth and velocity along a series of pre-selected transects for each of the sensitive areas. Substrates were also classified using physical collection and acoustic validation. Higher resolution combined sidescan and multibeam echosounder (MBES) technology was used to map the constructed shoal habitats.

Mean daily water level and flow data were provided by Manitoba Hydro.

3.1 DEPTH AND VELOCITY

Depth and velocity data were collected by Manitoba Hydro at each of the sensitive and constructed habitat areas using a SonTek M9 acoustic doppler current profiler (ADCP). Data were collected twice at each transect, from start to end bank and end bank to start bank. RiverySurveyor software was used to display full cross sectional water velocities at each transect. Data were sub-sample at five second intervals to display a depth-averaged velocity cross sections at each transect (Figure 1).

Mean, minimum, and maximum depth and velocity were calculated summarized for each survey area. ArcGIS mapping software was used to plot each transect and classify each as standing or 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.

3.2 SUBSTRATE

3.2.1 BOTTOM TYPE VALIDATION

Bottom type validation or substrate sampling was used to both observe and record substrate information at discrete locations and validate the acoustic bottom typing data. Substrate grab samples were collected using either a petite Ponar (0.023 m^2 surface area) or standard Ponar (0.052 m^2 surface area) dredge sampler. Primary, secondary, and tertiary substrate types were identified at each sampling site and classified according to a modified Wentworth sediment size classification, an estimate of the relative substrate composition of the sample was recorded (Table 1; Wentworth 1922). At several sites where fine or organic substrates were encountered, the grab samples were preserved for particle size analysis (PSA) and organic content analysis, conducted at ALS Laboratories. 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. Side-scan images collected using a Lowrance® Elite FS were also used during data processing to verify *in situ* substrate classification.

3.2.2 SUBSTRATE MAPPING AT SENSITIVE HABITATS

A BioSonics MX 200 kHz single-beam echosounder (SBES) beam sonar was used to create substrate maps at each of the sensitive habitat areas. A Trimble Pro XRT GNSS receiver using OmniSTAR real-time differential correction was used to provide horizontal positions for each sounding 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 accurately calculate depth across each transect. Sound velocity corrections were completed first by entering daily average water temperature from Manitoba Hydro's water temperature gauging station at Clark Lake into the calibration settings for each file. Bottom depth is detected in the field based on a signal threshold decibel (dB) level set in the BioSonics Visual Acquisition software. Depth detection was reanalyzed in Visual Aquatic software using a -55 dB rising level threshold to extract depth more accurately. Manual editing was completed and checked for signal error, pulse range omission, invalid depths, and acoustic waveform anomalies, and erroneous data.

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

3.2.3 SUBSTRATE MAPPING AT CONSTRUCTED HABITATS

A Lowrance® Elite FS sonar/GPS echosounder was used to collect general depth and bottom composition data as well as sidescan acoustic imagery at constructed habitat 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. 2013; 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. Positions of the substrate sampling locations were imported into SonarWiz 7 software and viewed with the high-resolution imagery as a backdrop. Sidescan image mosaics of each of the survey areas were produced with the software. The raw image data and georeferenced image mosaics will be used in future analyses to potentially detect substrate boundary differences in future years of monitoring.

A DSP Inc. 3DSS-IDX-450 combined sidescan sonar and multibeam echosounder (MBES) was used to create substrate maps at each of the constructed habitat areas. This system was used to provide higher resolution imagery. Data were collected using a 100 m swath. Navigation in some of the shoal areas was difficult due to shallow flooded terrestrial vegetation and floating debris. The echosounder was coupled to a Septentrio dual antenna GNSS receiver to provide precise positions. These data were also analyzed using SonarWiz software. The data were reviewed for anomalies and erroneous depth records were filtered out of each file. The swath bathymetric point data were then interpolated to 0.25 m cell resolution grids, the resulting bathymetric surfaces were then interpolated again to remove any gaps between measured depths. Final grids were exported to Surfer Binary Grid v7 file format compatible with ArcGIS 10.8 software for mapping.

4.0 RESULTS

4.1 SENSITIVE HABITATS

The five sensitive habitat areas were surveyed during open-water, 2021 (Map 2). ADCP depth and velocity data were not acquired in 2021. Since the powerhouse was not yet in operation and the spillway was in use much of the season, the downstream environment was likely not representative of future operating conditions under low flow scenarios. These data will be collected in 2022 after all Keeyask powerhouse units are in service.

4.1.1 LONG RAPIDS

4.1.1.1 DEPTH, WATER LEVEL, AND VELOCITY

Boat-based ADCP depth and velocity surveys were conducted at five pre-selected cross section transects on August 17, 2021 (Table 2; Figure 2; Map 4).

Estimated mean Nelson River inflow discharge was 2,069 m^3/s. Transect 1, located the farthest upstream, could not be surveyed safely due to turbulent flows. Satellite imagery from July 29, 2021 shows areas of white-water habitat at Transect 1 and farther upstream (Map 4). Transect 1.5, located downstream at approximately one third the distance between Transect one and two was surveyed as a proxy for Transect 1. Substrate and acoustic bottom type surveys omitted Transect 1.

Water surface elevation at the time of survey was estimated to be 161.27 m within the Long Rapids reach. Transect 1.5 (farthest upstream) was surveyed over 553 m, had a mean depth of 2.64 m, and a depth range of 0.92 to 5.81 m. The thalweg is located slightly closer to the right (north bank) at this point in the river. Velocities ranged from 0.07 to 2.92 m/s, with a mean depth averaged cross section velocity of 1.00 m/s. The highest velocities were recorded in the centre of the river, while standing (lentic) water velocities were recorded on the leeward side of an island situated towards the north riverbank on the south end of the cross section.

The remaining four transects are characterized by moderate water velocities along each bank and large areas of high velocity in the middle. Transect 3 has some areas of standing and low water velocity along the left (south) bank where the transect enters a small bay. Minimum water velocities range from 0.09–0.79 m/s and maximum velocities from 1.93–2.33 m/s. The entire reach is relatively shallow with mean depths ranging from 2.64–4.21 m and maximum depths from 5.41–6.60 m.

4.1.1.2 SUBSTRATE

Substrate validation and single-beam acoustic bottom typing surveys were conducted at the pre-selected cross section transects on August 14, 2021 (Tables 3 and 4; Map 5).

Twelve of the 15 pre-selected bottom type validation sites were sampled. Three of the sites along Transect 1 were omitted due to unsafe turbulent flow conditions. High velocities throughout this reach and the prevalence of large, coarse substrate required the use of the weighted sounding line method for determination of bottom types. Evidence of bedrock was observed throughout the reach. This classification was later updated by comparison to sidescan and downscan imagery acquired during surveys (Figure 3). The classes were further resolved to include boulder, cobble, and gravel sized aggregate where visible in the imagery (Table 3). Aggregate material was observed along the banks in multiple locations.

The acoustic substrate classification model indicated the area to be dominated (48%) by boulder/ bedrock followed by cobble at 14% (Table 4; Map 5). Smaller aggregates, gravel and gravel/sand comprised 11 and 14% of the surveyed transects respectively, with notable increases farther downstream (Transect 4 and 5). Finer substrates (mud and organics) were negligible and are associated with either acoustic misclassification or in small areas of current shadow or back eddies. Transect 3 was navigated farther west towards the north shore due to the presence of large boulder and bedrock outcrops.

4.1.2 BIRTHDAY RAPIDS

4.1.2.1 DEPTH, WATER LEVEL, AND VELOCITY

Boat-based ADCP depth and velocity surveys were conducted at eight pre-selected cross section transects on August 18 and 19, 2021 (Table 5; Figure 4; Map 6).

The water surface elevation at the time of survey was estimated to be 158.98 m throughout the reach. Transect 1 is located farthest upstream, within Birthday Rapids. It was surveyed over 306 m, had a mean depth of 5.36 m, and a depth range of 1.69 to 9.31 m. This cross section can be characterized as having moderate to very high velocities with a small area of low velocity along the north bank. Mean water velocity was 1.35 m/s, ranging from 0.27 to 1.93 m/s.

Water velocities moderate over much of the width of the river by Transect 2. This area is characterized by large areas of standing water on each bank and low to moderate velocities in the middle of the channel. Mean water velocity at this transect was 0.34 m/s, ranging from 0.02 to 1.30 m/s. Transect 3 and 4 are similar, both with areas of standing water along the left (south) bank. Water velocities are largely moderate in both areas, averaging 0.63 m/s in Transect 3 and 0.61 in Transect 4.

Transect 5 is located immediately downstream of Animal Island, and therefore is characterized by an area of shallow standing water in the middle, and two deeper channels with moderate velocities on either side. Water velocity ranged from 0.33 to 1.33 m/s over the transect (mean

0.55 m/s). Depth ranged from 2.18 m in the middle of the transect to 11.25 m in the left (south) channel.

Transects 6, 7, and 8 were similar with areas of standing water along each bank and low to moderate water velocities in the middle. All three transects had the main thalweg closer to the right (north) bank. Transects 6 and 7 were the widest transects in this section of the river with survey distances of 1,010 and 1,488 m, respectively. Mean water depths (mean 5.74 and 5.16 m) and velocity (mean 0.32 and 0.38 m/s) were similar along both transects.

Transect 8 is the farthest downstream surveyed in this area. It was surveyed over 626 m, had a mean depth of 6.65 m, and a depth range of 1.56 to 11.80 m. Water velocity was lower than at any other transect, ranging from 0.06 to 0.67 m/s (mean 0.34 m/s).

4.1.2.2 SUBSTRATE

Substrate validation and single-beam acoustic bottom typing surveys were conducted at the pre-selected cross section transects on August 14, 2021 (Tables 6 and 7; Map 7).

Twenty-three pre-selected bottom type validation sites were sampled. Due to very high water velocities that created unsafe boating conditions, substrate validation was not conducted within Transect 1. High velocities throughout this reach and the prevalence of large, coarse substrate required the use of the weighted sounding line method for confirmation of bottom types at all but one site (DST1-4 in Transect 7) where a standard Ponar dredge was used.

Hard substrates were found throughout the reach, classified as bedrock, cobble, and gravel and verified by comparison to sidescan and downscan imagery acquired during surveys (Table 6). The acoustic classification model indicated the area to be dominated (43%) by boulder/ bedrock followed by cobble and gravel, each at 17% (Table 7; Map 7). Acoustic signatures for smaller aggregates, gravel/sand and sand were found in smaller portions (14 and 7%, respectively), distributed in patches throughout the reach. Acoustic signatures representing finer substrates (*i.e.*, mud) were negligible, and largely found in off-current bays closest to shore at transects 6 and 7. No organics were observed.

4.1.3 ENTRANCE TO GULL LAKE

4.1.3.1 DEPTH, WATER LEVEL, AND VELOCITY

Boat-based ADCP depth and velocity surveys were conducted at nine pre-selected cross section transects on August 6 and 7, 2021 (Table 8; Figure 5; Map 8).

The water surface elevation at the time of survey was estimated to be 158.91 m throughout the reach. Transect 1 is located farthest upstream. It was surveyed over 610 m, had a mean depth of 10.38 m, and a depth range of 1.01 to 14.17 m. This cross section can be characterized as having low to moderate velocities with areas of standing water along each bank. Mean water velocity was 0.29 m/s, ranging from 0.02 to 0.66 m/s. Maximum water velocities can be found roughly within the middle of the channel.

Transect 2 is dominated by standing and low water velocities with a small area of moderate velocity (as high as 0.53 m/s). Transects 2–4 enter a bay on the right (north) shore and thus have large areas of standing water through this portion of the transects. Transects 3–9 are dominated by standing to low water velocities, averaging between 0.14 and 0.19 m/s (Transects 7 and 4, respectively).

This reach is generally deep, with maximum water depths ranging from 14.17 m in Transect 1 to 20.94 m in Transect 5.

4.1.3.2 SUBSTRATE

Substrate validation and single-beam acoustic bottom typing surveys were conducted at the pre-selected cross section transects on August 23, 2021 (Tables 9 and 10; Map 9).

Twenty-seven pre-selected bottom type validation sites were sampled. Each site was identified as bedrock using a sidescan sonar image. This classification was later updated by comparison to sidescan and downscan imagery acquired during surveys to include boulder, cobble, and gravel (Table 9). The acoustic classification model indicated the area to be dominated (36%) by boulder/ bedrock followed by gravel/sand (27%) (Table 10; Map 9). Gravel and cobble made up 15% and 12% of the area, respectively. Small areas of sand were found (9%), largely near the ends of Transects 3 and 4, but also in the middle of the channel at Transects 8 and 9. Acoustic signatures representing finer substrates (*i.e.*, mud) were negligible. No organics were observed.

4.1.4 CARIBOU ISLAND

4.1.4.1 DEPTH, WATER LEVEL, AND VELOCITY

Boat-based ADCP depth and velocity surveys were conducted at 11 pre-selected cross section transects on July 20 and 21, 2021 (Table 11; Figure 6; Map 10).

The survey reach extends throughout the area west, north, and east of Caribou Island. The water surface elevation at the time of survey was estimated to be 158.88–158.89 m throughout the reach. The entire reach is characterized by areas of low water velocity surrounded by areas of standing water with minimum water velocities ranging from 0.01–0.05 m/s and maximum ranging from 0.21–0.84 m/s. Mean cross sectional water velocities ranged from 0.11–0.18 m/s. Transect 13 (located northeast of caribou island) largely consists of areas of standing water with few areas of low water velocity. Flows are concentrated closer to Caribou Island (the left or east shore) within the three most upstream transects (Transects 6–8) and is roughly in the middle of the main channel in Transects 9–15. Transect 16 (the farthest downstream and most easterly transect) is less channelized, with areas of low and moderate velocities across nearly the entire transect.

This reach is generally deep, with maximum water depths ranging from 13.75 m in Transect 9 to 17.41 m in Transect 10.

4.1.4.2 SUBSTRATE

Substrate validation and single-beam acoustic bottom typing surveys were conducted at the pre-selected cross section transects on August 19, 2021 (Tables 12 and 13; Map 11).

Twenty-nine pre-selected bottom type validation sites were sampled. Substrate was sampled using a petite Ponar at 27 sites, while the weighted sounding line method was used at two sites where a grab could not be collected due to rocky substrate (Table 12). A sample could not be collected at a single site (DST3-34) where rocky substrates prevented a successful Ponar grab. Samples from four sites were collected and sent to ALS laboratories for particle size analysis (PSA) (Table 14).

Substrates were varied throughout the reach, ranging from hard boulder to areas of soft medium clay. Sand was the dominant substrate type in five sites located within the middle of the channel to the west and north of Caribou Island (Map 11). Two of these sites were sampled for PSA which confirmed that sand was the predominant substrate from both (DST3-33 and -37), comprising 96.9% and 58.7% of each sample, respectively (Photo 1). This area was bordered on the upstream and downstream sides by areas of rock and by areas of mud near the edges of each transect. Silt deposition was evident at 16 sites overlying silty sand and clay substrates, largely beginning near the downstream end of the sandy area at Transect 13.

The acoustic classification model indicated the area to be dominated by mud (silt/clay representing 23% and silt/clay/sand representing 17%) and organics (17%) (Table 13; Map 11). Acoustic signatures for sand were found in 7% of the reach and larger gravel/sand in 11%. Rocky substrates including gravel (10%), cobble (8%) and bedrock/boulder (6%) were also found.

4.1.5 STEPHENS LAKE

4.1.5.1 DEPTH, WATER LEVEL, AND VELOCITY

ADCP depth and velocity data were not acquired in 2021 but will be collected in 2022 after all Keeyask powerhouse units are in service.

4.1.5.2 SUBSTRATE

During the spring sampling period (June 5), 20 pre-selected bottom type validation sites were sampled using a petite Ponar (Table 15; Map 12). Sand was predominant (60–90%) at four sites located within the upstream portion of the reach. PSA (ALS Laboratories) indicated that sand was the dominant substrate type at four of five representative samples collected (representing 33–76% of each sample) (Table 14). Silt deposition was evident at the majority (n = 15) of sites during the spring sampling period, beginning approximately half-way through the study area. Organics were evident at ten sampling sites, consisting of detritus and loose, broken-down plant matter (Photo 2).

During the summer sampling period (August 20), the broader sampling area had 25 pre-selected bottom type validation sites, which were sampled using a petite Ponar (at 23 sites) and sidescan sonar (at two sites where a grab could not be collected) (Table 16; Map 13). Sand was found at fewer sites than in the spring sampling period. Sand was predominant (95–100%) at two sites including one located at the upstream portion of the reach as in spring (DST4-22). The second site was located on the farthest downstream transect and had a noticeable layer of silt overtop (Transect 12) near the northeastern shore. PSA indicated that sand was dominant at all three representative sites sampled (representing 46.5–66.4% of each sample) (Table 14). Silt deposition was evident at the majority (n = 14) of sites during the summer sampling period. Organics were evident at six sampling sites.

Acoustic classification was conducted a single time on August 17 and 21 (Table 18). The acoustic classification model indicated that all substrate types are found within the area, with only marginal difference in proportions (Table 17). Gravel composed the majority (19%) of the area, followed by gravel/sand (17%), cobble and bedrock/boulder (each 16%), sand (11%), silt/clay (10%), and silt/clay/sand (8%). Organics made up the lowest proportion of the substrate of the reach (2%).

During the fall sampling period (September 22), 20 pre-selected bottom type validation sites (the same as sampled in the spring) were sampled using a standard Ponar (Table 18; Map 14). A sample could not be collected from one site due to suspected hard substrate. Sand was predominant (70–80%) at four sites. PSA classified sand as the dominant substate at all five representative sample sites (51.9–78.0%) (Table 14). Silt deposition was evident at the majority (n = 16) of sampling sites during the fall sampling period. Organics were evident at 12 sampling sites.

4.2 CONSTRUCTED HABITATS

4.2.1 KEEYASK RESERVOIR CONSTRUCTED HABITATS

Nine constructed shoal habitats were surveyed in the Keeyask reservoir in 2021 (Map 15), Water surface elevation was 158.9 m at the time each shoal was surveyed (Table 19). Depths within the footprint of the shoal areas ranged between 1.24 and 6.49m (Maps 16-23). A qualitive comparison with the As-built elevations of the shoals indicated that mean depth was in good agreement with the high-resolution depth data. Data spikes, or higher and lower than expected depths, and most notably occurring at shoals H-North and H-South were a result of excessive boat pitching related to wave action. Overall, the structure and outlines of the shoals were detected very well within the high resolution bathymetric and acoustic imaging.

Water velocity was calculated as the depth averaged ADCP velocity from transects taken over, upstream, or downstream of each constructed spawning shoal. Survey dates varied from July 19 to August 5 (Table 19). Water velocity was generally low, ranging from an average of 0.10–0.24 m/s at each shoal. Water velocity was highest at shoal H-East, ranging from 0.13–0.40 m/s. Mean velocity was lowest at shoals G-South and -North (0.05–0.19 m/s) and shoal H-South and North (0.08–0.17 m/s, and 0.06-0.25 m/s).

Pre-selected bottom type validation sites were sampled at each constructed spawning shoal in the Keeyask reservoir using a weighted sounding line (Table 20; Maps 16–23). Hard boulder substrate was observed at all sites, confirmed with combined multibeam and sidescan imagery. No silt was observed. Multibeam and sidescan imagery could not be collected from constructed shoal H-East as water depths were too shallow (Map 15). Depth data were not useable for Shoal L due to apparent boat and transducer movement seen as “pitching” in the sidescan imagery and bathymetric data streams.

4.2.2 CAUSEWAY CONSTRUCTED HABITATS

Two constructed shoal habitats were surveyed in Stephens Lake in 2021 at the sites of the former N5 and G3 causeways (Map 24). Water surface elevation was 140.7 m at the time each causeway was surveyed (Table 19). The Ping DSP sonar was not used at these locations since water was very shallow at the time of survey with rocks located throughout. Sidescan data collected with the Lowrance Elite FS sonar were used to assess the shoal habitats.

ADCP depth and velocity data were not acquired in 2021 but will be collected in 2022 after all Keeyask powerhouse units are in service.

Five pre-selected bottom type validation sites were sampled at the N5 causeway and three at the G3 causeway using a weighted sounding line (Table 20; Maps 25 and 26). Hard boulder substrate was observed at all sites and were confirmed with sidescan imagery. No silt was observed.

5.0 DISCUSSION

5.1 SENSITIVE HABITATS

Sensitive Lake Sturgeon habitats (*i.e.*, spawning and rearing habitats) identified during baseline studies for the Project were sampled in 2021. These included spawning habitats at Long Rapids and Birthday Rapids, and young-of-the-year (YOY) and sub-adult habitats at Birthday Rapids, the Keeyask reservoir at the entrance to Gull Lake, the Keeyask reservoir in lower Gull Lake at the channel north of Caribou Island, and in Stephens Lake approximated 4–7 km downstream of the GS.

Substrates downstream of Long and Birthday rapids as well as in the Keeyask reservoir at the entrance to Gull Lake were generally hard, largely consisting of bedrock, boulder, and cobble with some areas of gravel present. No smaller substrates were found. Water velocities were generally fast with areas of very high (>2.5 m/s) velocity in the farthest upstream transects at Long Rapids. The area downstream of Birthday Rapids and at the entrance to Gull Lake were more moderate with areas of low and standing water velocities. Spawning adult Lake Sturgeon were captured downstream of Birthday Rapids in 2021 (Loeppky and Hrenchuk 2022). This suggests that habitat characteristics in this area in 2021 were suitable for Lake Sturgeon spawning.

The lower portion of the Keeyask reservoir (*i.e.*, the area around Caribou Island) is characterized by areas of low water velocity surrounded by areas of standing water with minimum water velocities. An area of sand was present within the middle of the channel to the west and north of Caribou Island, surrounded by mud (*i.e.*, silt and clay) in off-channel areas. Upstream and downstream of this sandy area, the main position of the channel is generally rocky. Some silt deposition was evident towards the downstream end of the sandy area.

Substrates in the sensitive Lake Sturgeon habitat in the upstream portion of Stephens Lake were sampled three times in 2021 in spring, summer, and fall. Spring and fall sampling were conducted as part of the deep water habitat monitoring study (see Larter and Hrenchuk 2022) and the data were used to supplement those collected in summer. Substrate also varied within this area. Areas of predominantly sand were found largely within the upstream portions of the reach. Farther downstream sites largely consisted of a mix of silt, sand, and clay. Silt deposition was evident towards the downstream end of the reach in spring and throughout the reach in summer and fall. Organic matter consisting of detritus and broken-down plant material was evident throughout the reach in all sampling periods.

5.2 CONSTRUCTED HABITATS

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. Rocky spawning shoals were constructed in the Keeyask reservoir to provide Lake Whitefish and Walleye spawning habitat immediately after impoundment and rockfill material was left in place at two temporary causeways (N-5 and G-3) in Stephens Lake to create shallow rocky habitat for fish and other aquatic species as a means of improving diversity at these areas.

Monitoring in 2021 indicated that each shoal was composed of boulders with no evidence of silt deposition. Each shoal was mapped and area, composition, and bed elevation will be compared each year as more data are collected.

5.3 NEXT STEPS

Sampling conducted in 2021 represents the first year of monitoring following impoundment of the Keeyask GS reservoir. Because of this, it is too soon to make inferences about changes to substrate types caused by the Project. Surveys will be repeated in 2022 and 2023 using the same measures to describe changes to sensitive and constructed habitat areas as the Keeyask reservoir ages and as operation of the GS continues. In 2021, a survey was not completed at shoal H-East as the area was too shallow for the survey boat to safely navigate. In 2022, a shallow profile boat will be used to complete the survey.

6.0 SUMMARY AND CONCLUSIONS

- Sensitive Lake Sturgeon habitats (*i.e.*, spawning and rearing habitats) were sampled in 2021.
    - Substrates downstream of Long and Birthday rapids as well as in the Keeyask reservoir at the entrance to Gull Lake were hard, consisting of bedrock, boulder, and cobble with some areas of gravel present. No smaller substrates were found. Water velocities were generally fast in each area. Spawning adult Lake Sturgeon were captured downstream of Birthday Rapids in 2021 which suggests that habitat characteristics in this area in 2021 were suitable for Lake Sturgeon spawning.
    - The lower portion of the Keeyask reservoir (*i.e.*, the area around Caribou Island) is characterized by areas of low water velocity surrounded by areas of standing water with minimum water velocities. An area of sand was present within the middle of the channel to the west and north of Caribou Island. Some silt deposition was evident towards the downstream end of the sandy area.
    - Areas of sand were found within the Stephens Lake sensitive habitat area, largely within the upstream portion of the reach. Farther downstream sites consisted of a mix of silt, sand, and clay. Silt deposition was evident towards the downstream end of the reach in spring and throughout the reach in summer and fall. Organic matter consisting of detritus and broken-down plant material was evident throughout the reach in all sampling periods.
- Constructed habitats including Keeyask reservoir spawning shoals and Stephens Lake rocky causeways were composed of boulders with no evidence of silt deposition Each shoal was mapped and area, composition, and depth relative to water surface elevation will be compared each year as more data are collected.
- As 2021 represents the first year of monitoring at sensitive and constructed habitats, it is too early to make conclusions regarding changes as a result of the Project. This study will be repeated annually until 2023.

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TABLES

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

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

Table 2: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for the five cross sections surveyed at the Long Rapids sensitive habitat area with the SonTek M9 ADCP on August 17, 2021 under a calculated mean daily inflow discharge of 2069.11 m^3/s and water level of 163.470 m at the Nelson River below Clark Lake hydrometric station (05UF759).

Transect ID	Filename	Start Bank	Total Samples	Survey Distance (m)	Estimated Inflow (cms)[1]	Estimated WSE (m)[2]	Depth (m)			Velocity (m/s)		
							Min	Max	Mean	Min	Max	Mean
1.5	20210817122750	left (south)	88	553	2069	161.27	0.92	5.81	2.64	0.07	2.92	1.00
2	20210817125039	left (south)	61	374	2069	160.58	1.30	5.41	3.44	0.68	2.26	1.36
3	20210817132035	left (south)	109	593	2069	160.41	0.89	6.60	3.69	0.09	1.93	1.12
4	20210817162732	right (north)	123	383	2069	160.18	1.71	5.93	4.21	0.79	2.33	1.63
5	20210817160108	left(south)	69	546	2069	159.90	1.04	6.26	2.99	0.50	2.00	1.15
Summary						**160.47**	**0.89**	**6.60**	**3.49**	**0.07**	**2.92**	**1.27**

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.

Table 3: Locations and results of field bottom type validation sampling and post-survey class verification at the Long Rapids sensitive habitat area, 2021.

Site ID	Transect ID	Method	Date	UTM Easting	UTM Northing	Depth	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
								Substrate 1	%	Substrate 2	%	Substrate 3	%		
DSTLR-1	5	weighted sounding line	14-Aug-21	327147	6240362	-	hard	bedrock	100	-	-	-	-	rock	bedrock/boulder/cobble
DSTLR-2	5	weighted sounding line	14-Aug-21	327018	6240610	-	hard	bedrock	100	-	-	-	-	rock	boulder/cobble/bedrock
DSTLR-3	5	weighted sounding line	14-Aug-21	326915	6240800	-	hard	bedrock	100	-	-	-	-	rock	cobble/boulder
DSTLR-4	4	weighted sounding line	14-Aug-21	326730	6240146	-	hard	bedrock	100	-	-	-	-	rock	boulder/cobble/bedrock
DSTLR-5	4	weighted sounding line	14-Aug-21	326677	6240246	-	hard	bedrock	100	-	-	-	-	rock	boulder/cobble/bedrock
DSTLR-6	4	weighted sounding line	14-Aug-21	326624	6240388	-	hard	bedrock	100	-	-	-	-	rock	bedrock/boulder/cobble
DSTLR-7	3	weighted sounding line	14-Aug-21	326342	6239847	-	hard	bedrock	100	-	-	-	-	rock	cobble/boulder
DSTLR-8	3	weighted sounding line	14-Aug-21	326296	6240182	-	hard	bedrock	100	-	-	-	-	rock	boulder/cobble/bedrock
DSTLR-9	3	weighted sounding line	14-Aug-21	326234	6240311	-	hard	bedrock	100	-	-	-	-	rock	boulder/cobble/bedrock
DSTLR-10	2	weighted sounding line	14-Aug-21	325717	6239850	-	hard	bedrock	100	-	-	-	-	rock	bedrock/boulder/cobble
DSTLR-11	2	weighted sounding line	14-Aug-21	325698	6240031	-	hard	bedrock	100	-	-	-	-	rock	bedrock/boulder/cobble
DSTLR-12	2	weighted sounding line	14-Aug-21	325651	6240222	-	hard	bedrock	100	-	-	-	-	rock	boulder/cobble/bedrock
DSTLR-13	1	not sampled	14-Aug-21	325175	6239799	-	-	-	-	-	-	-	-	-	-
DSTLR-14	1	not sampled	14-Aug-21	325139	6239952	-	-	-	-	-	-	-	-	-	-
DSTLR-15	1	not sampled	14-Aug-21	325086	6240183	-	-	-	-	-	-	-	-	-	-

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

Table 4: Results of acoustic classification of single beam data collected along transects at the Long Rapids sensitive habitat area, 2021.

Transect ID	Sampled	Date	Distance (m)	Total Samples	Acoustic Substrate Classification Composition (% Membership)								
					Organics	Mud		Sand	Rock				
					organics/FT	silt/clay	silt/clay/sand	sand	gravel/ sand	gravel	cobble	bedrock/boulder	Total
					Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	
1	no	-	-	-	-	-	-	-	-	-	-	-	-
2	yes	14-Aug-21	411	197	0	1	1	9	12	12	15	49	100
3	yes	14-Aug-21	440	511	1	1	4	8	9	9	12	55	100
4	yes	14-Aug-21	262	132	2	1	2	7	25	7	11	45	100
5	yes	14-Aug-21	348	194	0	2	3	7	18	14	18	38	100
Summary	**-**	**-**	**-**	**-**	**1**	**1**	**3**	**8**	**14**	**11**	**14**	**48**	**100**

Table 5: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for the eight cross sections surveyed in the Keeyask reservoir at the Birthday Rapids sensitive habitat area with the SonTek M9 ADCP on August 18 and 19, 2021.

Transect ID	Filename	Start Bank	Total Samples	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	20210818123058	left (south)	49	306	2112	158.98	1.69	9.31	5.36	0.27	1.93	1.35
SH1-2	20210818125320	left (south)	136	770	2112	158.98	2.03	9.37	5.33	0.02	1.30	0.34
SH1-3	20210818131810	left (south)	236	617	2112	158.98	1.92	9.73	6.85	0.03	0.97	0.63
SH1-4	20210818134200	right (north)	93	576	2112	158.98	2.67	10.46	5.65	0.13	0.95	0.61
SH1-5	20210818142303	left (south)	172	736	2112	158.98	2.18	11.25	5.86	0.03	1.33	0.55
SH1-6	20210818144346	right (north)	149	1010	2112	158.98	3.13	9.01	5.74	0.02	0.76	0.32
SH1-7	20210819002040	right (north)	211	1488	2014	158.98	1.18	10.52	5.16	0.04	0.93	0.38
SH1-8	20210819112721	right (north)	122	626	2014	158.98	1.56	11.80	6.65	0.06	0.67	0.34
Summary							**1.18**	**11.80**	**5.90**	**0.02**	**1.93**	**0.50**

1 - Estimated or virtualized inflow provided by MBH.

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

Table 6: Locations and results of field bottom type validation sampling and post-survey class verification in the Keeyask reservoir at the Birthday Rapids sensitive habitat area, 2021.

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	14-Aug-21	334384	6243720	3	hard	cobble	-	-	-	-	-	rock	cobble/boulder
DST1-2	8	weighted sounding line	14-Aug-21	334364	6243902	9.5	hard	cobble	-	-	-	-	-	rock	cobble/boulder
DST1-3	8	weighted sounding line	14-Aug-21	334348	6244132	10.5	hard	gravel	-	-	-	-	-	rock	gravel/cobble
DST1-4	7	standard Ponar	14-Aug-21	333888	6243184	4.6	hard	gravel	-	-	-	-	-	rock	gravel/cobble
DST1-5	7	weighted sounding line	14-Aug-21	333844	6243525	4.6	hard	gravel	-	-	-	-	-	rock	-
DST1-6	7	weighted sounding line	14-Aug-21	333803	6243889	3.1	hard	bedrock	-	-	-	-	-	rock	cobble/boulder
DST1-7	7	weighted sounding line	14-Aug-21	333780	6244135	3.5	hard	cobble	-	-	-	-	-	rock	cobble/boulder
DST1-8	6	weighted sounding line	14-Aug-21	333365	6243315	5.3	hard	cobble	-	-	-	-	-	rock	cobble/gravel/boulder
DST1-9	6	weighted sounding line	14-Aug-21	333342	6243538	5.2	hard	bedrock	-	-	-	-	-	rock	boulder/bedrock
DST1-10	6	weighted sounding line	14-Aug-21	333316	6243782	4.3	hard	cobble	-	-	-	-	-	rock	boulder/cobble
DST1-11	6	weighted sounding line	14-Aug-21	333293	6243989	4	hard	cobble	-	-	-	-	-	rock	cobble/large gravel
DST1-12	5	weighted sounding line	14-Aug-21	332878	6243338	4.2	hard	cobble	-	-	-	-	-	rock	bedrock/boulder
DST1-13	5	weighted sounding line	14-Aug-21	332847	6243484	3.3	hard	bedrock	-	-	-	-	-	rock	bedrock
DST1-14	5	weighted sounding line	14-Aug-21	332788	6243771	3.9	hard	cobble	-	-	-	-	-	rock	cobble/boulder
DST1-15	4	weighted sounding line	14-Aug-21	332452	6243197	6.3	hard	cobble	-	-	-	-	-	rock	cobble/boulder
DST1-16	4	weighted sounding line	14-Aug-21	332357	6243423	2.2	hard	bedrock	-	-	-	-	-	rock	boulder/bedrock
DST1-17	4	weighted sounding line	14-Aug-21	332260	6243659	2	hard	cobble	-	-	-	-	-	rock	cobble/gravel
DST1-18	3	weighted sounding line	14-Aug-21	332078	6243187	4.4	hard	cobble	-	-	-	-	-	rock	cobble/gravel
DST1-19	3	weighted sounding line	14-Aug-21	331960	6243366	7	hard	bedrock	-	-	-	-	-	rock	boulder/bedrock
DST1-20	3	weighted sounding line	14-Aug-21	331829	6243559	7.1	hard	cobble	-	-	-	-	-	rock	cobble/boulder
DST1-21	2	weighted sounding line	14-Aug-21	331901	6243074	5.5	hard	bedrock	-	-	-	-	-	rock	cobble/boulder
DST1-22	2	weighted sounding line	14-Aug-21	331616	6243194	7.2	hard	bedrock	-	-	-	-	-	rock	boulder/cobble
DST1-23	2	weighted sounding line	14-Aug-21	331360	6243305	5.8	hard	gravel	-	-	-	-	-	rock	gravel/cobble

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

Table 7: Results of acoustic classification of single beam data collected along transects in the Keeyask reservoir at the Birthday Rapids sensitive habitat area, 2021.

Transect ID	Sampled	Date	Distance (m)	Total Samples	Acoustic Substrate Classification Composition (% Membership)								Total
					Organics	Mud		Sand	Rock				
					organics/FT	silt/clay	silt/clay/sand	sand	gravel/ sand	gravel	cobble	bedrock/boulder	
					Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	
1	no	-	-	-	-	-	-	-	-	-	-	-	-
2	no	-	-	-	-	-	-	-	-	-	-	-	-
3	yes	14-Aug-21	500	162	0	1	0	4	14	13	14	55	100
4	yes	14-Aug-21	540	197	0	0	0	8	18	16	13	45	100
5	yes	14-Aug-21	510	253	0	0	0	4	22	13	16	45	100
6	yes	14-Aug-21	890	324	0	3	4	8	8	18	19	39	100
7	yes	14-Aug-21	990	416	0	0	0	9	13	22	18	39	100
8	no	-	-	-	-	-	-	-	-	-	-	-	-
Summary					**0**	**1**	**1**	**7**	**14**	**17**	**17**	**43**	**100**

Table 8: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for the eight cross sections surveyed in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area with the SonTek M9 ADCP on August 6 and 7, 2021.

Transect ID	Filename	Start Bank	Total Samples	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	20210806115106	right (north)	132	610	2002	158.91	1.01	14.17	10.38	0.02	0.66	0.29
SH2-2	20210806123851	right (north)	337	1782	2002	158.91	1.78	16.43	10.78	0.03	0.53	0.14
SH2-3	20210806131736	left (south)	284	1683	2002	158.91	2.42	14.85	10.14	0.02	0.42	0.15
SH2-4	20210806141342	left (south)	179	1068	2002	158.91	2.22	16.98	10.94	0.04	0.43	0.19
SH2-5	20210806154359	left (south)	149	968	2002	158.91	2.04	20.94	12.00	0.03	0.26	0.16
SH2-6	20210806161407	left (south)	150	973	2002	158.91	3.42	17.66	12.30	0.02	0.25	0.17
SH2-7	20210807095849	left (south)	206	1310	2050	158.92	2.14	17.45	11.50	0.05	0.27	0.15
SH2-8	20210807105940	left (south)	268	1450	2050	158.92	2.71	17.38	11.49	0.05	0.46	0.14
SH2-9	20210807120315	left (south)	173	1284	2050	158.92	1.84	16.56	11.08	0.07	0.25	0.15
Summary							**1.01**	**20.94**	**11.10**	**0.02**	**0.66**	**0.16**

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).

Table 9: Locations and results of field bottom type validation sampling and post-survey class verification in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area, 2021.

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	%		
DST2-1	9	side scan	23-Aug-21	349796	6243522	9	hard	bedrock	100	-	-	-	-	rock	cobble/gravel/boulder
DST2-2	9	side scan	23-Aug-21	349817	6244004	15	hard	bedrock	100	-	-	-	-	rock	gravel/cobble/boulder
DST2-3	9	side scan	23-Aug-21	349838	6244400	11	hard	bedrock	100	-	-	-	-	rock	cobble/gravel/boulder
DST2-4	8	side scan	23-Aug-21	349182	6243617	9	hard	bedrock	100	-	-	-	-	rock	bedrock/boulder/cobble
DST2-5	8	side scan	23-Aug-21	349198	6244035	16	hard	bedrock	100	-	-	-	-	rock	cobble/gravel/boulder
DST2-6	8	side scan	23-Aug-21	349217	6244432	16	hard	bedrock	100	-	-	-	-	rock	cobble/gravel/boulder
DST2-7	7	side scan	23-Aug-21	348605	6243686	11	hard	bedrock	100	-	-	-	-	rock	gravel/cobble/boulder
DST2-8	7	side scan	23-Aug-21	348595	6244104	14	hard	bedrock	100	-	-	-	-	rock	boulder/cobble/bedrock
DST2-9	7	side scan	23-Aug-21	348595	6244475	12	hard	bedrock	100	-	-	-	-	rock	gravel/cobble/boulder
DST2-10	6	side scan	23-Aug-21	348065	6243718	13	hard	bedrock	100	-	-	-	-	rock	gravel/cobble/boulder
DST2-11	6	side scan	23-Aug-21	348060	6244099	15	hard	bedrock	100	-	-	-	-	rock	boulder/cobble/gravel
DST2-12	6	side scan	23-Aug-21	348060	6244411	8	hard	bedrock	100	-	-	-	-	rock	cobble/gravel/boulder
DST2-13	5	side scan	23-Aug-21	347531	6243734	12	hard	bedrock	100	-	-	-	-	rock	gravel/cobble/boulder
DST2-14	5	side scan	23-Aug-21	347536	6244083	21	hard	bedrock	100	-	-	-	-	rock	gravel/bedrock
DST2-15	5	side scan	23-Aug-21	347531	6244385	7	hard	bedrock	100	-	-	-	-	rock	gravel/cobble
DST2-16	4	side scan	23-Aug-21	346975	6243718	10	hard	bedrock	100	-	-	-	-	rock	gravel/cobble/boulder
DST2-17	4	side scan	23-Aug-21	346965	6244125	13	hard	bedrock	100	-	-	-	-	rock	gravel/boulder/bedrock
DST2-18	4	side scan	23-Aug-21	346954	6244512	16	hard	bedrock	100	-	-	-	-	rock	cobble/gravel/boulder
DST2-19	3	side scan	23-Aug-21	346377	6244512	8	hard	bedrock	100	-	-	-	-	rock	gravel/cobble
DST2-20	3	side scan	23-Aug-21	346346	6244146	15	hard	bedrock	100	-	-	-	-	rock	gravel/cobble/boulder
DST2-21	3	side scan	23-Aug-21	346325	6244681	10	hard	bedrock	100	-	-	-	-	rock	cobble/gravel
DST2-22	2	side scan	23-Aug-21	345705	6243723	11	hard	bedrock	100	-	-	-	-	rock	gravel/bedrock
DST2-23	2	side scan	23-Aug-21	345700	6244099	14	hard	bedrock	100	-	-	-	-	rock	gravel/cobble/bedrock
DST2-24	2	side scan	23-Aug-21	345668	6244586	10	hard	bedrock	100	-	-	-	-	rock	gravel/cobble
DST2-25	1	side scan	23-Aug-21	345160	6243697	8	hard	bedrock	100	-	-	-	-	rock	gravel/cobble/bedrock
DST2-26	1	side scan	23-Aug-21	345150	6243945	14	hard	bedrock	100	-	-	-	-	rock	boulder/cobble/bedrock
DST2-27	1	side scan	23-Aug-21	345129	6244168	10	hard	bedrock	100	-	-	-	-	rock	gravel/cobble/boulder

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

Table 10: Results of acoustic classification of single beam data collected along transects in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area, 2021.

Transect ID	Sampled	Date	Distance (m)	Total Samples	Acoustic Substrate Classification Composition (% Membership)								Total
					Organics	Mud		Sand	Rock				
					organics/FT	silt/clay	silt/clay/sand	sand	gravel/ sand	gravel	cobble	bedrock/boulder	
					Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	
1	yes	23-Aug-21	551	229	0	1	0	6	25	14	6	49	100
2	yes	23-Aug-21	1003	387	0	0	0	9	19	20	14	38	100
3	yes	23-Aug-21	1140	346	0	0	0	13	22	17	13	34	100
4	yes	23-Aug-21	980	354	0	0	0	8	33	12	10	38	100
5	yes	23-Aug-21	800	292	0	0	0	11	30	15	10	35	100
6	yes	23-Aug-21	860	354	0	0	0	8	25	12	13	42	100
7	yes	23-Aug-21	920	319	0	0	0	8	27	15	10	41	100
8	yes	23-Aug-21	1100	398	0	0	0	10	31	18	18	23	100
9	yes	23-Aug-21	1010	352	0	1	1	12	30	17	18	22	100
Summary					**0**	**0**	**0**	**9**	**27**	**15**	**12**	**36**	**100**

Table 11: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for the 11 cross sections surveyed in the Keeyask reservoir at the Caribou Island sensitive habitat area with the SonTek M9 ADCP on July 20 and 21, 2021.

Transect ID	Filename	Start Bank	Total Samples	Sample Distance (m)	Estimated Inflow[1] (m^3/s)	Estimated WSE[2] (m)	Depth (m)			Velocity (m/s)		
							Min	Max	Mean	Min	Max	Mean
6	20210721101759	left (south)	207	1510	2523	158.89	0.81	16.39	8.84	0.03	0.35	0.13
7	20210721095213	right (north)	213	1316	2523	158.89	0.73	14.94	7.17	0.03	0.48	0.14
8	20210721113037	right (north)	202	1318	2523	158.89	2.52	14.34	8.33	0.02	0.41	0.13
9	20210721121303	right (north)	207	1399	2523	158.89	1.74	13.75	7.61	0.02	0.33	0.12
10	20210721133847	right (north)	281	1824	2523	158.89	1.52	17.41	7.72	0.02	0.30	0.11
11	20210721143457	right (north)	196	1286	2523	158.89	1.16	15.72	8.41	0.01	0.25	0.11
12	20210721151240	right (north)	161	1083	2523	158.89	1.74	16.31	8.50	0.01	0.23	0.13
13	20210720160532	left (south)	212	1431	2532	158.88	0.87	15.11	7.35	0.02	0.21	0.11
14	20210720151824	right (north)	151	881	2532	158.88	1.06	16.23	6.87	0.04	0.42	0.17
15	20210720144131	right (north)	134	848	2532	158.88	0.94	14.02	7.67	0.05	0.31	0.17
16	20210720135908	right (north)	239	1367	2532	158.88	0.86	13.90	5.98	0.03	0.84	0.18
Summary							**0.73**	**17.41**	**7.65**	**0.01**	**0.84**	**0.14**

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).

Table 12: Locations and results of field bottom type validation sampling and post-survey class verification in the Keeyask reservoir at the Caribou Island sensitive habitat area, 2021.

Site ID	Transect ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Silt Dep Evident	Class Verification[1]
								Substrate 1	%	Substrate 2	%	Substrate 3	%			
DST3-6	16	weighted sounding line	19-Aug-21	358269	6246631	9	hard	boulder	100	-	-	-	-	rock	no	cobble/gravel/boulder
DST3-7	16	petite Ponar	19-Aug-21	358655	6246864	6.6	medium	clay	95	silt	5	-	-	mud	yes	clay/silt
DST3-8	16	petite Ponar	19-Aug-21	359015	6247060	2.5	soft	organics	100	-	-	-	-	organic	no	organics/flooded terrestrial
DST3-9	15	weighted sounding line	19-Aug-21	357989	6247001	6	hard	boulder	100	-	-	-	-	rock	no	boulder/bedrock/cobble
DST3-10	15	petite Ponar	19-Aug-21	358280	6247261	11.2	hard	cobble	40	boulder	30	gravel	30	rock	no	cobble/boulder/gravel
DST3-11	15	petite Ponar	19-Aug-21	358523	6247462	3.2	soft	organic	100	-	-	-	-	organic	no	organics/flooded terrestrial
DST3-12	14	petite Ponar	19-Aug-21	357798	6247478	11.4	hard	boulder	100	-	-	-	-	rock	no	boulder/bedrock/cobble
DST3-13	14	petite Ponar	19-Aug-21	357931	6247710	6.7	hard	gravel	100	-	-	-	-	rock	no	gravel/cobble
DST3-14	14	petite Ponar	19-Aug-21	358100	6247991	3.5	soft	organics	100	-	-	-	-	organic	no	organics/flooded terrestrial
DST3-15	13	petite Ponar	19-Aug-21	357280	6247557	7.8	medium	clay	80	sand	10	silt	10	mud	yes	clay/sand/silt
DST3-16	13	petite Ponar	19-Aug-21	357412	6247864	10.7	hard	sand	95	silt	5	-	-	sand	yes	sand/silt
DST3-17	13	petite Ponar	19-Aug-21	357550	6248240	7.4	medium	clay	95	silt	5	-	-	mud	yes	clay/silt
DST3-18	12	petite Ponar	19-Aug-21	356835	6247557	6.3	medium	clay	95	silt	5	-	-	mud	yes	clay/silt/sand
DST3-19	12	petite Ponar	19-Aug-21	356893	6247848	6.9	medium	clay	95	silt	5			mud	yes	silt/sand/clay
DST3-20	12	petite Ponar	19-Aug-21	356973	6248213	16.2	medium	clay	95	silt	5			mud	yes	silt/clay/sand
DST3-21	11	petite Ponar	19-Aug-21	356412	6247472	6.8	medium	clay	95	silt	5			mud	yes	clay/silt/sand
DST3-22	11	petite Ponar	19-Aug-21	356317	6247816	8.2	medium	sand	95	silt	5			sand	yes	sand/silt
DST3-23	11	petite Ponar	19-Aug-21	356195	6248218	10.3	medium	clay	95	silt	5			mud	yes	clay/silt
DST3-24	10	petite Ponar	19-Aug-21	356010	6247329	2.1	n/a	organics	100	-	-	-	-	organic	no	organics/flooded terrestrial
DST3-25	10	petite Ponar	19-Aug-21	355840	6247610	13.7	hard	sand	100	-	-	-	-	sand	yes	sand/silt
DST3-26	10	petite Ponar	19-Aug-21	355682	6247880	6.5	soft	clay	70	silt	15	gravel	15	mud	yes	clay/silt/gravel
DST3-27	9	petite Ponar	19-Aug-21	355740	6247107	6.5	medium	clay	80	sand	10	silt	10	mud	yes	clay/sand/silt
DST3-28	9	petite Ponar	19-Aug-21	355412	6247303	13	medium	sand	100	-	-	-	-	sand	no	sand
DST3-29	9	petite Ponar	19-Aug-21	355015	6247541	6.5	medium	clay	70	sand	15	silt	15	mud	yes	clay/silt/sand
DST3-30	8	petite Ponar	19-Aug-21	355602	6246784	6.2	medium	clay	70	sand	20	silt	10	mud	yes	clay/sand/silt
DST3-31	8	petite Ponar	19-Aug-21	355179	6246927	10.5	hard	gravel	100	-	-	-	-	rock	no	gravel
DST3-32	8	petite Ponar	19-Aug-21	354628	6247112	6.9	medium	clay	70	silt	30	-	-	mud	yes	clay/silt
DST3-33	7	petite Ponar	19-Aug-21	355438	6246509	13.1	hard	sand	100	-	-	-	-	sand	no	sand/gravel
DST3-34	6	no sample	19-Aug-21	355639	6246271	13.9	-	gravel	50	cobble	50	-	-	rock	no	gravel/cobble

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

Table 13: Results of acoustic classification of single beam data collected along transects in the Keeyask reservoir at the Caribou Island sensitive habitat area, 2021.

Transect ID	Sampled	Date	Distance (m)	Total Samples	Acoustic Substrate Classification Composition (% Membership)								Total
					Organics	Mud		Sand	Rock				
					organics/FT	silt/clay	silt/clay/sand	sand	gravel/ sand	gravel	cobble	bedrock/boulder	
					Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	
6	yes	19-Aug-21	610	192	10	24	15	5	16	6	7	17	100
7	yes	19-Aug-21	580	190	12	13	14	7	21	13	9	12	100
8	yes	19-Aug-21	1120	333	17	27	18	6	12	7	3	11	100
9	yes	19-Aug-21	1010	330	25	25	14	5	4	12	11	5	100
10	yes	19-Aug-21	710	257	11	18	17	9	14	14	12	4	100
11	yes	19-Aug-21	1010	342	25	25	24	5	3	9	8	1	100
12	yes	19-Aug-21	880	310	34	24	15	7	5	7	7	1	100
13	yes	19-Aug-21	910	251	12	33	25	6	3	11	9	2	100
14	yes	19-Aug-21	710	235	8	17	14	6	23	14	9	10	100
15	yes	19-Aug-21	770	213	9	13	9	9	22	12	10	14	100
16	yes	19-Aug-21	990	389	14	26	18	8	12	11	9	2	100
Summary					**17**	**23**	**17**	**7**	**11**	**10**	**8**	**6**	**100**

Table 14: Results of particle size analysis (conducted at ALS Laboratories) from samples collected at selected sites in the Keeyask reservoir at the Caribou Island sensitive habitat area in August and in the Stephens Lake sensitive habitat area in June, August, and September, 2021

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
August	DST3	Caribou Island	DST3-17	2.06	17.2	4.08	2.02	22.6	67.9	9.5	silt loam
August	DST3	Caribou Island	DST3-32	2.09	17.4	4.28	2.19	4.7	84.2	11.1	silt
August	DST3	Caribou Island	DST3-33	2.15	17.9	2.46	<0.49	96.9	1.9	1.2	sand
August	DST3	Caribou Island	DST3-37	1.94	16.2	4.1	2.16	58.7	35.9	5.4	sandy loam
June	SH4	Stephens Lake	T3-3	-	-	-	-	76.2	15.7	8.1	sandy loam
June	SH4	Stephens Lake	T3-4	-	-	-	-	46.4	35	18.5	loam
June	SH4	Stephens Lake	T3-5	-	-	-	-	33.1	39.6	27.3	loam / clay loam
June	SH4	Stephens Lake	T4-3	-	-	-	-	45	34.2	20.8	loam
June	SH4	Stephens Lake	T5-3	-	-	-	-	72.9	15.4	11.7	sandy loam
August	DST4	Stephens Lake	DST4-4	1.7	14.2	4.53	2.83	54.4	38.3	7.3	sandy loam
August	DST4	Stephens Lake	DST4-17	1.67	13.9	4.13	2.46	66.4	26.5	7.1	sandy loam
August	DST4	Stephens Lake	DST4-18	1.91	15.9	4.44	2.53	46.5	44.9	8.6	loam
September	SH4	Stephens Lake	T3-3	1.7	14.2	3.54	1.84	78	16.8	5.2	loamy sand
September	SH4	Stephens Lake	T3-4	1.85	15.4	5.69	3.84	51.9	39.8	8.3	loam
September	SH4	Stephens Lake	T3-5	1.6	13.3	3.47	1.87	66	27.3	6.7	sandy loam
September	SH4	Stephens Lake	T4-3	2.23	18.6	3.67	1.44	75.8	20.2	4	loamy sand
September	SH4	Stephens Lake	T5-3	1.64	13.7	4.47	2.83	59.7	32.6	7.7	sandy loam

Table 15: Locations and results of field bottom type validation sampling and post-survey class verification in the Stephens Lake sensitive habitat area, June 2021.

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	%			
T1-1	T1	petite Ponar	5-Jun-21	368451	6248897	13.2	soft	silt	90	sand	10	-	-	mud	yes	silt/sand
T1-2	T1	petite Ponar	5-Jun-21	368668	6249002	12.9	soft	silt	100	-	-	-	-	mud	yes	silt
T1-3	T1	petite Ponar	5-Jun-21	368928	6249113	13.6	soft	silt	80	clay	10	sand	10	mud	yes	silt/clay/sand
T2-1	T2	petite Ponar	5-Jun-21	368255	6248525	13.3	medium	sand	80	gravel	15	cobble	5	sand	no	sand/gravel
T2-2	T2	petite Ponar	5-Jun-21	368546	6248653	16	medium	gravel	80	sand	20	-	-	rock	no	gravel/sand
T2-3	T2	petite Ponar	5-Jun-21	368795	6248767	18.7	soft	silt	90	organics	10	-	-	mud	yes	silt/organics
T2-4	T2	petite Ponar	5-Jun-21	369012	6248871	14	soft	sand	40	organics	40	silt	20	mud	yes	sand/organics/silt
T2-5	T2	petite Ponar	5-Jun-21	369269	6249009	13.6	soft	organics	60	silt	30	sand	10	organics	yes	organics/silt/sand
T3-1	T3	petite Ponar	5-Jun-21	368381	6248286	12.6	hard	gravel	60	cobble	20	sand	20	rock	no	gravel/sand
T3-2	T3	petite Ponar	5-Jun-21	368640	6248437	12.3	hard	gravel	60	sand	30	silt	10	rock	yes	gravel/sand/silt
T3-3	T3	petite Ponar	5-Jun-21	368836	6248527	17.2	medium	sand	60	gravel	20	silt	20	sand	yes	sand/gravel/silt
T3-4	T3	petite Ponar	5-Jun-21	369074	6248671	14.8	soft	organics	85	silt	15	-	-	organics	yes	organics/silt
T3-5	T3	petite Ponar	5-Jun-21	369324	6248810	13.2	soft	organics	70	silt	30	-	-	organics	yes	organics/silt
T4-1	T4	petite Ponar	5-Jun-21	368506	6248087	13.2	soft	silt	80	organics	20	-	-	mud	yes	silt/organics
T4-2	T4	petite Ponar	5-Jun-21	368762	6248212	12.6	medium	sand	80	gravel	15	silt	5	sand	no	sand/gravel/silt
T4-3	T4	petite Ponar	5-Jun-21	369094	6248361	12.5	soft	silt	50	organics	50	-	-	mud	yes	silt/organics
T4-4	T4	petite Ponar	5-Jun-21	369337	6248499	13.9	soft	silt	60	organics	30	sand	10	mud	yes	silt/organics/sand
T5-1	T5	petite Ponar	5-Jun-21	368818	6248005	9.6	medium	sand	60	gravel	10	-	-	sand	no	sand/gravel
T5-2	T5	petite Ponar	5-Jun-21	369088	6248152	12.6	soft	silt	70	sand	20	organics	10	mud	yes	silt/sand/organics
T5-3	T5	petite Ponar	5-Jun-21	369444	6248320	13.4	soft	silt	70	clay	20	organics	10	mud	yes	silt/clay/organics

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

Table 16: Locations and results of field bottom type validation sampling and post-survey class verification in the Stephens Lake sensitive habitat area, August 2021.

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	%			
DST4-4	12	petite Ponar	20-Aug-21	369795	6247184	15.6	soft	silt	90	clay	5	organics	5	mud	yes	silt/clay/organics
DST4-5	12	petite Ponar	20-Aug-21	370536	6247988	15	soft	organics	60	silt	40	-	-	organics	yes	silt/organics
DST4-6	12	petite Ponar	20-Aug-21	371108	6248613	1.8	soft	sand	95	silt	5	-	-	sand	yes	sand/silt
DST4-7	11	petite Ponar	20-Aug-21	369176	6247138	15	soft	clay	50	organics	40	sand	10	mud	yes	silt/organics
DST4-8	11	petite Ponar	20-Aug-21	369881	6248133	18.2	soft	silt		clay		organics		mud	yes	silt/clay/organics
DST4-9	11	petite Ponar	20-Aug-21	370182	6248560	15.6	soft	clay	50	silt	40	organics	10	mud	yes	silt/clay/organics
DST4-10	10	side scan	20-Aug-21	368693	6246893	14.4	hard	cobble	50	gravel	30	boulder	20	rock	no	cobble/gravel/boulder
DST4-11	10	petite Ponar	20-Aug-21	368918	6247340	13.8	soft	clay	60	silt	40	-	-	mud	yes	silt/clay
DST4-12	10	petite Ponar	20-Aug-21	369256	6247975	12.6	soft	clay	90	silt	10	-	-	mud	yes	clay/silt
DST4-13	10	petite Ponar	20-Aug-21	369729	6248884	15.5	hard	cobble	50	boulder	40	silt	10	rock	yes	cobble/boulder/silt
DST4-14	9	petite Ponar	20-Aug-21	368273	6246873	13.6	hard	cobble	50	gravel	30	boulder	20	rock	no	cobble/gravel/boulder
DST4-15	9	petite Ponar	20-Aug-21	368525	6247525	14.6	hard	cobble		boulder		silt		rock	yes	cobble/boulder/silt
DST4-16	9	side scan	20-Aug-21	368723	6248047	12	hard	cobble	50	gravel	40	boulder	10	rock	no	cobble/gravel/boulder
DST4-17	9	petite Ponar	20-Aug-21	368885	6248474	16.4	soft	silt	50	sand	40	clay	10	mud	yes	silt/sand/clay
DST4-18	9	petite Ponar	20-Aug-21	369054	6248911	15	soft	silt	50	sand	30	clay	20	mud	yes	silt/sand/clay
DST4-19	18	petite Ponar	20-Aug-21	368015	6246949	9	hard	cobble	50	gravel	30	boulder	20	rock	no	cobble/gravel/boulder
DST4-20	8	petite Ponar	20-Aug-21	368134	6247492	13.5	hard	gravel	50	cobble	30	boulder	20	rock	no	gravel/cobble/boulder
DST4-21	8	petite Ponar	20-Aug-21	368227	6247915	15.6	hard	gravel	50	cobble	30	boulder	20	rock	no	gravel/cobble/boulder
DST4-22	8	petite Ponar	20-Aug-21	368330	6248405	7.3	medium	sand	100	-	-	-	-	sand	no	sand
DST4-23	8	petite Ponar	20-Aug-21	368432	6248854	13.6	medium	gravel	70	silt	20	clay	10	rock	yes	gravel/silt/clay
DST4-24	17	petite Ponar	20-Aug-21	367671	6246992	6.6	hard	cobble	60	gravel	30	boulder	10	rock	no	cobble/gravel/boulder
DST4-25	7	petite Ponar	20-Aug-21	367724	6247528	14	hard	gravel	60	cobble	30	boulder	20	rock	no	gravel/cobble/boulder
DST4-26	7	petite Ponar	20-Aug-21	367774	6247932	13.2	hard	boulder	50	cobble	30	gravel	20	rock	no	boulder/cobble/gravel
DST4-27	7	petite Ponar	20-Aug-21	367810	6248355	12.7	hard	gravel	70	sand	30	-	-	rock	no	gravel/sand
DST4-28	7	petite Ponar	20-Aug-21	367863	6248785	14.2	soft	organics	90	silt	10	-	-	organics	yes	organics/silt

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

Table 17: Results of acoustic classification of single beam data collected along transects in the Stephens Lake sensitive habitat area, August 2021.

Transect ID	Sampled	Date	Distance (m)	Total Samples	Acoustic Substrate Classification Composition (% Membership)								Total
					Organics	Mud		Sand	Rock				
					organics/FT	silt/clay	silt/clay/sand	sand	gravel/ sand	gravel	cobble	bedrock/boulder	
					Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	
T1	no	-	-	-	-	-	-	-	-	-	-	-	-
T2	yes	17-Aug-21	1460	421	0	3	2	11	19	17	13	35	100
T3	yes	17-Aug-21	1330	458	0	2	3	10	20	25	17	24	100
T4	yes	17-Aug-21	1412	402	0	1	2	11	21	16	16	32	100
T5	no	-	-	-	-	-	-	-	-	-	-	-	-
7	yes	20-Aug-21	624	205	0	0	0	7	27	22	11	33	100
8	yes	20-Aug-21	1270	396	0	1	2	9	19	21	23	24	100
9	yes	20-Aug-21	1604	541	7	10	8	11	21	19	18	6	100
10	yes	20-Aug-21	1602	362	0	11	10	16	18	25	19	1	100
11	yes	20-Aug-21	1120	396	1	24	16	12	10	20	16	2	100
12	yes	20-Aug-21	1527	532	8	26	21	10	8	14	9	3	100
Summary					**2**	**10**	**8**	**11**	**17**	**19**	**16**	**16**	**100**

Table 18: Locations and results of field bottom type validation sampling and post-survey class verification in the Stephens Lake sensitive habitat area, September 2021.

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	%			
T1-1	T1	no sample	22-Sep-21	368452	6248907	-	-	-	-	-	-	-	-	-	-	-
T1-2	T1	standard Ponar	22-Sep-21	368689	6249001	-	hard	clay	95	sand	5	-	-	mud	no	clay/sand
T1-3	T1	standard Ponar	22-Sep-21	368944	6249116	-	soft	silt	70	sand	20	organics	10	mud	yes	silt/sand/organics
T2-1	T2	standard Ponar	22-Sep-21	368267	6248531	13.6	medium	gravel	70	sand	20	silt	10	rock	yes	gravel/sand/silt
T2-2	T2	standard Ponar	22-Sep-21	368540	6248646	15.3	soft	silt	60	organics	20	gravel	20	mud	yes	silt/organics/gravel
T2-3	T2	standard Ponar	22-Sep-21	368808	6248778	16.1	medium	silt	45	sand	45	organics	10	mud	yes	silt/sand/organics
T2-4	T2	standard Ponar	22-Sep-21	369001	6248875	14.2	soft	organics	80	silt	20	-	-	organics	yes	organics/silt
T2-5	T2	standard Ponar	22-Sep-21	369271	6248999	14	soft	silt	80	sand	15	organics	5	mud	yes	silt/sand/organics
T3-1	T3	standard Ponar	22-Sep-21	368380	6248268	13.9	hard	cobble	90	gravel	10	-	-	rock	no	cobble/gravel
T3-2	T3	standard Ponar	22-Sep-21	368650	6248433	13.4	medium	sand	70	gravel	30	-	-	sand	no	sand/gravel
T3-3	T3	standard Ponar	22-Sep-21	368859	6248533	18.3	soft	silt	60	sand	30	organics	10	mud	yes	silt/sand/organics
T3-4	T3	standard Ponar	22-Sep-21	369081	6248651	15.7	soft	organics	70	silt	30	-	-	organics	yes	organics/silt
T3-5	T3	standard Ponar	22-Sep-21	369351	6248793	16.9	soft	silt	60	sand	20	organics	20	mud	yes	silt/sand/organics
T4-1	T4	standard Ponar	22-Sep-21	368491	6248062	13	soft	silt	70	sand	20	organics	10	mud	yes	silt/sand/organics
T4-2	T4	standard Ponar	22-Sep-21	368772	6248204	14	medium	gravel	70	sand	20	silt	10	rock	yes	gravel/sand/silt
T4-3	T4	standard Ponar	22-Sep-21	369085	6248356	13.6	medium	sand	80	silt	20	-	-	sand	yes	gravel/silt
T4-4	T4	standard Ponar	22-Sep-21	369340	6248497	15	soft	organics	70	silt	30	-	-	organics	yes	organics/silt
T5-1	T5	standard Ponar	22-Sep-21	368814	6247991	10.6	soft	sand	80	silt	20	-	-	sand	yes	sand/silt
T5-2	T5	standard Ponar	22-Sep-21	369078	6248142	13.3	soft	sand	80	silt	15	organics	5	sand	yes	sand/silt/organics
T5-3	T5	standard Ponar	22-Sep-21	369417	6248318	14.1	soft	silt	60	organics	30	sand	10	mud	yes	silt/organics/sand

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

Table 19: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for cross sections surveyed at constructed shoal habitats in the Keeyask reservoir and Stephens Lake, 2021.

Area	Shoal	Depth Survey Date	Estimated Area (m^2)	Water Surface Elevation[2] (m)	Depth (m)			Velocity[1] (m/s)				
					min	max	mean	Date	samples	min	max	mean
Keeyask reservoir	G-South	23-Aug-21	1036	158.90	2.16	4.48	2.84	21-Jul-21	56	0.05	0.19	0.10
Keeyask reservoir	G-North	23-Aug-21	1795	158.90	2.50	4.26	3.30	21-Jul-21	56	0.05	0.19	0.10
Keeyask reservoir	F-North	23-Aug-21	1326	158.90	1.78	4.57	2.97	22-Jul-21	11	0.11	0.26	0.18
Keeyask reservoir	F-South	23-Aug-21	2223	158.90	2.61	4.09	3.18	5-Aug-21	16	0.12	0.20	0.17
Keeyask reservoir	F-East	23-Aug-21	2808	158.90	2.29	4.15	3.01	22-Jul-21	35	0.11	0.29	0.20
Keeyask reservoir	H-North	23-Aug-21	5236	158.90	1.70	6.23	3.20	22-Jul-21	21	0.06	0.25	0.14
Keeyask reservoir	H-South	23-Aug-21	2961	158.90	1.24	6.49	3.52	22-Jul-21	13	0.08	0.17	0.14
Keeyask reservoir	H-East	23-Aug-21	2378	158.90	-	-	-	22-Jul-21	14	0.13	0.40	0.24
Keeyask reservoir	L	23-Aug-21	10411	158.90				19-Jul-21	100	0.11	0.21	0.17
Stephens Lake	G3	13-Aug-21		140.74	-	-	-	-	-	-	-	-
Stephens Lake	N5	13-Aug-21		140.74	-	-	-	-	-	-	-	-

1. Velocity samples are averaged subsets of depth averaged ADCP velocity transects taken over, upstream, or downstream of constructed shoal.

2. Daily mean water surface elevation from MBH gauge station Gull Lake (05UF596) or Stephens Lake (05UF709).

Table 20: Locations and results of field bottom type validation sampling and post-survey class verification at the constructed habitats in the Keeyask reservoir and Stephens Lake, 2021.

Waterbody	Shoal	Date	Site ID	Gear	Location		Flooded (Y or N)	Depth (m)	Compaction	Estimated Sample Composition						Basic Class	Substrate Class Verification[1]
					Easting	Northing				Substrate	%	Substrate	%	Substrate	%		
Keeyask reservoir	G-South	23-Aug-21	G-South-1	weighted sounding line	354876	6247228	Y	2	hard	boulder	100	-	-	-	-	rock	boulder
	G-South		G-South-2	weighted sounding line	354917	6247211	Y	2	hard	boulder	100	-	-	-	-	rock	boulder
	G-South		G-South-3	weighted sounding line	354955	6247207	Y	2	hard	boulder	100	-	-	-	-	rock	boulder
	G-North		G-North-1	weighted sounding line	354877	6247306	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	G-North		G-North-2	weighted sounding line	354782	6247290	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	G-North		G-North-3	weighted sounding line	354710	6247323	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	F-North	23-Aug-21	F-North-1	weighted sounding line	353943	6245516	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	F-North		F-North-2	weighted sounding line	354031	6245584	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	F-North		F-North-3	weighted sounding line	354034	6245651	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	F-South		F-South-1	weighted sounding line	354030	6245302	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	F-South		F-South-2	weighted sounding line	353943	6245266	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	F-South		F-South-3	weighted sounding line	353860	6245212	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	F-East		F-East-1	weighted sounding line	354769	6245488	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	F-East		F-East-2	weighted sounding line	354666	6245428	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	F-East		F-East-3	weighted sounding line	354536	6245385	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	H-North	23-Aug-21	H-North-1	weighted sounding line	355476	6245185	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	H-North		H-North-2	weighted sounding line	355718	6245226	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	H-North		H-North-3	weighted sounding line	355980	6245213	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	H-South		H-South-1	weighted sounding line	345172	6243644	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	H-South		H-South-2	weighted sounding line	355609	6245042	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	H-South		H-South-3	weighted sounding line	355711	6244985	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	H-East		H-East-1	weighted sounding line	356660	6244877	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	H-East		H-East-2	weighted sounding line	356764	6244901	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	H-East		H-East-3	weighted sounding line	356850	6244914	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	L	23-Aug-21	L-1	weighted sounding line	358109	6245530	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	L		L-2	weighted sounding line	358340	6245566	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
	L		L-3	weighted sounding line	358579	6245579	Y	-	hard	boulder	100	-	-	-	-	rock	boulder
Stephens Lake	N5	13-Aug-21	N5-1	weighted sounding line	364587	6248100	N	-	hard	boulder	100	-	-	-	-	rock	boulder
	N5		N5-2	weighted sounding line	364605	6248062	N	-	hard	boulder	100	-	-	-	-	rock	boulder
	N5		N5-3	weighted sounding line	364687	6248030	N	-	hard	boulder	100	-	-	-	-	rock	boulder
	N5		N5-4	weighted sounding line	364643	6248065	N	-	hard	boulder	100	-	-	-	-	rock	boulder
	N5		N5-5	weighted sounding line	364619	6248045	N	-	hard	boulder	100	-	-	-	-	rock	boulder
	G3	13-Aug-21	G3-1	weighted sounding line	365074	6249109	N	-	hard	boulder	100	-	-	-	-	rock	boulder
	G3		G3-2	weighted sounding line	365101	6249087	N	-	hard	boulder	100	-	-	-	-	rock	boulder
	G3		G3-3	weighted sounding line	365138	6249079	N	-	hard	boulder	100	-	-	-	-	rock	boulder

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

FIGURES

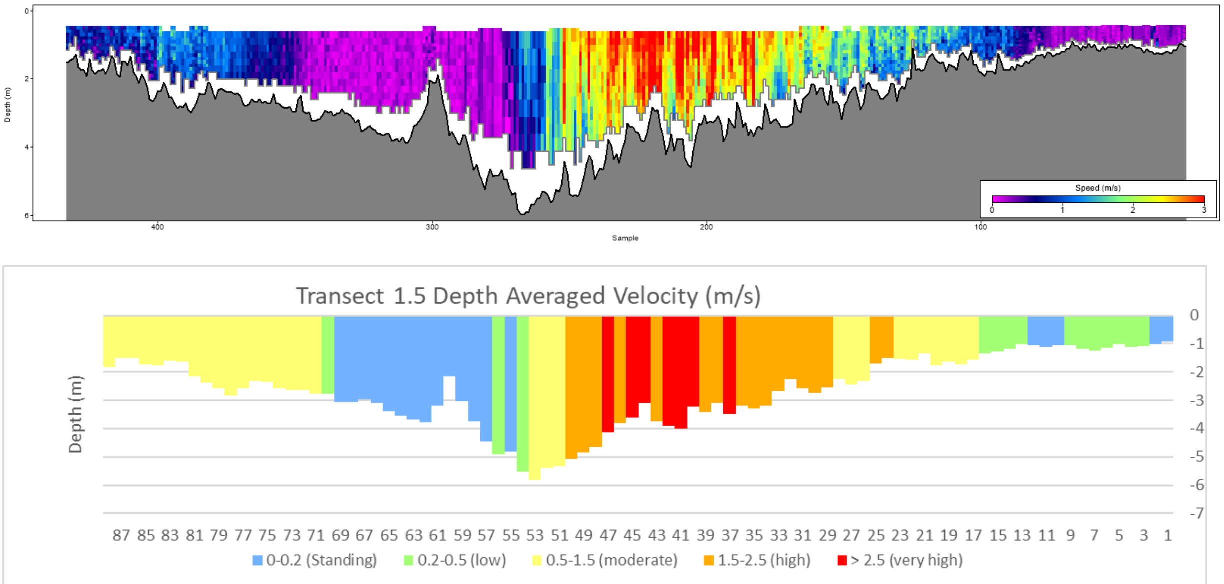


Figure 1: Full ADCP profile (top) sampled at Transect 1.5 at Long Rapids on August 17, 2021. Classified sub-sampled depth averaged velocity representation of Transect 1.5 (bottom). Cross sections are viewed looking downstream (left to right bank).

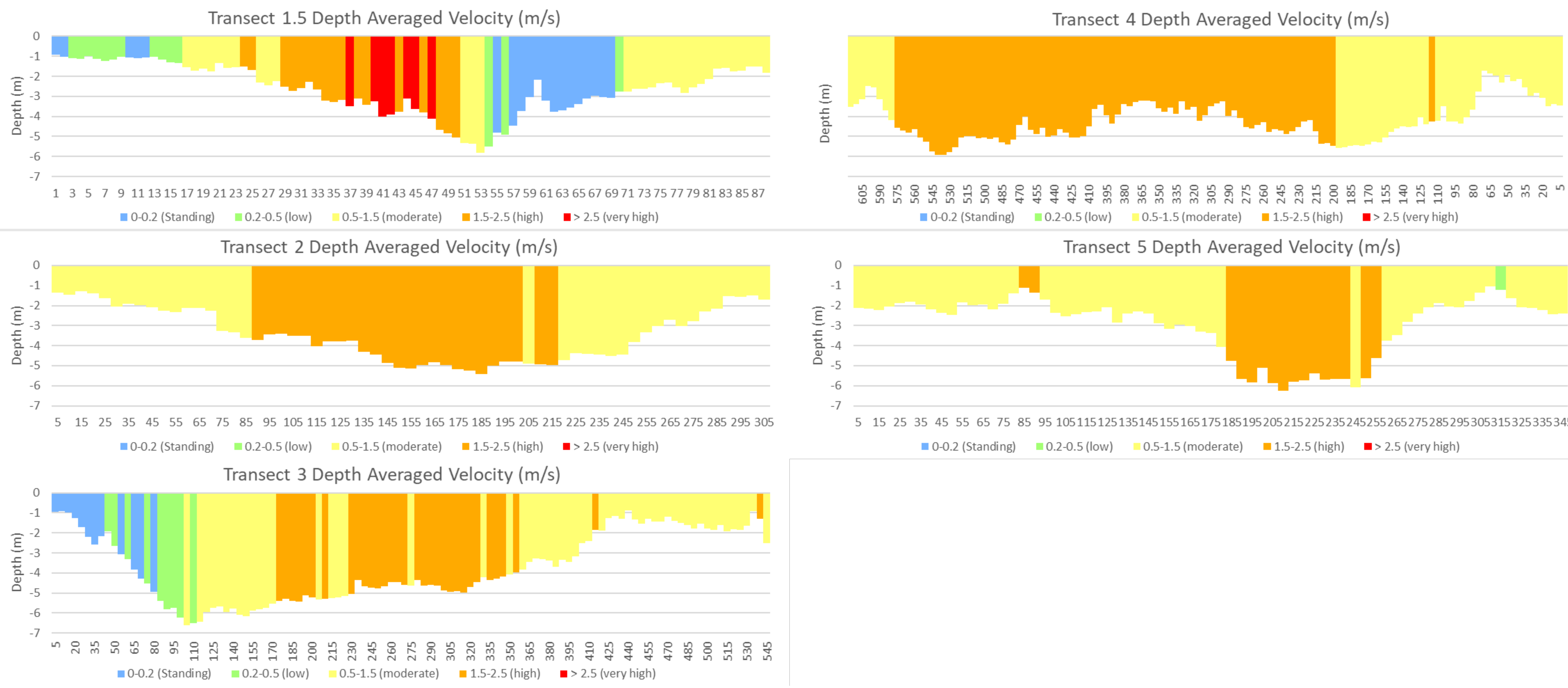


Figure 2: **Classified sub-sampled depth averaged velocity representation of 5 transects sampled using an ADCP at the Long Rapids sensitive habitat area, 2021. Cross sections are viewed looking upstream (left to right bank).**

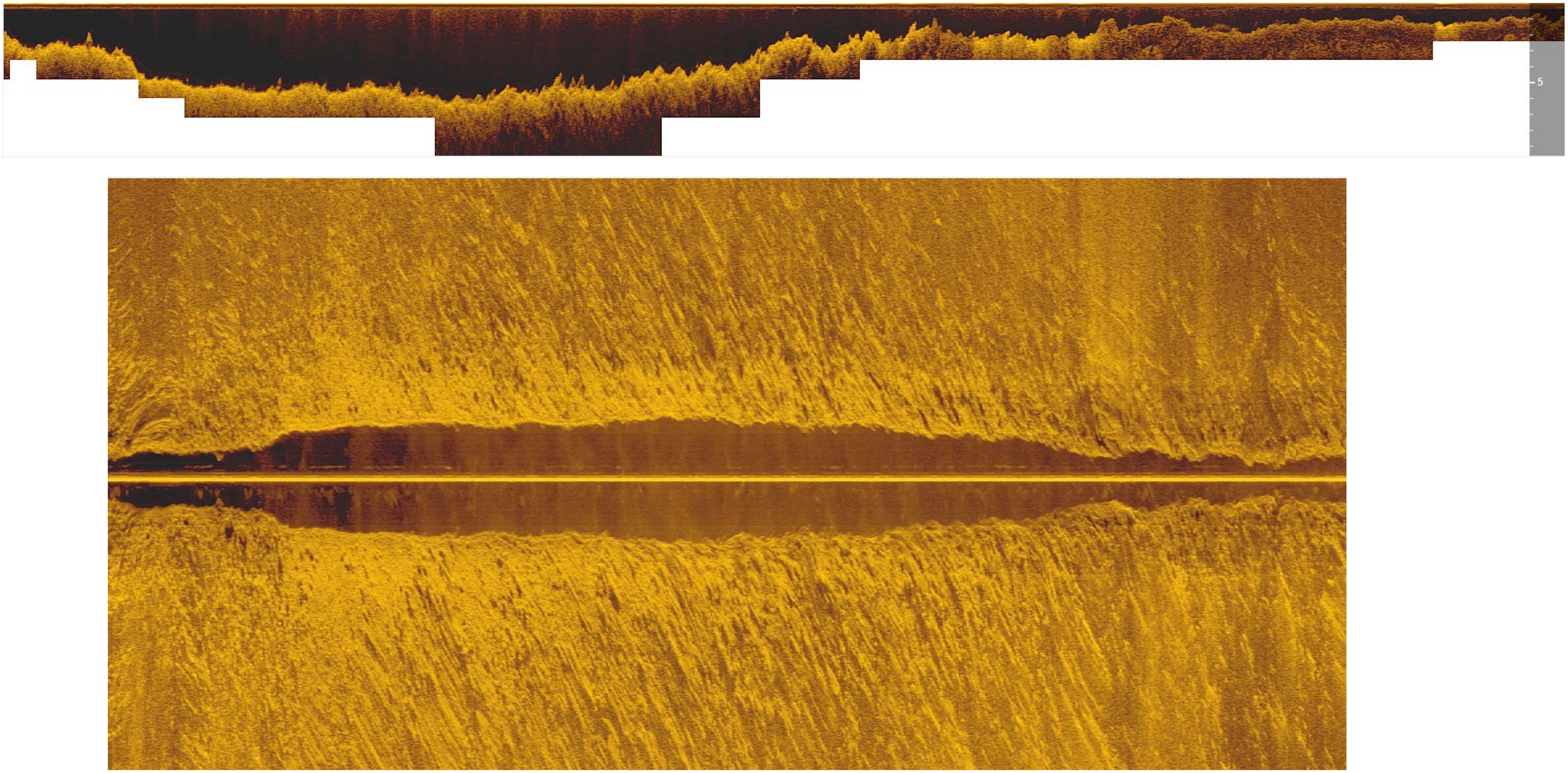


Figure 3: Lowrance Elite FS 455 kHz down scan (top) and side scan (bottom) imagery of transect/cross section 2 at the Long Rapids sensitive habitat area.

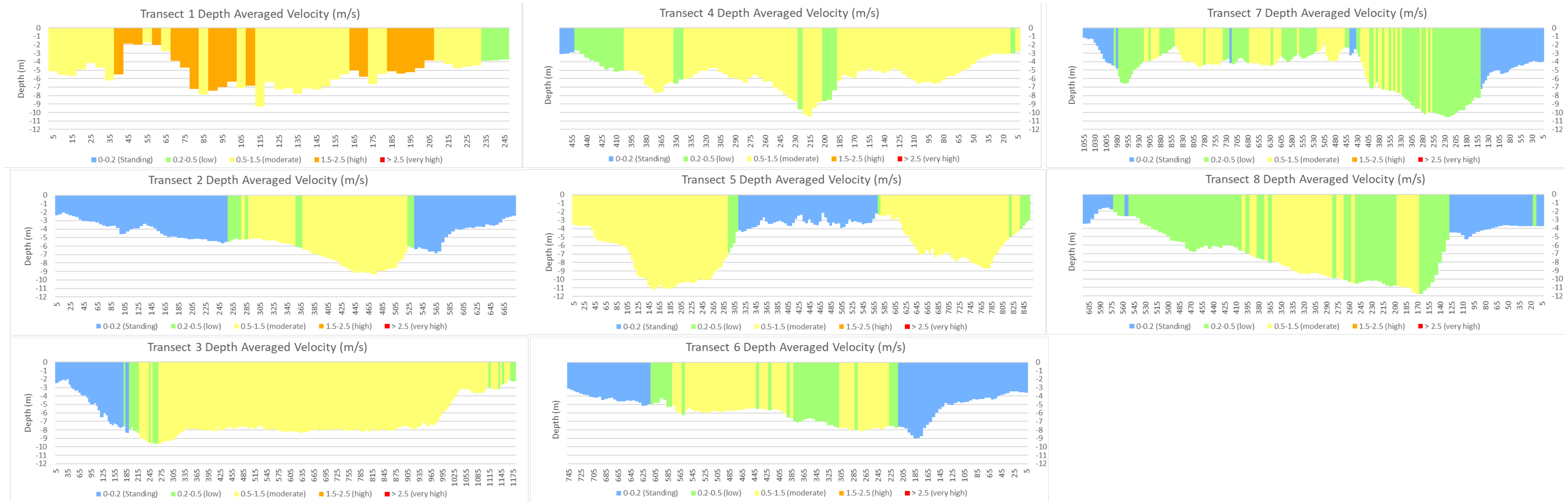


Figure 4: **Classified sub-sampled depth averaged velocity representation of 8 transects sampled using an ADCP in the Keeyask reservoir at the Birthday Rapids sensitive habitat area, 2021. Cross sections are viewed looking upstream (left to right bank).**

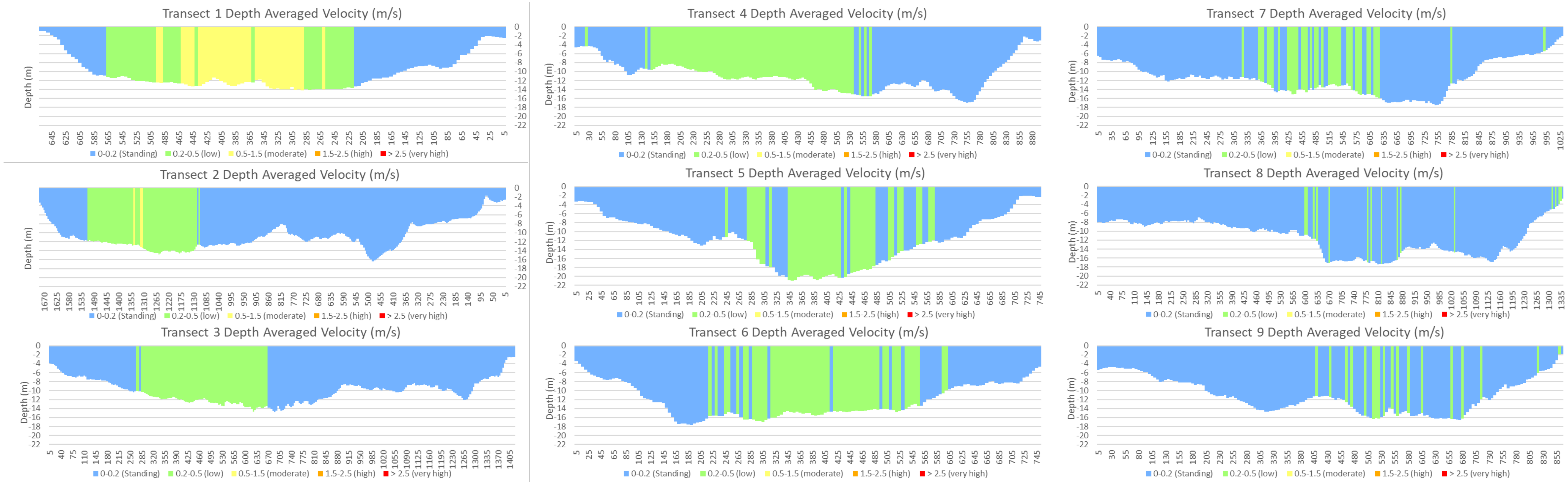


Figure 5: Classified sub-sampled depth averaged velocity representation of 9 transects sampled using an ADCP in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area, 2021. Cross sections are viewed looking upstream (left to right bank).

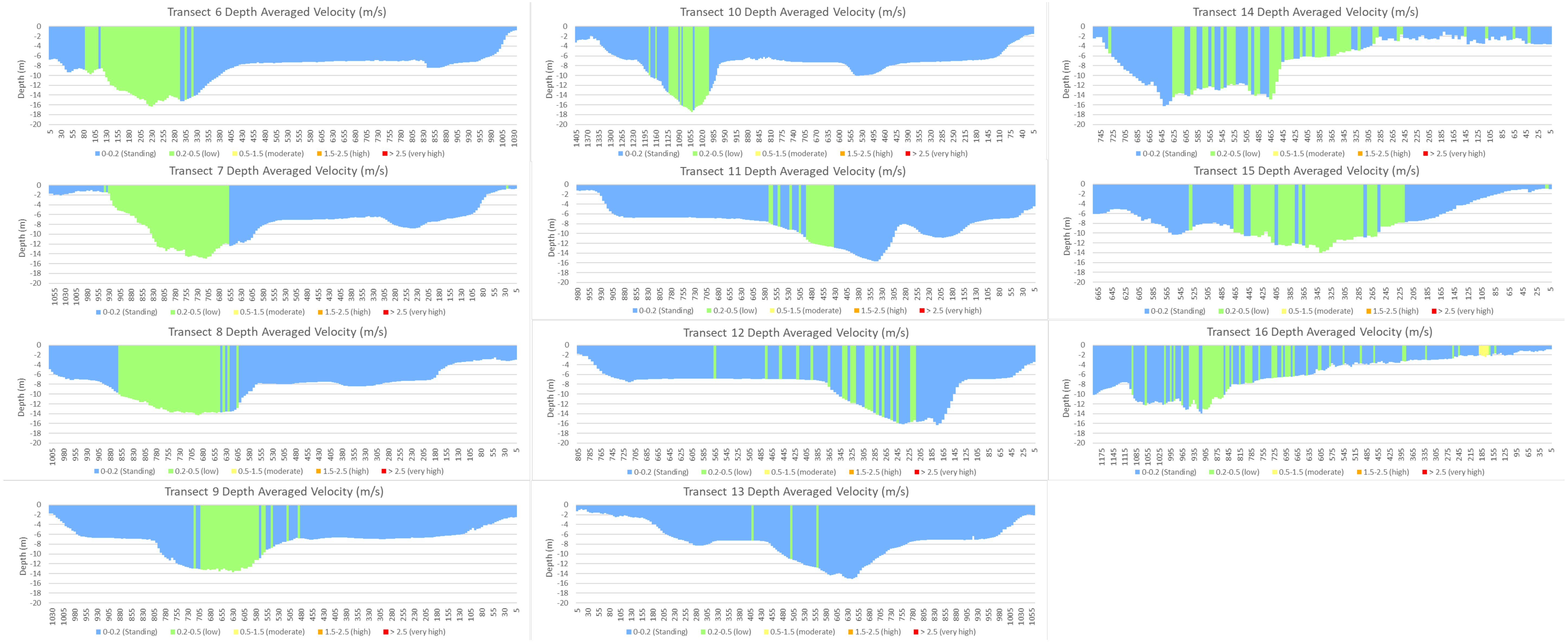
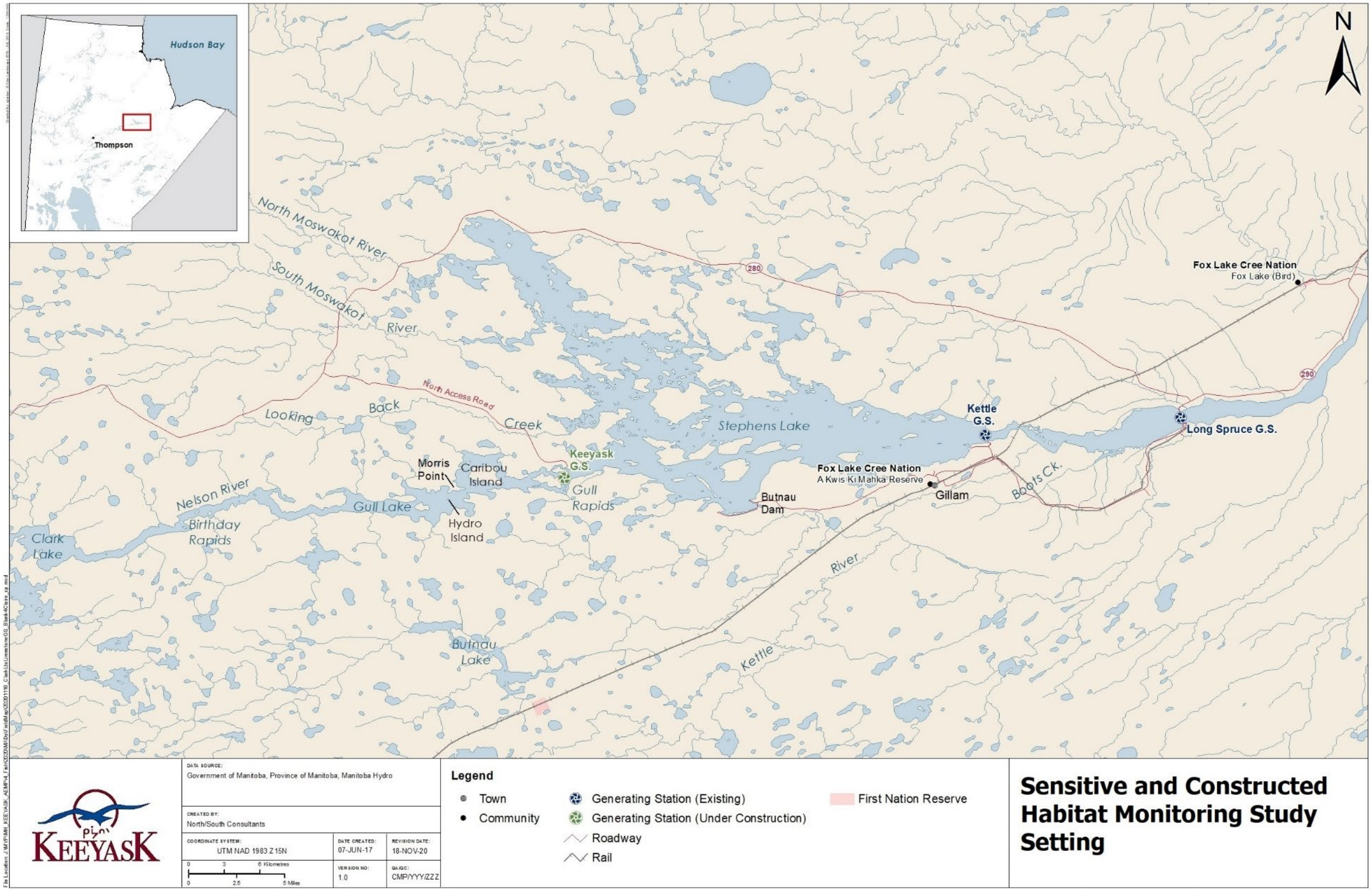
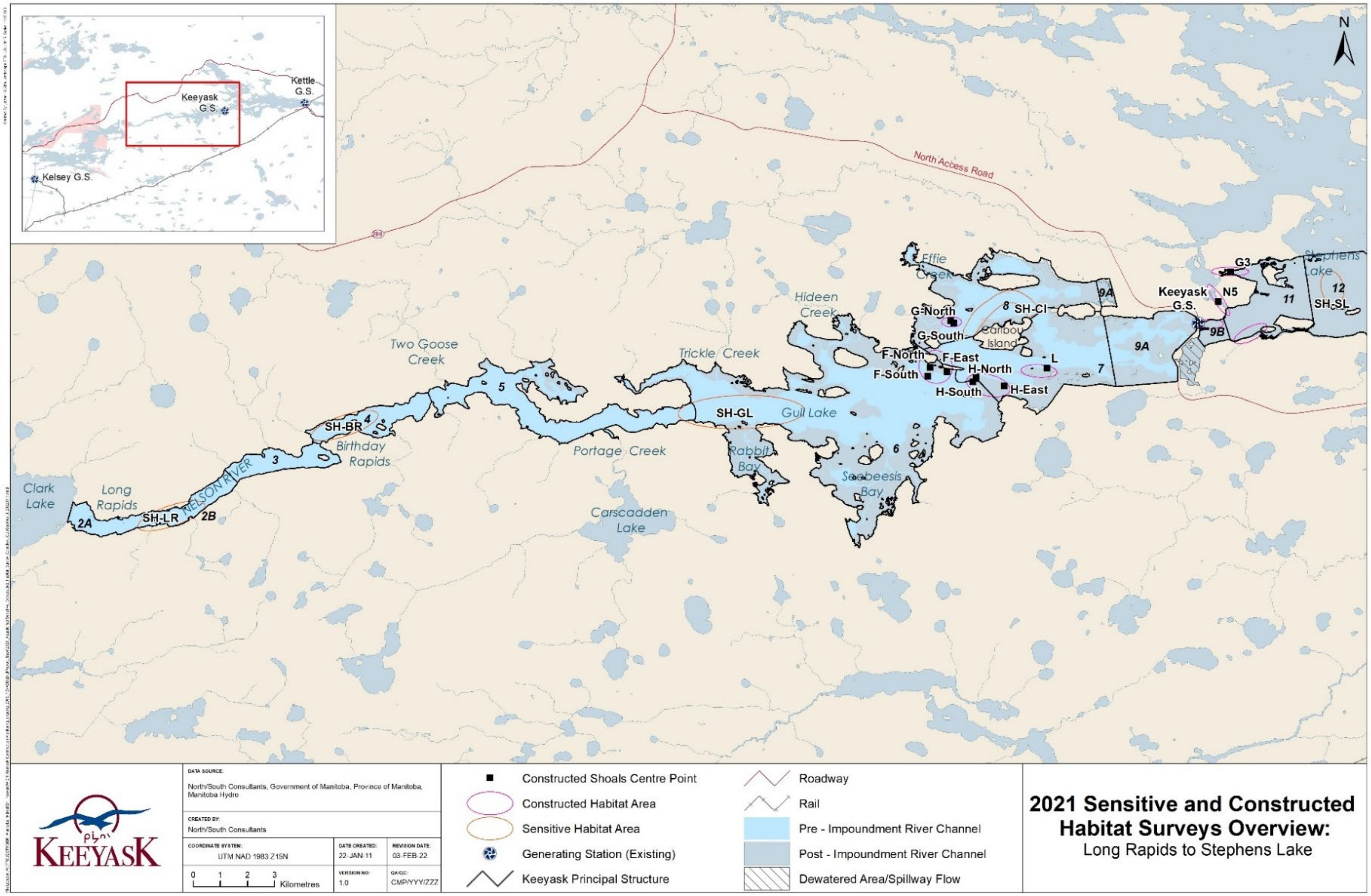


Figure 6: **Classified sub-sampled depth averaged velocity representation of 11 transects sampled using an ADCP in the Keeyask reservoir at the Caribou Island sensitive habitat area, 2021. Cross sections are viewed looking upstream (left to right bank).**

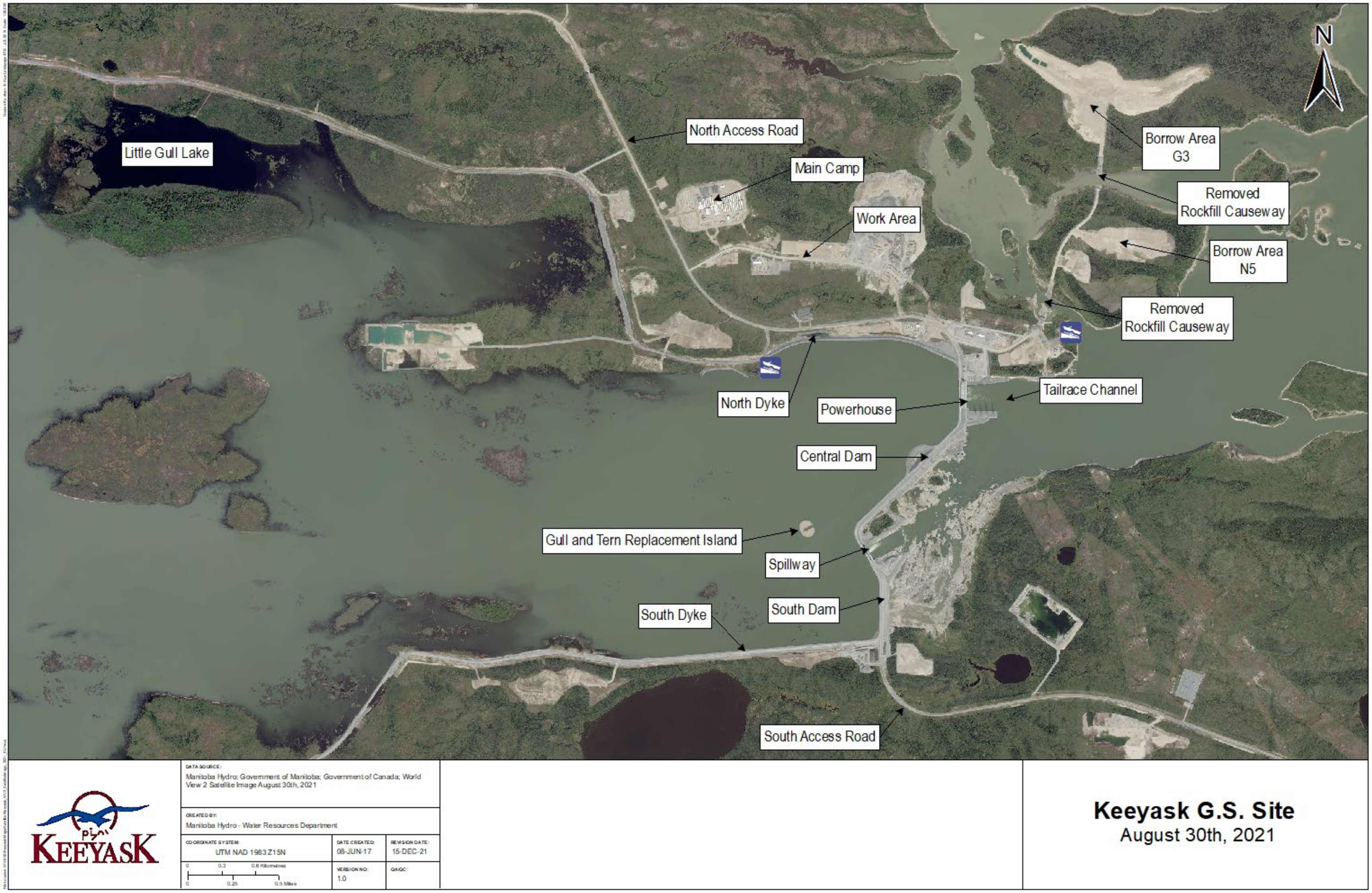
MAPS



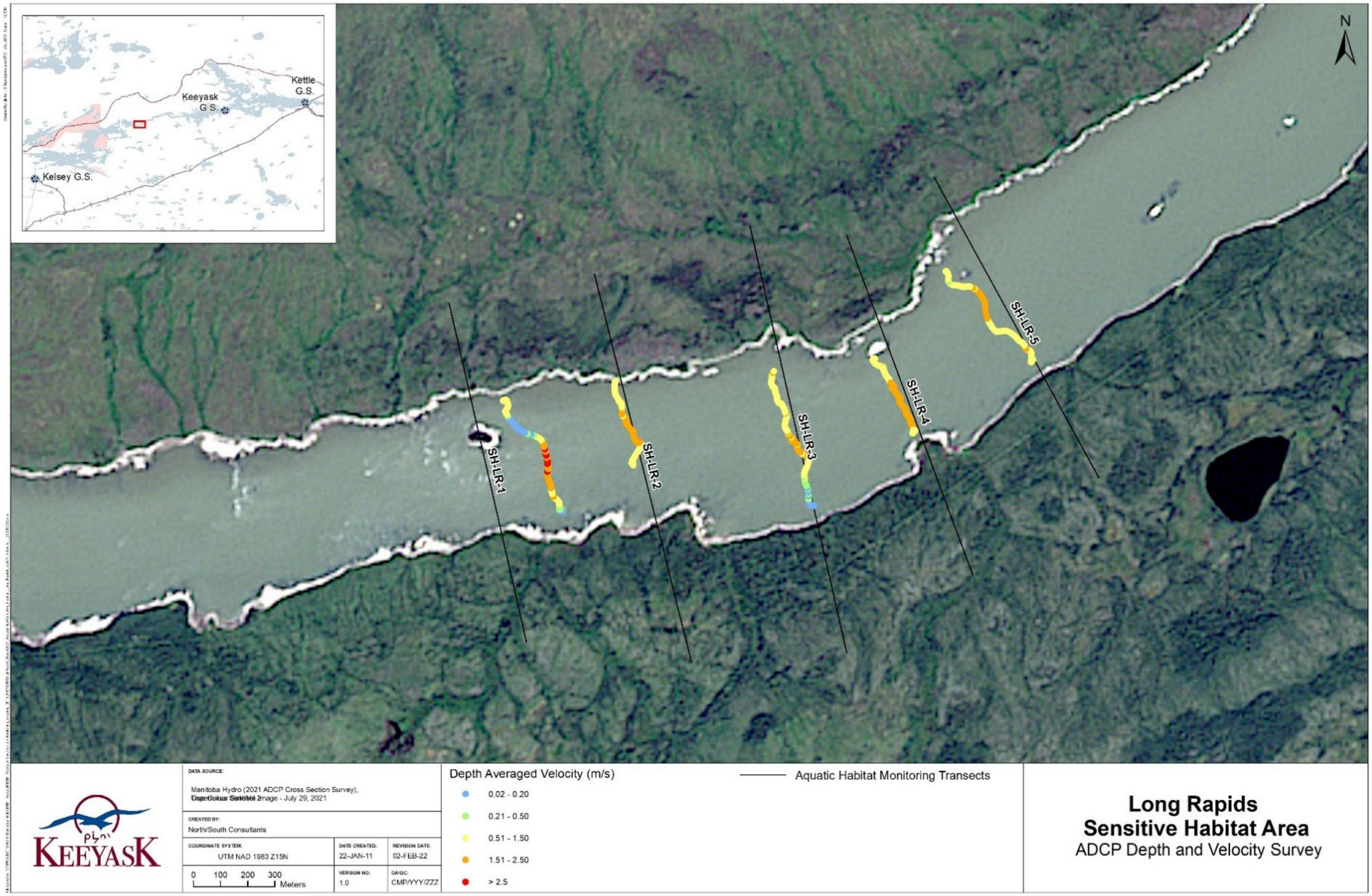
Map 1: **Map of the Nelson River showing the site of the Keeyask Generating Station and the sensitive and constructed habitat monitoring study setting.**



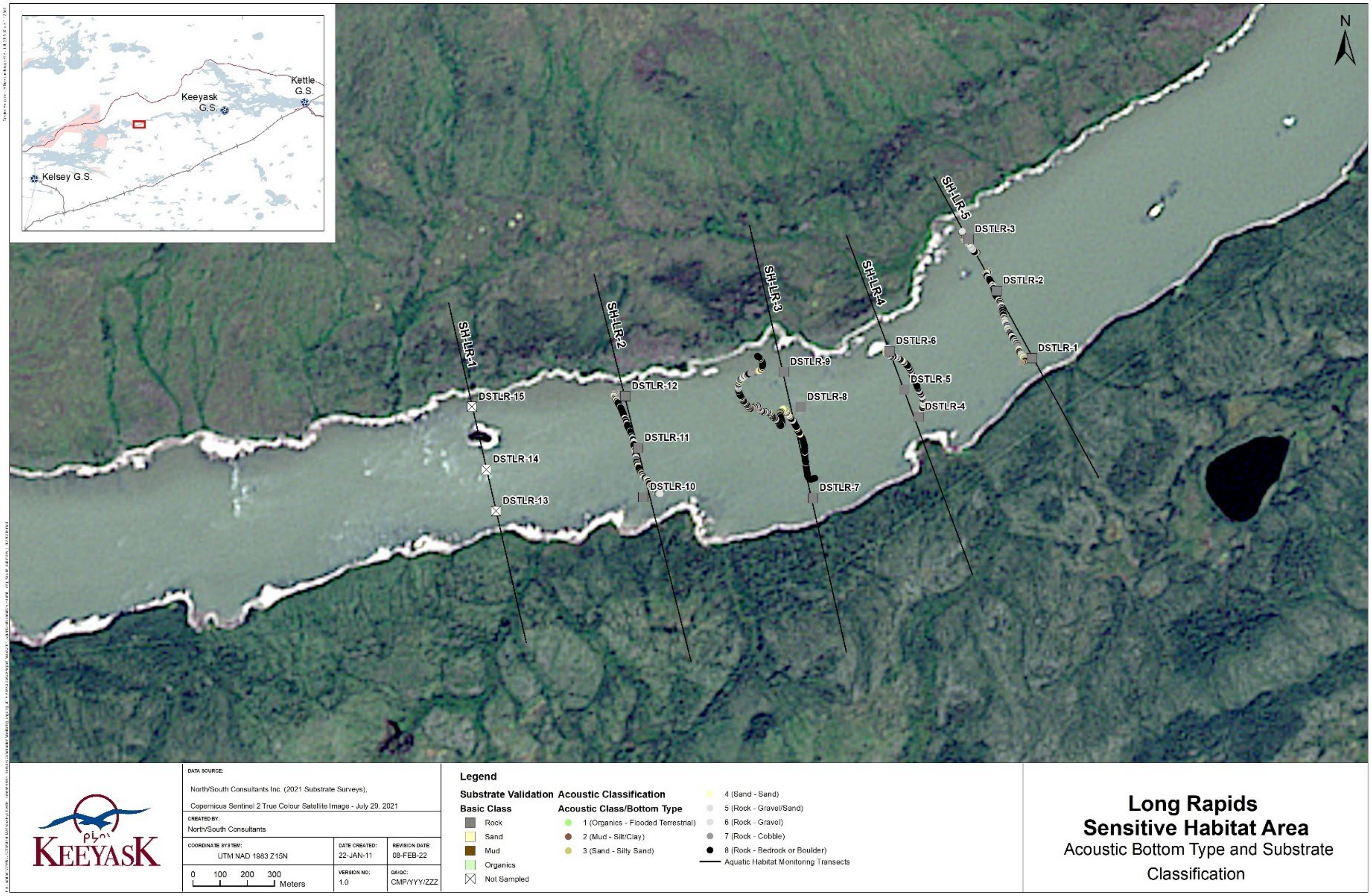
Map 2: **Overview map of 2021 sensitive and constructed aquatic habitat monitoring areas and sites, habitat reaches 2A-12 are indicated.**



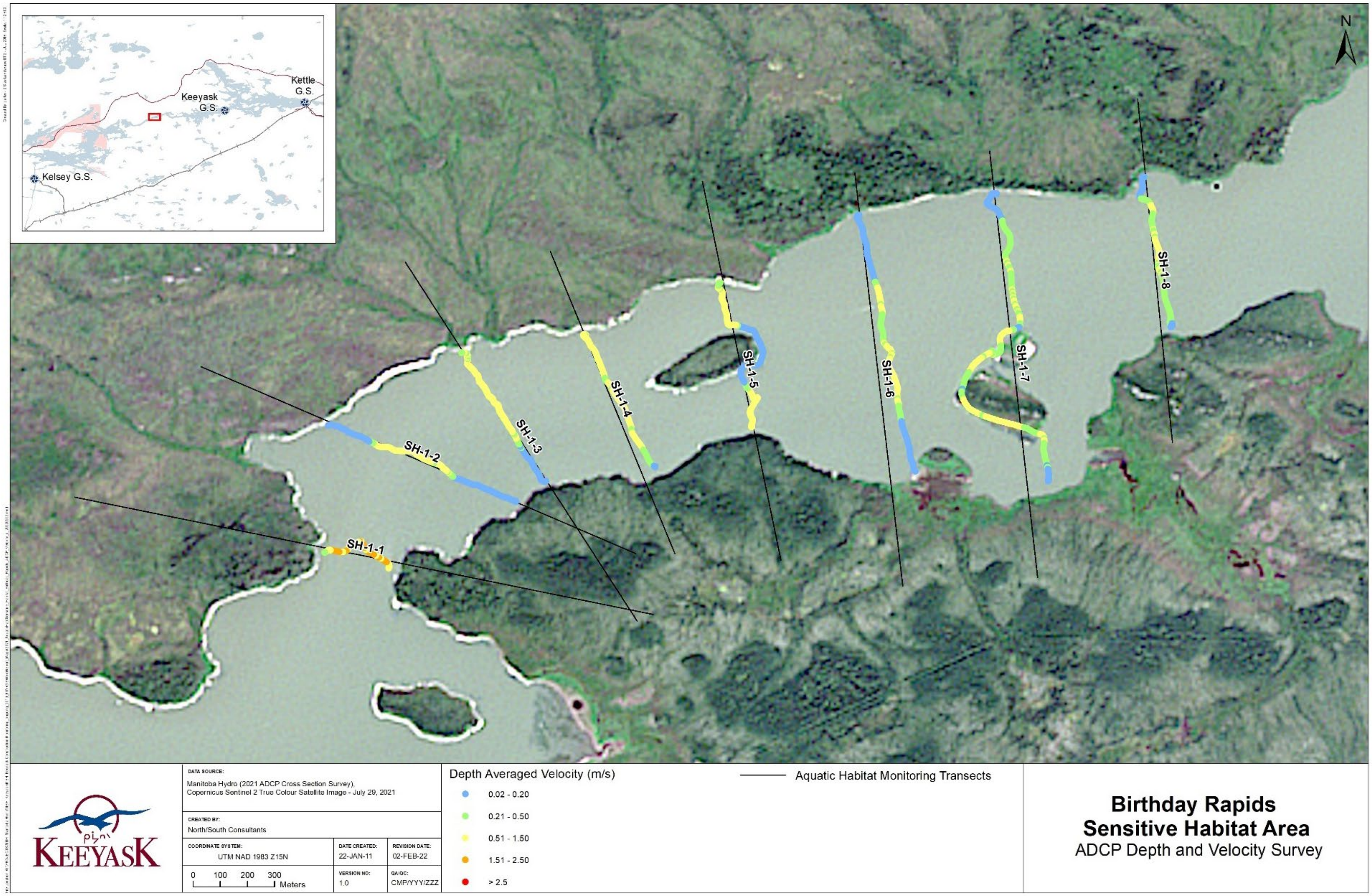
Map 3: Map illustrating instream structures at the Keeyask Generating Station site after reservoir flooding, August 2021.



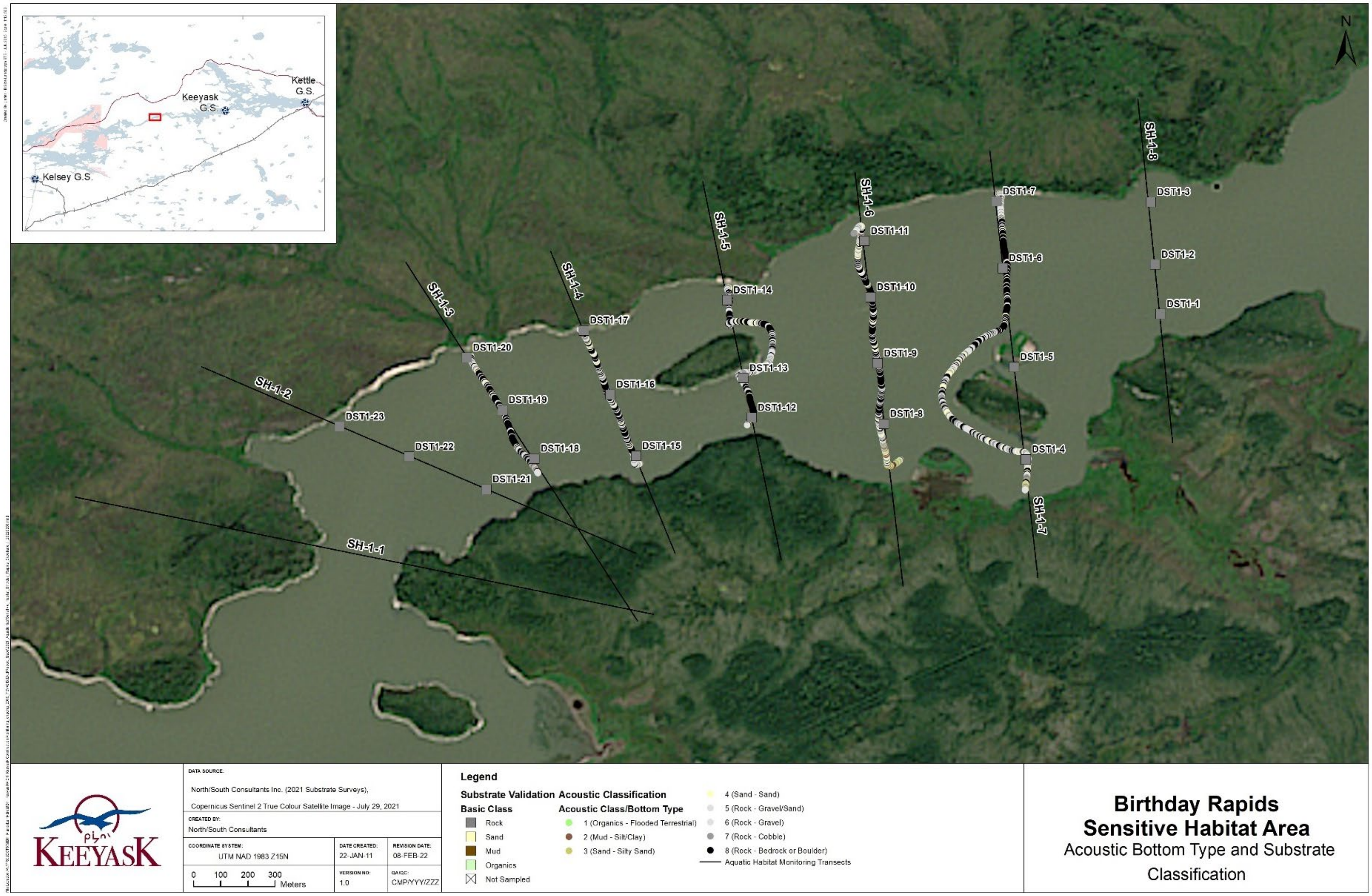
Map 4: **Classified depth averaged velocity data resulting from ADCP transect surveys at the Long Rapids sensitive habitat area, 2021.**



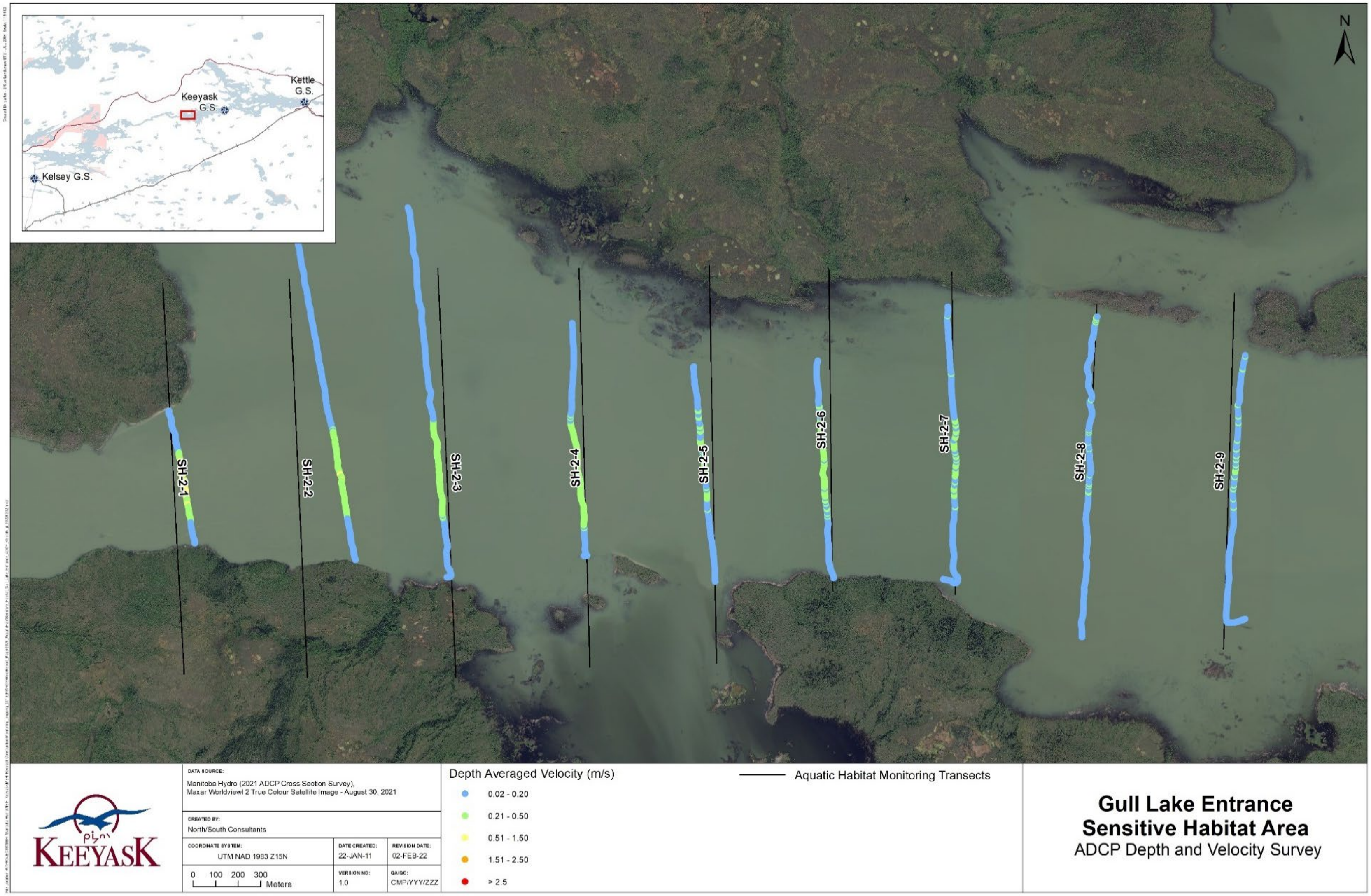
Map 5: **Classified acoustic bottom type data and substrate validation results from substrate transect surveys conducted at the Long Rapids sensitive habitat area, 2021.**



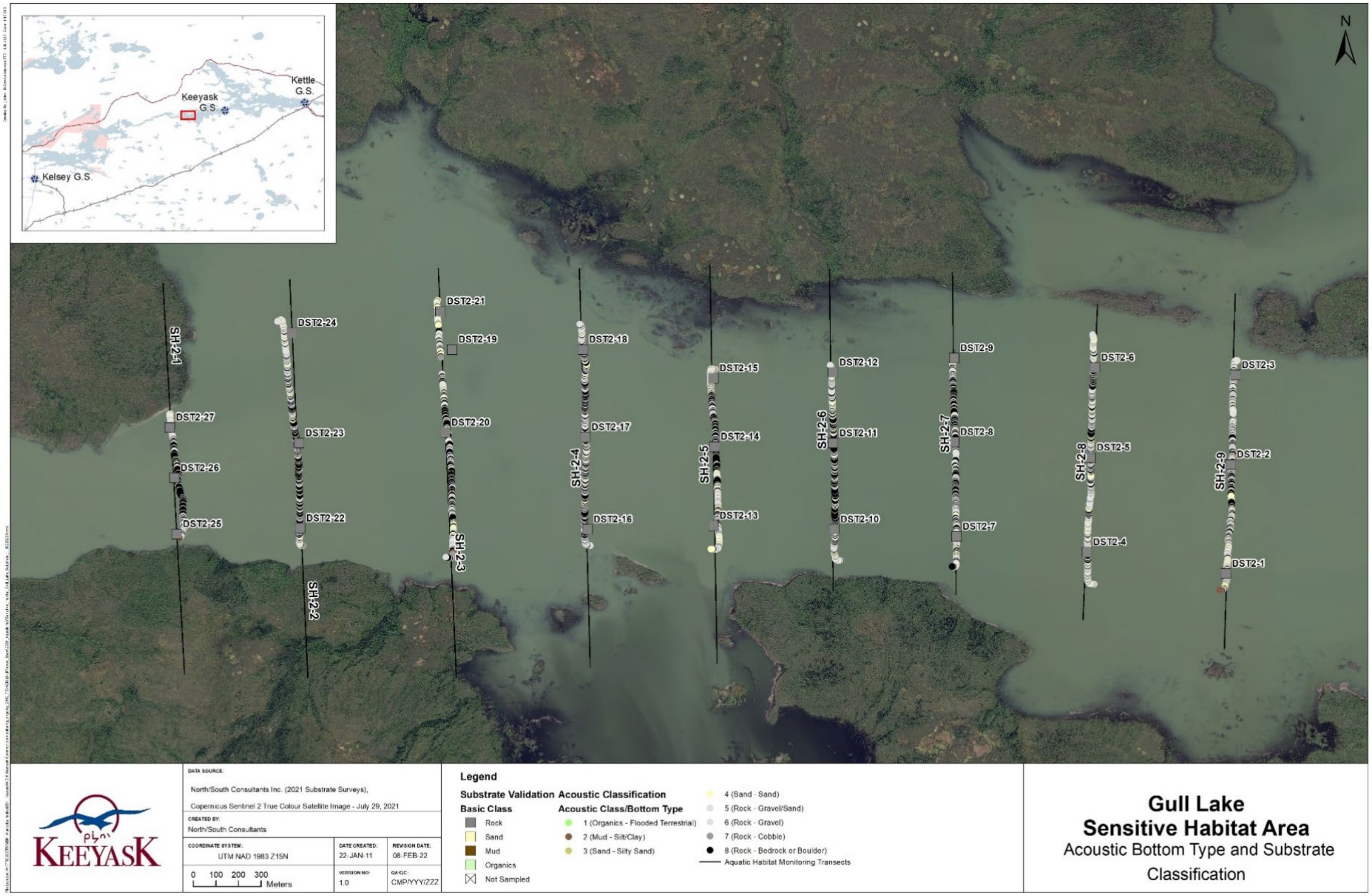
Map 6: **Classified depth averaged velocity data resulting from ADCP transect surveys in the Keeyask reservoir at the Birthday Rapids sensitive habitat area, 2021.**



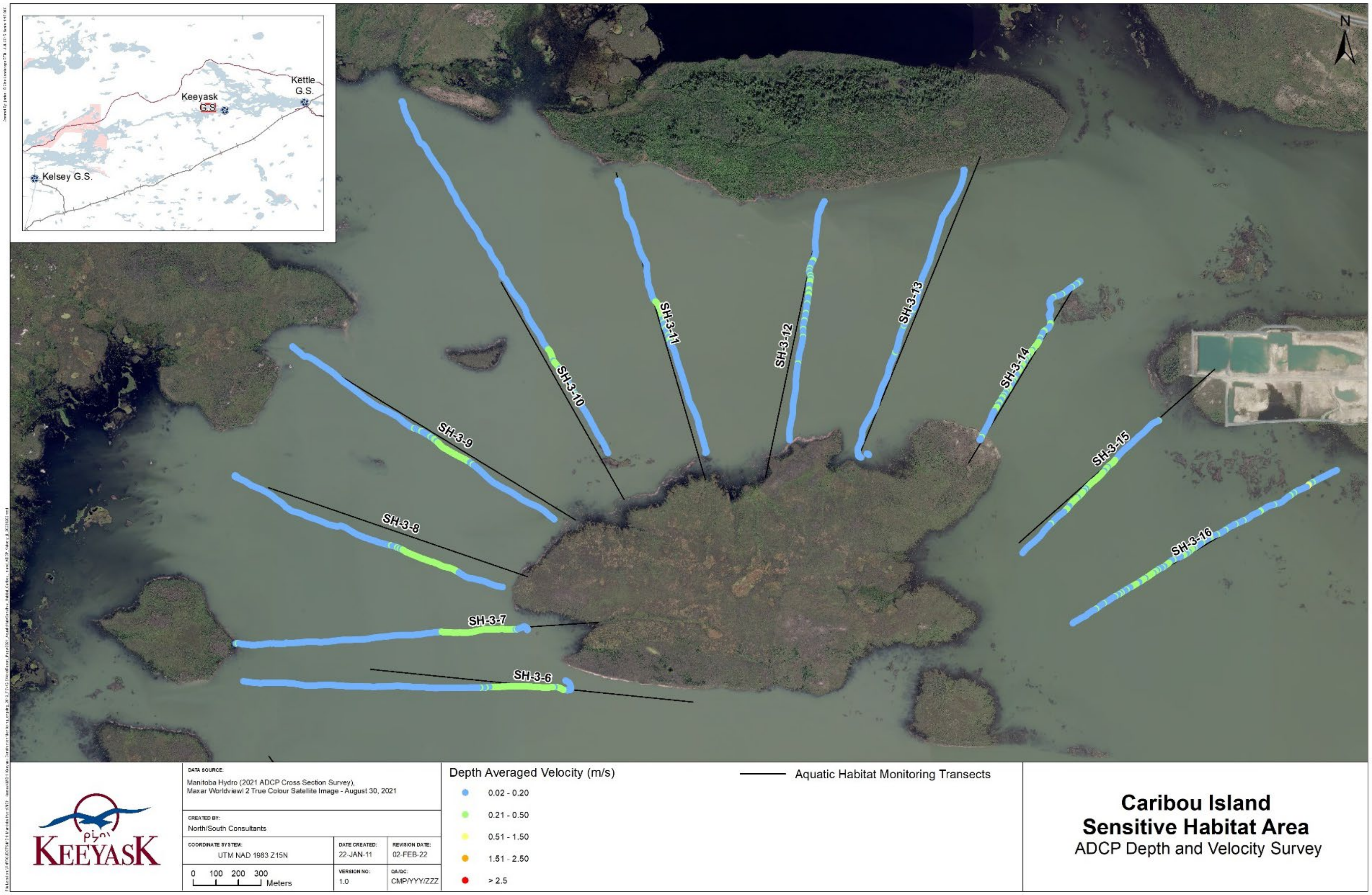
Map 7: **Classified acoustic bottom type data and substrate validation results from substrate transect surveys conducted in the Keeyask reservoir at the Birthday Rapids sensitive habitat area, 2021.**



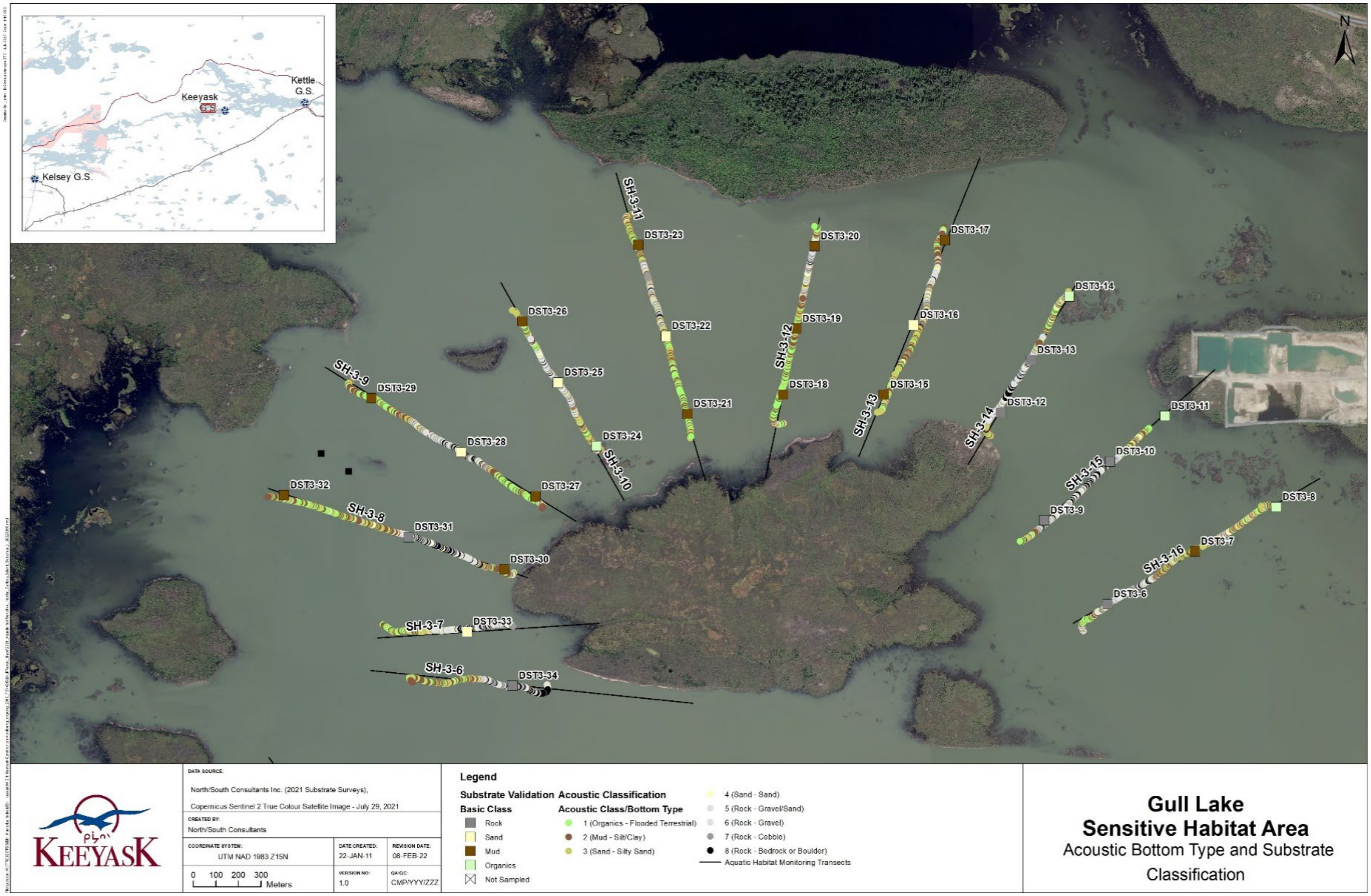
Map 8: **Classified depth averaged velocity data resulting from ADCP transect surveys in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area, 2021.**



Map 9: **Classified acoustic bottom type data and substrate validation results from substrate transect surveys conducted in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area, 2021.**

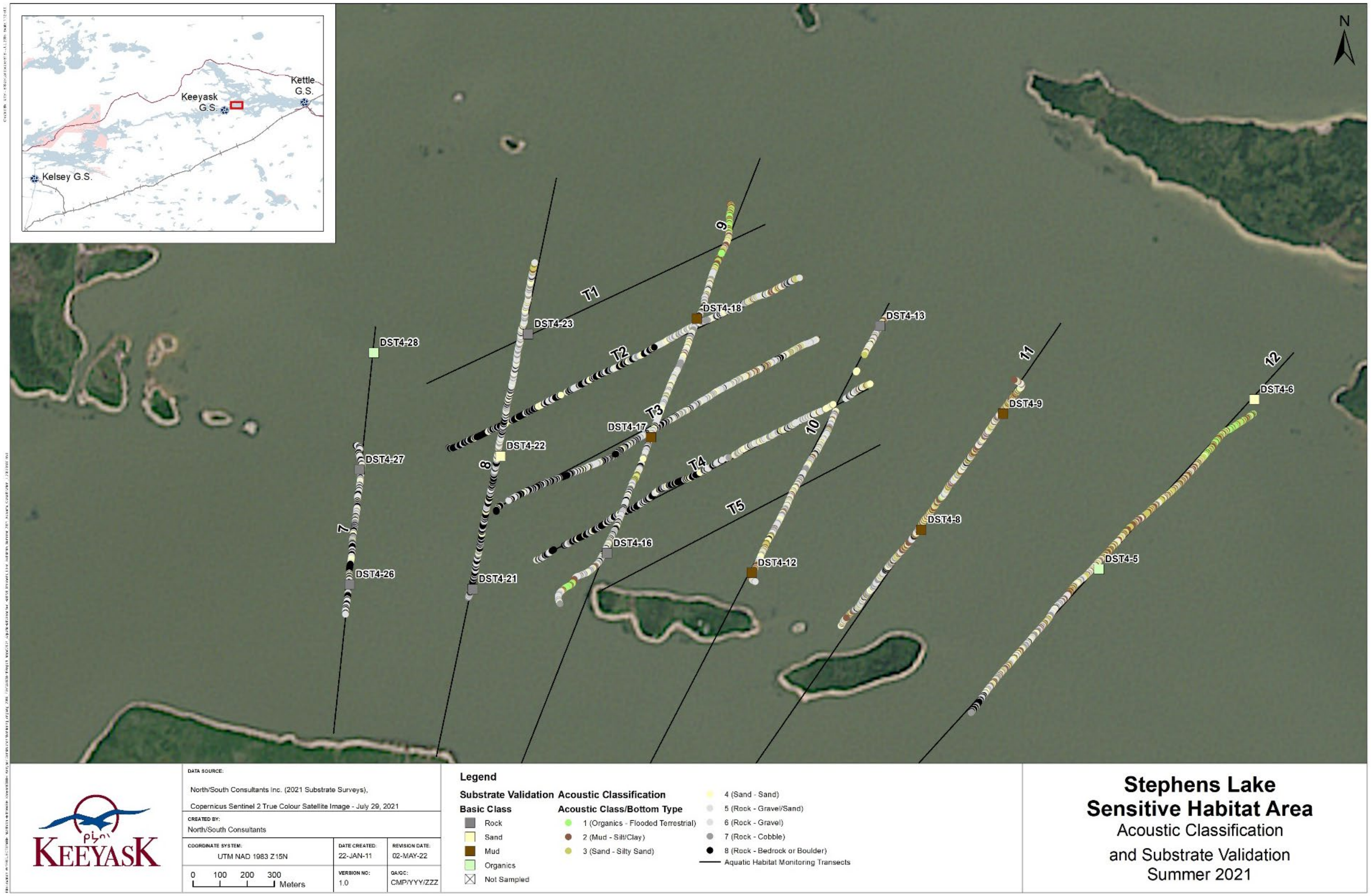


Map 10: **Classified depth averaged velocity data resulting from ADCP transect surveys in the Keeyask reservoir at the Caribou Island sensitive habitat area, 2021.**



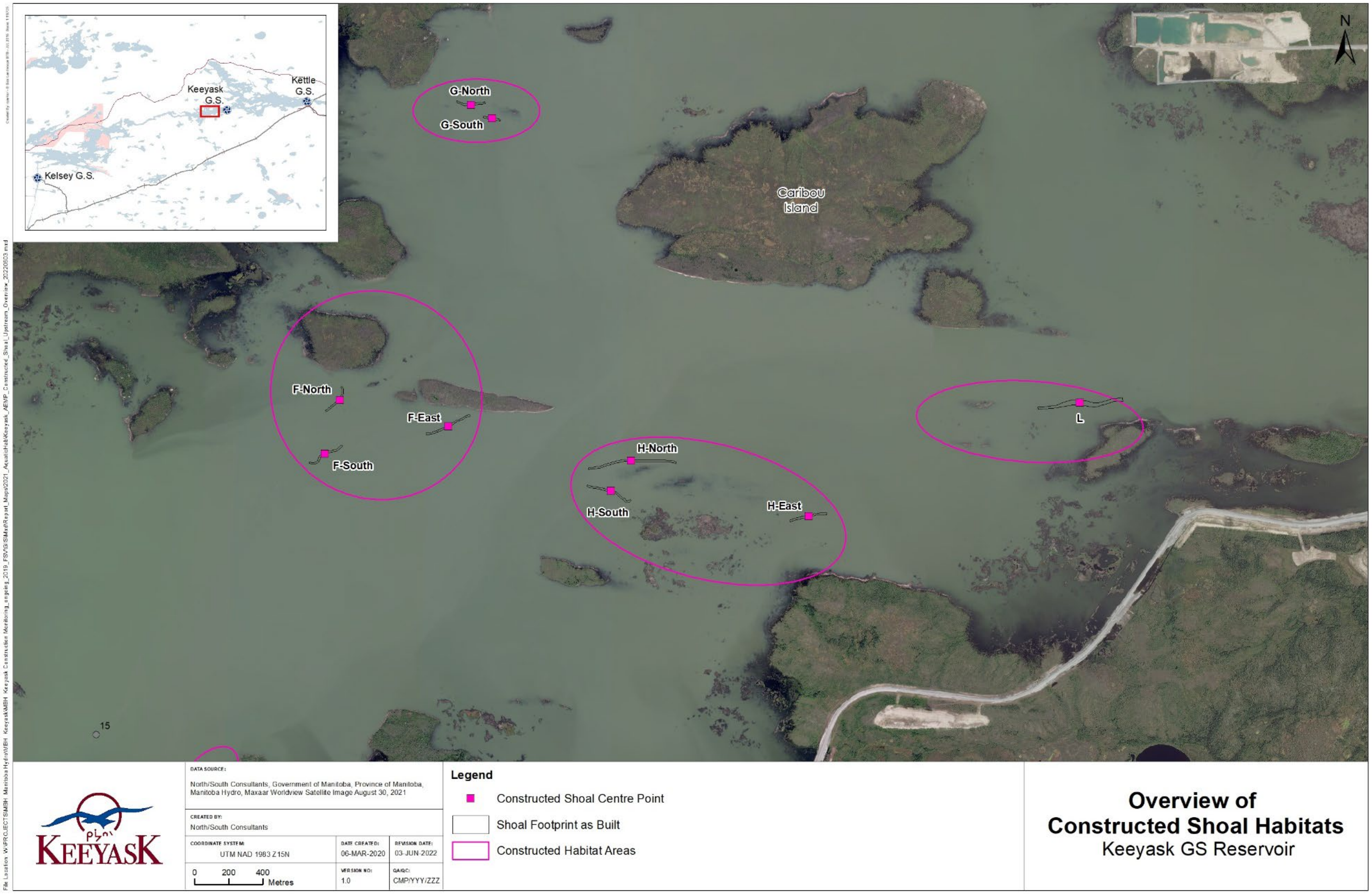
Map 11: **Classified acoustic bottom type data and substrate validation results from substrate transect surveys conducted in the Keeyask reservoir at the Caribou Island sensitive habitat area, 2021.**

Map 12: **Classified acoustic bottom type data and substrate validation results from substrate transect surveys conducted at the Stephens Lake sensitive habitat area, June 2021.**

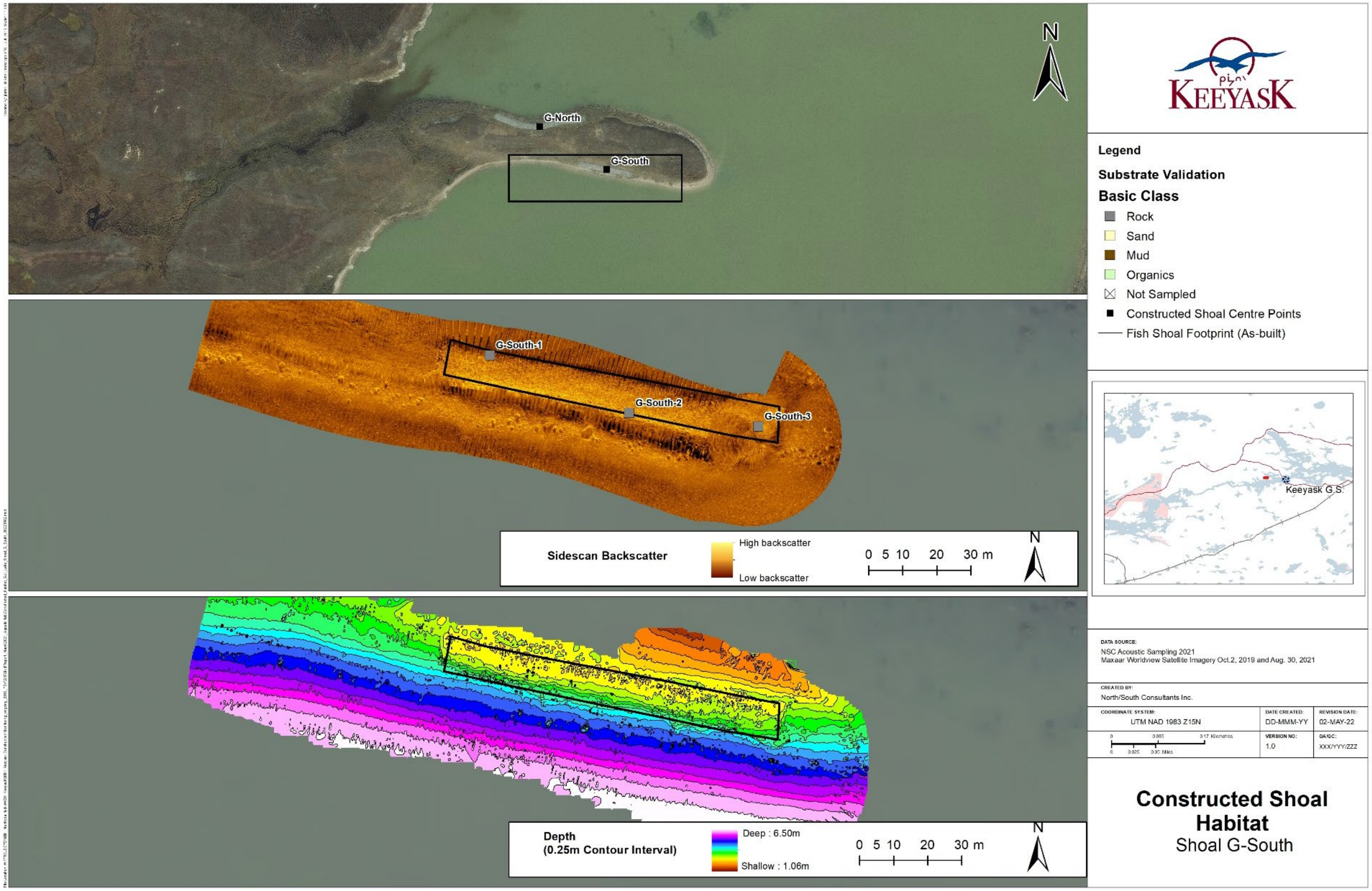


Map 13: **Classified acoustic bottom type data and substrate validation results from substrate transect surveys conducted at the Stephens Lake sensitive habitat area, August 2021.**

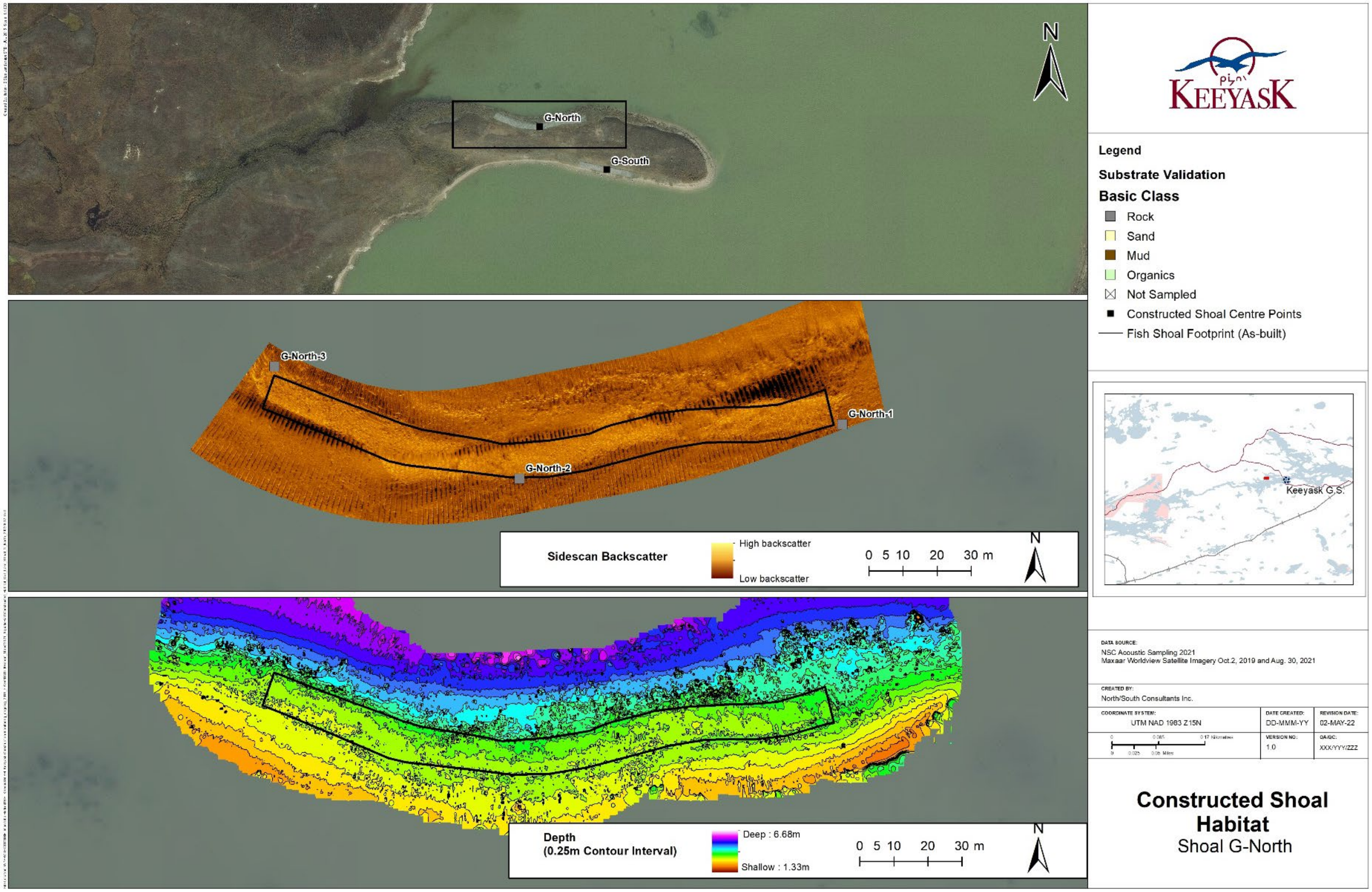
Map 14: **Classified acoustic bottom type data and substrate validation results from substrate transect surveys conducted at the Stephens Lake sensitive habitat area, September 2021.**



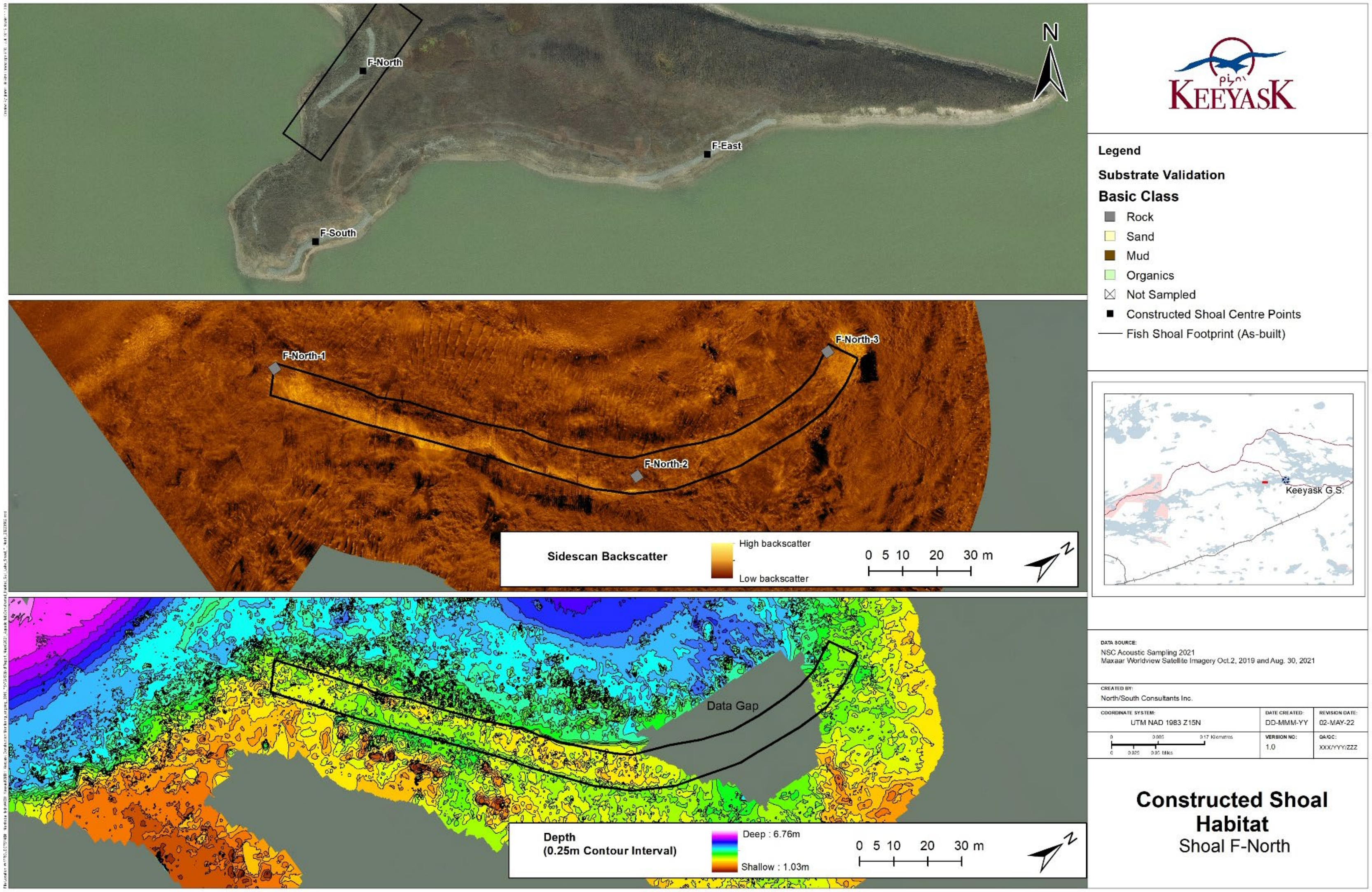
Map 15: Map of 2021 Keeyask GS reservoir constructed habitat aquatic habitat monitoring sampling areas showing their locations following reservoir impoundment.



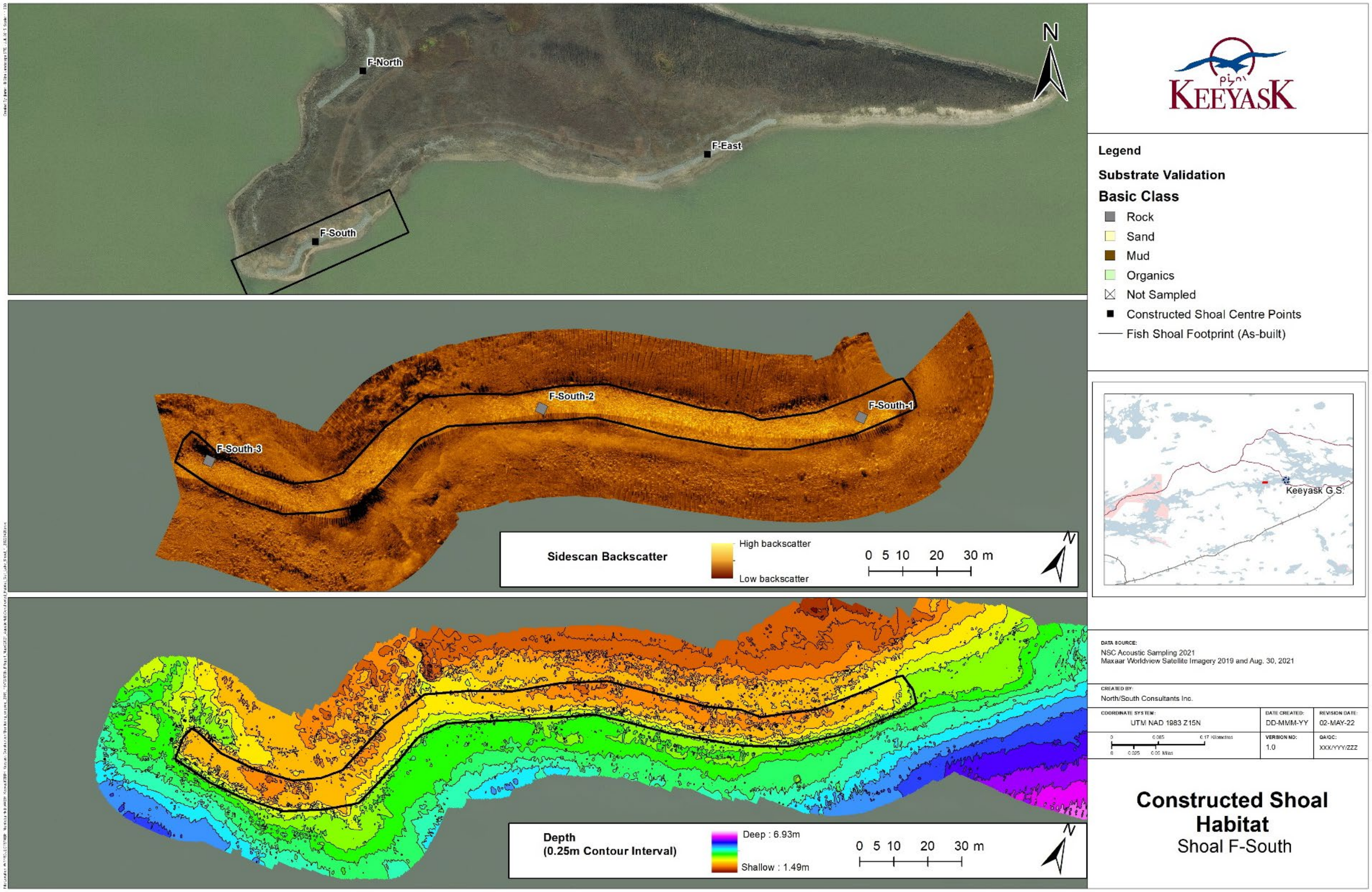
Map 16: Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the G-South shoal.



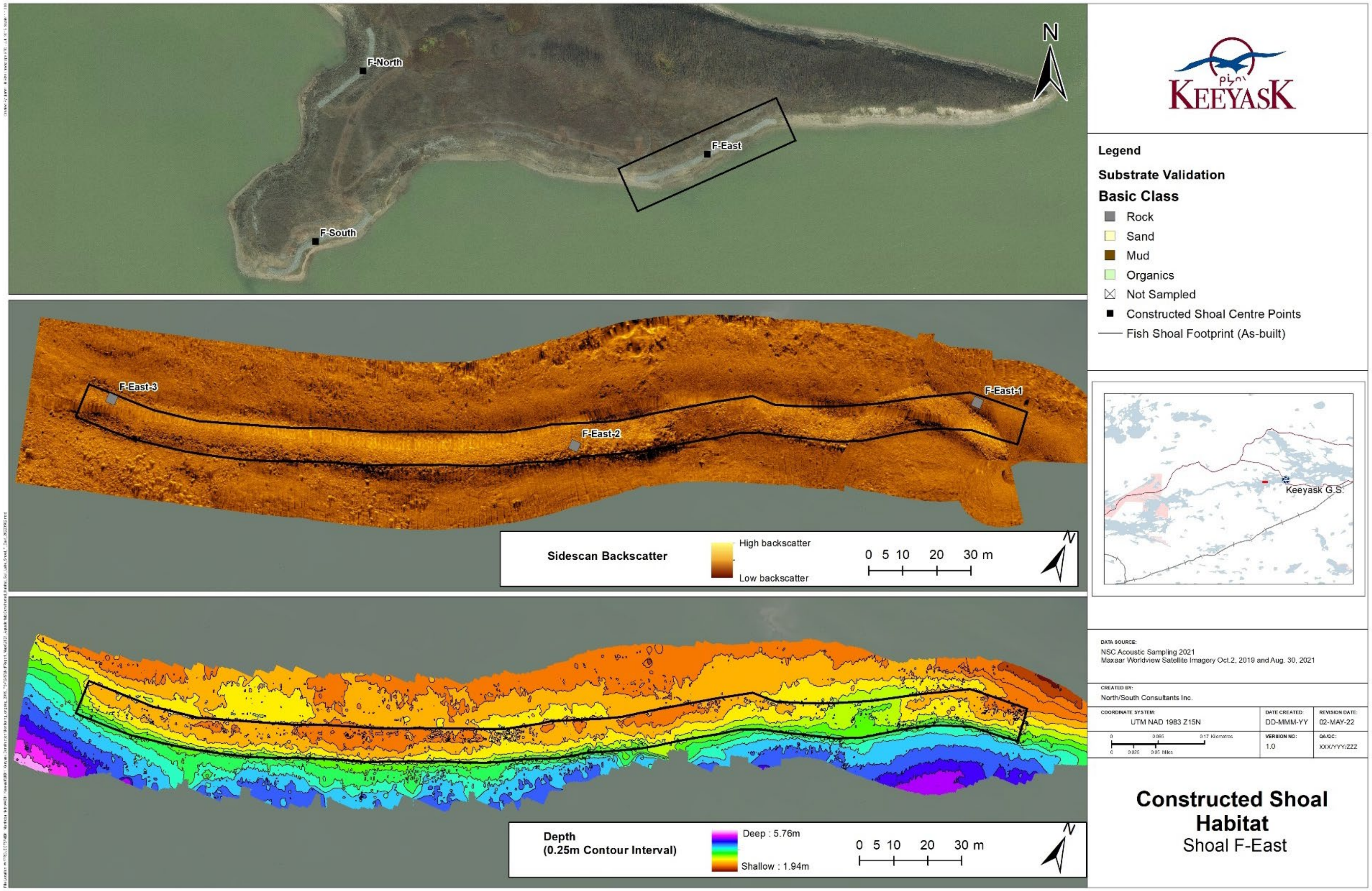
Map 17: Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the G-North shoal.



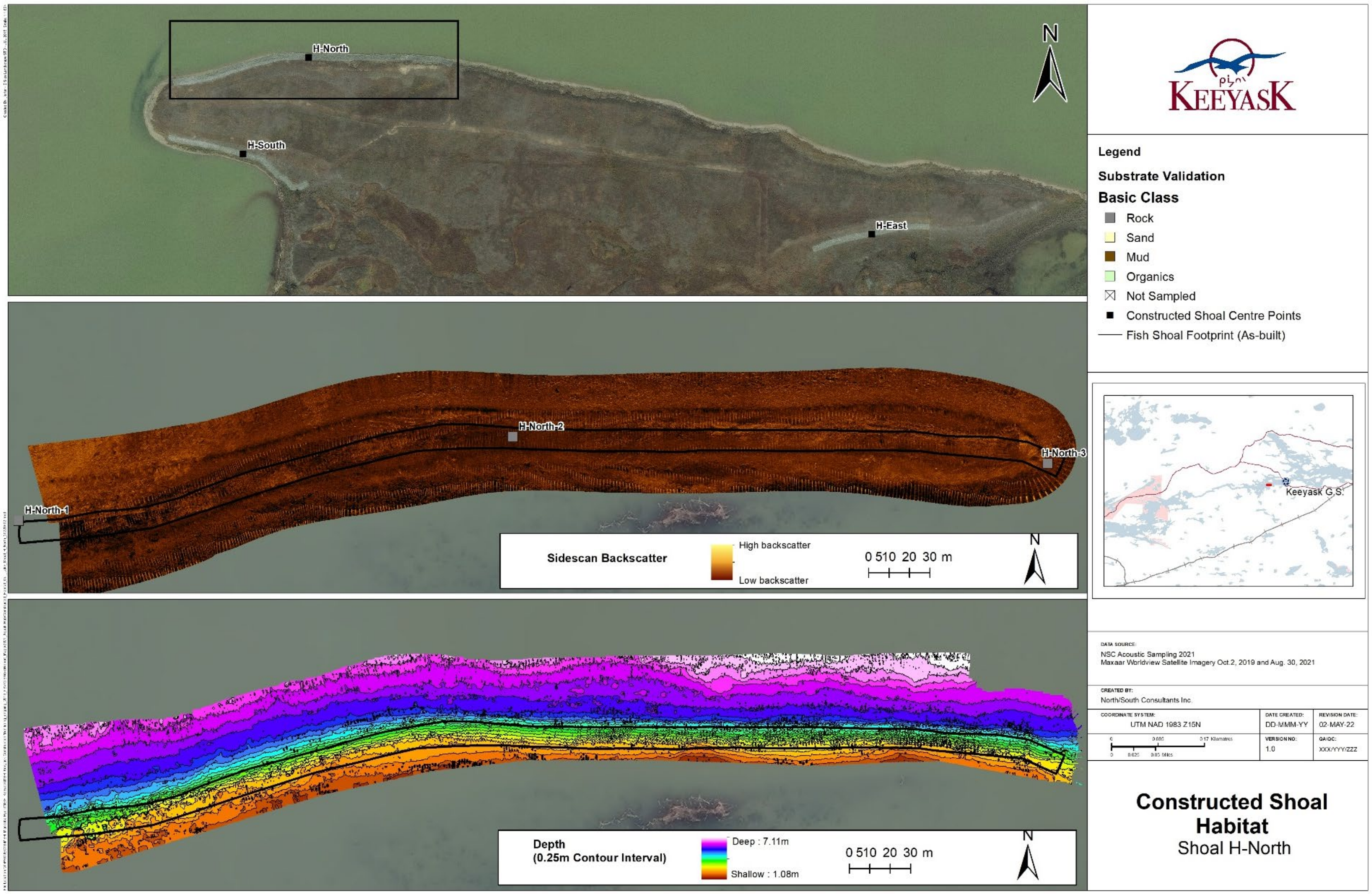
Map 18: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the F-North shoal.**



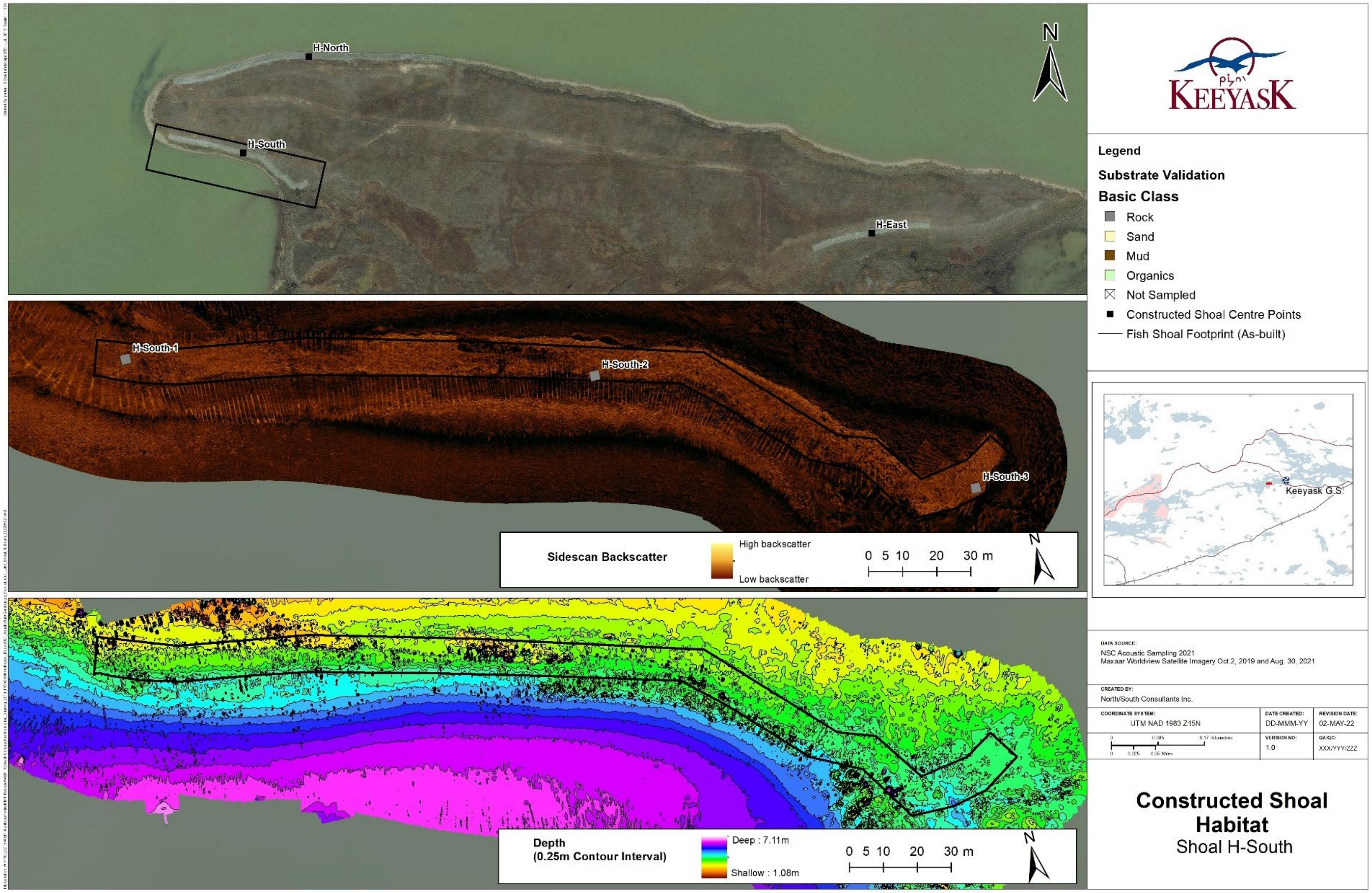
Map 19: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the F-South shoal.**



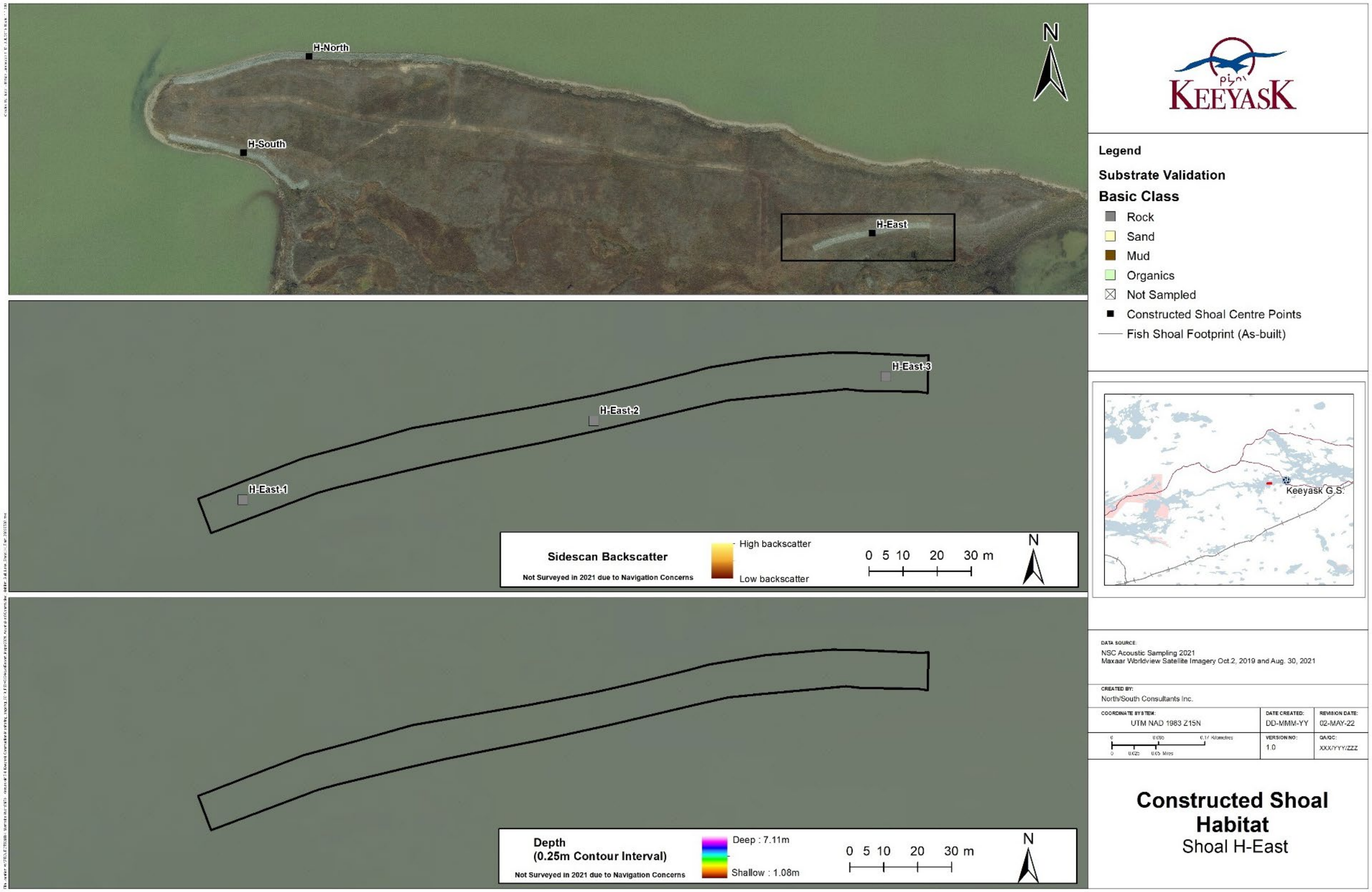
Map 20: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the F-East shoal.**



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 H-North shoal.**

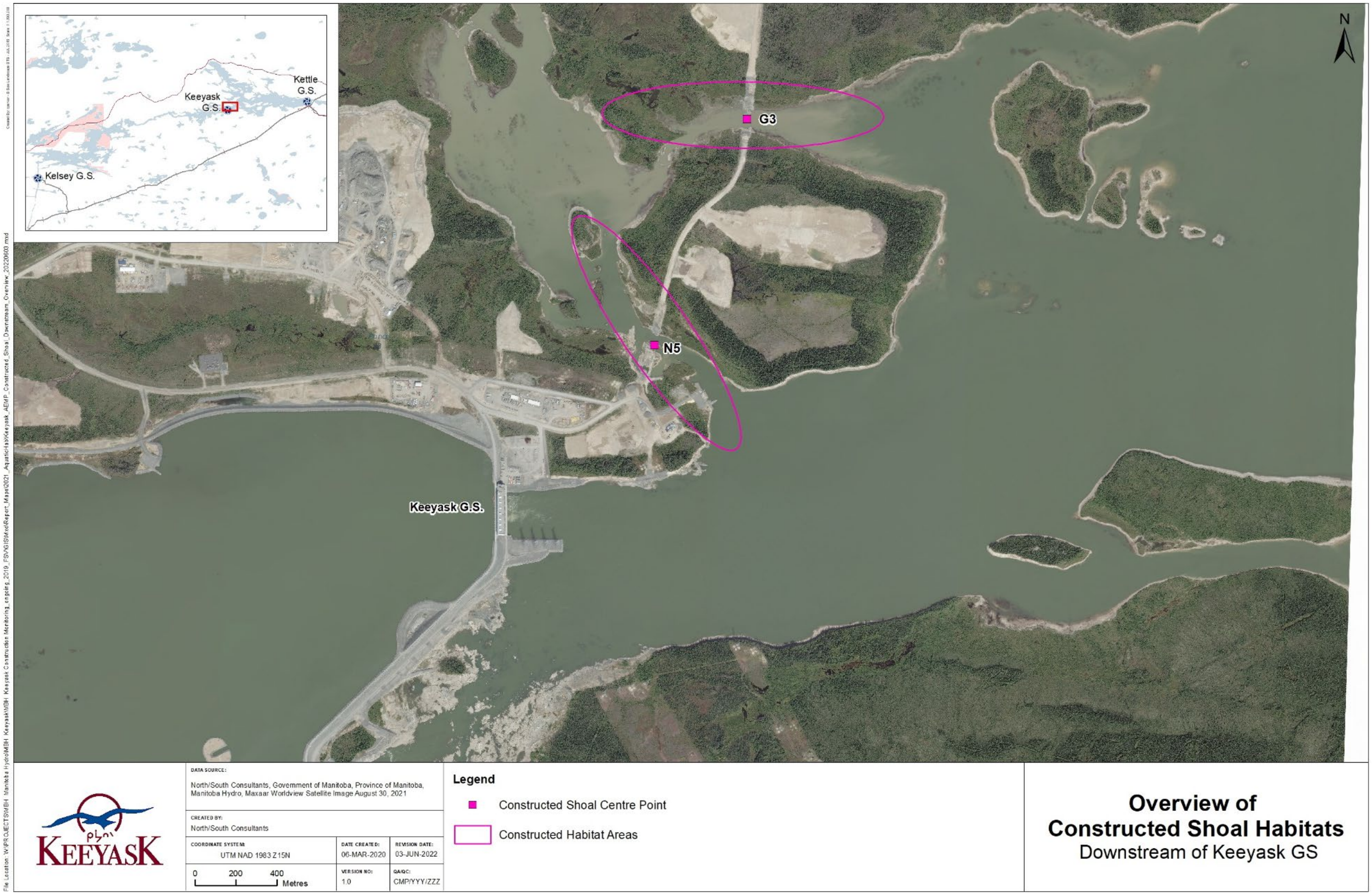


Map 22: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the H-South shoal.**



Map 23: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results and as-built shoal footprint (middle) at the H-East shoal. Sidescan and depth not captured due to navigation issues.**

Map 24: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results and as-built shoal footprint (middle), and depth data not captured due to technical issues (bottom) at the L shoal.**



Map 24: Map of 2021 Downstream of Keeyask GS constructed habitat aquatic habitat monitoring sampling sites.

Map 25: **Map illustrating the results of substrate composition sampling sites and acoustic imaging for the N5 causeway shoal in Stephens Lake, 2021.**

Map 26: **Map illustrating the results of substrate composition sampling sites and acoustic imaging for the G3 causeway shoal in Stephens Lake, 2021.**

PHOTOS

Photo 1: **Substrate collected at site DST3-33 in the area of the Keeyask reservoir surrounding Caribou Island showing sand.**

Photo 2: Substrate collected at site T3-4 in the upper Stephens Lake sensitive habitat area in June 2021 showing organics and silt.