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MUSKRAT FALLS 2010 SITE INVESTIGATIONS GEOTECHNICAL REPORT

VOLUME 1 - GENERAL REPORT

Contract no.: 15073-OB
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June 2011

SNC·LAVALIN
BAE-Newplan

LOWER CHURCHILL PROJECT

MF1300 – MUSKRAT FALLS 2010 SITE INVESTIGATIONS

VOLUME 1 – GENERAL REPORT

Document No: 503334-MF-1300-4GER-0001-0

June 2011

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EXECUTIVE SUMMARY

This report presents the field data and laboratory test results obtained during the 2010 site investigation program carried out at the site of the proposed Muskrat Falls Hydroelectric Development on the Churchill River in Labrador.

The field investigation program involved drilling through overburden and bedrock, test pitting, portable hammer sounding (Pionjar) and resistivity surveys at the proposed sites of the dam and related structures (powerhouse, spillway and channels, switchyard and converter station), at the site of the accommodations complex and at the borrow areas. Also included were topographic surveys of the north spur, structure locations, and major stream crossings on the proposed access road to the project site from the Trans Labrador Highway.

Sampling and in situ testing were carried out in soil and rock at the borehole locations. In situ testing in soils included standard penetration tests (SPT) and dynamic cone penetration tests (DCPT). In situ testing in bedrock consisted of water pressure tests and acoustic and optic televiewer surveys.

Laboratory analyses consisted of soil and rock testing of foundation and construction materials. This testing ranged from simple sieve analysis to Swedish cone tests for the clay material. Laboratory testing for construction materials was an important part of the material search, enabling the delineation of borrow areas of good quality materials and the determination of rock properties for use in concrete aggregate. The geomechanical parameters required for the excavation design in rock were obtained through a meticulous core logging program.

1 INTRODUCTION

1.1 MANDATE

Nalcor Energy retained the services of SNC-Lavalin Inc. to carry out the 2010 field investigation program at Muskrat Falls on the Churchill River in Labrador. The purpose of the campaign was to gather field data required for the final design of the Muskrat Falls Hydroelectric Development (dam and related structures). The project location is shown on Drawing no 503334-MF-1300-4GDD-0001 in Volume 6.

The field investigation program was carried out in accordance with the scope of work and execution plan set out in Work Task Order (WTO) MF1300 – 2010 Site Investigation Program.

1.2 SCOPE OF WORK

In the context of the Muskrat Falls Hydroelectric Development, the following sites were investigated: the north RCC dam, the spillway and channels on the south shore, the south RCC dam and the powerhouse with related excavations on the south shore, the switchyard, the converter station and the accommodations complex.

The site investigations were intended to collect all the outstanding data needed for the project design. The soil investigations focused on the stratigraphic nature and the geotechnical characterization of the overburden. Bedrock investigations focused on the rock mass structures and permeability that could affect open cut excavations.

Some 13 borrow areas were also investigated for characterization of available construction materials (till and granular materials).

The site investigations were complemented by a specific laboratory testing program for both soil and rock materials.

1.3 WORK ORGANIZATION AND LOGISTICS

1.3.1 Organization

In order to carry out the 2010 site investigation program at Muskrat Falls, SNC-Lavalin subcontracted the following firms specializing in site investigation work:

- Logan Drilling Limited for drilling and in situ soil testing;
- AMEC Earth and Environmental who provided a Winkie drill;
- Hickey Construction for the provision of excavators;
- Sigma Geophysics Inc. for resistivity surveys and interpretation;
- Innu Development Limited Partnership (IDLP) for the local office support, the provision of labourers (line cutters, survey assistants, etc.) and procurement support in Goose Bay;
- École Polytechnique de Montréal for rock testing; and
- Colorado School of Mines for rock testing.

The organization chart for the field campaign is presented in Figure 1.

1.3.2 Work Schedule

The field work started August 3, 2010 and was completed on October 19, 2010.

1.3.3 Investigation Results, Verification and Data Base

The data collected in the field from boreholes and test pits and the results of the laboratory analyses were compiled and subsequently verified. The information was then entered into an electronic database which was kept up to date on a regular basis and which is provided with the final report. The commercial gINT software was used for the electronic database; it also allowed the issuing of different reports such as the borehole or the test pit log and the grain size distribution log (see Volumes 2A, 2B, 2C and 2D). The original copies of the field and laboratory documents were kept at the SNC-Lavalin office in Goose Bay and later transferred to the office in Montreal where the final report was assembled.

The results of the resistivity surveys, the acoustic and optic televiewer surveys as well as some of the in situ and laboratory testing have been provided as separate reports and are included in Volumes 3A, 3B, 4 and 5 of this report.

1.3.4 Air Photo Interpretation

Prior to starting the field investigation, Poly-Géo Inc. was mandated by SNC-Lavalin to proceed with a detailed air photo analysis in order to identify and delineate potential borrow material sources along the proposed access road to the Muskrat Falls powerhouse. The air photo interpretation report is presented in Volume 4.

1.3.5 References

The following is a listing of reference documents which were used for the preparation of this report:

- Wardle, R.J. and Crisby, L., 1986, “Geology of the Goose Bay Area”, 13F/SE, Map 86-60, Scale: 1:100 000, Government of Newfoundland and Labrador, Department of Mines and Energy;
- Liverman, D.G.E., 1997, “Quaternary Geology of the Goose Bay Area”, Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Report 97-01;
- Geological Survey Department of Natural Resources of Newfoundland and Labrador, 2004, “Geological Map of Labrador”; and
- Poly-Géo Inc., 2010, “Air photo and characterization of potential borrow material sources along the proposed access road to the Muskrat Falls powerhouse, Labrador”, Preliminary technical report presented to SNC-Lavalin, 7 pages and 3 appendices.

NALCOR ENEGY
2010 Site Investigation Program

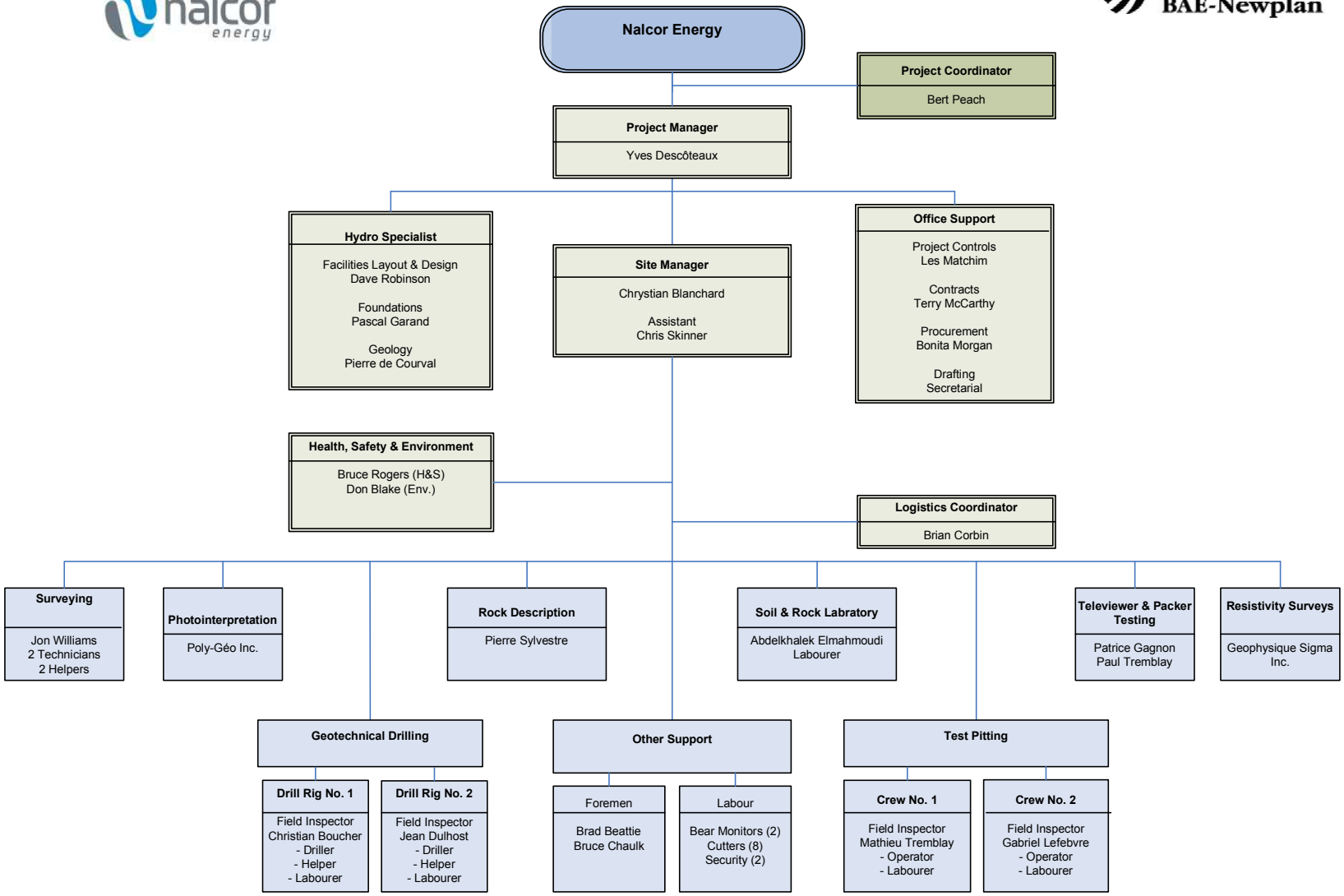


FIGURE 1 : ORGANIZATION CHART

2 FIELD INVESTIGATIONS

2.1 WORK SUMMARY

The following areas were investigated during the 2010 Muskrat Falls Site Investigations:

- The north RCC dam;
- The spillway channel, including both inlet and outlet channels on the south shore;
- The powerhouse, with the inlet and outlet channels on the south shore;
- The south RCC dam;
- The switchyard;
- The converter station;
- The accommodations complex; and
- 13 potential borrow material sources.

A field program was developed in order to acquire the data pertaining to overburden and rock properties required for the final design stage. The field program consisted of the following:

- Surveying of borehole and test pit locations;
- Drilling for overburden and rock characterization;
- In situ permeability tests in bedrock;
- Standard penetration tests (SPT) in overburden;
- Dynamic cone penetration tests (DCPT) in overburden;
- Clay sampling with Shelby tubes;
- Bedrock structural description logs;
- Downhole acoustic and optic televiewer surveys;
- Test pitting;
- Portable hammer sounding (pionjar);
- Resistivity survey;
- Laboratory testing on soil and rock samples;
- Topographic surveys of the north spur;

- Topographic surveys of the structure locations; and
- Topographic surveys of major stream crossings on the proposed access road on the south side of the Churchill River.

The work carried out is discussed in detail in the following sections of the report.

2.2 SURVEYING

The projection and datum were chosen to be consistent with previous data recorded for the project. The geoid model used was CGG200-e. The datum used was NAD 83 and the projection was UTM North, Zone 20.

A Real Time Kinematic global positioning system (RTK-GPS) was chosen to do the survey work. This RTK-GPS system consists of two GPS receivers one of which is positioned over a known point and remains stationary (base station). The second GPS receiver is free to move from point to point (rover) and provides accurate real time topographic information through the use of a correction link with the base.

For the purpose of this field program two short range Topcon Hiper Ga/Gb systems where used on site. A Pacific Crest 35 Watt radio was added in order to increase the range to bring control onto the site from Goose Bay and to survey the river crossings, most of which were over the 5 km range of the basic system. These systems meet all the requirements set out by the Association of Newfoundland Land Surveyors in the GPS standards and Guidelines for Legal Surveying.

To establish a control network on site, the base station was set up on Dome Hill, near Happy Valley-Goose Bay, in order to reduce the amount of obstructions between the base and the rover on site. This meant that the correction link would have a good “line of sight” between the base and the rover. The base was corrected to the coordinate system using the coordinate values issued by the Government of Newfoundland on monuments 388007 and 76G2736. As well monuments 98G9101 and 98G9100 were used to check the network against the LCP control that was put in place in 1998. TBM 1 and TBM 2 were established on the north side of the site. These monuments consisted of three foot wooden pegs driven completely into the sand. A nail was placed into the exposed section and occupied by the GPS receiver.

On the south side four benchmarks were grouted in the rocks using stainless steel anchors. These are labelled PBM 1 through 4. Each benchmark was occupied three times using thirty epochs for each occupation. Then a least squares adjustment was done to combine the redundant measurements and reduce the mean square errors. Once the cutting of the centerline on the main structures was completed this process was repeated to put benchmarks at locations around the dam site using one inch diameter iron re-bar. The coordinate values of these benchmarks are shown on Drawing no 503334-MF1300-41DD-0101, Volume 6. It is important to note that there is no SL1-1-10. This is due to fact that after a re-occupation near the end of the job this monument was found to be in error. The reason for this is un-clear however it may have been knocked out of place over the course of field operations in the area.

Surveying conducted during the 2010 field investigations was performed by crews composed of 1 surveyor, assisted by workers from the local aboriginal communities.

At the sites of the main structures (dam, spillway channels, powerhouse, switchyard and converter station), RTK-GPS was used throughout the fieldwork program to locate boreholes, test pits, seismic lines and record topographic information. Typically, before drilling or test pitting, each borehole or test pit was first located on a leveled area and the coordinates and grade elevation were recorded using the RTK GPS receiver. The borehole or test pit location was then set out by driving a stake clearly identifying the sounding to be carried out. In the case of inclined boreholes, the plunge azimuth was indicated using a front sight stick. Once drilling or test pitting was completed, the location of the sounding (coordinates, grade elevation) was determined again using the RTK GPS receiver.

At the accommodations complex site and in borrow areas, the coordinates of boreholes and test pits were surveyed using a portable handheld GPS. Depending on the quality of the satellite signal at the time of its pick up, the precision of the coordinates given by the portable GPS can vary between 3 and 10 m. Ground elevations were not recorded at the location of the soundings, as the portable GPS is not sufficiently accurate for this purpose.

Topographic surveys were carried out on the north spur. The locations of the topographic surveys are shown on Drawing no 503334-MF1300-41DD-0102, Volume 6.

Surveys were carried out on the major stream crossings on the proposed access road along the south side of the Churchill River to the project site from the Trans Labrador Highway. The locations of the stream crossing surveys are shown on Drawing no 503334-MF1300-41DD-0103, Volume 6. Topographic surveys were also carried out at structure locations including the dam, the spillway and channels, the powerhouse, the switchyard and the converter station. CAD files of the topographic surveys and stream crossings are included on a disc appended to Volume 6.

2.3 RESISTIVITY SURVEYS

Sigma Geophysics Inc. (Sigma) was mandated by SNC-Lavalin to perform resistivity surveys at the proposed sites for the powerhouse and the switchyard at Muskrat Falls. The field method and the results of the surveys are contained in Sigma's report which is included in Volume 4.

2.4 TEST PITTING

2.4.1 Work Performed

A total of 121 test pits were excavated at the sites of the main structures (dam, powerhouse, switchyard, converter station, spillway and channels) at the accommodations complex and at the borrow areas (granular and till). The materials encountered during the excavations were visually assessed and described. Whenever possible, grab samples were retrieved from the test pits and taken to the Site Laboratory for natural moisture content determinations and particle size analyses down to the 200 mesh size (0.075 mm). Once the excavation and sampling was completed, the test pits were backfilled and compacted with particular care using the excavated material.

Table 1 is a list of test pits that were excavated during the 2010 field program.

TABLE 1: 2010 INVESTIGATIONS – LIST OF TEST PITS

SITE	NUMBER OF TEST PITS	LISTING OF TEST PITS
North RCC dam	1	TP-1-10
South RCC dam	-	
Spillway and channels	4	TP-5-10 to TP-8-10
Powerhouse and channels	8	TP-9-10, TP-10-10 and TP-12-10 to TP-17-10
Switchyard	8	SY-TP-2-10 to SY-TP-9-10
Converter station	16	CS-TP-1-10 to CS-TP-16-10
Accommodations complex	16	AC-TP-2-10 to AC-TP-4-10, AC-TP-6-10, AC-TP-8-10, AC-TP-13-10, AC-TP-16-10, AC-TP-17-10, AC-TP-20-10, AC-TP-21-10, AC-TP-26-10 to AC-TP-28-10, AC-TP-30-10, AC-TP-31-10 and AC-TP-33-10
Borrow Area TD-4 (till)	9	TD-4-TP-1-10 to TD-4-TP-9-10
Borrow Area TD-5 (till)	4	TD-5-TP-1-10 to TD-5-TP-4-10
Borrow Area TD-6 (till)	2	TD-6-TP-1-10 and TD-6-TP-2-10
Borrow Area TD-7 (till)	3	TD-7-TP-1-10 to TD-7-TP-3-10
Borrow Area TD-8 (till)	3	TD-8-TP-1-10 to TD-8-TP-3-10
Borrow Area TD-11 (till)	2	TD-11-TP-1-10 and TD-11-TP-2-10
Borrow Area GD-7 (granular material)	4	GD-7-TP-1-10 to GD-7-TP-4-10
Borrow Area GD-8 (granular material)	5	GD-8-TP-1-10 to GD-8-TP-5-10
Borrow Area GD-10 (granular material)	4	GD-10-TP-1-10 to GD-10-TP-4-10
Borrow Area GD-11 (granular material)	10	GD-11-TP-1-10 to GD-11-TP-10-10
Borrow Area GR-5 (granular material)	22	GR-5-TP-1-10 to GR-5-TP-22-10

2.4.2 Methodology

All of the test pits were excavated by means of a Takeuchi TB-108 mini-excavator with a maximum digging depth of 3.5 m. The mini-excavator was airlifted around the site using an Astar helicopter.

2.4.3 Soil Description

Each test pit was excavated under the supervision of a field inspector who carried out the following tasks:

- Visual description of the encountered soils: Cobble and boulder percentages were determined visually;
- Sampling of the encountered soils: At least one 20 kg to 30 kg grab sample was collected within the strata encountered underneath the layer of topsoil or oxidized soil for the realisation of particle size analyses and standard Proctor compaction tests. In the borrow area test pits, 1 kg of soil was generally taken at each meter in order to determine the soil native moisture content;
- Taking note of all pertinent information regarding groundwater infiltration and wall stability (sloughing);
- Taking photographs of the test pit as well as the excavation cuttings; and
- Supervising the backfilling of the test pit while making sure the surficial topsoil layer was put back at grade level.

The locations of all test pits are indicated on Drawings nos 503334-MF-1300-4GDD-0001, 503334-MF-1300-4GDD-0003, 503334-MF-1300-4GDD-0005, 503334-MF-1300-4GDD-0006 and 503334-MF-1300-4GDD-0007 (Volume 6). Test pit logs, including gradation curves and photographs, are included for each main structure area in Volumes 2A to 2D.

2.5 PORTABLE HAMMER SOUNDING (PIONJAR)

2.5.1 Work Performed

A total of 15 soundings with a portable hammer drill (Pionjar) were carried out at the sites of the north RCC dam (3 soundings) and at the accommodation complex

(12 soundings). Table 2 presents the results of these 15 portable hammer drill soundings.

TABLE 2: PORTABLE HAMMER DRILL SOUNDING

SITE	SOUNDING NO.	COORDINATES UTM NAD83		REFUSAL DEPTH (m)		
		East	North	West (1)	Center	East (1)
North RCC dam	P-1-10	648854	5902225	1.46	1.34	1.90
	P-2-10	648762	5902184	8.1	8.03	7.43
	P-3-10	648767	5902163	5.69	3.51 (2)	6.00
Accommodations complex	AC-P-1-10	650980	5900945		>8.10	
	AC-P-2-10	650903	5900920		>10.10	
	AC-P-3-10	650828	5900908		>10.10	
	AC-P-4-10	650790	5900902		>10.10	
	AC-P-5-10	650733	5900890		>10.10	
	AC-P-6-10	650701	5900914		>8.10	
	AC-P-7-10	650405	5900880		>3.10	
	AC-P-8-10	650470	5900848		>3.10	
	AC-P-9-10	650535	5900767		>4.10	
	AC-P-10-10	650572	5900740	2.29	2.85	2.47
	AC-P-11-10	650623	5900723		>5.10	
	AC-P-12-10	650775	5900688		>4.10	

Notes 1: Additional test carried out on the east side or the west side of the first test, at a distance of about 1 to 1.5 m.
2: The refusal at depth of 3.51 m is probably obtained on a cobble or boulder.

2.5.2 Methodology

Pionjar sounding consists of driving a steel rod, 25 mm in diameter, into the subsoil until a practical refusal is obtained or a specified depth is reached. For these investigations, when refusal was obtained before the specified depth, additional tests were carried out at a distance of about 1 to 1.5 m westward and eastward from the

first test. The locations of the portable hammer drill soundings are shown on Drawings nos 503334-MF-1300-4GDD-0001 and 503334-MF-1300-4GDD-0003 (Volume 6).

2.6 DRILLING

2.6.1 Work Performed

A total of 51 vertical or inclined boreholes were drilled during the course of the 2010 site investigation at Muskrat Falls. Initially, 26 boreholes were planned. However, during the course of the field work, some adjustments were deemed necessary based on preliminary results in conjunction with the data required for the project. Then, only 18 boreholes from the original program were carried out and 33 new boreholes were added.

Three (3) boreholes were located on the Churchill River's north bank for the investigation of the north RCC dam.

On the south bank, 48 boreholes were drilled for the investigation of the structures and channels distributed as follows: the North RCC dam (1), the spillway and channels (4), the powerhouse and channels (8), the south RCC dam (9), the switchyard (7), the converter station (11) and the accommodations complex (8).

Table 3 gives the characteristics of each of the 51 boreholes which were completed during the 2010 site investigations at Muskrat Falls (site, coordinates, hole inclination and azimuth, lengths through overburden and bedrock). It is to be pointed out that the azimuth and hole inclination values given in Table 3 are theoretical values and they can be somewhat different from those indicated on Table 1 of Volume 3A, which were obtained through televiewer surveys. Table 4 is a summary of the sampling and in situ testing program which was conducted in the boreholes. Sampling and testing methods for overburden and bedrock are discussed in subsections 2.6.3 and 2.6.4, respectively.

2.6.2 Methodology

Boreholes were drilled under the supervision of a field inspector, who produced daily reports on drilling procedures, sampling and in situ testing. The overall technical operations were coordinated by the site geologist.

Different drill rigs were employed for overburden and rock drilling. Rotary drills with diamond bits were used for boreholes having to penetrate into bedrock. A Winkie drill was employed mainly for overburden drilling and sampling at shallow depths.

2.6.2.1 Winkie Drilling

Twenty-four (24) boreholes were drilled using the Winkie drill, without any casing. In these boreholes, soils were sampled in a continuous sequence with a 51 mm O.D. split spoon sampler, until refusal was obtained or the hole collapsed. When the hole collapsed, the borehole was extended by a dynamic cone penetration test.

In the 24 boreholes, refusals to split spoon sampler or dynamic cone penetration were obtained at depths varying between 1.52 and 18.26 m.

2.6.2.2 Diamond Drilling

Diamond drilling was generally carried out using NW casing (76 mm inside diameter) and NQ double-tube core barrel for rock drilling (48 mm diameter core size). The length of each run into bedrock was either 1.5 m or 3.1 m. Two (2) Duralite 1000 N drill rigs were assigned to drill the 27 boreholes, ranging in depth from 9.16 m to 180.27 m.

TABLE 3: MUSKRAT FALLS SITE INVESTIGATIONS – BOREHOLE CHARACTERISTICS

SITE	HOLE NO.	COORDINATES UTM NAD83		AZIMUTH (°)	HOLE INCLINATION (1) (°)	DRILLING (m)			
		East	North			Planned	Drilled	Overburden	Rock
North RCC dam	BH-1-10	648774	5902218	330	49	52	58.12	1.86	56.26
	BH-2-10	648771	5902220	154	81	30	30.15	7.03	23.12
	BH-3-10	648853	5902131	143	30	179	169.31	0	169.31
	BH-4-10	649051	5901901	324	29	179	180.27	0	180.27

TABLE 3: MUSKRAT FALLS SITE INVESTIGATIONS – BOREHOLE CHARACTERISTICS

SITE	HOLE NO.	COORDINATES UTM NAD83		AZIMUTH (°)	HOLE INCLINATION [1] (°)	DRILLING (m)			
		East	North			Planned	Drilled	Overburden	Rock
South RCC dam	BH-5-10	649230	5901537	-	90	28	30.53	3.82	26.71
	BH-6-10	649213	5901408	-	90	28	33.60	10.24	23.36
	BH-19-10	649190	5901271	-	90	[2]	21.62	9.17	12.49
	BH-25-10	649171	5901161	-	90	[2]	30.70	15.15	15.55
	BH-26-10	649086	5901547	-	90	[2]	17.18	2.16	15.02
	BH-27-10	649056	5901443	-	90	[2]	19.17	3.76	15.41
	BH-31-10	649329	5901649	-	90	[2]	4.34	4.34	-
	BH-32-10	649241	5901609	-	90	[2]	2.44	2.44	-
	BH-33-10	649221	5901488	-	90	[2]	11.61	11.61	-
Spillway and channels	BH-7-10	648879	5901798	345	60	35	35.20	0	35.20
	BH-8-10	649014	5901765	-	90	25	27.55	2.43	25.12
	BH-9-10	649090	5901906	171	60	46	55.09	0	55.09
	BH-10-10	649228	5901954	165	70	43	50.67	0.85	49.82
Powerhouse and channels	BH-11-10	649109	5901827	25	70	57	57.24	3.26	53.98
	BH-12-10	649245	5901765	101	58	70	71.03	8.60	62.43
	BH-13-10	649321	5901925	182	70	47	49.66	0.05	49.61
	BH-14-10	649217	5901702	271	75	35	61.95	2.10	59.85
	BH-15-10	648830	5901763	162	70	20	24.12	1.74	22.38
	BH-16-10	648663	5901742	-	90	20	21.33	1.69	19.64
	BH-17-10	648823	5901641	-	90	28	29.25	8.98	20.27
	BH-18-10	648995	5901572	196	43	46	45.13	3.15	41.98
Converter station	CS-BH-1-10	649636	5901173	-	90	[2]	11.28	11.28	-
	CS-BH-2-10	649512	5901317	-	90	[2]	5.64	5.64	-
	CS-BH-3-10	649418	5901093	-	90	[2]	10.49	10.49	-
	CS-BH-4-10	649669	5900993	-	90	[2]	18.26	18.26	-
	CS-BH-5-10	649534	5901134	-	90	[2]	17.12	17.12	-
	CS-BH-20-10	649569	5901141	-	90	[2]	24.63	14.12	10.51
	BH-21-10	649702	5901353	-	90	[2]	25.59	14.72	10.87
	BH-22-10	649825	5901556	-	90	[2]	10.44	0.47	9.97
	BH-28-10	649456	5901516	-	90	[2]	6.07	6.07	-
	BH-29-10	649548	5901441	-	90	[2]	6.68	6.68	-
	BH-30-10	649429	5901397	-	90	[2]	2.06	2.06	-

TABLE 3: MUSKRAT FALLS SITE INVESTIGATIONS – BOREHOLE CHARACTERISTICS

SITE	HOLE NO.	COORDINATES UTM NAD83		AZIMUTH (°)	HOLE INCLINATION [1] (°)	DRILLING (m)			
		East	North			Planned	Drilled	Overburden	Rock
Switchyard	SY-BH-1-10	649465	5901794	-	90	[2]	2.69	2.69	-
	SY-BH-2-10	649566	5901700	-	90	[2]	7.19	7.19	-
	SY-BH-3-10	649469	5901604	-	90	[2]	4.37	4.37	-
	SY-BH-4-10	649359	5901693	-	90	[2]	5.44	5.44	-
	SY-BH-5-10	649468	5901702	-	90	[2]	5.89	5.89	-
	BH-23-10	649354	5901695	-	90	[2]	13.77	4.61	9.16
	BH-24-10	649573	5901693	-	90	[2]	23.00	12.85	10.15
Accommodations Complex	AC-BH-1-10	650965	5900900	-	90	[2]	6.71	6.71	-
	AC-BH-2-10	651045	5900713	-	90	[2]	1.52	1.52	-
	AC-BH-3-10	650916	5900817	-	90	[2]	6.71	>6.71	-
	AC-BH-4-10	650763	5900797	-	90	[2]	6.71	>6.71	-
	AC-BH-5-10	650606	5900789	-	90	[2]	6.71	>6.71	-
	AC-BH-6-10	650626	5900839	-	90	[2]	6.71	>6.71	-
	AC-BH-7-10	650567	5900856	-	90	[2]	6.71	>6.71	-
	AC-BH-8-10	650537	5900785	-	90	[2]	6.05	6.05	-

Notes 1: The inclination angle is measured from the horizontal.
2: Borehole not included in the original investigation program.

TABLE 4: MUSKRAT FALLS SITE INVESTIGATIONS – IN SITU TESTING PROGRAM

SITE	HOLE NO.	HOLE INCLINATION [1] (°)	OVERBURDEN IN SITU TESTING			ROCK IN SITU TESTING		
						Water Tests		Cameras
			SPT	DCPT	Shelby	Lugeon (5 pressure steps)	1 pressure step	
North RCC dam	BH-1-10	50				X		X
	BH-2-10	80				X		X
	BH-3-10	30				X	X	X
	BH-4-10	30				X	X	X
South RCC dam	BH-5-10	90	X			X		X
	BH-6-10	90	X			X		X
	BH-19-10	90	X					
	BH-25-10	90	X					

TABLE 4: MUSKRAT FALLS SITE INVESTIGATIONS – IN SITU TESTING PROGRAM

SITE	HOLE NO.	HOLE INCLINATION [1] (°)	OVERBURDEN IN SITU TESTING			ROCK IN SITU TESTING		
						Water Tests		Cameras
			SPT	DCPT	Shelby	Lugeon (5 pressure steps)	1 pressure step	
South RCC dam (continued)	BH-26-10	90	X					
	BH-27-10	90	X					
	BH-31-10	90	X	X				
	BH-32-10	90	X					
	BH-33-10	90	X	X				
Spillway and channels	BH-7-10	60					X	X
	BH-8-10	90	X			Cancelled		Cancelled
	BH-9-10	60					X	X
	BH-10-10	70					X	X
Powerhouse and channels	BH-11-10	70				X		X
	BH-12-10	60				X		X
	BH-13-10	70					X	X
	BH-14-10	75				X		X
	BH-15-10	70					X	X
	BH-16-10	90	X				X	X
	BH-17-10	90	X				X	X
	BH-18-10	50					X	X
Converter station	CS-BH-1-10	90	X	X				
	CS-BH-2-10	90	X	X				
	CS-BH-3-10	90	X	X				
	CS-BH-4-10	90	X	X				
	CS-BH-5-10	90	X	X				
	CS-BH-20-10	90	X		X			
	BH-21-10	90	X					
	BH-22-10	90	X					
	BH-28-10	90	X	X				
	BH-29-10	90	X	X				
	BH-30-10	90	X	X				

TABLE 4: MUSKRAT FALLS SITE INVESTIGATIONS – IN SITU TESTING PROGRAM

SITE	HOLE NO.	HOLE INCLINATION [1] (°)	OVERBURDEN IN SITU TESTING			ROCK IN SITU TESTING		
						Water Tests		Cameras
			SPT	DCPT	Shelby	Lugeon (5 pressure steps)	1 pressure step	
Switchyard	SY-BH-1-10	90	X					
	SY-BH-2-10	90	X					
	SY-BH-3-10	90	X	X				
	SY-BH-4-10	90	X	X				
	SY-BH-5-10	90	X	X				
	BH-23-10	90	X					
	BH-24-10	90	X					
Accommodations Complex	AC-BH-1-10	90	X	X				
	AC-BH-2-10	90	X					
	AC-BH-3-10	90	X	X				
	AC-BH-4-10	90	X	X				
	AC-BH-5-10	90	X	X				
	AC-BH-6-10	90	X	X				
	AC-BH-7-10	90	X	X				
	AC-BH-8-10	90	X	X				

2.6.3 Overburden In Situ Testing

2.6.3.1 Standard Penetration Test (SPT)

A partial characterization of the soil as well as the profile of soil resistance was obtained by standard penetration tests at 38 borehole locations (Table 4). The tests were carried out in accordance with ASTM D1586-08. The SPT results are presented with the respective borehole logs in Volumes 2A, 2B and 2C.

2.6.3.2 Dynamic Cone Penetration Test (DCPT)

The determination of soil resistance was also obtained by dynamic cone penetration tests (DCPT) in 20 boreholes (Table 4). The tests were performed in accordance

with ASTM D5778-95 (2000). They were used to extend Winkie drill holes after the holes had collapsed. The DCPT results are presented in Volumes 2B and 2C.

2.6.3.3 Shelby Tubes

Shelby tubes were used to recover intact clay samples at the site of the converter station, on the south shore. They were used in Borehole BH-20-10 specifically, and the clay samples collected were sent to the SNC-Lavalin laboratory in Montreal for further testing.

2.6.4 Rock In Situ Testing

2.6.4.1 Water Pressure Tests

Water pressure tests were conducted with the objective of evaluating the rock mass permeability in almost all the inclined boreholes. No tests were carried out in Borehole BH-8-10 as the hole was blocked at the approximate depth of 3 m, probably due to some wall caving.

The water tests were performed with an arrangement of 2 packers that isolated an approximate 5 m section of the hole. They were generally performed using the Lugeon procedure, which normally consists of measuring the water absorption at 5 pressure steps. The water absorption is measured for each pressure step. The water pressure for each test was determined using the following parameters:

- 25 kPa/m of rock; and
- 20 kPa/m of soil.

In selected boreholes, the Lugeon procedure was not used. Instead a water pressure test was performed with a single pressure step. This procedure was used on those holes where the advantage of the Lugeon methodology was not required.

Water pressure tests were carried out in 17 boreholes (Table 4). The water pressure test (Lugeon and single pressure step) results are presented in Volumes 2A and 2B following the respective borehole logs.

2.6.4.2 Downhole Acoustic and Optic Televiewer Surveys

Special camera equipment was used in order to better define the rock mass structure. This equipment enabled the viewing of discontinuities, such as joints, faults and intrusions, as well as the presence of gouge and discontinuity openings. Televiewer surveys using acoustic and optical probes were carried out inside 17 boreholes (Boreholes BH-1-10 to BH-7-10, and BH-9-10 to BH-18-10) in order to measure the position, thickness and orientation (strike and dip) of structural features.

A complete description of the surveying method, the related results and a general description of the main structural features identified at the sites of the north and the south dams, of the spillway and the powerhouse are given in Volumes 3A and 3B.

2.6.5 Hole Backfilling

After completion of all the tests, the holes in bedrock were backfilled with a mixture of water and Portland cement. The backfilling operation was carried out from the bottom of the hole up to the bedrock level before retrieving the casing from the hole.

2.7 ROCK CORE STRUCTURAL DESCRIPTION

For every borehole driven into the bedrock, 2 logs were prepared. One log (borehole log) includes a subsoil description followed by a brief description of the bedrock. The second is a structural log with a detailed description of the discontinuities of the rock mass encountered in the borehole such as joint roughness, joint infilling thickness and type of material, joint weathering, etc.

The structural log describes the rock parameters and provides a better knowledge of the rock mass. Using these parameters and the well known Quality (Q) and Rock Mass Rating (RMR) rock mass classifications, the rock mass can be classified for comparison and for design purposes. The structural description logs are presented in Volumes 2A, 2B and 2C following the respective borehole logs.

2.8 IN SITU SITE INVESTIGATION DRAWINGS

Drawings have been prepared to show the extent of the site investigations at the dam and related structures and at the borrow areas.

Borehole and test pit locations are indicated on plan view drawings, in reference to the UTM, NAD 83, coordinate system. The plan view drawings are the basis for all the cross sections that are presented in this report. The drawings are inserted in Volume 6.

2.9 LABORATORY TESTING

2.9.1 Soil Testing

Laboratory tests were performed on soil samples retrieved from the boreholes and the test pits which were executed at the sites of the investigations. These tests generally consisted of the following:

- Particle size analysis (sieve analysis) down to the No. 200 (0.075 mm) sieve;
- Determination of native moisture content;
- Standard Proctor compaction test;
- Relative density determination;
- Hydrometer testing;
- Determination of Atterberg limits;
- Swedish fall cone test; and
- One dimension consolidation test.

The laboratory testing program aiming to characterize soils is detailed in Table 5.

TABLE 5: LABORATORY TESTING PROGRAM

SITE	TYPE AND NUMBER OF SOUNDINGS	PARTICLE SIZE ANALYSIS	NATIVE MOISTURE CONTENT	STANDARD PROCTOR COMPACTION TEST	RELATIVE DENSITY	HYDROMETER ANALYSIS	ATTERBERG LIMITS	SWEDISH FALL CONE TEST	ONE DIMENSIONAL CONSOLIDATION TEST
North RCC dam	1 test pit 4 boreholes		2				2		
South RCC dam	9 boreholes	54	4				3		
Spillway and channels	4 test pits 4 boreholes	4 2							
Powerhouse and channels	8 test pits 8 boreholes	8 7							
Converter station	16 test pits 11 boreholes	23 59	14				9	2	2
Switchyard	8 test pits 7boreholes	10 45							
Accommodations complex	16 test pits 8 boreholes	19 28	20 15				11 14		
Borrow Area GD-7	4 test pits	4	8						
Borrow Area GD-8	5 test pits	5	7						
Borrow Area GD-10	4 test pits	3	5						
Borrow Area GD-11	10 test pits	17	21						
Borrow Area GR-5	22 test pits	29	33						
Borrow Area TD-4	9 test pits	8	13	1	2	1			
Borrow Area TD-5	4 test pits	6	5						
Borrow Area TD-6	2 test pits	2	4	1	2	1			
Borrow Area TD-7	3 test pits	3	5	1	2	1			
Borrow Area TD-8	3 test pits	4	2						
Borrow Area TD-11	2 test pits	-	-						
TOTAL		**340**	**158**	**3**	**6**	**3**	**39**	**2**	**2**

Except for clay samples, the tests on soils were carried out at the Goose Bay field laboratory. Clay samples were sent to and tested in SNC-Lavalin's Montreal laboratory. All the soil test results appear on the borehole and test pit reports or following the corresponding report, in Volumes 2A to 2D.

Moreover, specific tests were carried out on sand samples recovered from Borrow Area GD-11 in order to validate the use of the sand as concrete fine aggregate. Table 6 indicates the type and the numbers of these tests, which were performed in SNC-Lavalin's Montreal laboratory.

TABLE 6: LABORATORY TESTING FOR CONCRETE FINE AGGREGATE

TYPE OF TEST	NUMBER OF TESTS
Grain size analysis	3
Test for organic impurities in fine aggregate	28
Relative density and absorption of fine aggregate	2
Low-density granular material in aggregate	1
Mortar-strength properties in fine aggregate	6
Air content of hydraulic cement mortar	6

All the results of the tests indicated in Table 6 and the report are contained in Volume 5.

2.9.2 Rock Testing

Laboratory tests were carried out on rock samples recovered from boreholes. The objectives of these tests were to:

- Determine mechanical properties of rock as required for cut and support design; and
- Validate the use of crushed rock as concrete coarse aggregate.

Table 7 summarizes the laboratory testing program performed on rock samples. It notably indicates the type and numbers of tests together with the performer of the tests.

TABLE 7: LABORATORY TEST PROGRAM ON ROCK SAMPLES

TYPE	SOURCE OF ROCK		NUMBER OF TESTS	PERFORMER
	Site	Borehole		
Mechanical tests for cut and support design (tests on intact rock cores)				
Compressive strength and elastic moduli	Spillway	BH-8-10	3	École Polytechnique de Montréal
	Powerhouse	BH-11-10, BH-12-10	7	
Compressive strength	Spillway	BH-7-10	3	SNC-Lavalin Montreal laboratory
		BH-9-10	3	
	Powerhouse	BH-11-10 to BH-14-10	9	
Cerchar test (abrasivity index)	Spillway	BH-7-10, BH-8-10, BH-9-10	7	Colorado School of Mines
	Powerhouse	BH-11-10 to BH-14-10	8	
Tests for concrete coarse aggregate (tests on crushed rock)				
Petrographic description (thin section)	Spillway	BH-7-10, BH-8-10, BH-9-10	3	SNC-Lavalin Jonquière Division
	Powerhouse	BH-11-10 to BH-14-10	4	

TABLE 7: LABORATORY TEST PROGRAM ON ROCK SAMPLES

TYPE	SOURCE OF ROCK		NUMBER OF TESTS	PERFORMER
	Site	Borehole		
Potential of acid generating rock (modified acid/base accounting method) and sulphide content	Spillway	BH-7-10, BH-8-10, BH-9-10	3	Techni-Lab S.G.B. Abitibi Inc.
	Powerhouse	BH-11-10 to BH-14-10	4	
• Alkali aggregate reaction – short term and long term • Micro-Deval • Los Angeles • Resistance of unconfined coarse aggregate to freezing and thawing • Soundness of fine and of coarse aggregate by use of magnesium sulphate • Relative density and absorption of fine and coarse aggregate	Spillway	BH-7-10, BH-8-10, BH-9-10	3	SNC-Lavalin Montreal laboratory
	Powerhouse	BH-11-10 to BH-14-10	4	

All the results of the tests indicated in Table 7 are contained in Volume 5.

3 GEOLOGY

REGIONAL GEOLOGY

3.1 PHYSIOGRAPHY

The Muskrat Falls power project is located downstream of the Churchill Falls hydroelectric power plant, on the Churchill River. The Churchill River is the longest in Labrador. It runs easterly from the Smallwood reservoir to Happy Valley-Goose Bay and ends at Lake Melville, where it enters the Atlantic Ocean. The river flows inside a steep U-shaped valley of glacial origin. The valley is 1 to 2 kilometres wide and hundreds of meters deep. Downstream from Gull Island, both the river and the valley become wider (few hundreds of meters for the river and several kilometres for the valley). The river presents a winding to straight path down to Muskrat Falls. The valley follows the route of an old rift valley formed in late Proterozoic times. The valley boundaries were created by 2 regional faults. The valley itself was moulded to its actual morphology during the last glaciation. From Muskrat Falls to Lake Melville, the river is more winding and shows several ramifications.

3.2 PROTEROZOIC EPOCH

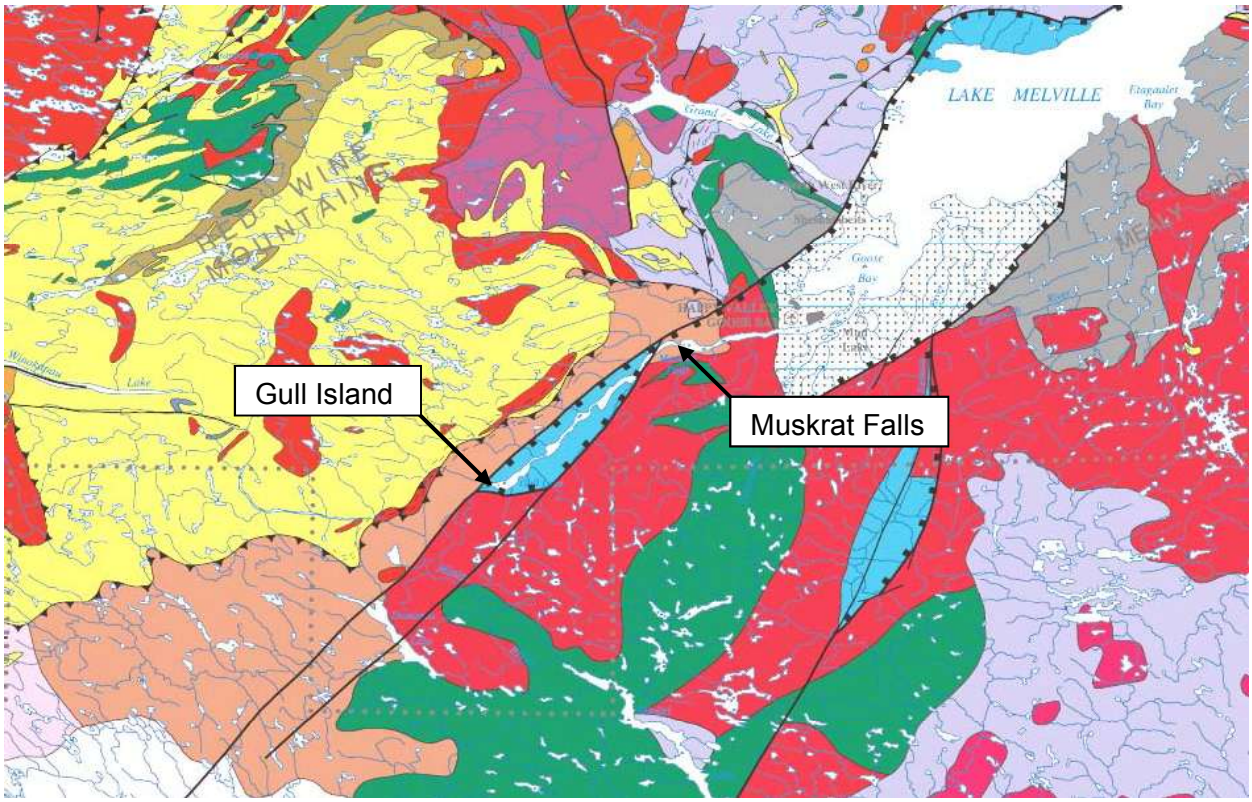
The Muskrat Falls project is located in the Grenville structural province of the Canadian Shield, on the Churchill River, Labrador. The bedrock of the site area is principally composed of granitoid types of rock, such as granite, diorite, granodiorite and tonalite, which have undergone regional metamorphism (granitic orthogneiss and migmatites). It contains many inclusions of dark coloured biotite and hornblende gneiss.

These underlying rocks are of late paleoproterozoic age. On the north bank of the river, the rocks belong to the Dome Mountain Intrusive Suite; on the south bank, they belong to the Mealy Mountain Intrusive Suite.

As shown on the Labrador Geological Map (Figure 2), this part of Labrador is crossed by regional lineaments trending roughly south-west/north-east and extending over long distances (100 km to 200 km approximately). These major

structural features are normal and thrust faults. The river valley, from Gull Lake to 50 km downstream along the river, is surrounded by 2 normal faults with downthrown movement oriented inward. The faults are somewhat curved between Gull Island and Muskrat Falls and form a lens like shape. This pattern corresponds most likely to a grabben, and the proposed dam axis is located a few kilometres east of the eastern extremity, of where the 2 faults intercept.

FIGURE 2: GEOLOGICAL MAP OF LABRADOR (GEOLOGICAL SURVEY DEPARTMENT OF NATURAL RESOURCES NEWFOUNDLAND AND LABRADOR, 2004)



3.3 PLEISTOCENE EPOCH

In the vicinity of the project site, the Precambrian rocks are covered almost entirely with Quaternary sediments of glacial, glacio-fluvial, marine and fluvial origins.

The glacial sediments in the Churchill Valley and in the surrounding areas were deposited during the Late Wisconsinian glaciation by the Labrador sector of the

Laurentide Ice Sheet, approximately between 25,000 and 8,000 years ago. Ice flow was mostly eastward. Deglaciation took place prior to 7,500 years before present, and was followed by deposition of thick sequences of glaciomarine sediments below 135 m above sea level, in the area of interest. Since deglaciation, the sea level has fallen continuously with the formation of closely spaced strandlines.

According to the literature, there are indications that the ice sheet advanced at least twice over the Labrador Plateau. The nature of the sediments deposited during this period is mainly related to the erosion factor where basal tills of various thicknesses and ablation tills were left in place. The period of time associated with the glacier's retreat (melt) is not well defined but stands between 10,000 to 8,000 years. A considerable amount of granular material ranging in size from silt to cobbles and boulders was deposited by the glacier melt water leaving typical geomorphologic formations such as eskers and terraces.

By the end or during the ice melting process, the valley was partly flooded by marine waters incoming westward. Clayey materials were then deposited. Thick sequences are seen along the northern bank of the Churchill River, below Muskrat Falls. The presence of those clays underlying the sand terraces resulted in many large rotational landslides in the past 50 years. One of the largest ones is located at Muskrat Falls, just north of the spur.

With the isostasic uplift of the continent after the glaciers retreated, the sea receded and the rivers and creeks flowing in the main and secondary valleys carved the existing terraces and other deposits forming the actual landscape. The outwash material consists of recent alluviums and is typically found in the Churchill riverbed and on both shores.

4 LOCAL GEOLOGY

The Muskrat Falls site is located approximately 30 km west-southwest of Goose Bay. Bedrock is present on both sides of the river, forming large outcrops. It is mainly composed of pinkish-grey to greyish-pink migmatites, containing several inclusions of biotite and hornblende gneiss. A bedrock ridge crosses the river parallel to the projected dam axis, forming the falls. As mentioned before, the hill on the north side of the river is part of the Dome Mountain Intrusive Suite, while the rocks on the south shore belong to the Mealy Mountains Intrusive Suite.

5 INVESTIGATION RESULTS

Results of the investigations at the sites of the dam and related structures, at the site of the accommodations complex and at the borrow areas are summarized hereafter. Note that the word depth, as used in the following text and tables, is referring to either a vertical or an inclined length.

5.1 NORTH RCC DAM

5.1.1 Site Investigation Summary

The 2010 site investigations in the vicinity of the north RCC dam consisted of 4 boreholes (BH-1-10 to BH-4-10), 1 test pit (TP-1-10) and 3 soundings with a Pionjar portable hammer drill (P-1-10 to P-3-10). Acoustic and optic televiewer surveys and water tests were done in all boreholes. Boreholes BH-1-10 to BH-3-10, Test Pit TP-1-10 and Pionjar Soundings P-1-10 to P-3-10 were executed on the north bank of the Churchill River while Borehole BH-4-10 was executed on the south bank.

Table 3 indicates the borehole coordinates. The results of acoustic and optic televiewer surveys are given in Volumes 3A and 3B. The locations of boreholes and soundings are shown on Drawing no 503334-MF-1300-4GDD-0001 in Volume 6.

5.1.2 Borehole, Test Pit and Pionjar Sounding Results

The results of Boreholes BH-1-10 to BH-4-10 are summarized in Table 8.

TABLE 8: NORTH RCC DAM - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min/m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
BH-1-10	0 – 1.86 (41.31 – 39.89)	Overburden				
	1.86 – 58.12 (39.89 – -3.21)	Rock:: medium grained granitic gneiss and medium to fine grained biotite and hornblende gneiss	2.64 – 22.12 22.12 – 25.12 25.12 – 58.12	81 – 100 68 – 79 94 – 100	4.25 – 35.22 39.20 – 44.22 45.70 – 55.72	< 1.2 3.7 < 1.2
BH-2-10	0 – 7.03 (42.20 – 35.28)	Overburden				
	7.03 – 30.15 (35.28 – 12.51)	Rock : medium to coarse grained granitic gneiss	7.11 – 18.4 18.42 – 20.64 20.64 – 27.10 27.10 – 30.15	46 – 64 15 60 – 74 94	9.70 – 14.72 15.50 – 25.52 23.40 – 28.42	0.8 2.7 – 3.1 0.4
BH-3-10	0 – 169.31 (9.93 – 74.73)	Rock : fine to medium grained biotite and hornblende gneiss and medium to coarse grained granitic gneiss	3.03 – 23.68 23.68 – 26.68 26.68 – 71.68 71.68 – 74.14 74.14 – 110.18 110.68 – 117.55 117.55 – 124.47 124.47 – 133.36 133.36 – 134.68 134.68 – 158.68 158.68 – 165.35 165.35 – 166.46 166.46 – 169.31	83 – 100 47 57 – 100 41 51 – 99 0 – 28 18 -54 0 – 12 78 0 – 57 62 – 80 32 – 38 60 – 100	4.50 – 20.52 20.70 – 30.72 30.70 – 40.72 42.50 – 59.52 59.50 – 70.45 70.45 – 105.00 105.0 – 169.31	0 0.3 – 1.2 4.1 – 12.5 0.2 – 1.0 2.9 – 8.2 0 – 0.7 12.0 – 12.3
BH-4-10	0 – 180.27 (10.78 – -79.35)	Rock : medium to coarse grained granitic gneiss and fine to medium grained biotite and hornblende gneiss	0.77 – 100.40 100.40 – 100.84 100.84 – 111.27 111.27 – 125.67 125.67 – 147.27 147.27 – 150.27 150.27 – 153.27 153.27 – 168.24 168.24 – 180.27	73 – 100 0 74 – 97 10 – 66 75 – 98 59 91 41 – 73 88 – 99	3.60 – 8.62 8.60 – 13.62 13.60 – 18.62 18.60 – 23.62 23.60 – 28.62 28.60 – 53.62 53.60 – 58.62 58.60 – 63.62 63.60 – 68.62 68.60 – 73.62 73.60 – 93.62 93.60 – 103.62 103.6 – 108.62 108.60 – 128.62 128.60 – 138.62 138.60 – 148.62 148.60 – 153.62 153.60 – 158.62	0 0.7 5.0 0.2 9.4 0 – 0.5 3.9 0.3 1.8 11.1 0 – 0.9 11.5 0.1 1.7 – 9.2 0 – 0.1 12.2 – 12.3 0 5.2

In Boreholes BH-1-10 and BH-2-10, bedrock was encountered, at respective depths of 1.86 m and 7.03 m, or at corresponding elevations of 39.89 m and 35.28 m. In Borehole BH-3-10 and BH-4-10, bedrock was found at the ground surface, at respective elevations of 9.93 m and 10.78 m. Bedrock was drilled over respective lengths of 56.26 m (BH-1-10), 23.12 m (BH-2-10), 169.31 m (BH-3-10) and 180.27 m (BH-4-10).

In general, bedrock in the 4 boreholes is mostly composed of medium to coarse grained granitic gneiss and of fine to medium grained biotite and hornblende gneiss. These 2 rock facies were found in an irregular sequence of strips with thicknesses that can reach many meters. The rock is slightly to highly foliated. Granitic and pegmatitic horizons were observed respectively in Borehole BH-3-10 and Borehole BH-4-10. The rock is generally fresh to moderately weathered with joint surfaces stained with oxides, particularly with hematite, which gives the rock its typical reddish color. Exceptionally, between depths of 120.50 m and 145.30 m in Borehole BH-3-10, the rock is moderately to highly weathered and includes many breccia zones that could correspond to a shear zone. During the drilling of this borehole, the hole collapsed between approximate depths of 128 m and 143 m; it was then required to pull out 15 m of rods and to re-drill the hole. Also, while drilling hole BH-3-10, some important rises of soils (sand) inside the casings were observed from the approximate depth of 9 m, due to the occurrence of a joint with an opening of about 100 mm. Cementation of the hole and re-drilling were then necessary to pursue the boring.

Water pressure tests were carried out in the 4 boreholes following either a 5-step (Lugeon) or a 1-step procedure. The 1-step procedure was used in Boreholes BH-3-10 and BH-4-10 from the depth of about 60 m. The tests were generally performed over hole sections of about 5 m. Exceptionally, in Borehole BH-3-10, after some obstruction was encountered, a test was conducted with a single packer system over the whole section extending from the depth of 110 m to the end of the hole (169.31 m).

Rock quality according to the RQD indexes is generally fair to excellent with the exception of some fractured sections. In Borehole BH-2-10, between depths of

18.42 m and 20.64 m, the rock is of very poor quality. In Borehole BH-3-10, between depths of 110.68 m and 158.68 m and depths of 111.27 m and 125.67 m, and in Borehole BH-4-10, between depths of 153.27 m and 168.24 m, the rock is often of very poor to poor quality.

The water pressure tests in the 4 boreholes indicated absorption values generally lower than 5 L/min/m. Absorption values varying between 5.0 and 12.5 L/min/m were obtained in Boreholes BH-3-10 and BH-4-10 for respectively 9 and 5 of the tested hole sections.

Test Pit TP-1-10 was excavated on the north bank of the Churchill River. Table 9 summarizes the results of the test pit. Underneath a thin layer of organic soil, a silty clay deposit was encountered in Test Pit TP-1-10. The test pit was stopped within this deposit at the depth of 2.35 m. Based on the results of 2 Atterberg limits determinations, the silty clay of Test Pit TP-1-10 is of medium plasticity. Atterberg limits values are given on the test pit report.

TABLE 9: NORTH RCC DAM - SUMMARY OF TEST PIT RESULTS

TEST PIT No	DEPTH (m)	DESCRIPTION
TP-1-10	0 – 0.20	Organic soil
	0.20 – 2.30	Silty clay of medium plasticity
	2.35	End of test pit

Soundings with the portable hammer drill (Pionjar) were carried out on the south bank of the Churchill River. These soundings indicated refusal at depths varying between 1.34 m and 1.90 m at P-1-10, between 7.43 m to 8.10 m at P-2-10 and between 3.51 m and 6.00 m at P-3-10.

5.2 SOUTH RCC DAM

5.2.1 Site Investigation Summary

The 2010 site investigations in the vicinity of the south RCC dam consisted of 9 boreholes (BH-5-10, BH-6-10, BH-19-10, BH-25-10 to BH-27-10 and BH-31-10 to BH-33-10). Acoustic and optic televiewer surveys and water pressure tests were also done in Boreholes BH-5-10 and BH-6-10. All boreholes were executed on the south bank.

Table 3 presents the borehole coordinates. The results of acoustic and optic televiewer surveys are given in Volumes 3A and 3B. The locations of boreholes are shown on Drawing no 503334-MF-1300-4GDD-0001 in Volume 6.

5.2.2 Borehole Results

Table 10 presents a summary of the borehole results.

TABLE 10: SOUTH RCC DAM - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min-m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
BH-5-10	0 – 3.82 (32.97 – 29.15)	Organic soil overlying layers of silt and sand with some silt. Compact condition.				
	3.82 – 20.06 (29.15 – 12.91)	Rock : coarse grained granitic pegmatite and medium to coarse grained granitic gneiss.	3.82 – 20.06	43 – 90	5.70 – 28.97	0.1 – 2.2
BH-6-10	0 – 4.57 (34.99 – 30.42)	Organic soil overlying layers of sand and silt to sand with some silt, with traces of gravel. Loose to compact condition				

TABLE 10: SOUTH RCC DAM - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min-m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
BH-6-10 (continued	4.57 – 10.24 (30.42 – 24.75)	Layers of gravelly and sandy silt to sand and gravel with traces or some silt. Very dense condition.				
	10.24 – 33.60 (24.75 – 1.39)	Rock : medium grained biotite gneiss and granitic gneiss.	10.24 – 33.6	83 – 100	11.98 – 32.00	0 – 2.1
BH-19-10	0 – 5.19 (49.70 – 44.51)	Organic soil overlying layers of sand with traces of silt to silty sand, with locally traces of gravel. Very loose to loose condition.				
	5.19 – 9.17 (44.51 – 40.53)	Layers of sandy silt to silty sand, with traces of gravel to gravelly. Compact condition.				
	9.17 – 21.62 (40.53 – 28.08)	Rock : fine to medium grained biotite and hornblende gneiss and medium grained granitic gneiss.	17.05 – 22.20	78 - 100	-	-
BH-25-10	0 – 15.15 (58.33 – 43.18)	Indured sand with some silt overlying sand with traces of silt and locally traces of gravel. Very loose to compact condition.				
	15.15 – 30.70 (43.18 – 27.63)	Rock : medium to coarse grained granitic gneiss.	15.15 – 30.70	92 - 100	-	-
BH-26-10	0 – 2.16 (31.02 – 28.86)	Layers of silt and sand to sand and silt. Loose to dense condition.				
	2.16 – 17.18 (28.86 – 13.84)	Rock : medium to coarse grained granitic gneiss.	2.16 – 17.18	88 – 100	-	-

TABLE 10: SOUTH RCC DAM - SUMMARY OF BOREHOLE RESULTS

Borehole No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min-m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
BH-27-10	0 – 3.76 (31.05 – 27.29)	Organic soil overlying layers of sand and silt to silt with some sand, with locally some gravel and clay. Loose to very loose condition.				
	3.76 – 19.17 (27.29 – 11.88)	Rock : medium grained granitic gneiss.	3.76 – 19.17	85 - 100	-	-
BH-31-10	0 – 3.05 (24.65 – 21.60)	Organic soil overlying layers of sandy silt to silty sand. Loose condition.				
	3.05 – 4.34 (21.60 – 20.31)	Dynamic cone penetration test to refusal.				
BH-32-10	0 – 2.44 (26.96 – 24.52)	Organic soil overlying layers of silt with some sand to sand and silt. Loose to compact condition.				
	2.44 (24.52)	Refusal to the penetration of the split spoon.				
BH-33-10	0 – 3.15 (33.91 – 30.76)	Organic soil overlying sand and silt to silt and sand. Loose condition.				
	3.15 – 4.88 (30.76 – 29.03)	Sand with traces to some silt to sandy silt, stratified with layers of silty clay. Loose condition.				
	4.88 – 11.66 (29.03 – 22.30)	Dynamic cone penetration test to refusal.				

In Boreholes BH-5-10, BH-6-10, BH-19-10 and BH-25-10 to BH-27-10, the overburden cover is varying in thickness from 2.16 m to 15.15 m. In Boreholes

BH-31-10 to BH-33-10, refusals to the penetration of the split spoon sampler or to the dynamic cone penetration test were obtained at depths ranging between 2.44 m and 11.66 m.

Overburden generally consists of various sand/silt layers. The composition of the layer varies from sand with traces of silt, to sand and silt or silt and sand, to silt with traces or some sand. Occasionally, the silt/sand soils contain traces or some gravel and exceptionally some clay (BH-27-10). In Borehole BH-33-10, between depths of 3.15 m and 4.88 m, sand/silt soils are stratified with thin clay layers. Typically, the standard penetration resistance "N" determined in sand/silt layers indicated a very loose to loose condition.

In Boreholes BH-6-10 and BH-19-10, between depths of 4.57 m and 10.24 m, and depths of 6.72 m and 9.17 m respectively, generally gravelly soil layers were encountered. The composition of these soil layers varies from sand and gravel with traces of silt, to gravelly silty sand, to gravelly and sandy silt. Based on the standard penetration test results, these gravelly soils were found in a compact to very dense condition.

Bedrock was encountered in Boreholes BH-5-10, BH-6-10, BH-19-10 and BH-25-10 to BH-27-10 at depths varying between 2.16 m and 15.15 m, or at elevations ranging from 42.18 m to 20.21 m. It was drilled over lengths ranging from 15.02 m and 23.36 m.

Rock recovered from boreholes is mostly composed of medium to coarse grained granitic gneiss and locally of fine to medium grained biotite and hornblende gneiss. It is slightly to highly foliated. Granitic, pegmatitic and hematized horizons were observed in Borehole BH-19-10 and Boreholes BH-25-10 to BH-27-10. The rock is generally fresh to moderately weathered with joint surfaces stained with oxides and particularly with hematite, which can give the rock its typical reddish color.

Rock quality according to the RQD indexes is generally good to excellent with the exception of a few sections in Borehole BH-5-10 where the rock quality is poor to fair.

Water pressure tests of Lugeon type were carried out in Boreholes BH-5-10 and BH-6-10. The tests indicated absorption values lower than 2.2 L/min/m.

5.3 SPILLWAY AND CHANNELS

5.3.1 Site Investigation Summary

The 2010 site investigations in the vicinity of the spillway and channels consisted of 4 boreholes numbered BH-7-10 to BH-10-10 and of 4 test pits designated TP-5-10 to TP-8-10. Acoustic and optic televiewer surveys and water tests were done in all boreholes. All boreholes and test pits were completed on the south bank.

Table 3 presents the borehole coordinates. The results of acoustic and optic televiewer survey are given in Volumes 3A and 3B. The locations of boreholes and test pits are shown on Drawing no 503334-MF-1300-4GDD-0001 in Volume 6.

5.3.2 Borehole and Test Pits Results

The summary of borehole results is given in Table 11.

TABLE 11: SPILLWAY AND CHANNELS - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min/m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
BH-7-10	0 – 35.20 (13.56 – -16.93)	Rock : medium grained granitic gneiss and medium to fine grained biotite and hornblende gneiss.	0 – 35.20	61 - 100	3.00 – 8.00 8.00 – 13.00 13.00 – 29.00 29.00 – 34.00	13.3 0 6.1 – 11.2 0 – 1.0
BH-8-10	0 – 2.43 (22.11 – 19.68)	Oxidized silt and sand overlying silty and gravelly sand. Loose to very dense condition.				
	2.43 – 27.55 (19.68 – -5.44)	Rock : medium grained granitic gneiss.	2.43 – 3.62 3.62 – 5.26 5.26 – 7.32 7.32 – 27.55	36 – 62 88 25 – 36 81 - 100		

TABLE 11: SPILLWAY AND CHANNELS - SUMMARY OF BOREHOLE RESULTS

Borehole no	Depth (m) / Elevation (m)	Description	RQD (%)		Absorption (l/min/m)	
			Depth (m)	Value	Depth (m)	Value
BH-9-10	0 – 55.09 (9.56 – -38.15)	Rock : medium to coarse grained granitic gneiss and fine to medium grained biotite and hornblende gneiss.	1.06 – 44.80 44.80 – 46.01 46.01 – 47.51 47.51 – 47.86 47.86 – 49.37 49.37 – 49.55 49.55 – 55.09	71 – 100 61 80 31 87 0 76 - 91	3.56 – 18.58 18.56 – 38.58 38.56 – 43.58 43.56 – 53.58	4.5 – 5.9 11.8 – 12.5 0.1 12.7
BH-10-10	0 – 0.85 (6.74 – 5.95)	Overburden.				
	0.85 – 50.67 (5.95 – -40.87)	Rock : medium to coarse grained granitic gneiss and fine to medium grained biotite and hornblende gneiss.	1.47 – 50.67	73 - 100	3.5 – 8.5 8.00 – 18.00 18.00 – 28.00 29.00 – 34.00 34.00 – 50.55	0 4.8 2.4 – 3.8 0 8.7 – 11.5

Bedrock was observed at the ground surface at the location of Boreholes BH-7-10 and BH-9-10. It was encountered at respective depths of 2.43 m and 0.85 m in Boreholes BH-8-10 and BH-10-10. Soil sampling was carried out only in the vertical Borehole BH-8-10.

Overburden in Borehole BH-8-10 is composed of a thin surficial silt and sand layer in a loose condition, underlain by very dense to dense silty and gravelly sand.

The bedrock surface as observed in Borehole BH-7-10 to BH-10-10 is lying between elevations 19.68 m and 5.95 m. Bedrock was drilled in Boreholes BH-7-10 to BH-10-10 over lengths ranging from 25.12 m to 55.09 m.

In general, bedrock in the 4 boreholes is mostly composed of medium to coarse grained granitic gneiss and of fine to medium grained biotite and hornblende gneiss. These 2 facies of rock were found in the 4 boreholes in an irregular sequence of strips of thicknesses that reach many meters. Exceptionally, the presence of syenite was noted between depths of 18.26 m and 25.30 m in Borehole BH-7-10. The rock is slightly to highly foliated and generally fresh to moderately weathered with joint surfaces stained with oxides and particularly with hematite, which gives the rock its typical reddish color.

Rock quality according to the RQD indexes is generally fair to excellent. It varies from poor to fair in Borehole BH-8-10 between depths of 2.43 m and 3.62 m, and depths of 5.26 m and 7.32 m. It is poor to very poor in Borehole BH-9-10 between depths of 47.51 m and 47.86 m, and depths of 49.37 m and 49.55 m.

Water pressure tests were carried out in Boreholes BH-7-10, BH-9-10 and BH-10-10, using the single step procedure. No test was performed in Borehole BH-8-10 as the hole was obstructed at the depth of about 3.0 m. The tests indicated absorption values more often between 4.5 and 13.3 L/min/m. Values lower than 3.8 L/min/m were obtained in BH-7-10 between depths of 8.00 m and 13.00 m and depths of 29.00 m and 34.00 m, in Borehole BH-9-10 between depths of 38.56 m and 43.58 m, and in Borehole BH-10-10 between depths of 3.50 m and 8.50 m and depths of 18.00 m and 34.00 m.

Test Pits TP-5-10 to TP-8-10 were excavated to depths ranging between 1.10 m and 2.30 m. Table 12 summarizes the test pitting results.

TABLE 12: SPILLWAY AND CHANNELS - SUMMARY OF TEST PIT RESULTS

TEST PIT No	DEPTH (m)	DESCRIPTION
TP-5-10	0 – 0.90	Organic soil overlying oxidized silt with some sand. Presence of cobbles (0-5 %) and boulders (0-5 %).
	0.90 – 2.30	Silty sand with traces of gravel. Presence of cobbles (0-5 %) and boulders (0-5 %)
	2.30	End of test pit
TP-6-10	0 – 0,40	Organic soil overlying oxidized silt with some sand and traces of gravel.
	0.40 – 1.10	Silty sand with some gravel. Presence of cobbles (0-5 %) and boulders (0-5 %)
	1.10	End of test pit – Refusal on probable bedrock

TABLE 12: SPILLWAY AND CHANNELS - SUMMARY OF TEST PIT RESULTS

TEST PIT No	DEPTH (m)	DESCRIPTION
TP-7-10	0 – 0.90	Organic soil overlying oxidized silt with some sand.
	0.90 – 2.30	Sand and silt with traces of gravel. Presence of cobbles (0-5 %) and boulders (0-5 %)
	2.30	End of test pit – Refusal on probable bedrock
TP-8-10	0 – 0.60	Organic soil overlying oxidized silt with some sand. Presence of cobbles (0-5 %) and boulders (0-5 %).
	0.60 – 2.00	Silty sand with some gravel. Presence of cobbles (0-5 %) and boulders (0-5 %)
	2.00	End of test pit

From the depth of 0.20 m, underneath the surficial organic soil layer, subsoil consists of a sand/silt deposit whose composition varies from a silt with some sand in the upper oxidized part of the deposit, to a silty sand or sand and silt below. The deposit also contains traces or some gravel, cobbles (0-5 %) and boulders (0-5 %). Test Pits TP-5-10 and TP-8-10 were terminated in this deposit at respective depths of 2.30 m and 2.00 m. Test Pits TP-6-10 and TP-7-10 were stopped at respective depths of 1.10 m and 2.30 m when refusals were obtained on probably bedrock. Water infiltrations were observed in all test pits between depths 0.90 m and 2.30 m.

5.4 POWERHOUSE AND CHANNELS

5.4.1 Site Investigation Summary

The 2010 site investigations in the vicinity of the powerhouse and channels, on the south bank, consisted of 2 resistivity lines, 8 boreholes numbered BH-11-10 to BH-18-10 and 8 test pits designated TP-9-10, TP-10-10 and TP-12-10 to TP-17-10. Acoustic and optic televiewer surveys and water tests were done in all boreholes.

Table 3 indicates the borehole coordinates. The results of acoustic and optic televiewer surveys are given in Volumes 3A and 3B. The locations of the soundings are shown on Drawing no 503334-MF-1300-4GDD-0001 in Volume 6.

5.4.2 Borehole and Test Pit Results

The following Table 13 summarizes the results of the boreholes.

TABLE 13: POWERHOUSE AND CHANNELS - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min/m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
BH-11-10	0 – 3.26 (15.83 – 12.76)	Overburden.				
	3.26 – 57.24 (12.76 – -37.96)	Rock : medium to coarse grained granitic gneiss and fine to medium grained biotite and hornblende gneiss.	3.26 – 18.28 18.28 – 19.78 19.78 – 31.80 31.80 – 34.80 34.80 – 55.78 55.78 – 57.24	90 – 100 40 78 – 100 45 – 70 87 – 100 53	5.26 – 20.48 20.76 – 25.78 25.76 – 30.78 30.26 – 40.28 40.26 – 50.28 50.26 – 55.28	0 – 1.4 3.0 0.3 2.1 – 3.4 0 12.3
BH-12-10	0 – 8.60 (21.28 – 13.83)	Overburden.				
	8.60 – 71.03 (13.83 – -40.24)	Rock : medium to coarse grained granitic gneiss and fine to medium grained biotite gneiss.	8.46 – 11.07 11.07 – 12.62 12.62 – 71.03	83 – 89 62 86 – 100	10.75 – 19.04 19.02 – 29.04 29.02 – 34.04 34.02 – 39.04 39.02 – 49.04 49.02 – 64.04 64.02 – 69.04	0.6 5.5 – 12..0 0.2 6.8 0 – 0.5 4.5 – 12.2 0
BH-13-10	0 – 0.05 (6.77 – 6.73)	Overburden.				
	0.05 – 49.66 (6.73 – -39.89)	Rock : medium grained granitic gneiss and fine to medium grained biotite and hornblende gneiss.	0.05 – 49.66	95 - 100	3.00 – 38.50 38.50 – 49.60	0 – 2.5 4.1 – 4.3
BH-14-10	0 – 2.10 (22.06 – 20.03)	Overburden.				
	2.10 – 61.95 (20.03 – -37.78)	Rock : coarse grained granitic gneiss.	2.10 – 61.95	80 - 100	5.47 – 15.49 15.47 – 20.49 20.47 – 50.49 50.47 – 55.49 55.47 – 60.49	0.2 – 0.3 4.1 0 – 0.3 2.0 0

TABLE 13: POWERHOUSE AND CHANNELS - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min/m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
BH-15-10	0 – 1.74 (14.37 – 12.74)	Overburden.				
	1.74 – 24.12 (12.74 – -8.29)	Rock : medium grained granitic gneiss and fine to medium grained biotite and hornblende gneiss.	1.74 – 15.14 15.14 – 16.67 16.67 – 24.12	85 – 100 70 91 - 100	4.00 – 19.30 19.30 – 23.5	0.3 – 0.5 2.8
BH-16-10	0 – 1.24 (14.85 – 13.61)	Organic soil overlying oxidized sand with some gravel, traces of silt. Loose to compact condition.				
	1.24 – 1.69 (13.61 – 11.84)	Gravelly sand with some silt.				
	1.69 – 21.33 (11.84 – -6.48)	Rock : medium grained granodioritic gneiss and fine to medium grained biotite gneiss.	1.69 – 21.33	91 - 100	6.50 – 16.50 16.50 – 21.23	0.2 – 0.3 2.0
BH-17-10	0 – 4.11 (22.48 – 18.37)	Oxidized silty sand overlying sand with some silt. Very loose to compact condition.				
	4.11 – 5.18 (18.37 – 17.30)	Gravelly sand with traces of silt. Compact condition.				
	5.18 – 8.98 (17.30 – 13.50)	Sand with some silt and gravel to silt and sand with some gravel. Compact to dense condition.				
	8.98 – 29.25 (13.50 – -6.77)	Rock : fine to medium grained biotite and hornblende gneiss and medium grained granitic gneiss.	8.98 – 10.12 10.12 – 29.25	54 – 70 85 - 100	10.60 – 26.00	0 – 1.5
BH-18-10	0 – 3.15 (28.77 – 26.36)	Overburden.				
	3.15 – 45.13 (26.36 – -5.80)	Rock : coarse grained granitic gneiss.	3.15 – 45.13	76 - 100	13.50 – 18.50 18.70 – 33.70 35.00 – 44.89	0 10.4 – 11.5 0.2 – 2.5

In Boreholes BH-11-10 to BH-18-10, overburden was encountered over thicknesses varying between 0.05 m (BH-13-10) and 8.98 m (BH-17-10). It was sampled only in the 2 vertical boreholes, namely, Boreholes BH-16-10 and BH-17-10.

In borehole BH-16-10, underneath a 0.1 m thick surficial organic layer, overburden consisted of oxidized sand with some gravel and traces of silt till to depth of 1.24 m, and of gravelly sand with some silt down to a depth of 1.69 m. In Borehole BH-17-10, it consisted of a sand/silt deposit from the surface to a depth of 8.98 m. This deposit is varying in composition from sand with traces of silt, to silty sand and to silt and sand; it is gravelly or containing some gravel from a depth of 4.11 m. According to the standard penetration test results, the soils were found in a loose to compact condition in Borehole BH-16-10 and in Borehole BH-17-10 until a depth of about 6.7 m. Below the depth of 6.7 m in Borehole BH-17-10, “N” values indicated a dense condition.

Bedrock was encountered in Boreholes BH-11-10 to BH-18-10 at depths varying between 0.05 m and 8.98 m, which correspond to elevations ranging from 26.36 m and 6.73 m. It was drilled over lengths varying between 19.64 m and 62.43 m.

In general, the bedrock is mostly composed of medium to coarse grained granitic gneiss and of fine to medium grained biotite and hornblende gneiss. These facies were found in the boreholes in an irregular sequence of strips with thicknesses that reach many meters. Pegmatite layers and hematized horizons were observed in many boreholes. The gneisses are slightly to highly foliated. The rock is generally fresh to moderately weathered with joint surfaces stained with oxides and particularly with hematite, which gives the rock its typical reddish color.

Rock quality according to the RQD indexes is generally good to excellent. It varies from poor to fair in Borehole BH-11-10 between depths of 18.28 m and 19.78 m, of 31.80 m and 34.80 m, and of 55.78 m and 57.24 m. It is fair in Borehole BH-12-10 between depths of 11.07 m and 12.62 m, in Borehole BH-15-10 between depths of 15.15 m and 16.67 m, and in Borehole BH-17-10 between depths of 8.98 m and 10.12 m.

Water pressure tests were carried out in Boreholes BH-11-10, BH-12-10 and BH-14-10 following the Lugeon procedure, and in Boreholes BH-13-10, BH-15-10 to BH-18-10 using a single pressure step procedure. The absorption values obtained from these tests were generally lower than 4.5 L/min/m. Values varying between 4.5 and 12.3 L/min/m were recorded in Borehole BH-11-10 (50.26 m to 55.28 m), BH-12-10 (19.02 m to 29.04 m, 49.02 m to 64.04 m) and in Borehole BH-18-10 (18.70 m to 33.70 m).

The results of Test Pits TP-9-10, TP-10-10 and TP-12-10 to TP-17-10 are summarized in Table 14. Except for Test Pit TP-10-10 where bedrock was found at the ground surface, test pits were excavated to depths varying between 0.70 m and 3.10 m. Test Pits TP-9-10 and TP-16-10 were stopped at respective depths of 0.7 m and 1.50 m on probably bedrock (refusal). Test Pit TP-15-10 was stopped at the depth of 0.90 m due to side instability.

TABLE 14: POWERHOUSE AND CHANNELS - SUMMARY OF TEST PIT RESULTS

TEST PIT No	DEPTH (m)	DESCRIPTION
TP-9-10	0 – 0.70	Organic soil overlying oxidized silt with some sand.
	0.70	End of test pit – Refusal on probable bedrock
TP-10-10	0	Rock at the ground surface
TP-12-10	0 – 0.60	Organic soil overlying oxidized silt with some sand.
	0.60 – 2.60	Gravelly sand with traces of silt. Presence of cobbles (0-5 %).
	2.60	End of test pit
TP-13-10	0 – 0.60	Organic soil overlying oxidized silt with some sand.
	0.60 – 1.70	Sand with some silt and traces of gravel.
	1.70 – 2.70	Silty sand with traces of gravel. Presence of cobbles (0-5 %).
	2.70	End of test pit
TP-14-10	0 – 0.90	Organic soil overlying oxidized silt with some sand. Presence of cobbles (5 – 10 %) and boulders (0-5 %).
	0.90 – 3.10	Sand with some silt and traces of gravel. Presence of cobbles (0-5 %).
	3.10	End of test pit

TABLE 14: POWERHOUSE AND CHANNELS - SUMMARY OF TEST PIT RESULTS

TEST PIT No	Depth (m)	DESCRIPTION
TP-15-10	0 – 0.20	Organic soil
	0.20 – 0.90	Silt and sand.
	0.90	End of test pit – Side of test pit collapsing during the excavation.
TP-16-10	0 – 0.20	Organic soil
	0.20 – 1.50	Silt and sand with traces of gravel.
	1.50	End of test pit – Refusal on probable bedrock
TP-17-10	0 – 1.00	Organic soil overlying oxidized silt with some sand.
	1.00 – 2.20	Silty sand with traces of gravel. Presence of cobbles (0-5 %) and boulders (0-5 %)
	2.00	End of test pit

Underneath a thin surficial organic layer, subsoil encountered in test pits mainly consists of sand/silt soil layers whose composition is generally varying from sand with some silt, to silty sand, to silt and sand. The soil layers also contained traces of gravel, and locally cobbles (0-10%) and boulders (0-5%). Exceptionally, in Test Pit TP-12-10, gravelly sand with traces of silt was identified, from the depth of 0.60 m to the end of the test pit (2.60 m).

Water infiltrations were observed during the excavation of Test Pits TP-15-10, TP-16-10 and TP-17-10. They occurred from depth of 0.1 m in Test Pits TP-15-10 and TP-16-10, and from depth of 1.1 m in Test Pit TP-17-10.

5.5 CONVERTER STATION

5.5.1 Site Investigation Summary

The 2010 site investigations in the vicinity of the converter station consisted of 11 boreholes (CS-BH-1-10 to CS-BH-5-10, BH-20-10 to BH-22-10 and BH-28-10 to BH-30-10) and 16 test pits (CS-TP-1-10 to CS-TP-16-10). All boreholes and test pits were carried out on the south bank.

Borehole coordinates are indicated in Table 3. Borehole and test pit locations are shown on Drawing no 503334-MF-1300-4GDD-0001 in Volume 6.

5.5.2 Boreholes and Test Pit Results

A summary of the borehole results is given in Table 15.

TABLE 15: CONVERTER STATION - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min-m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
CS-BH-1-10	0 – 1.30 (45.90 – 44.60)	Organic soil overlying layers of oxidized silt and sand and of silty sand to sandy silt. Compact condition.				
	1.30 – 3.25 (44.60 – 42.65)	Sand with traces to some silt. Loose to compact condition.				
	3.25 – 4.34 (42.65 – 41.56)	Silty clay of low plasticity.				
	4.34 – 11.28 (41.56 – 34.62)	Dynamic cone penetration test to refusal.				
CS-BH-2-10	0 – 3.68 (43.97 – 40.31)	Layers of sand and silt to silt and of sand, with traces of gravel. Very loose to compact condition.				
	3.68 – 5.64 (40.31 – 38.33)	Dynamic cone penetration test to refusal.				
CS-BH-3-10	0 – 1.22 (48.22 – 47.00)	Organic soil overlying layers of oxidized sandy silt and of silt and sand. Loose condition.				
	1.22 – 10.49 (47.00 – 37.73)	Dynamic cone penetration test to refusal.				
CS-BH-4-10	0 – 1.22 (46.35 – 45.13)	Organic soil overlying silt with traces of sand. Loose condition.				
	1.22 – 2.67 (45.13 – 43.68)	Layers of silt and sand to silty sand. Compact condition.				

TABLE 15: CONVERTER STATION - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min-m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
CS-BH-4-10 (continued)	2.67 – 4.27 43.68 – 42.08	Sand with traces of silt. Loose to compact condition.				
	4.27 – 18.26 (42.08 – 28.09)	Dynamic cone penetration test to refusal.				
CS-BH-5-10	0 – 3.05 (48.51 – 45.46)	Organic soil overlying layers of oxidized silt with traces of sand, and of silt and sand to sand and silt. Loose to compact condition.				
	3.05 – 17.12 (45.46 – 31.39)	Dynamic cone penetration test to refusal.				
BH-20-10	0 – 2.74 (45.32 – 42.58)	Organic soil overlying layers of silt with some sand to sand with some silt. Loose to compact condition.				
	2.74 – 7.92 (45.32 – 37.40)	Silty clay with traces to some sand. Low plasticity. Very soft to firm consistency.				
	7.92 – 14.12 (37.40 – 31.20)	Layers of silt and sand to sand with some silt. Some gravel locally. Compact condition.				
	14.12 – 24.63 (31.20 – 20.69)	Rock : fine grained biotite and hornblende gneiss and medium grained granitic gneiss.	14.12 – 24.63	93 - 99	-	-
BH-21-10	0 – 2.59 (37.53 – 34.94)	Organic soil overlying layers of silt and sand to sand and silt. Loose to compact condition.				
	2.59 – 14.72 (34.94 – 22.81)	Sand with traces to some silt, traces to some gravel. Presence of cobbles and boulders from the depth of 6.10 m. Compact to very dense condition.				

TABLE 15: CONVERTER STATION - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min-m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
BH-21-10 (continued)	14.72 – 25.59 (22.81 – 20.31)	Rock : medium to coarse grained granitic gneiss.	14.72 – 22.49 22.49 – 25.59	97 – 98 67		
BH-22-10	0 – 0.47 (9.48 – 9.01)	Organic soil overlying gravelly sand with some silt.				
	0.47 – 10.44 (10.44 - -0.96)	Rock : fine to medium grained granodioriitic and granitic gneisses.	0.47 – 1.11 1.11 – 10.44	59 95 - 96		
BH-28-10	0 – 3.05 (28.30 – 25.25)	Organic soil overlying layers of oxidized silt and sand, and of silt with some sand to sandy silt. Compact condition.				
	3.05 – 4.88 (25.25 – 23.42)	Silty sand, to sand with some silt and traces of gravel. Presence of a thin layer of silty clay. Loose condition.				
	4.88 – 6.07 (23.42 – 22.23)	Dynamic cone penetration test to refusal.				
BH-29-10	0 – 2.69 (31.60 – 28.91)	Organic soil overlying layers of oxidized sandy silt, and of silty sand to sand and silt. Occasional traces of gravel. Compact condition.				
	2.69 – 5.49 (28.91 – 26.11)	Gravelly or with some gravel silty sand. Compact to dense condition.				
	5.49 – 6.68 (26.11 – 24.92)	Dynamic cone penetration test to refusal.				

TABLE 15: CONVERTER STATION - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min-m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
BH-30-10	0 – 0.61 (34.92 – 34.31)	Organic soil overlying oxidized silt with some sand. Loose condition.				
	0.61 – 2.06 (34.31 – 32.86)	Silt and sand to silty sand with traces to some gravel. Compact to very dense condition.				
	2.06 (32.86)	Refusal to the penetration of the split spoon.				

In Boreholes BH-20-10, BH-21-10, BH-22-10, overburden was found over respective thicknesses of 14.12 m, 14.72 m and 0.47 m. Other boreholes were stopped at various depths within overburden and generally followed by dynamic cone penetration tests to refusal. Refusals to the cone penetration tests and, in Borehole BH-30-10, refusal to split spoon sampler penetration were obtained at depths ranging from 2.06 m (BH-30-10) to 18.26 m (CS-BH-4-10).

Overburden mainly consisted of various layers of sand/silt soils with composition varying from silt with traces to some sand, to silt and sand or sand and silt, to sand with some silt to silty. Locally, namely in Boreholes CS-BH-1-10, CS-BH-4-10, BH-20-10 and BH-21-10, sand layers containing traces or some silt were found in alternation with sand/silt layers. Numerous cobbles and boulders were encountered especially in Borehole BH-21-10 from depth of 6.1 m. Based on the standard penetration test results, sand and sand/silt layers are generally in loose to compact condition. Dense or very dense soils were encountered locally in Boreholes BH-21-10, BH-29-10 and BH-30-10.

Silty clay strata were also identified in Boreholes CS-BH-1-10, CS-BH-20-10 and BH-28-10, intercalated within sand and sand/silt layers. Silty clay strata were found at depths of 3.25 m, 2.74 m and 2.74 m in Boreholes CS-BH-1-10, CS-BH-20-10 and

BH-28-10, over respective thicknesses of 1.09 m, 5.18 m and 0.54 m. The results of 8 Atterberg limits determinations indicated the clay is of low plasticity. Swedish fall cone tests on 2 presumed intact clay samples recovered from depths of 3.68 m and 6.86 m in Borehole BH-20-10 indicated undrained shear strength values of 6 kPa and 43 kPa, thus suggesting a very soft and firm consistency. Consolidation tests were also carried out on the 2 presumed intact clay samples of Borehole BH-20-10. Results of these tests are given in a graphical format on the figures following the corresponding borehole report. Overconsolidation pressure values of about 37 kPa and 287 kPa were obtained from these tests.

Bedrock was encountered in BH-20-10, BH-21-10 and BH-22-10 at respective depths of 14.12 m, 14.72 m and 0.47 m, or at corresponding elevations of 31.20 m, 22.81 m and 9.01 m. Bedrock was drilled over lengths of 10.51 m, 10.87 m and 9.97 m respectively.

In general, bedrock recovered from boreholes is composed of medium grained granitic gneiss and includes some bands of fine grained biotite and hornblende gneiss (BH-20-10, BH-21-10) and of fine to medium grained granodioritic gneiss (BH-22-10). These types of rocks are slightly to highly foliated. Pegmatite and hematized horizons were observed in Borehole BH-20-10 and Borehole BH-22-10. The rock is generally fresh to moderately weathered with joint surfaces stained with oxides and particularly with hematite which gives the rock its typical reddish color.

Rock quality according to the RQD indexes is excellent, except in Borehole BH-21-10 between depths of 22.49 m and 25.59 m, and in borehole BH-22-10 between depths of 0.47 m and 1.11 m where it is fair.

Test pit results are summarized in Table 16. Test pits CS-TP-1-10 to CS-TP-16-10 were excavated to depths ranging from a minimum of 1.2 m (CS-TP-14-10) to a maximum of 2.7 m (CS-TP-1-10). Underneath a thin organic surficial layer, subsoil in the pits mainly consists of sand/silt materials with the composition of silt with some sand, to silt and sand or sand and silt. Locally, layers of sand with traces of silt were identified, namely in Test Pits CS-TP-7-10, CS-TP-11-10 and CS-TP-12-10. Presence of cobbles was noted in Test Pits CS-TP-5-10 (5-10 %), CS-TP-6-10

(0-5 %) and CS-TP-8-10 (0-5 %), and of boulders in Test Pit CS-TP-5-10 (0-5 %). Water infiltrations were observed in test pits CS-TP-8-10 to CS-TP-15-10 between depths of 0.8 m and 2.4 m.

TABLE 16: CONVERTER STATION – SUMMARY OF TEST PIT RESULTS

TEST PIT No	DEPTH (m)	DESCRIPTION
CS-TP-1-10	0 – 0.60	Organic soil overlying oxidized sand with some silt.
	0.60 – 2.70	Sand and silt to sandy silt layers. Occasional traces of gravel.
	2.70	End of test pit.
CS-TP-2-10	0 – 0.6	Organic soil overlying oxidized silt with some sand.
	0.6 – 2.40	Silt and sand.
	2.40	End of test pit.
CS-TP-3-10	0 – 0.60	Organic soil overlying oxidized silt with some sand.
	0.60 – 2.40	Sand and silt.
	2.40	End of test pit
CS-TP-4-10	0 – 0.60	Organic soil overlying oxidized sand and silt.
	0.60 – 2.40	Silt with some sand to sand and silt layers.
	2.40	End of test pit.
CS-TP-5-10	0 – 0.60	Organic soil overlying oxidized silt with some sand.
	0.60 – 2.40	Silty and gravelly sand. Presence of cobbles (5-10 %) and boulders (0-5 %).
	2.40	End of test pit.
CS-TP-6-10	0 – 0.70	Organic soil overlying oxidized silt with traces of sand.
	0.70 – 2.30	Silty sand with traces of gravel. Presence of cobbles (0-5 %).
	2.30	End of test pit.
CS-TP-7-10	0 – 0.55	Organic soil overlying oxidized sand and silt.
	0.55 – 2.40	Silty sand to sand with traces or some silt layers.
	2.40	End of test pit.
CS-TP-8-10	0 – 0.60	Organic soil overlying oxidized silt with traces of sand.
	0.60 – 2.00	Silty sand. Presence of cobbles (0-5 %).
	2.00	End of test pit.

TABLE 16: CONVERTER STATION - SUMMARY OF TEST PIT RESULTS

TEST PIT No	DEPTH (m)	DESCRIPTION
CS-TP-9-10	0 – 0.70	Organic soil overlying oxidized silt with some sand.
	0.70 – 2.40	Silt with some sand.
	2.40	End of test pit.
CS-TP-10-10	0 – 0.60	Organic soil overlying oxidized sand and silt.
	0.60 – 2.30	Silt and sand.
	2.30	End of test pit.
CS-TP-11-10	0 – 0.60	Organic soil overlying oxidized silt with traces of sand.
	0.60 – 2.30	Sand and silt overlying sand with traces of silt.
	2.30	End of test pit.
CS-TP-12-10	0 – 0.60	Organic soil overlying oxidized silt with traces of sand.
	0.60 – 2.20	Sand with traces of silt and traces of gravel.
	2.20	End of test pit.
CS-TP-13-10	0 – 0.50	Organic soil overlying oxidized silt and sand.
	0.50 – 1.30	Silt with some sand.
	1.30	End of test pit.
CS-TP-14-10	0 – 0.60	Organic soil overlying oxidized silt and sand.
	0.60 – 1.20	Silt and sand.
	1.20	End of test pit.
CS-TP-15-10	0 – 0.30	Organic soil.
	0.30 – 2.20	Silt with traces to some sand.
	2.20	End of test pit.
CS-TP-16-10	0 – 0.30	Organic soil.
	0.30 – 2.40	Silt with traces of sand overlying silt and sand.
	2.40	End of test pit.

5.6 SWITCHYARD

5.6.1 Site Investigation Summary

The 2010 site investigations in the vicinity of the converter station consisted of 2 resistivity lines, 7 boreholes (SY-BH-1-10 to SY-BH-5-10, BH-23-10 and BH-24-10)

and 8 test pits (SY-TP-1-10 to SY-TP-16-10). All Boreholes and test pits were carried on the south bank.

Table 3 gives the borehole coordinates. Borehole and test pit locations are shown on Drawing no 503334-MF-1300-4GDD-0001 in Volume 6.

5.6.2 Boreholes and Test Pits Results

A summary of borehole results is given in Table 17.

TABLE 17: SWITCHYARD - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min-m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
SY-BH-1-10	0 – 2.69 (15.60 –12.91)	Organic soil overlying silty sand with traces of gravel. Very loose to compact condition.				
	2.69 (12.91)	Refusal to penetration of the split spoon.				
SY-BH-2-10	0 – 0.20 (23.64 – 23.44)	Organic soil overlying oxidized sand with traces of silt.				
	0.20 – 7.19 (23.44 – 16.45)	Sand with traces of silt. Very loose to compact condition.				
	7.19 (16.45)	Refusal to penetration of the split spoon.				
SY-BH-3-10	0 – 3.05 (23.08 – 20.03)	Organic soil overlying layers of oxidized silt with some sand, and of sandy silt to sand and silt. Loose to compact condition.				
	3.05 – 4.37 (20.03 – 18.71)	Dynamic cone penetration test to refusal.				
SY-BH-4-10	0 – 3.05 (22.22 – 19.17)	Organic soil overlying layers of sandy silt to silty sand. Loose to compact condition.				
	3.05 – 3.66 (19.17 – 18.56)	Sand with some gravel and traces of silt. Dense condition.				

TABLE 17: SWITCHYARD - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min-m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
SY-BH-4-10 (continued)	3.66 – 5.44 (18.56 – 16.78)	Dynamic cone penetration test to refusal.				
SY-BH-5-10	0 – 0.61 (23.95 – 23.34)	Organic soil overlying oxidized sand with some silt.				
	0.61 – 2.44 (23.34 – 21.51)	Sand with traces to some silt. Loose condition.				
	2.44 – 5.89 (21.51 – 18.06)	Dynamic cone penetration test to refusal.				
BH-23-10	0 – 4.61 (23.06 – 18.45)	Oxidized silt with some sand overlying layers of sandy silt to silty sand. Very loose to compact condition.				
	4.61 – 13.77 (18.45 – 13.77)	Rock : medium to coarse grained granitic gneiss and medium grained granite.	4.61 – 13.77	65 - 100	-	-
BH-24-10	0 – 6.40 (23.57 – 17.17)	Organic soil overlying sand with traces to some silt. Very loose to compact condition.				
	6.40 – 12.85 (17.17 – 10.72)	Gravelly sand with some silt. Presence of cobbles and boulders. Compact condition.				
	12.85 – 23.00 (10.72 – 0.57)	Rock : fine grained biotite and hornblende gneiss and medium grained granitic gneiss.	12.85 – 23.00	73 – 97		

In Boreholes BH-23-10 and BH-24-10, overburden was encountered over respective thicknesses of 4.61 m and 12.85 m. Other boreholes were stopped within overburden at various depths. Boreholes SY-BH-1-10 and SY-BH-2-10 were terminated when refusals to the penetration of the split spoon sampler were

obtained, at depths of 2.69 m and 7.19 m respectively. Boreholes SY-BH-3-10, SY-BH-4-10 and SY-BH-5-10 were followed by dynamic cone penetration tests until refusals, which were obtained at depths of 4.37 m, 5.44 m and 5.89 m.

Overburden in boreholes consisted of sand/silt and sand layers, whose composition varied from silt with some sand, to silt and sand or sand and silt, to sand with traces of silt. These layers locally contained traces or some gravel. Exceptionally in Borehole BH-24-10, between depths of 6.4 m and 12.85 m, a gravelly sand, with some silt, layer was encountered. The presence of cobbles and boulders was observed within this layer. Standard penetration test resistance values that were determined within the sand/silt and sand layers indicated a very loose to compact condition.

Bedrock was found in Boreholes BH-23-10 and BH-24-10 at respective depths of 4.61 m and 12.85 m, or at corresponding elevations of 18.45 m and 10.72 m. Bedrock was drilled over lengths of 9.16 m (BH-23-10) and 10.15 m (BH-24-10).

In Borehole BH-23-10, bedrock is composed of medium to coarse grained granitic gneiss and of medium grained granite. In borehole BH-24-10, it is composed of fine grained biotite and hornblende gneiss and of medium grained granitic gneiss. Except granite, rock in boreholes is slightly to highly foliated. The rock is generally fresh to moderately weathered with joint surfaces stained with oxides and particularly with hematite, which can give the rock its typical reddish color.

Rock quality according to the RQD indexes varies from fair to excellent.

A summary of the test pit results is given in Table 18.

TABLE 18: SWITCHYARD - SUMMARY OF TEST PIT RESULTS

TEST PIT No	DEPTH (m)	DESCRIPTION
SY-TP-2-10	0 – 0.90	Organic soil overlying sand with traces of silt.
	0.90 – 1.60	Gravel and sand with traces of silt. Presence of cobbles (5-10 %).
	1.60	End of test pit.
SY-TP-3-10	0 – 0.45	Organic soil overlying indurated layer.
	0.45 – 1.20	Sand with some silt.
	1.20 – 2.40	Sand.
	2.40	End of test pit.
SY-TP-4-10	0 – 0.60	Organic soil overlying oxidized silt with some sand.
	0.60 – 2.30	Sand with some silt.
	2.30	End of test pit.
SY-TP-5-10	0 – 0.60	Organic soil overlying oxidized sand with some silt and gravel.
	0.60 – 2.20	Sand with traces of silt.
	2.20	End of test pit.
SY-TP-6-10	0 – 0.70	Organic soil overlying oxidized sand with some silt.
	0.70 – 2.30	Sand with some silt.
	2.30	End of test pit.
SY-TP-7-10	0 – 0.60	Organic soil overlying oxidized sand with some silt.
	0.60 – 2.30	Sandy silt.
	2.30	End of test pit.
SY-TP-8-10	0 – 0.60	Organic soil overlying oxidized silt with traces of sand.
	0.60 – 2.30	Silty sand.
	2.30	End of test pit.
SY-TP-9-10	0 – 0.60	Organic soil overlying oxidized sand with some silt.
	0.60 – 1.20	Silt with traces of sand.
	1.20– 2.3	Sandy silt.
	2.30	End of test pit.

Test pits were stopped within overburden at depths ranging from 1.60 m and 2.40 m. Soils in test pits consisted of various layers of sand/silt soils (silt with some sand, sandy silt, silty sand) and of sand with traces to some silt and occasionally traces or

some gravel. Exceptionally in Test Pit SY-TP-2-10, a gravel and sand layer containing traces of gravel and cobbles (5-10%) was encountered from the depth of 0.90 m to the end of the pit (1.60 m). Water infiltrations were observed in Test Pits SY-TP-2-10, SY-TP-5-10, SY-TP-7-10 and SY-TP-9-10 at depths varying between 0.2 m and 2.3 m.

5.7 ACCOMMODATIONS COMPLEX

5.7.1 Site Investigation Summary

The 2010 site investigation in the vicinity of the accommodations complex consisted of 8 boreholes (AC-BH-1-10 to AC-BH-8-10), 16 test pits (AC-TP-2-10 to AC-TP-4-10, AC-TP-6-10, AC-TP-8-10, AC-TP-13-10, AC-TP-16-10, AC-TP-17-10, AC-TP-20-10, AC-TP-21-10, AC-TP-26-10 to AC-TP-28-10, AC-TP-30-10, AC-TP-31-10 and AC-TP-33-10) and of 12 soundings with a portable hammer drill (Pionjar) (AC-P-1-10 to AC-P-12-10). The accommodations complex is located on the south bank, about 2 km south-east of the dam site.

Table 3 indicates the borehole coordinates. The locations of the boreholes, the test pits and the Pionjar soundings are shown on Drawing no 503334-MF-1300-4GDD-0003 in Volume 6.

5.7.2 Borehole, Test Pits and Pionjar Sounding Results

Borehole results are summarized in Table 19.

TABLE 19: ACCOMMODATIONS COMPLEX - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min-m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
AC-BH-1-10	0 – 1.07	Organic soil overlying sand with traces of silt. Very loose condition.				
	1.07 – 1.91	Silty clay of medium plasticity.				
	1.91 – 3.66	Sand with some silt, traces of gravel. Compact condition.				

TABLE 19: ACCOMMODATIONS COMPLEX - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min-m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
AC-BH-1-10 (continued)	3.66 – 6.71	Dynamic cone penetration test.				
AC-BH-2-10	0 – 1.52	Organic soil overlying layers of gravel and sand to sand and gravel, traces to some silt. Compact condition.				
	1.52	Refusal to penetration of the split spoon sampler.				
AC-BH-3-10	0 – 0.61	Organic soil overlying silty clay of medium plasticity.				
	0.61 – 1.22	Sand with some silt. Compact condition.				
	1.22 – 1.83	Sand and gravel, traces of silt. Compact condition.				
	1.83 – 6.71	Dynamic cone penetration test.				
AC-BH-4-10	0 – 0.23	Organic soil overlying silt with some sand.				
	0.23 – 1.22	Sand with trace of silt and locally traces of gravel. Compact condition.				
	1.22 – 3.66	Layers of gravelly sand and of sand with some gravel, traces of silt. Compact to very loose condition.				
	3.66 – 4.27	Layers of silty sand and of silt with traces of sand, traces to some gravel. Loose condition.				
	4.27 – 6.71	Dynamic cone penetration test.				

TABLE 19: ACCOMMODATIONS COMPLEX - SUMMARY OF BOREHOLE RESULTS

BOREHOLE No	DEPTH (m)	DESCRIPTION	RQD (%)		ABSORPTION (l/min-m)	
	Elevation (m)		Depth (m)	Value	Depth (m)	Value
AC-BH-5-10	0 – 0.61	Organic soil overlying silt with traces of sand.				
	0.61 – 3.05	Layers of silty clay with some sand and of silty clay and sand. Low plasticity.				
	3.05 – 6.71	Dynamic cone penetration test.				
AC-BH-6-10	0 – 1.83	Organic soil overlying silt with traces of sand to sandy silt. Very loose to compact condition.				
	1.83 – 6.71	Dynamic cone penetration test.				
AC-BH-7-10	0 – 1.83	Organic soil overlying silt with traces or some clay to silty clay with sand. Medium to low plasticity.				
	1.83 – 3.05	Silt and sand with traces of clay. Compact condition.				
	3.05 – 6.71	Dynamic cone penetration test.				
AC-BH-8-10	0 – 4.88	Organic soil overlying layers of sand and silt with traces or some clay, and of silty clay and sand.				
	4.88 – 6.05	Dynamic cone penetration test to refusal.				

All boreholes were stopped in overburden at depths varying between 1.52 m (AC-BH-2-10) and 4.88 m (AC-BH-8-10). Borehole AC-BH-2-10 was terminated when a refusal to the penetration of the split spoon sampler was obtained, at the depth of 1.52 m. The other 7 boreholes were followed by dynamic cone penetration

tests. These tests were stopped at the depth of 6.71 m underneath existing ground surface without any refusal being obtained, with the exception of the test in Borehole AC-BH-8-10 which indicated refusal at the depth of 6.05 m.

Overburden in boreholes mainly consists of different layers of sand containing variable proportions of silt and gravel. The composition of these soil layers is varying from sand with traces or some silt, to silt with some sand to silty sand, and to gravelly sand and sand and gravel. Based on the standard penetration test "N" values, these soils are in a very loose to compact condition. Some layers of silty clay and of silty clay/sand materials (silty clay with some sand, silty clay and sand) were also encountered in some boreholes, namely Boreholes AC-BH-1-10, AC-BH-3-10, AC-BH-5-10, AC-BH-7-10 and AC-BH-8-10, over thicknesses ranging from 0.58 m to 2.44 m. Clayey soils are of low to medium plasticity.

The results of the test pits are summarized in Table 20.

TABLE 20: ACCOMMODATIONS COMPLEX - SUMMARY OF TEST PIT RESULTS

TEST PIT No	DEPTH (m)	DESCRIPTION
AC-TP-2-10	0 – 0.55	Organic soil overlying silty clay with some sand (low plasticity).
	0.55 – 2.80	Sand with some silt, traces of gravel below the depth of 2.2 m.
	2.80	End of test pit.
AC-TP-3-10	0 – 2.70	Organic soil overlying silty clay with traces of sand. Low to medium plasticity.
	2.70	End of test pit.
AC-TP-4-10	0 – 0.80	Organic soil overlying silt with traces of clay.
	0.80 – 2.90	Sand with traces of silt.
	2.90	End of test pit.
AC-TP-6-10	0 – 1.20	Organic soil overlying silt with traces of clay and traces of sand.
	1.20 – 2.20	Silt and sand.
	2.20	End of test pit.

TABLE 20: ACCOMMODATIONS COMPLEX – SUMMARY OF TEST PIT RESULTS

TEST PIT No	DEPTH (m)	DESCRIPTION
AC-TP-8-10	0 – 0.60	Organic soil overlying oxidized silt with some sand.
	0.60 – 2.70	Sand with traces on silt.
	2.70	End of test pit.
AC-TP-13-10	0 – 3.00	Organic soil overlying silty clay with traces of sand. Medium plasticity.
	3.00	End of test pit.
AC-TP-16-10	0 – 0.75	Organic soil overlying oxidized sand with traces of silt.
	0.75 – 2.90	Sand with traces of silt.
	2.90	End of test pit.
AC-TP-17-10	0 – 1.70	Organic soil overlying silt with traces or some clay.
	1.70	End of test pit.
AC-TP-20-10	0 – 2.50	Organic soil overlying silt with traces or some clay.
	2.50 – 2.90	Sand and gravel with some silt. Presence of cobbles (0-5%).
	2.90	End of test pit.
AC-TP-21-10	0 – 0.60	Organic soil overlying oxidized silt with some sand.
	0.60 – 2.70	Sand with traces of silt.
	2.70	End of test pit.
AC-TP-26-10	0 – 1.50	Organic soil overlying silty and gravelly sand. Presence of cobbles (0-5 %).
	1.50	End of test pit.
AC-TP-27-10	0 – 1.00	Organic soil overlying silty sand with traces of gravel.
	1.00 – 2.20	Sand and gravel with traces of silt.
	2.20	End of test pit.
AC-TP-28-10	0 – 0.65	Organic soil overlying oxidized sand with some sand.
	0.65 – 2.80	Sand overlying sand and gravel with traces of silt.
	2.80 – 2.90	Silty clay. Low plasticity.
	2.90	End of test pit.

TABLE 20: ACCOMMODATIONS COMPLEX - SUMMARY OF TEST PIT RESULTS

TEST PIT No	DEPTH (m)	DESCRIPTION
AC-TP-30-10	0 – 0.30	Organic soil
	0.30 – 2.20	Gravel and sand with traces of silt. Presence of cobbles (15-20 %) and of one boulder.
	2.20	End of test pit.
AC-TP-31-10	0 – 0.30	Organic soil.
	0.30 – 2.20	Gravel and sand with traces of silt. Presence of cobbles (10-15 %).
	2.20	End of test pit.
AC-TP-33-10	0 – 0.30	Organic soil overlying oxidized silty sand.
	0.30 – 2.40	Sand with traces of silt.
	2.40	End of test pit.

Test pits were excavated to depths ranging from 1.5 m (AC-TP-26-10) to 3.0 m (AC-TP-13-10). In 7 of the 16 test pits that were carried out at the accommodations complex site (AC-TP-2-10, AC-TP-4-10, AC-TP-8-10, AC-TP-16-10, AC-TP-21-10, and AC-TP-33-10), underneath surficial organic and oxidized layers, the subsoil is mainly composed of sand with traces of silt. In 4 other test pits, namely Test Pits AC-TP-26-10, AC-TP-27-10, AC-TP-30-10 and AC-TP-31-10, soils whose composition varies from gravelly sand to sand and gravel or gravel and sand are prevailing. These sand/gravel soils generally contain traces of silt, and cobbles in proportions that can reach about 20 %. One boulder was encountered in Test Pit AC-TP-30-10. Finally, in the last 5 test pits (AC-TP-3-10, AC-TP-6-10, AC-TP-13-10, AC-TP-17-10 and AC-TP-20-10), the subsoil mainly consists of fine silt/clay materials. The composition is silt with traces or some clay and of silty clay. Clayey soils are of low to medium plasticity. Water infiltrations were observed in Test Pits AC-TP-2-10 to AC-TP-4-10, AC-TP-6-10, AC-TP-13-10, AC-TP-17-10 and AC-TP-27-10 between depths of 0.2 m and 2.2 m.

Pionjar Sounding AC-P-10-10 indicated refusals at depths between 2.29 m and 2.85 m. All other Pionjar soundings were stopped without any refusal being obtained, at depths varying between 3.10 m and 10.10 m.

5.8 BORROW AREAS

In 2010, a total of 13 borrow areas were investigated, consisting of 8 till deposits (TD-4 to TD-11) and 5 granular material deposits (GD-6, GD-7, GD-8, GD-10, GD-11 and GR-5).

Of those, 2 till deposits (TD-9 and TD-10) were rejected, due to the presence of numerous rock outcrops at the surface.

5.8.1 Granular Material

5.8.1.1 Borrow Area GR-5

General Description

Borrow Area GR-5 is located approximately 5.5 km northwest of the Churchill River and approximately 10 km west of the Muskrat Falls dam site (see Drawing no 503334-MF-1300-4GDD-0004 in Volume 6). The shortest distance from the Trans Labrador Highway to the GR-5 Borrow Area is approximately 1.2 km, with two small brooks to cross. The area comprises 2 sections, identified as GR-5 East and GR-5 West, separated by a stream flowing in a north-south direction. As a whole, Borrow Area GR-5 stretches nearly 2 km from east to west, with a width generally varying from 200 to 300 m.

The western section is composed of 2 terraces of different levels, the southern one being approximately 30 m below the north terrace. A steep slope separates those terraces. This western section is bounded at its northwest by a lake and on its northeast, east and south sides by streams. The eastern terrace (GR-5 East) is delimited at its north, east and west sides by streams and at its south by a steep slope over 30 m high.

The borrow area is generally sparsely wooded with slightly more densely wooded areas located along the streams and in the lower terrace of the GR-5 west section. The ground surfaces along the terraces are relatively flat, particularly along the eastern section.

A photograph of Borrow Area GR-5 is presented on Figure 3 and shows approximate limits of the area.

FIGURE 3: AERIAL PHOTOGRAPH OF BORROW AREA GR-5 EAST, VIEWING TO THE WEST

Summary of Investigations

The 2010 field program consisted of the excavation of 22 test pits numbered GR-5-TP-1-10 to GR-5-TP-22-10. All test pits were stopped in overburden at depths varying between 1.60 m and 3.40 m. Twenty-eight (28) sieve analyses and 33 moisture content determinations were also performed on samples retrieved from the test pits. The results of the grain size analysis are presented in a graphical

format on a figure following the corresponding test pit report. The results of the water content determinations are indicated on test pit reports.

The locations of the test pits are shown on Drawing no 503334-MF-1300-4GDD-0005 in Volume 6.

Soil Description

In Test pits GR-5-TP-1-10 to GR-5-TP-22-10, underneath surficial organic and oxidized layers, from depths varying between 0.25 m and 1.40 m, subsoil is consisting of a granular material deposit generally composed of gravel and sand or sand and gravel, of gravelly sand and of sand with traces or some gravel. The deposit contains traces of silt except locally in Test Pit GR-5-TP-7-10 (1.85 m to 3.0 m) and in Test Pit GR-5-TP-12-10 (2.7 m to 3.0 m) where strata of sand with some silt and of silt and sand were encountered. The presence of cobbles and boulders was observed in most of the test pits, in proportions that can reach respectively 30 to 35% (15 test pits) and 5 to 10% (5 test pits).

The following Figures 4 to 9 give the results of all grain size analyses that were carried out on samples from Borrow Area GR-5, in comparison to the granular fill specification. These figures show that the granular fill specifications are met for samples from Test Pits GR-5-TP-1-10 to GR-5-TP-6-10, GR-5-TP-7-10 to GR-5-TP-9-10, GR-5-TP-16-10 and GR-5-TP-17-10, with the exception of sample BS-2 from Test Pit GR-5-TP-7-10.

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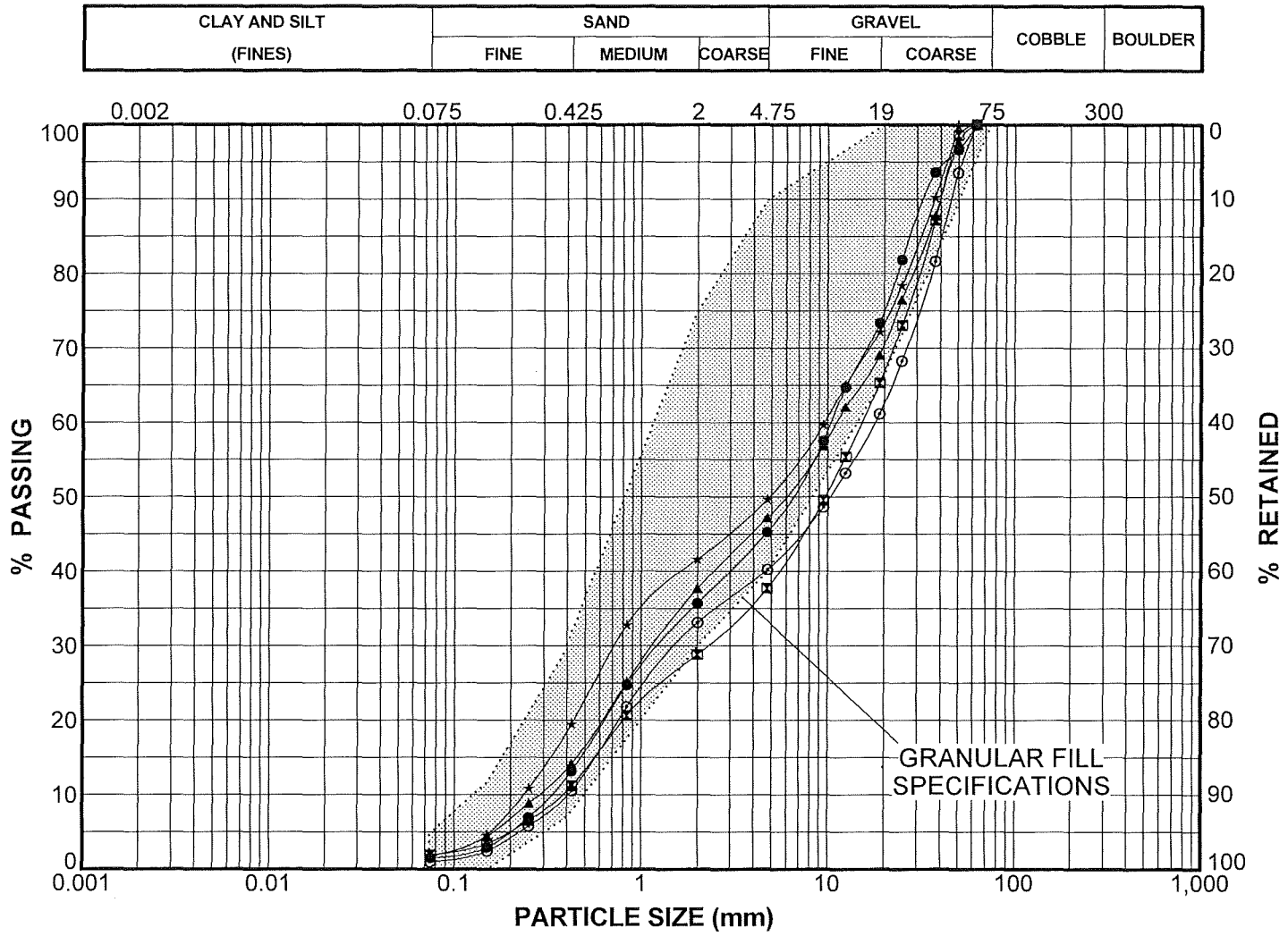
PARTICLE SIZE DISTRIBUTION

FIGURE 4

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area GR-5
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	GR-5-TP- 1-10	BS-1	1.50	2.30	55	44	2	**Gravel and sand** with traces of silt.
⊠	GR-5-TP- 2-10	BS-1	1.30	2.30	62	36	2	**Gravel and sand** with traces of silt.
▲	GR-5-TP- 3-10	BS-1	1.20	2.50	53	45	2	**Gravel and sand** with traces of silt.
★	GR-5-TP- 4-10	BS-1	1.20	2.80	50	48	2	**Gravel and sand** with traces of silt.
⊙	GR-5-TP- 5-10	BS-1	1.10	2.20	60	39	1	**Gravel and sand** with traces of silt.

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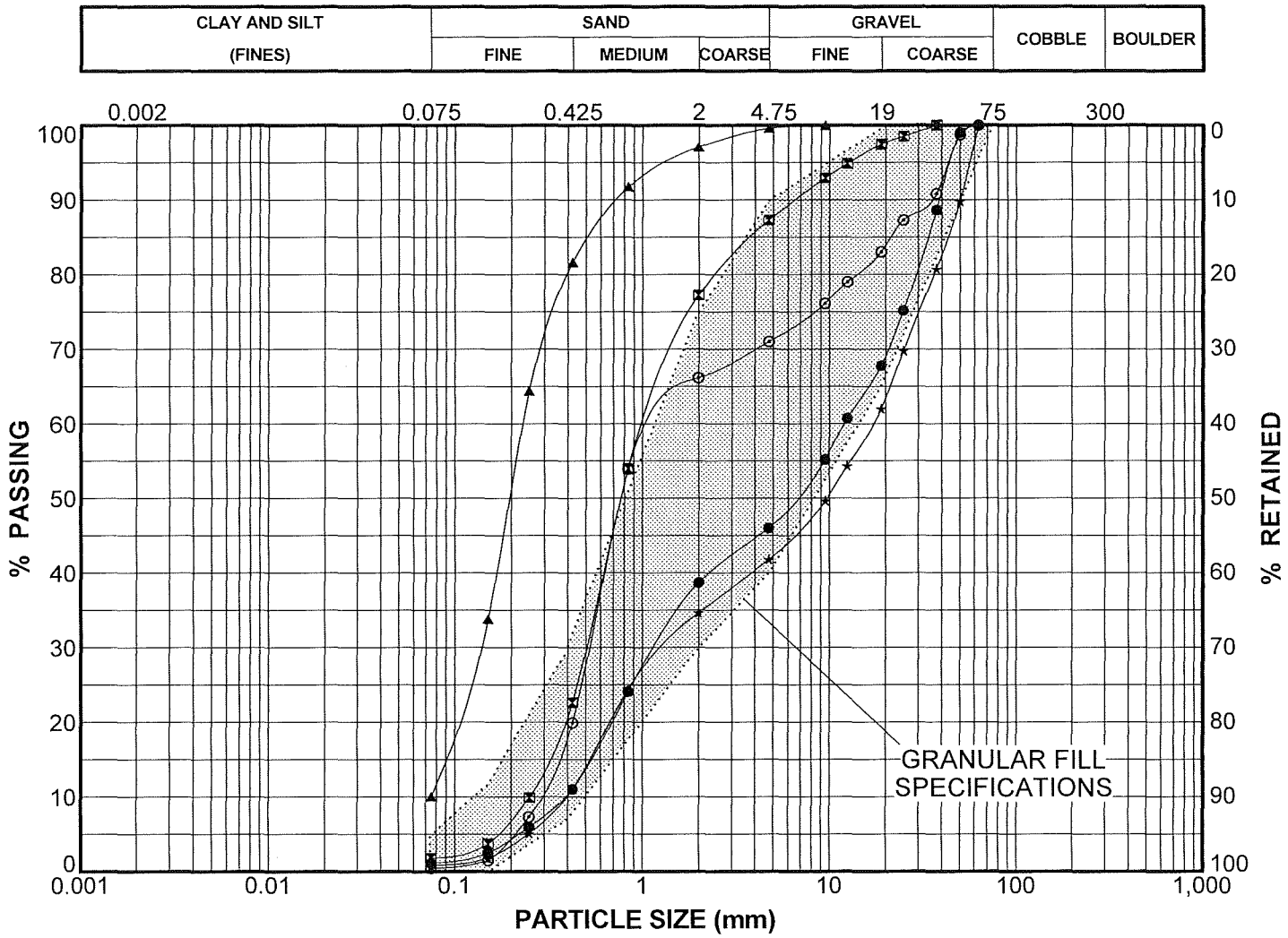
PARTICLE SIZE DISTRIBUTION

FIGURE 5

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area GR-5
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	GR-5-TP- 6-10	BS-1	1.20	2.10	54	45	1	**Gravel and sand** with traces of silt.
⊠	GR-5-TP- 7-10	BS-1	1.00	1.80	13	85	2	**Sand** with some gravel and traces of silt.
▲	GR-5-TP- 7-10	BS-2	2.00	2.90	0	90	10	**Sand** with some silt.
★	GR-5-TP- 8-10	BS-1	1.20	2.00	58	41	1	**Gravel and sand** with traces of silt.
⊙	GR-5-TP- 8-10	BS-2	2.00	2.80	29	71	0	**Gravelly sand.**

REMARKS :

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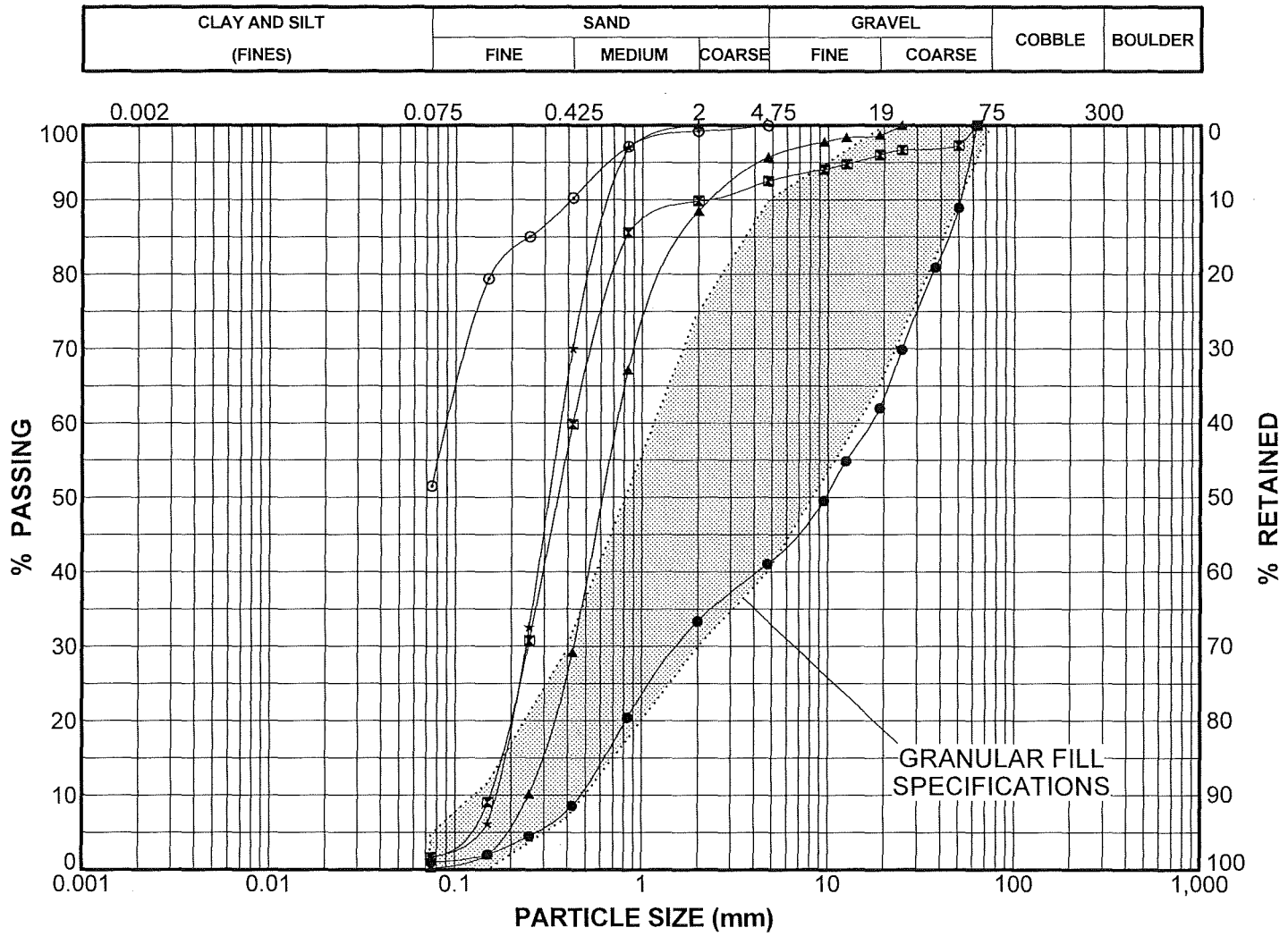
PARTICLE SIZE DISTRIBUTION

FIGURE 6

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area GR-5
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	GR-5-TP- 9-10	BS-1	1.00	3.00	59	40	1	**Gravel and sand** with traces of silt.
⊠	GR-5-TP-10-10	BS-1	1.00	3.00	7	91	2	**Sand** with traces of gravel and traces of silt.
▲	GR-5-TP-11-10	BS-1	0.40	1.70	4	96	0	**Sand** with traces of gravel.
★	GR-5-TP-12-10	BS-1	1.00	2.70	0	98	2	**Sand** with traces of silt.
⊙	GR-5-TP-12-10	BS-2	2.70	3.00	0	48	52	**Silt and sand.**

REMARKS :

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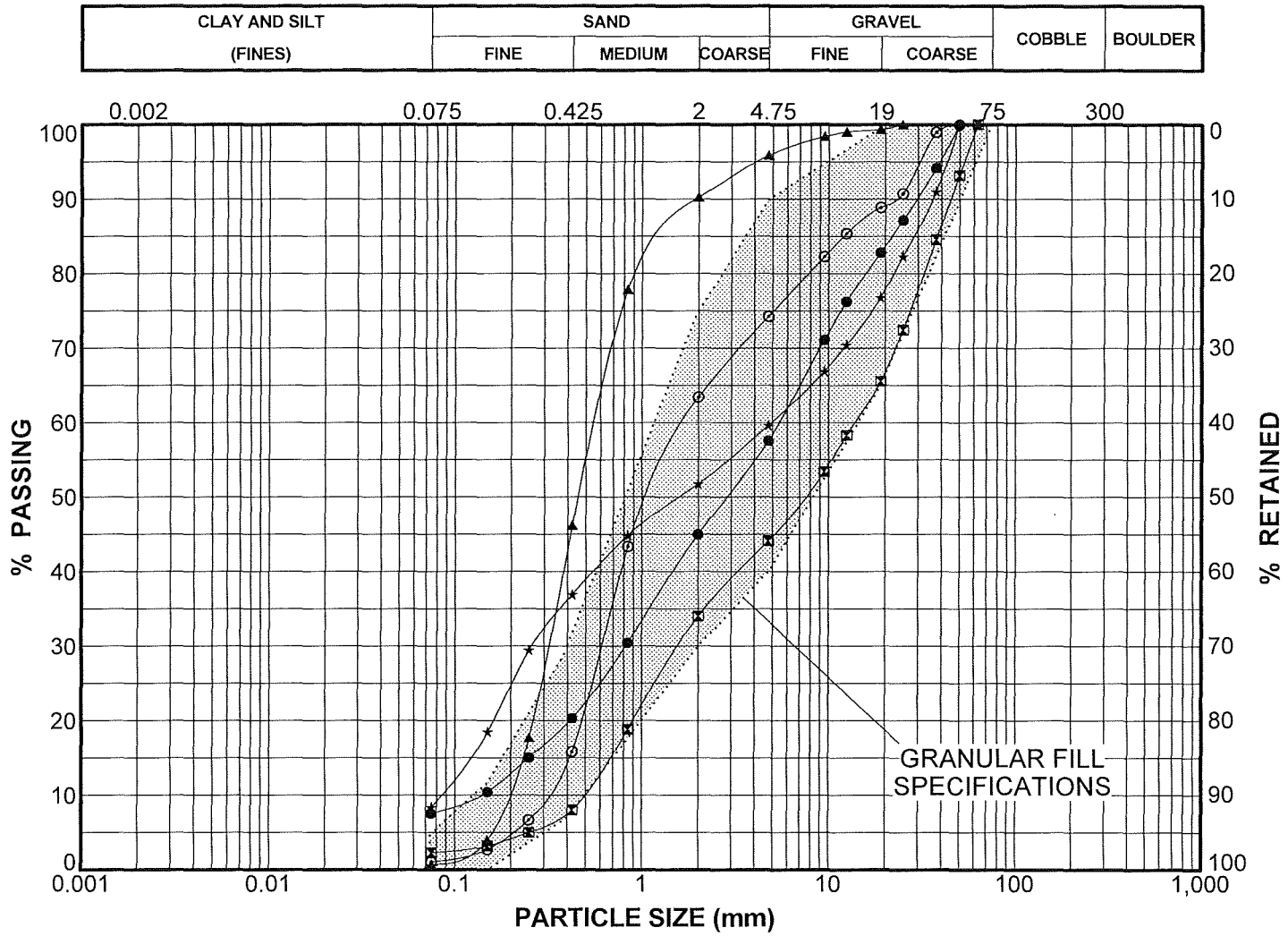
PARTICLE SIZE DISTRIBUTION

FIGURE 7

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area GR-5
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	GR-5-TP-13-10	BS-1	0.70	2.50	42	50	8	**Sand and gravel** with traces of silt.
⊠	GR-5-TP-14-10	BS-1	0.80	1.00	56	42	2	**Gravel and sand** with traces of silt.
▲	GR-5-TP-14-10	BS-2	1.40	3.10	4	95	1	**Sand** with traces of gravel and traces of silt.
★	GR-5-TP-15-10	BS1	0.60	1.50	40	51	8	**Sand and gravel** with traces of silt.
⊙	GR-5-TP-16-10	BS-1	1.20	2.60	26	73	1	**Gravelly sand** with traces of silt.

REMARKS :

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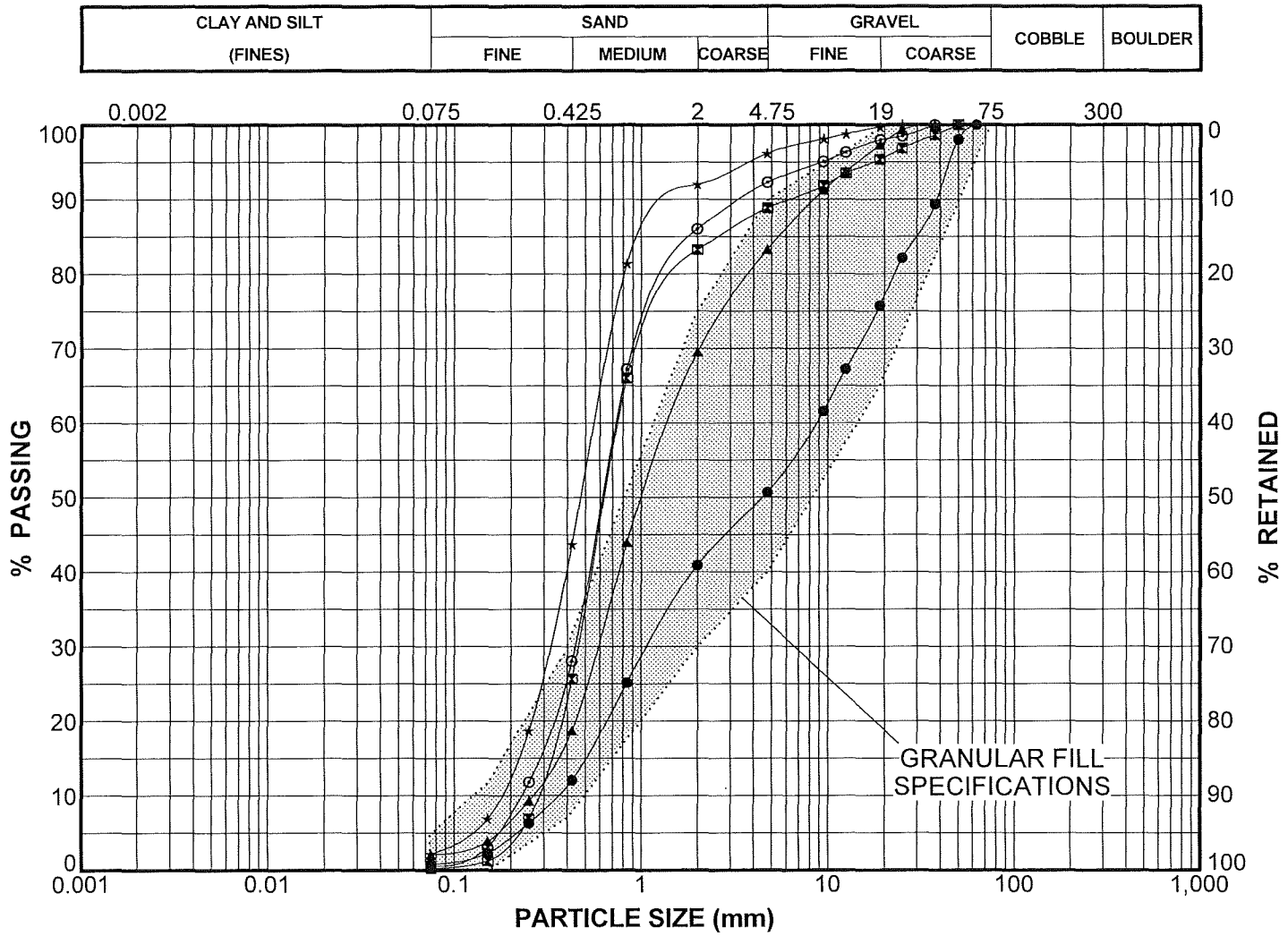
PARTICLE SIZE DISTRIBUTION

FIGURE 8

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area GR-5
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	GR-5-TP-17-10	BS-1	1.20	2.70	49	50	1	**Sand and gravel** with traces of silt.
⊠	GR-5-TP-18-10	BS-1	1.30	2.60	11	89	0	**Sand** with some gravel.
▲	GR-5-TP-19-10	BS-1	1.20	1.60	17	81	2	**Sand** with some gravel and traces of silt.
★	GR-5-TP-19-10	BS-2	1.90	2.80	4	94	2	**Sand** with traces of gravel and traces of silt.
⊙	GR-5-TP-20-10	BS-1	1.00	2.70	8	92	1	**Sand** with traces of gravel and traces of silt.

REMARKS :

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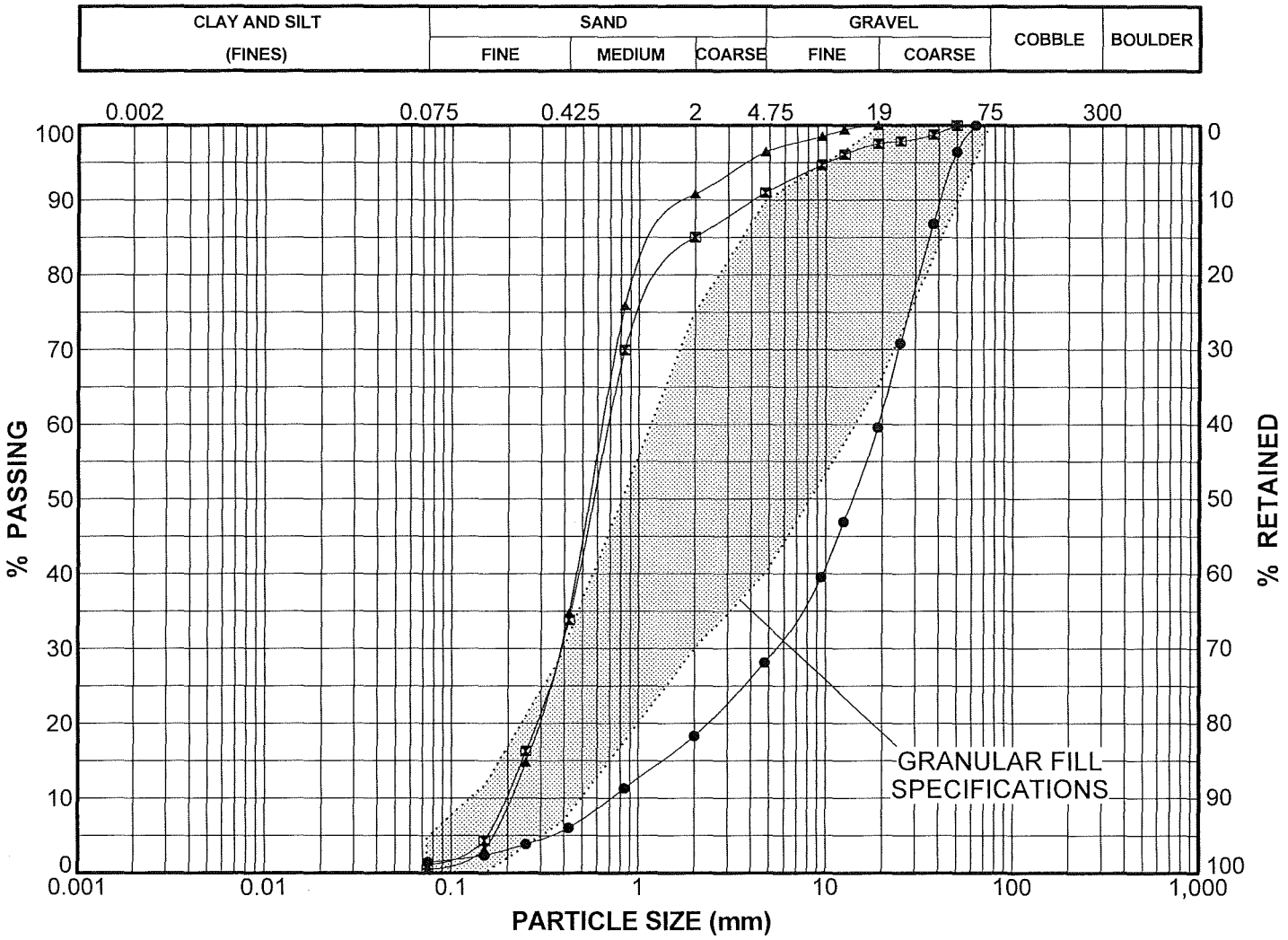
PARTICLE SIZE DISTRIBUTION

FIGURE 9

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area GR-5
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	GR-5-TP-21-10	BS-1	0.60	1.50	72	27	1	**Sandy gravel** with traces of silt.
⊠	GR-5-TP-22-10	BS-1	1.10	1.30	9	90	1	**Sand** with traces of gravel and silt.
▲	GR-5-TP-22-10	BS-2	2.60	3.30	4	96	0	**Sand** with traces of gravel

REMARKS :

Water Infiltration

Water infiltrations were observed in Test Pits GR-5-TP-1-10, GR-5-TP-3-10, GR-5-TP-4-10, GR-5-TP-10-10, GR-5-TP-11-10, GR-5-TP-15-10 and GR-5-TP-21-10, all located in the west portion of the borrow area, at depths ranging from 0.3 m to 2.4 m.

Estimated Volume

Borrow Area GR-5 can be separated into two sections, west and east. The total west section area and east section area for which the materials meet the granular fill specifications are approximately 298,000 m^2 and of 119,000 m^2 respectively. The average thicknesses of suitable material within west and east section areas are 1.8 m and 1.5 m respectively, after stripping organic and oxidized soil layers. The total estimated gross volume of available material is 285,000 m^3 for both sections, considering cobble contents of 20% and 5% for the west and east sections, and a boulder content of 5% for the east section. A safety factor of 2 was applied (i.e. half of the total available is suitable for project use).

5.8.1.2 Borrow Area GD-7

General Description

Borrow Area GD-7 is located approximately 8.5 km south-east of the Muskrat Falls dam site, and 2.5 km south of the Churchill river (see Drawing no 503334-MF-1300-4GDD-0004 in Volume 6). The proposed project access road should cross the south western section of the area. The area of interest has an irregular shape, stretching approximately 900 m from the south-west to the north-east, with a width generally varying from 150 to 200 m. The borrow area is bounded at its north by boggy lands, while a stream bounds its eastern side. The surface is densely wooded. The photograph in Figure 10 shows the site and approximate limits of the area.

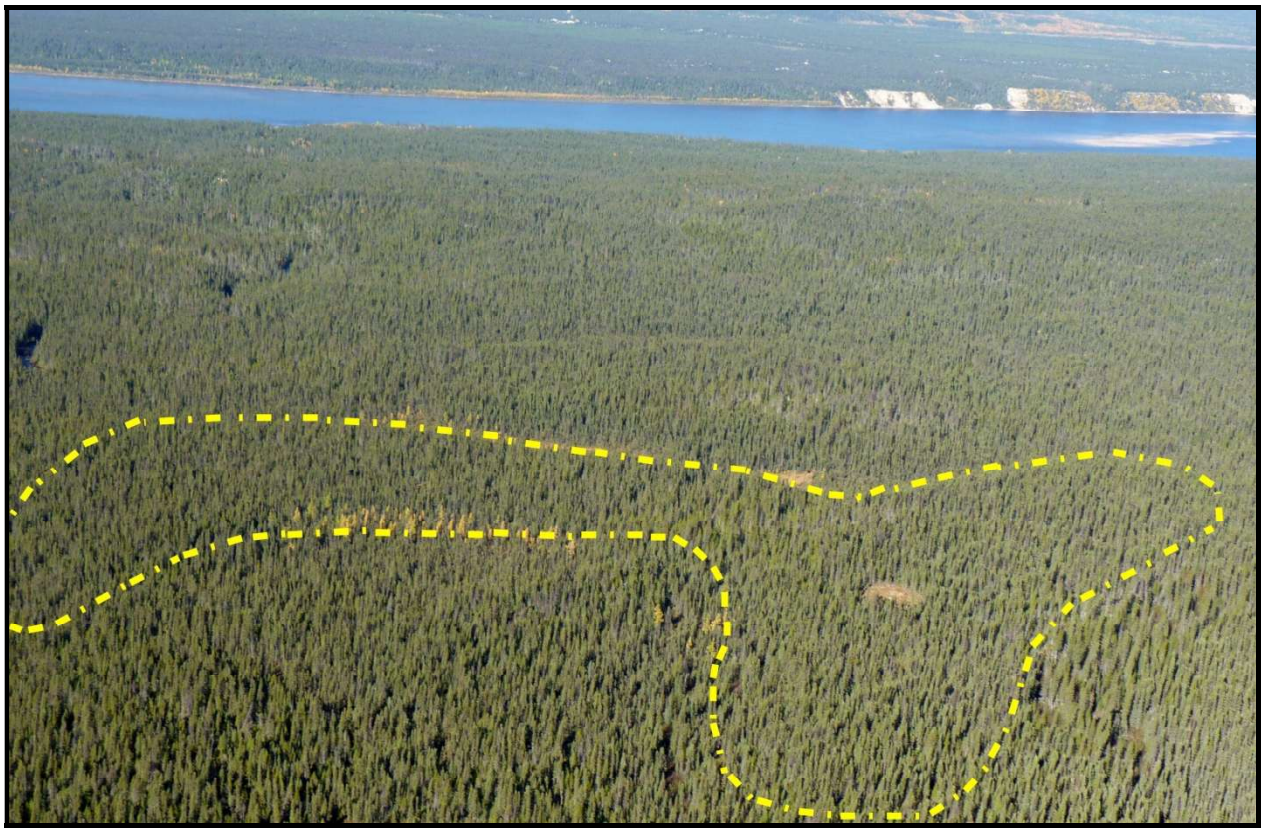


FIGURE 10: AERIAL PHOTOGRAPH OF BORROW AREA GD-7, VIEWING TO THE NORTH

Summary of Investigations

The 2010 field program consisted of the excavation of 4 test pits designated GD-7-TP-1-10 to GD-7-TP-4-10. All test pits were stopped in overburden at depths varying between 2.60 m and 2.95 m. Four (4) sieve analyses and 8 native moisture content determinations were carried out on soil samples recovered from test pits. Results of the grain size analyses are presented in a graphical format on a figure following the corresponding test pit report. Results of the water content are indicated on test pit reports.

The locations of the test pits are shown on Drawing no 503334-MF-1300-4GDD-0006 in Volume 6.

Soil Description

Beneath surficial layers of organic and oxidized soils, from depths varying between 0.50 m and 1.10 m, subsoil in Test Pits GD-7-TP-1-10 and GD-7-TP-2-10 is mainly composed of silty sand or of sand with some silt. It contains traces of gravel, cobbles (0-5%) and boulders (0-5%). In Test Pits GD-7-TP-3-10 and GD-7-TP-4-10, subsoil consists of sand with traces of gravel and of gravelly sand to sand and gravel. It generally contains traces of silt, and cobbles (0-10%).

The results of all grain size analyses that were carried out on samples from Borrow Area GD-7 are shown on Figure 11, compared to the granular fill specifications. From this figure, it appears that materials from Borrow Area GD-7 are not suitable for use as granular fill. Nevertheless, it is to be pointed out that sand from Test Pit GD-7-TP-4-10, after screening the portion retained on the 4.75 mm sieve, could meet sieve specifications for concrete fine aggregate.

Water Infiltration

No water infiltration was observed during the excavation of the 4 test pits at Borrow Area GD-7.

Estimated Volume

Estimation of available material volume was not pertinent for Borrow Area GD-7, the material being unsuitable for granular fill.

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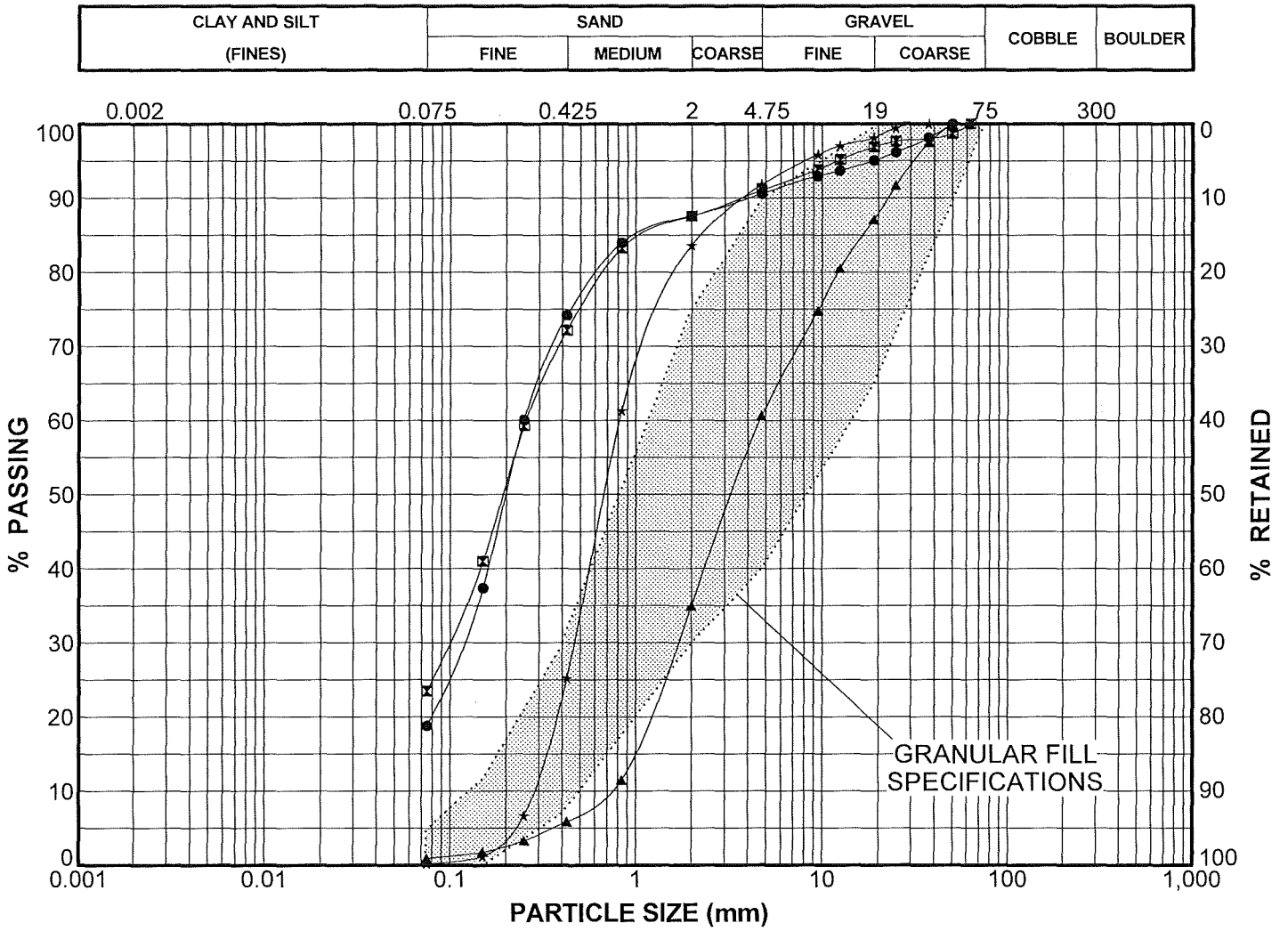
FIGURE 11

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area GD-7
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	GD- 7-TP-1-10	BS-1	1.20	2.80	9	72	19	**Sand** with some silt and traces of gravel.
⊠	GD- 7-TP-2-10	BS-1	1.00	2.50	9	68	24	**Silty sand** with traces of gravel.
▲	GD- 7-TP-3-10	BS-1	1.00	2.60	39	60	1	**Sand and gravel** with traces of silt.
★	GD- 7-TP-4-10	BS-1	1.40	2.60	8	92	0	**Sand** with traces of gravel.

REMARKS :

5.8.1.3 Borrow Area GD-8

General Description

Borrow Area GD-8 is located approximately 7.3 km south-east of the Muskrat Falls dam site, and 3.3 km south of the Churchill River (see Drawing no 503334-MF-1300-4GDD-0004 in Volume 6). It is also located 2.7 km south of the proposed access road to the project site. The deposit stretches approximately 700 m from the south-west to the north-east, with a width varying from 150 m (south-west) and to 400 m (north-east). The borrow area consists of a moderately to densely wooded plateau, bounded on the south-east side by a small river.

Figure 12 is a photograph of Borrow Area GD-8.

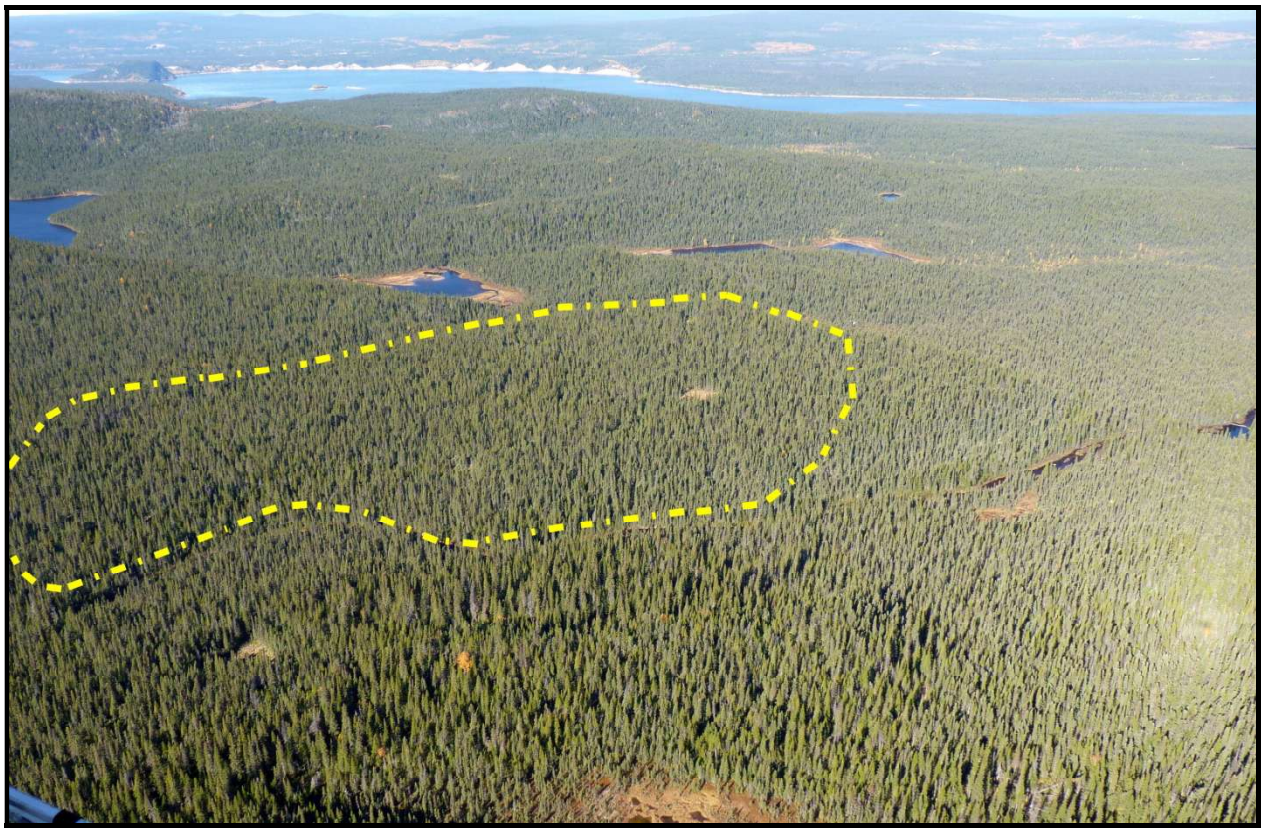


FIGURE 12: AERIAL PHOTOGRAPH OF BORROW AREA GD-8, VIEWING TO THE NORTH-WEST

Summary of Investigations

Borrow Area GD-8 was investigated in 2010 by means of 5 test pits numbered GD-8-TP-1-10 to GD-8-TP-5-10. All test pits were stopped in overburden at depths varying between 2.40 m and 2.85 m. Four (4) sieve analyses, and 7 native moisture content determinations were performed in the laboratory on samples retrieved from test pits. The results of the grain size analyses are presented in a graphical format on a figure following the corresponding test pit report. The results of the water content determinations appear on test pit reports.

The locations of the test pits are shown on Drawing no 503334-MF-1300-4GDD-0006 in Volume 6.

Soil Description

A soil deposit mainly composed of gravel and sand with traces of silt was encountered in Test Pits GD-8-TP-1-10 to GD-8-TP-5-10, underneath surficial layers of organic and oxidized soils, from depths varying between 0.45 m and 1.20 m. This deposit contains cobbles and boulders in respective proportions of 5% to 15% and of 0% to 5%.

Results of grain size analyses that were carried out on samples from Borrow Area GD-8 are presented on Figure 13, in comparison with the granular fill specifications. The figure shows that materials from Test Pit GD-8-TP-1-10 to GD-8-TP-4-10 generally meet granular fill specifications with the exception of the fraction passing the 4.75 mm and 2 mm sieve, which are less than the specifications.

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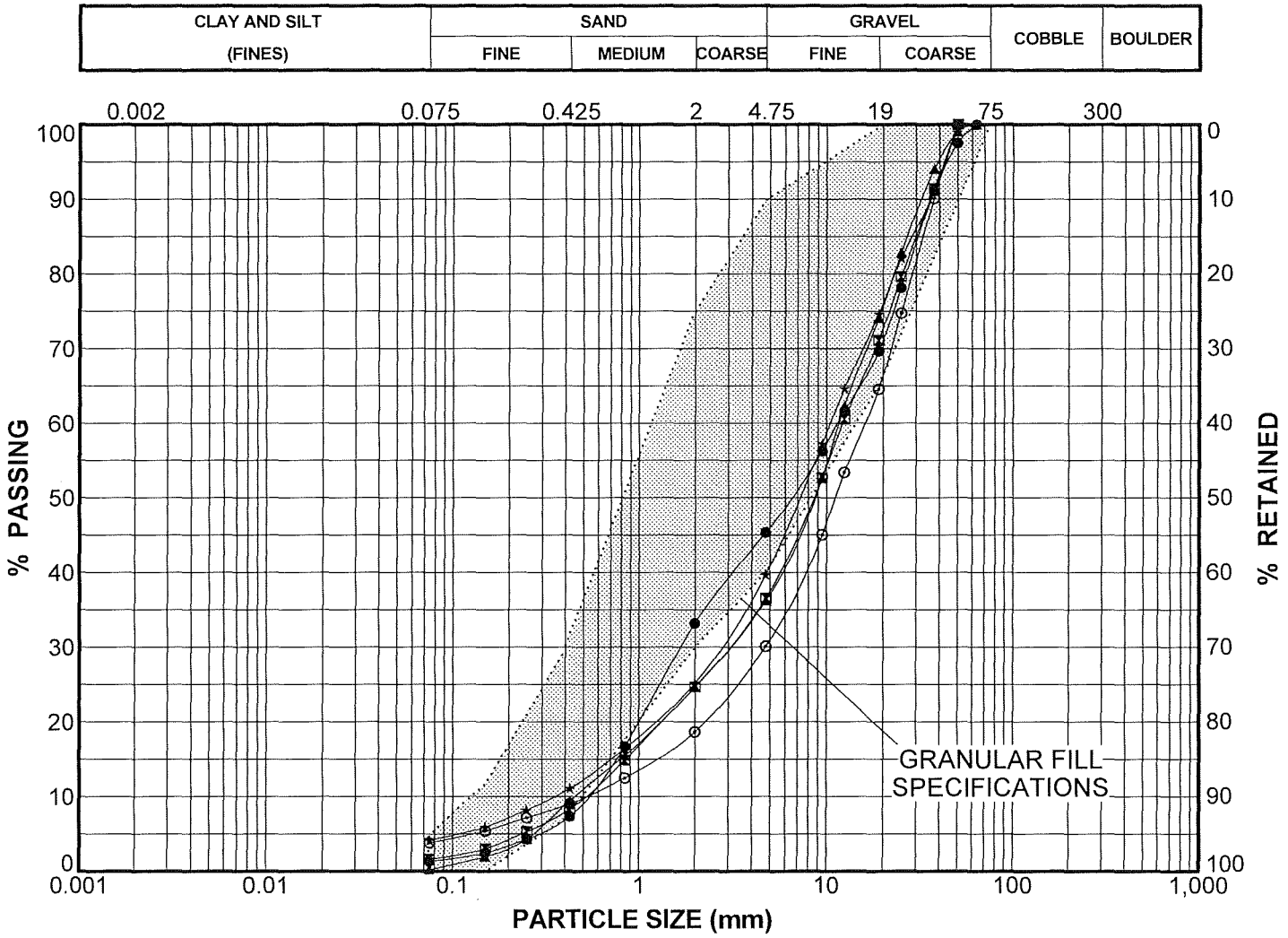
PARTICLE SIZE DISTRIBUTION

FIGURE 13

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area GD-8
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	GD- 8-TP-1-10	BS-1	1.00	2.60	55	44	1	**Gravel and sand** with traces of silt.
■	GD- 8-TP-2-10	BS-1	1.00	2.70	63	35	2	**Gravel and sand** with traces of silt.
▲	GD- 8-TP-3-10	BS-1	1.00	2.50	64	36	0	**Gravel and sand.**
★	GD- 8-TP-4-10	BS-1	1.00	2.30	60	36	4	**Gravel and sand** with traces of silt.
⊙	GD- 8-TP-5-10	BS-1	1.40	2.50	70	26	4	**Sandy gravel** with traces of silt.

REMARKS :

Water Infiltration

No water infiltration was observed during the excavation of the test pits in borrow Area GD-8.

Estimated Volume

The materials generally meeting the granular fill specifications cover an approximate area of 162,500 m^2. The average thickness of suitable material is about 1.8 m, after stripping organic and oxidized layers. The total estimated gross volume of available material is 117,000 m^3 considering cobble content of 15%, boulder content of 5% and a safety factor of 2.0.

5.8.1.4 Borrow Area GD-10

General Description

Borrow Area GD-10 is located approximately 3.3 km south-east of the dam site, and 2.5 km south of the Churchill River (see Drawing no 503334-MF-1300-4GDD-0004 in Volume 6). It is also located approximately 2.0 km south of the proposed access road to the project site. The deposit stretches approximately 650 m from the north-west to the south-east, with an average width near 250 m. The surface is densely wooded, and gently dipping to the north. It is bounded on the north side by a steep slope and on the south side by hilly terrain with thin soil cover. On the east side, it is delimited by a steep slope to the McKenzie River.

This borrow area is of fluvioglacial origin. The proposed boundary extended to the south-east, but the field reconnaissance showed a thin soil cover with a few rock outcrops in that area.

The photograph in Figure 14 shows Borrow Area GD-10 and its approximate limits.

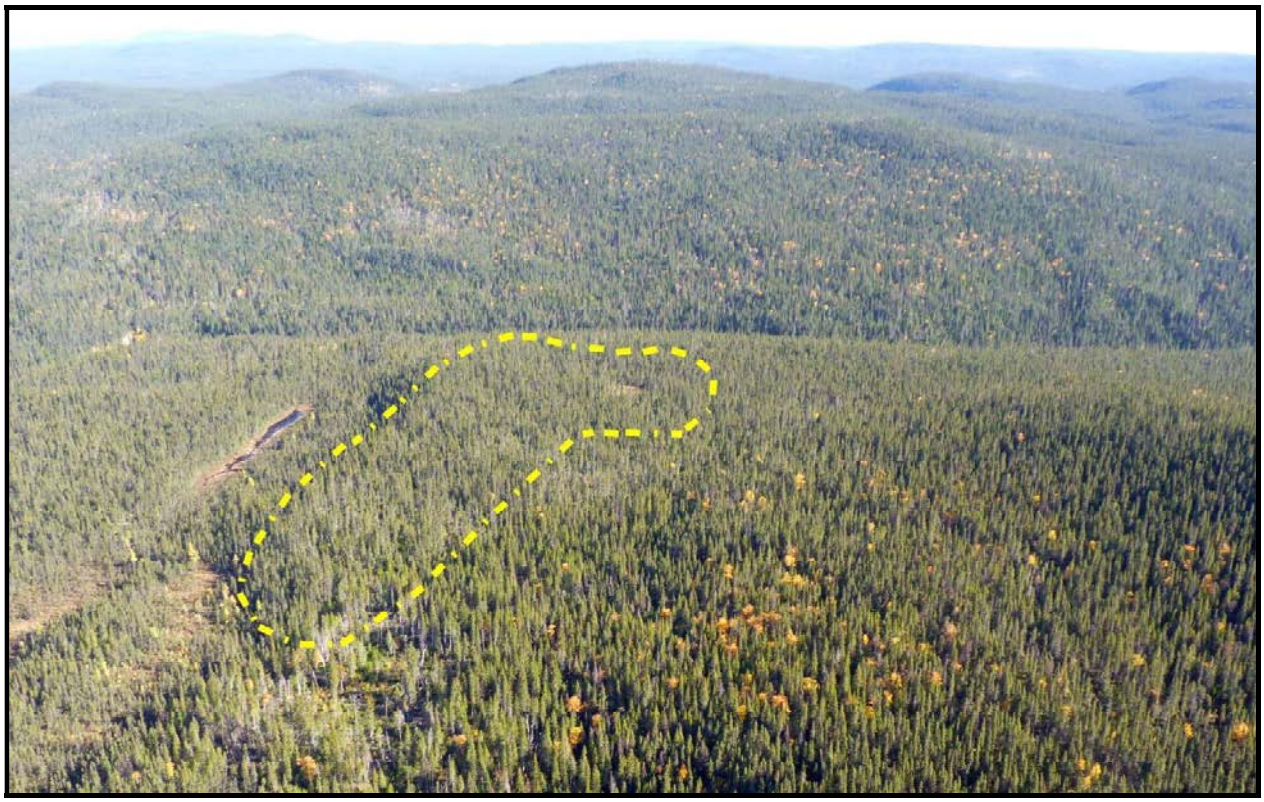


FIGURE 14: AERIAL PHOTOGRAPH OF BORROW AREA GD-10, VIEWING TO THE EAST

Summary of Investigations

The 2010 field program consisted of the excavation of 4 test pits designated GD-10-TP-1-10 to GD-10-TP-4-10. Test pits were stopped in overburden at depths varying between 2.30 m and 2.60 m, except GD-10-TP-3-10 which was stopped at the depth of 0.80 m when refusal was obtained on a boulder or possible bedrock. Three (3) sieve analyses and 5 native moisture content determinations were performed in laboratory on samples from Borrow Area GD-10. Results of the grain size analyses are presented in a graphical format on a figure following the corresponding test pit report. Results of the water content determinations are indicated on test pit reports.

The locations of the test pits are illustrated on Drawing no 503334-MF-1300-4GDD-0006 in Volume 6.

Soil Description

From depths varying between 0.45 m and 1.15 m, underneath surficial organic and oxidized layers, subsoil encountered in Test Pits GD-10-TP-1-10 to GD-10-TP-4-10 is mainly composed of sand and silt, and of sand with traces or some silt and traces of gravel. No cobble or boulder was identified in the pits.

Results of sieve analyses carried out on samples of Test Pits GD-10-TP-1-10, GD-10-TP-2-10 and GD-10-TP-4-10 are presented on Figure 15, compared to the granular fill specifications. Based on this figure, materials from Borrow Area GD-10 do not satisfy requirements for use as a granular fill.

Water Infiltration

No water infiltration was observed during the excavation of the test pits at the Borrow Area GD-10.

Estimated Volume

Estimation of available material volume was not pertinent for the Borrow Area GD-10, since materials are not suitable for granular fill or for concrete fine aggregate.

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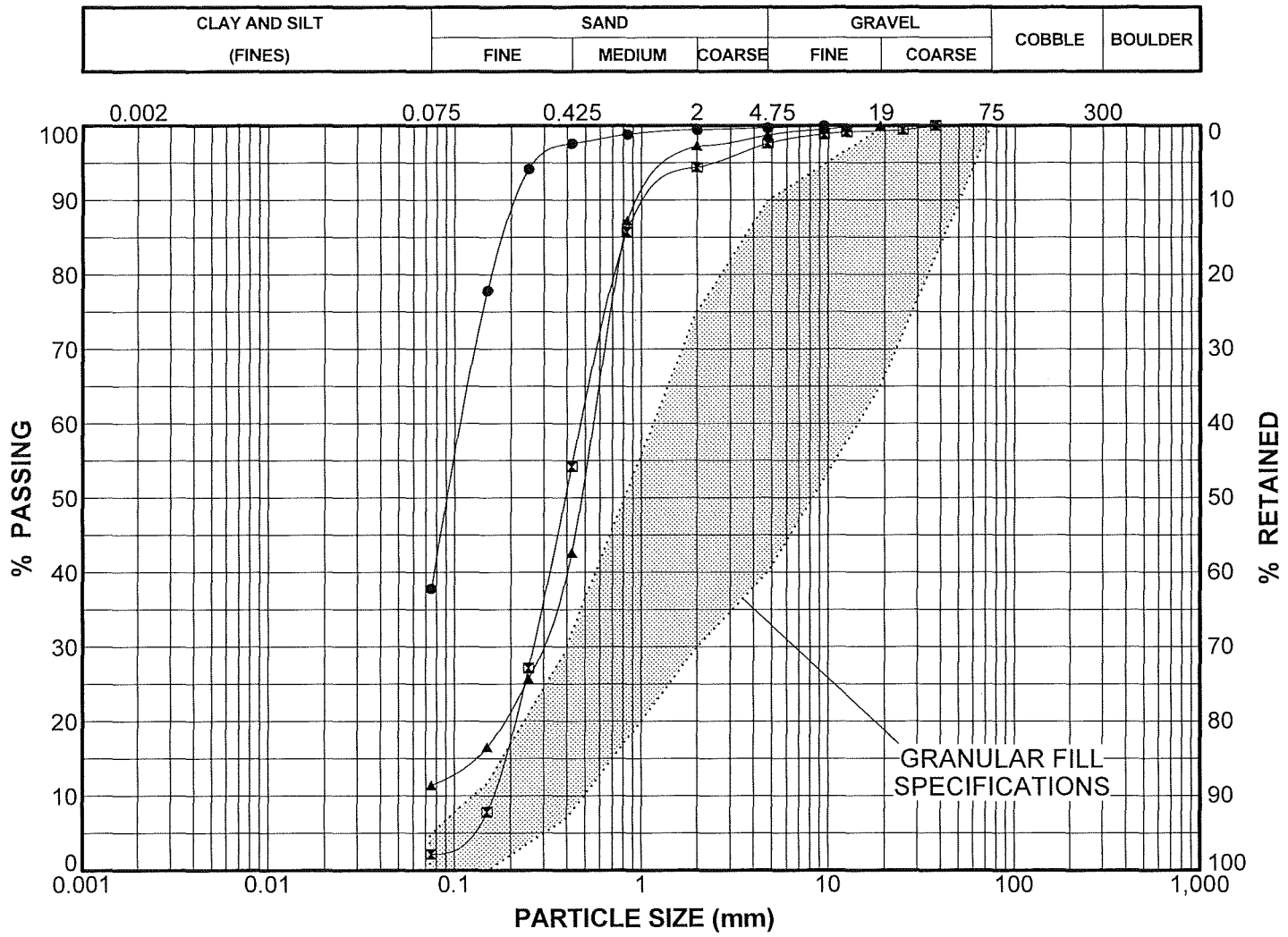
PARTICLE SIZE DISTRIBUTION

FIGURE 15

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area GD-10
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	GD-10-TP-1-10	BS-2	1.00	2.30	0	62	38	**Sand and silt.**
⊠	GD-10-TP-2-10	BS-1	1.15	1.75	2	95	2	**Sand** with traces of gravel and traces of silt.
▲	GD-10-TP-4-10	BS-1	1.10		1	87	11	**Sand** with some silt and traces of gravel.

REMARKS :

5.8.1.5 Borrow Area GD-11

General Description

Borrow Area GD-11 is located approximately 1.7 km south of the Churchill River and approximately 2.6 km south-east of the dam site, at a distance of about 1.3 km south of the proposed access road to the project site (see Drawing no 503334-MF-1300-4GDD-0004 in Volume 6). The east section of the borrow area is oriented northwest–southeast, and measures approximately 700 m long and 230 m wide. The west section extends about 300 m in a northeast-southwest direction and is about 120 m wide.

The area consists of a generally densely wooded terrace with a relatively even surface.

The layout of the borrow area is shown on Figure 16.

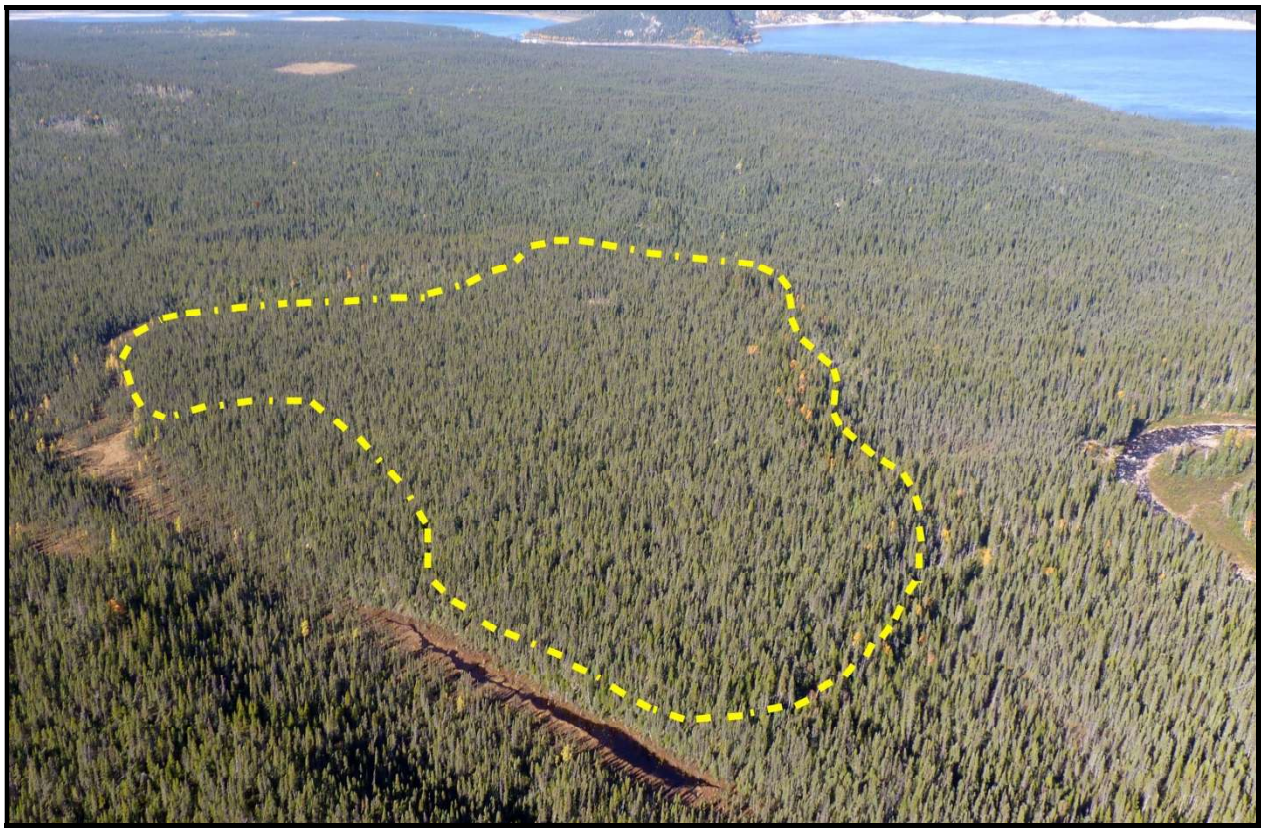


FIGURE 16: AERIAL PHOTOGRAPH OF BORROW AREA GD-11, VIEWING TO THE NORTHWEST

Summary of Investigations

The 2010 field program consisted of the excavation of 10 test pits numbered GD-11-TP-1-10 to GD-11-TP-10-10. All test pits were stopped in overburden at depths varying between 2.30 m and 3.10 m. Seventeen (17) sieve analyses and 21 moisture content determinations were performed on samples retrieved from the test pits. Results of the grain size analyses are presented in a graphical format on a figure following the corresponding test pit report. Results of the water content determinations are given on test pit reports.

The locations of the test pits are shown on Drawing no 503334-MF-1300-4GDD-0006 in Volume 6.

Soil Description

Underlying surficial organic and oxidized layers, from depths varying between 0.50 m and 0.90 m, subsoil in test pits is generally composed of sand with traces of silt and with variable proportions of gravel. Presence of cobbles was observed in most test pits in proportions varying between 0% and 10%. No boulders were encountered in test pits.

Figures 17 and 18 give the results of the grain size analyses that were performed on sand materials of Borrow Area GD-11 after screening particles retained on the 4.75 mm sieve. Figures show that sand samples from Test Pits GD-11-TP-1-10 to GD-11-TP-10-10 could generally meet the sieve specifications for concrete fine aggregate.

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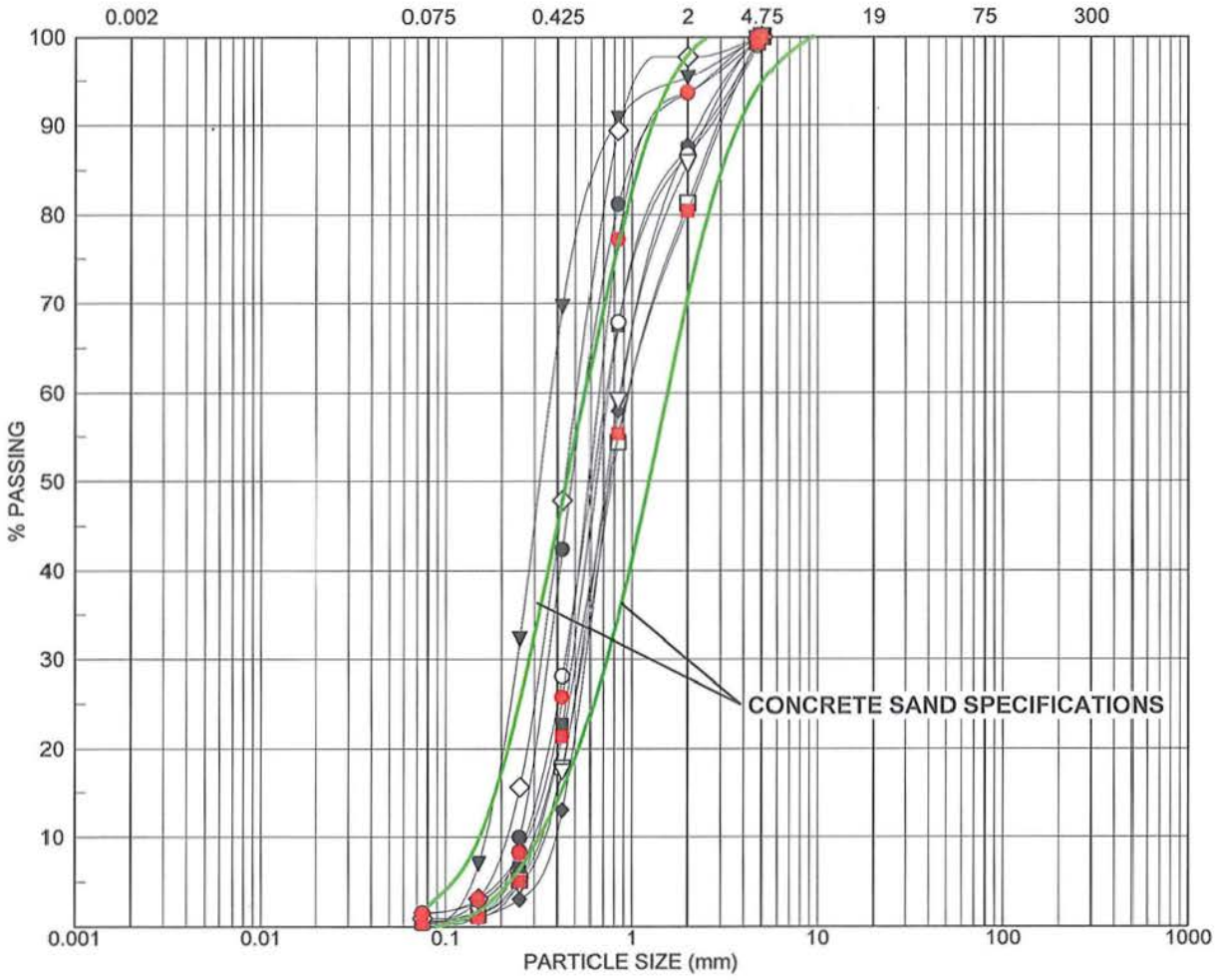
PARTICLE SIZE DISTRIBUTION

FIGURE 17

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigation
LOCATION : Borrow area GD-11
FILE : G10192



	Sounding	Sample	Depth (m)	Description	Gravel (%)	Sand (%)	Silt & Clay (%)
●	GD-11-TP- 1-10	BS-1	0.5	Sand with some gravel.	0	99	0.5
■	GD-11-TP- 2-10	BS-1	1.0	Gravelly sand.	0	100	0.3
▼	GD-11-TP- 2-10	BS-2	2.0	Sand with traces of gravel.	0	100	0.4
◆	GD-11-TP- 3-10	BS-1	1.2	Sand with some gravel and traces of silt.	0	99	0.6
○	GD-11-TP- 4-10	BS-1	1.1	Gravelly sand with traces of silt.	0	98	1.6
□	GD-11-TP- 4-10	BS-2	1.7	Sand with some gravel and traces of silt.	0	99	0.6
▽	GD-11-TP- 5-10	BS-1	0.6	Sand with some gravel and traces of silt.	0	99	0.7
◇	GD-11-TP- 5-10	BS-2	2.8	Sand with traces of gravel and traces of silt.	0	99	0.9
●	GD-11-TP- 6-10	BS-1	1.0	Sand with traces of gravel and traces of silt.	0	99	1.5
■	GD-11-TP- 6-10	BS-2	1.6	Gravelly sand.	0	100	0.4

REMARKS: The sample data has the values above 5 mm removed. Concrete sand specification: CSA-CAN3-A23.1-94 STANDARD.

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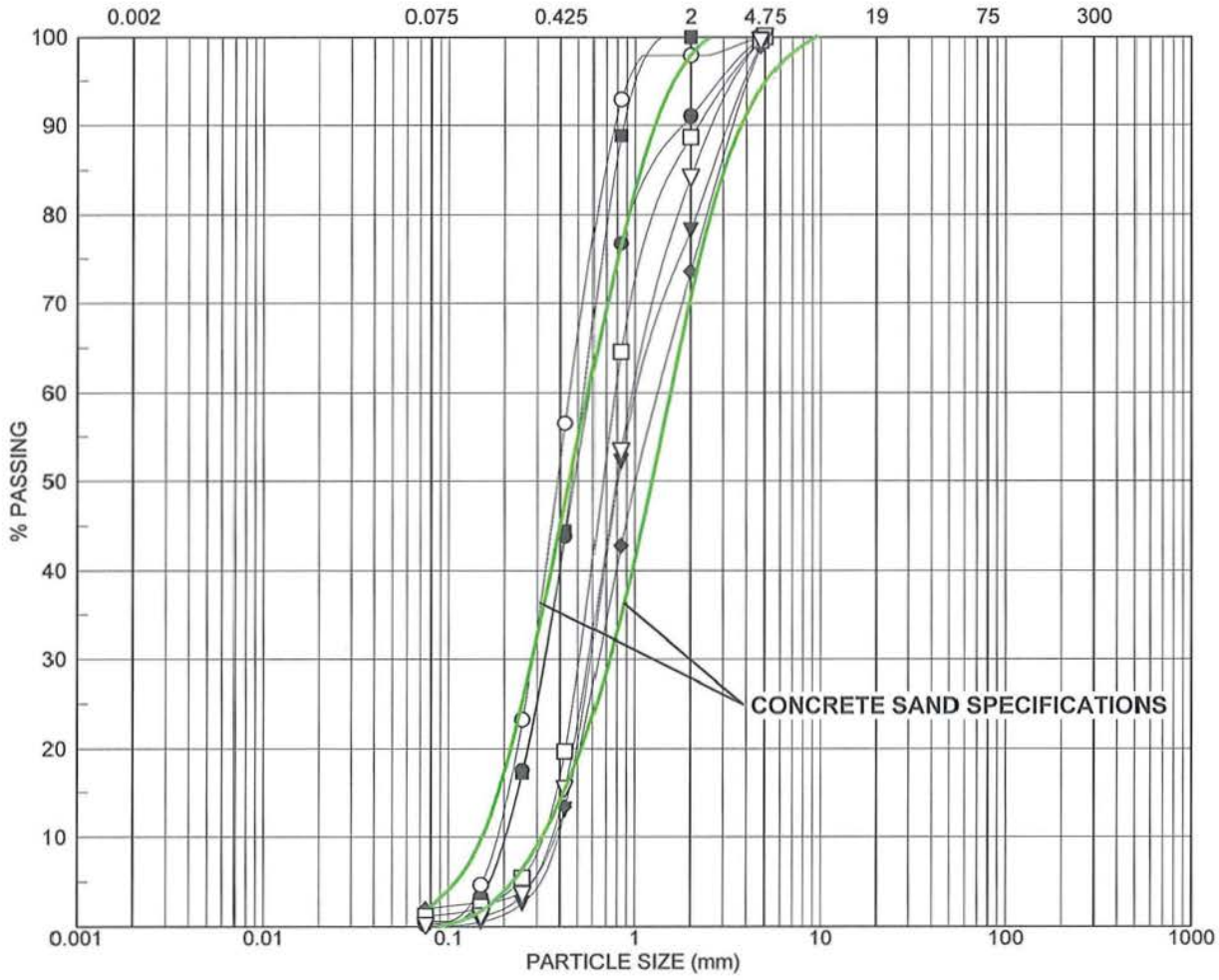
PARTICLE SIZE DISTRIBUTION

FIGURE 18

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigation
LOCATION : Borrow area GD-11
FILE : G10192



	Sounding	Sample	Depth (m)	Description	Gravel (%)	Sand (%)	Silt & Clay (%)
●	GD-11-TP- 7-10	BS-1	1.6	Sand with traces of gravel.	0	100	0.2
■	GD-11-TP- 8-10	BS-1	0.9	Sand with traces of gravel and traces of silt.	0	99	0.5
▼	GD-11-TP- 8-10	BS-2	1.4	Gravelly sand.	0	100	0.0
◆	GD-11-TP- 9-10	BS-1	1.0	Gravelly sand with traces of silt.	0	98	2.1
○	GD-11-TP- 9-10	BS-2	2.0	Sand with traces of gravel and traces of silt.	0	99	0.6
□	GD-11-TP-10-10	BS-1	0.7	Sand with traces of gravel and traces of silt.	0	99	1.2
▽	GD-11-TP-10-10	BS-2	1.5	Sand with some gravel.	0	100	0.2

REMARKS: The sample data has the values above 5 mm removed. Concrete sand specification: CSA-CAN3-A23.1-94 STANDARD.

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Water Infiltration

No water infiltration was observed during excavation of the test pits in Borrow Area GD-11.

Specific Laboratory Testing

A sand sample composed of materials from test pits GD-11-TP-5-10 to GD-11-TP-7-10 and GD-11-TP-10-10 was submitted for specific laboratory testing in order to determine the material suitability as concrete fine aggregate. The results of these tests are included in Appendix 7 in Volume 5 of the report.

Estimated Volume

The laboratory testing program that was carried out on sand (Appendix 7 in Volume 5) indicated the sand is not suitable for use in concrete. So, estimation of available material volume is not pertinent for Borrow Area GD-11.

5.8.2 Till

5.8.2.1 Borrow Area TD-4

General Description

Borrow Area TD-4 is located approximately 11.6 km east of the Muskrat Falls dam site, 3.5 km south of the Churchill River and some 650 m north of the proposed project access road. The area consists of a drumlinoid shape glacial deposit that stretches some 1.4 km from east to west, with a width generally varying from 150 to 280 m.

The borrow area surface is densely wooded. It is bounded on its south side by a small stream and on the other sides by lower lands where a few peat bogs can be seen. The southeast section is delimited by a very steep slope, while the other sides are formed of more gentle slopes.

The layout of the Borrow Area TD-4 is shown on Figure 19.

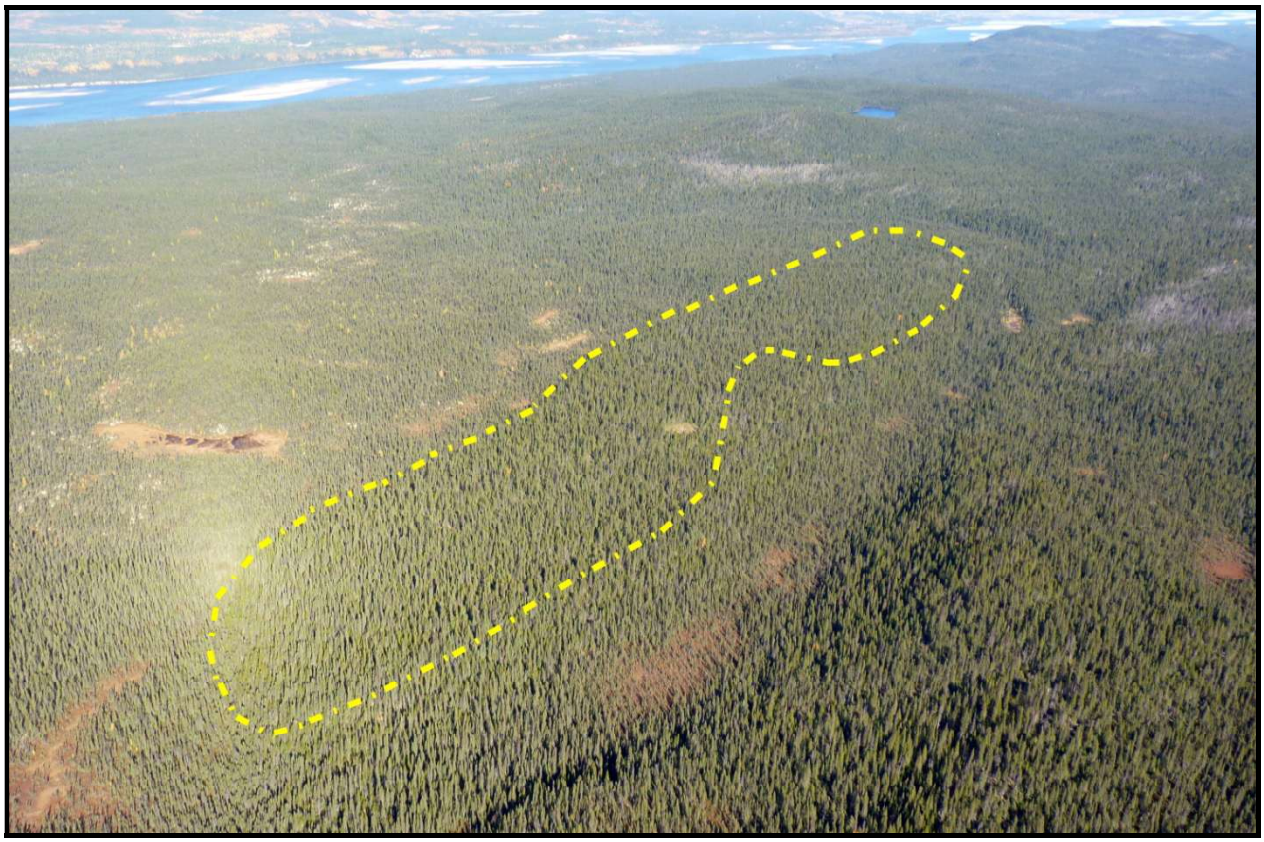

FIGURE 19: AERIAL PHOTOGRAPH OF BORROW AREA TD-4, VIEWING TO THE NORTHEAST

Summary of Investigations

Investigations conducted in 2010 consisted of 9 test pits numbered TD-4-TP-1-10 to TD-4-TP-9-10. All test pits were stopped in overburden at depths varying between 2.30 m and 3.50 m, except test pit TD-4-TP-7-10 which was terminated at the depth of 0.80 m when refusal was obtained on probable bedrock. Eight (8) sieve analyses and 13 moisture content determinations were performed on samples retrieved from the test pits. The results of the grain size analyses are presented in a graphical format on a figure following the corresponding test pit report. The results of the water content determinations are given on test pit reports.

The locations of the test pits are shown on Drawing no 503334-MF-1300-4GDD-0007 in Volume 6.

Soils Description

Subsoil in Test Pits TD-4-TP-1-10 to TD-4-TP-6-10, TD-4-TP-8-10 and TD-4-TP-9-10, underneath surficial organic and oxidized layers, from depths varying between 0.55 m and 0.90 m, is generally composed of silty sand with some gravel. Exceptionally in Test Pits TD-4-TP-6-10 and TD-4-TP-8-10, it is consisting of silt and sand with some gravel and of sand with some silt and traces of gravel. Test Pit TD-4-TP-7-10 was terminated at the depth of 0.80 m on probably bedrock, after having passed through the surficial organic layer. Cobbles and boulders were generally encountered in test pits in proportions that could reach 5% to 10% and 15% to 20% respectively.

Results of grain size analyses are presented on Figures 20 and 21 in comparison with the impervious fill (till) specifications. The figures show that samples retrieved from Test Pits TD-4-TP-1-10 to TD-4-TP-6-10 and TD-4-TP-9-10 meet the impervious till specifications.

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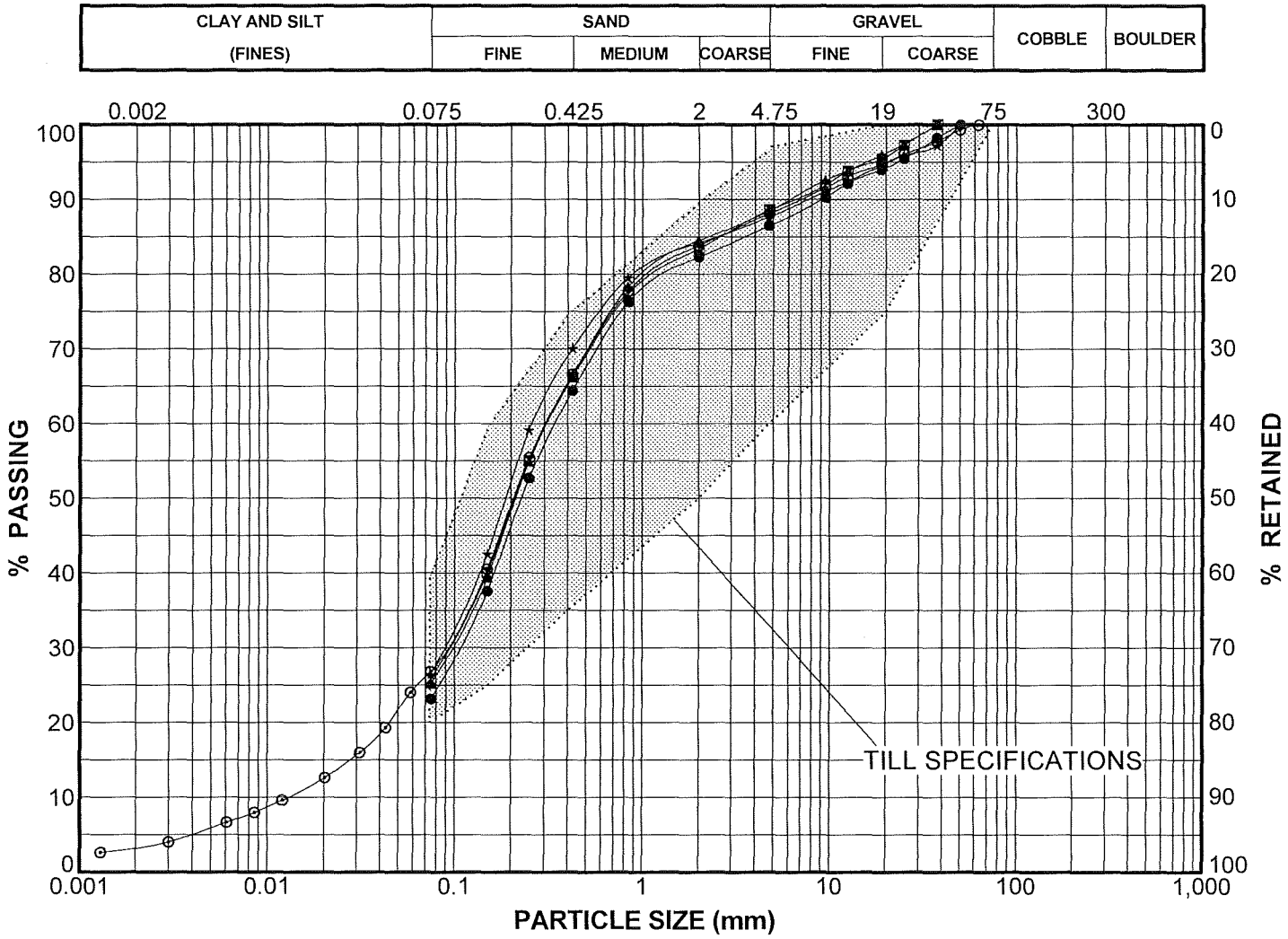
PARTICLE SIZE DISTRIBUTION

FIGURE 20

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area TD-4
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	TD- 4-TP-1-10	BS-1	1.00	2.90	14	63	23	**Silty sand** with some gravel.
■	TD- 4-TP-2-10	BS-1	1.00	2.90	11	63	26	**Silty sand** with some gravel.
▲	TD- 4-TP-3-10	BS-1	1.00	3.20	12	63	25	**Silty sand** with some gravel.
★	TD- 4-TP-4-10	BS-1	1.00	2.70	12	61	26	**Silty sand** with some gravel.
⊙	TD- 4-TP-5-10	BS-1	1.00	2.20	12	61	23 3	**Silty sand** with some gravel and traces of clay.

REMARKS :

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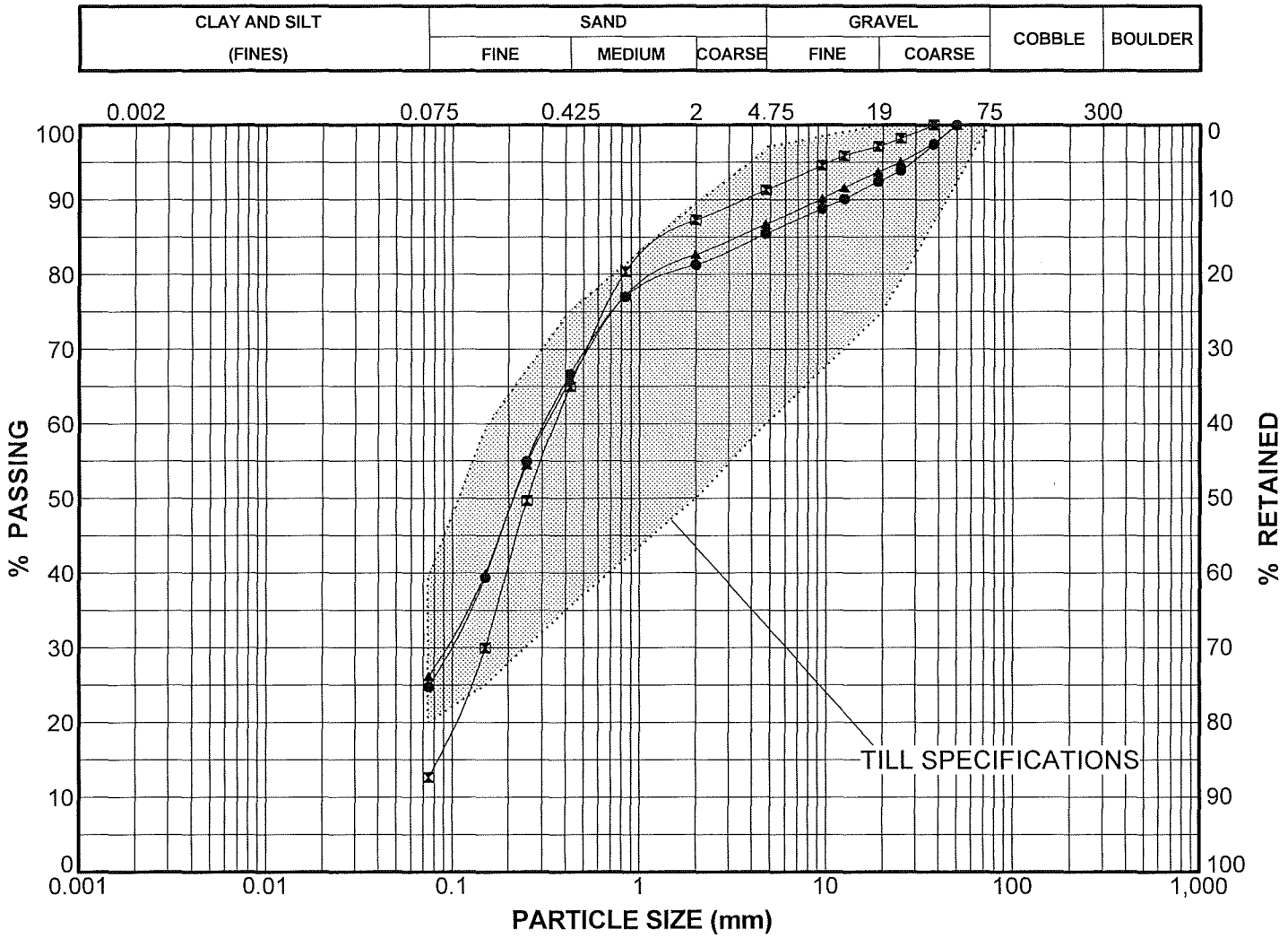
PARTICLE SIZE DISTRIBUTION

FIGURE 21

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area TD-4
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	TD- 4-TP-6-10	BS-1	1.00	3.00	15	61	25	**Silty sand** with some gravel.
⊠	TD- 4-TP-8-10	BS-1	1.00	3.00	9	79	13	**Sand** with some silt and traces of gravel.
▲	TD- 4-TP-9-10	BS-1	1.10	3.00	13	61	26	**Silty sand** with some gravel.

REMARKS :

Complementary laboratory tests, namely hydrometer analyses, standard Proctor test and relative density determinations, were carried out on sample BS-1 of Test Pit TD-4-TP-5-10. Table 21 gives a summary of the test results. The results of the standard Proctor is presented in a graphical format on a figure following the corresponding test pit report. All other results are indicated on the test pit report.

TABLE 21: BORROW AREA TD-4 - SUMMARY LABORATORY TEST RESULTS ON TILL SAMPLE

TEST	RESULT
	TD-4-TP-5-10 BS-1 1.0 – 2.2 m
Particle size	
Gravel (%)	12
Sand (%)	61
Silt (%)	23
Clay (%)	3
Standard Proctor (Method C)	
Maximum dry density (kg/ m^3)	2 130
Optimum water content (%)	6.8
Relative density > 5 mm	2.693
Relative density < 5 mm	2.760

Eleven (11) determinations of native moisture content were carried out in the laboratory on till materials that met sieve specifications for impervious fill. All results ranged between 6% and 11% with an average value near 8%.

Water Infiltration

Water infiltration was observed only in Test Pit TD-4-TP-5-10 between depths of 0.30 m and 0.60 m.

Estimated Volume

The till for use as impervious material in Borrow Area TD-4 covers an approximate area of 212,400 m^2. Based on an average investigated thickness of 2.3 m, a boulder content of 10% and considering a safety factor of 2, the estimated gross volume of available material is 220,000 m^3.

5.8.2.2 Borrow Area TD-5

General Description

Borrow Area TD-4 is located approximately 10.4 km east of the Muskrat Falls dam site, 4.1 km south of the Churchill River and about 320 m south of the proposed project access road (see Drawing no 503334-MF-1300-4GDD-0004 in Volume 6). It extends approximately 850 m in a southwest-northeast direction, with an average width of about 200 m. The area is densely wooded, and the topography is very irregular.

This deposit is likely to be composed of ablation till, which generally yields a coarser material than basal till.

Summary of Investigations

The 2010 field program consisted of the excavation of 4 test pits numbered TD-5-TP-1-10 to TD-5-TP-4-10. All test pits were stopped in overburden at depths varying between 1.50 m and 2.85 m. Test pit TD-5-TP-2-10 was stopped at the depth of 1.50 m on a refusal on a boulder. Six (6) sieve analyses and 5 moisture content determinations were performed on samples retrieved from the test pits. Results of the grain size analyses are presented in a graphical format on a figure following the corresponding test pit report. Results of the water content determinations are indicated on test pit reports.

The locations of the test pits are shown illustrated on Drawing no 503334-MF-1300-4GDD-0007 in Volume 6.

Soils Description

Underneath surficial organic and oxidized layers, from depths varying between 0.70 m and 0.90 m, subsoil in test pits consists of a sand/gravel deposit, whose composition generally varies from gravelly sand, to sand and gravel, or gravel and sand. The deposit contains traces of silt, and cobbles and boulders in proportions that reach 15% to 20% and 5% to 10% respectively.

Figures 22 and 23 presents the results of grain size analyses carried out on 6 samples retrieved from Test Pits TD-5-TP-1-10 to TD-5-TP-4-10, in comparison to the impervious till specifications. The figures show that materials from Test Pits TD-5-TP-1-10 to TD-5-TP-4-10 do not meet the impervious fill specifications.

Water Infiltration

No water infiltration was observed during the excavation of the test pits.

Estimated Volume

Estimation of available material volume is not pertinent for Borrow Area TD-5 since materials are not suitable for use as impervious fill.

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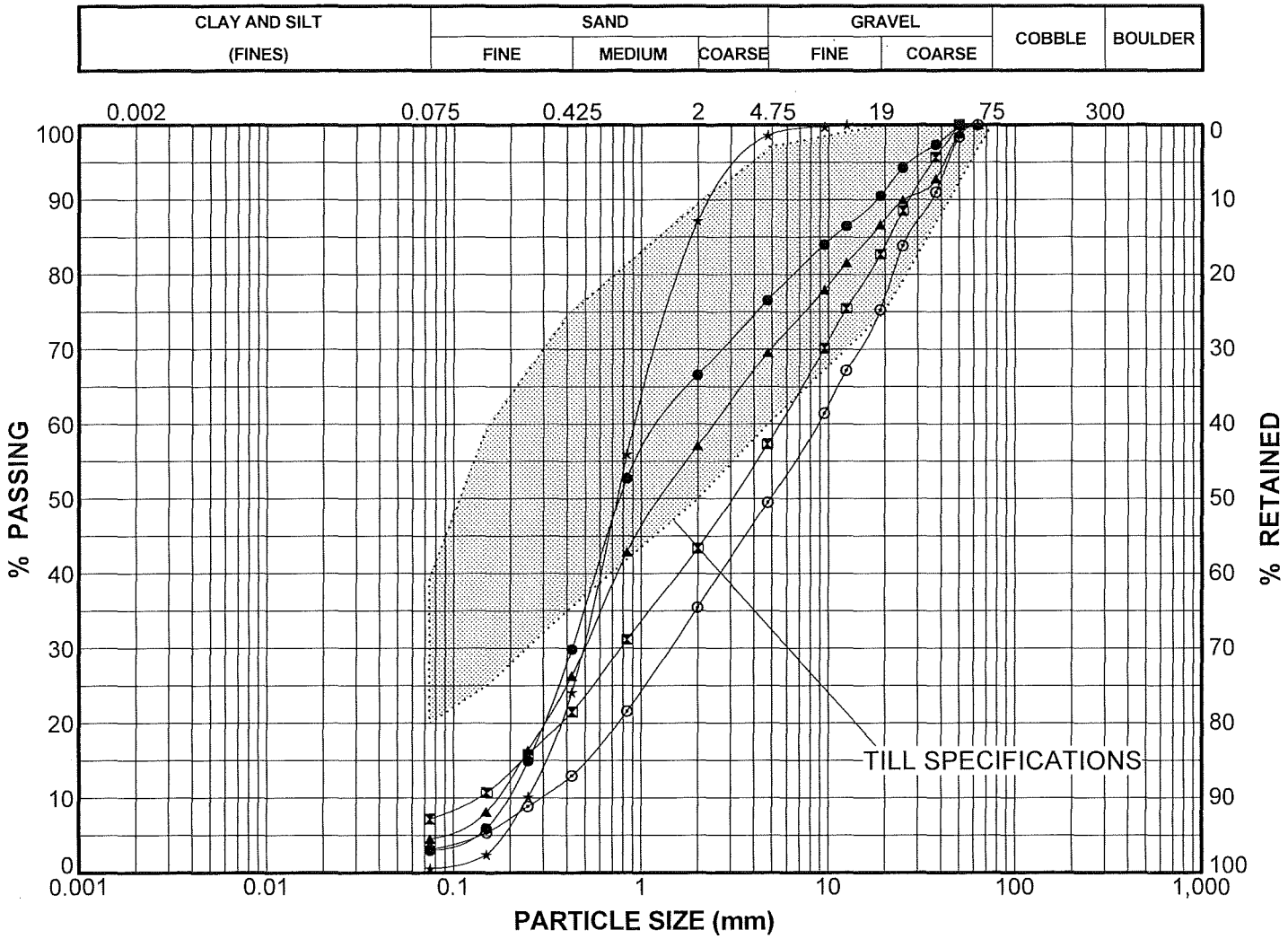
PARTICLE SIZE DISTRIBUTION

FIGURE 22

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area TD-5
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	TD- 5-TP-1-10	BS-1	1.00	2.60	23	74	3	**Gravelly sand** with traces of silt.
⊠	TD- 5-TP-2-10	BS-1	0.90	1.10	43	50	7	**Sand and gravel** with traces of silt.
▲	TD- 5-TP-3-10	BS-1	0.90	1.30	30	65	5	**Gravelly sand** with traces of silt.
★	TD- 5-TP-3-10	BS-2	1.30	1.50	1	98	1	**Sand** with traces of gravel and traces of silt.
⊙	TD- 5-TP-3-10	BS-3	1.60	2.80	50	46	3	**Gravel and sand** with traces of silt.

REMARKS :

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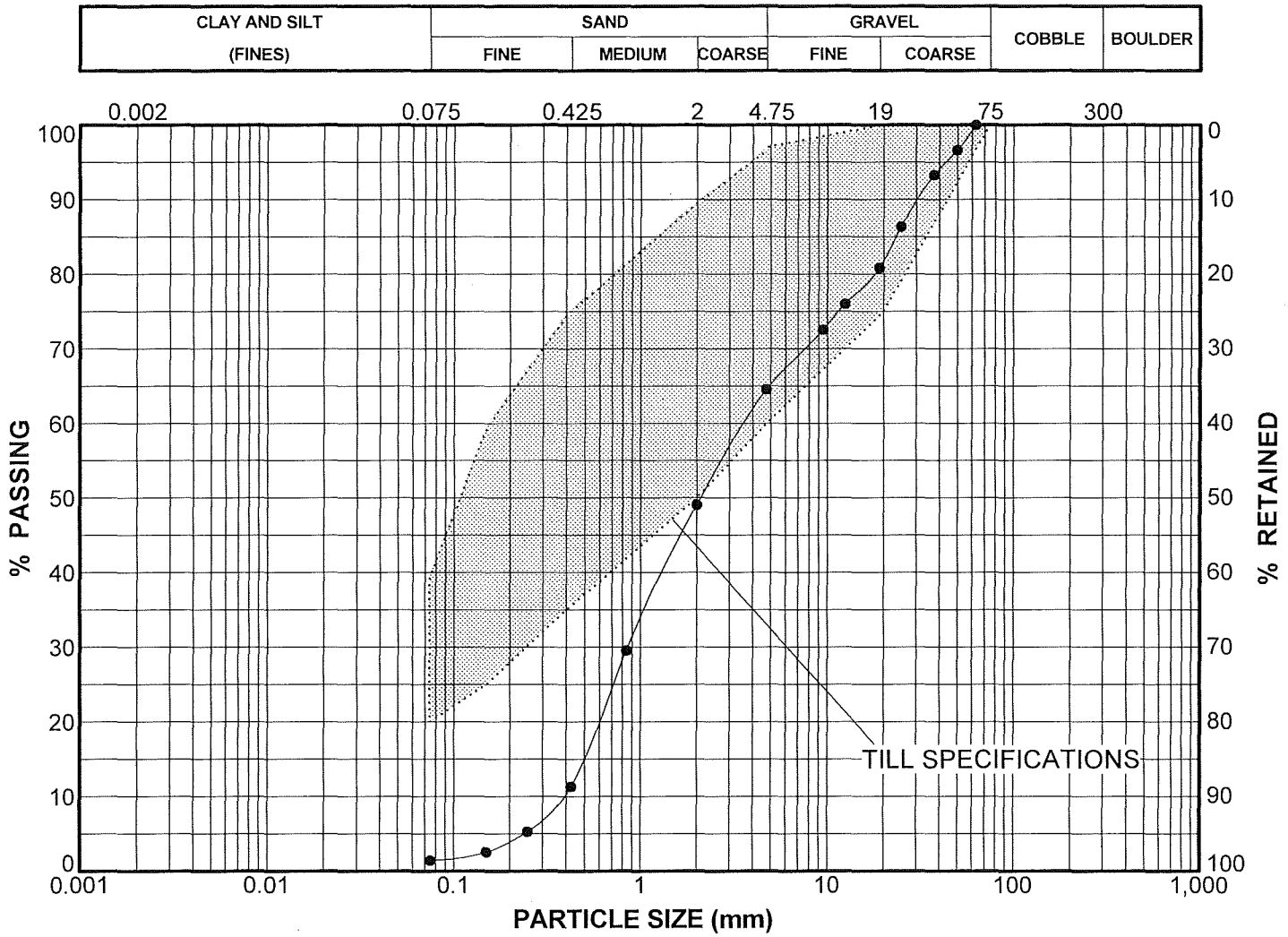
PARTICLE SIZE DISTRIBUTION

FIGURE 23

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area TD-5
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	TD- 5-TP-4-10	BS-1	1.00	2.00	35	63	1	**Sand and gravel** with traces of silt.

REMARKS :

5.8.2.3 Borrow Area TD-6

General Description

Borrow Area TD-6 is located approximately 10.0 km east of the Muskrat Falls dam site, 3.3 km south of the Churchill River and less than 100 m north of the proposed project access road (see Drawing no 503334-MF-1300-4GDD-0004 in Volume 6). The area consists of a drumlinoid shape glacial deposit that stretches approximately 320 m in a southwest-northeast direction, with an average width of about 120 m. The area is densely wooded, and the topography is relatively even.

The layout of the area is shown on Figure 24.

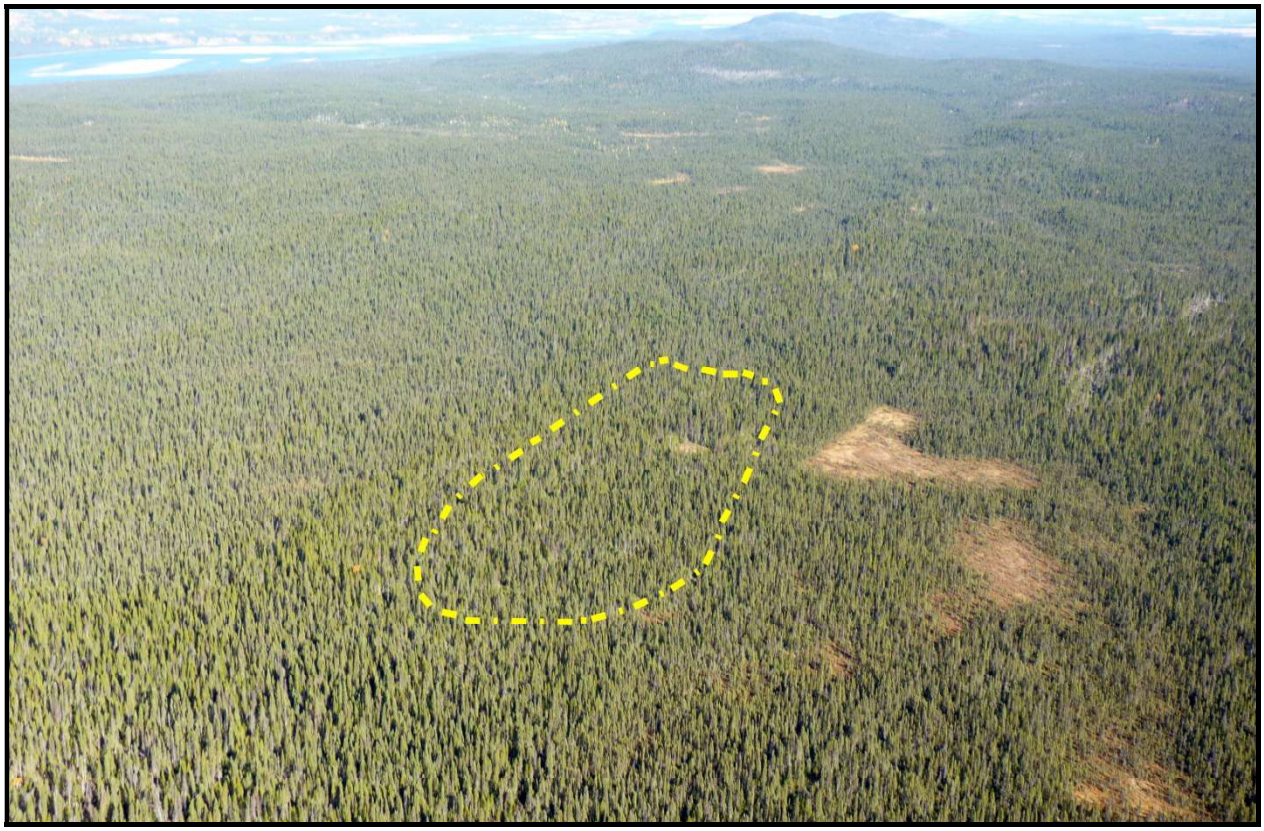


FIGURE 24: AERIAL PHOTOGRAPH OF BORROW AREA TD-6, VIEWING TO THE NORTHEAST

Summary of Investigations

The 2010 field program consisted of the excavation of only 2 test pits numbered TD-6-TP-1-10 and TD-6-TP-2-10. Test pits were stopped in overburden at respective depths 2.90 m and 2.60 m. Two (2) sieve analyses and 4 moisture content determinations were performed on samples retrieved from the test pits. Results of the grain size analyses are presented in a graphical format on a figure following the corresponding test pit report. Results of the water content determinations are indicated on test pit reports.

The locations of the test pits are shown on Drawing no 503334-MF-1300-4GDD-0007 in Volume 6.

Soils Description

From depths of 0.55 m and 0.7 m in Test Pits TD-4-TP-1-10 and TD-6-TP-2-10, underneath surficial organic and oxidized layers, subsoil consists of silty sand with some gravel and traces of clay. Cobbles and boulders were found in proportions of 0-5% and 0-10% respectively.

Results of grain size analyses are presented on Figure 25 in comparison with the impervious fill (till) specifications. The figure shows that the samples retrieved from Test Pits TD-6-TP-1-10 and TD-6-TP-2-10 meet the impervious till specifications.

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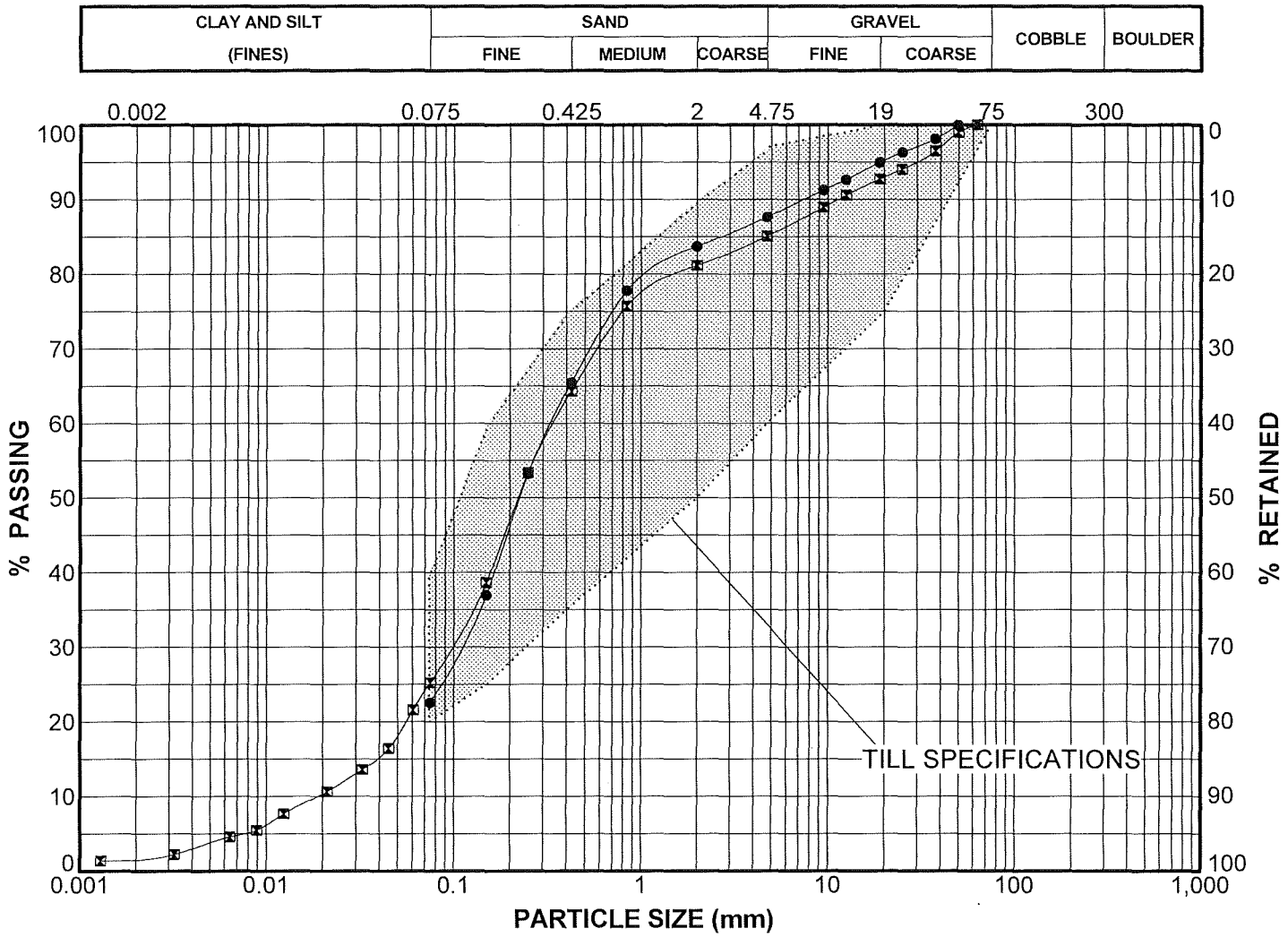
PARTICLE SIZE DISTRIBUTION

FIGURE 25

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area TD-6
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	TD- 6-TP-1-10	BS-1	1.20	2.80	12	65	23	**Silty sand** with some gravel.
⊠	TD- 6-TP-2-10	BS-1	1.10	2.60	15	60	23 2	**Silty sand** with some gravel and traces of clay.

REMARKS :

Complementary laboratory tests, namely hydrometer analysis, standard Proctor test and relative density determinations were carried out on sample BS-1 of test pit TD-6-TP-2-10. Table 22 is a summary of the test results. Results of the standard Proctor test is given in a graphical format on a figure following the corresponding test pit report. All others results are indicated on the test pit report.

TABLE 22: BORROW AREA TD-6 - SUMMARY LABORATORY TEST RESULTS ON TILL SAMPLE

TEST	RESULT
	TD-6-TP-2-10 BS-1 1.1 – 2.6 m
Particle size	
Gravel (%)	15
Sand (%)	60
Silt (%)	23
Clay (%)	2
Standard Proctor (Method C)	
Maximum dry density (kg/ m^3)	2 100
Optimum water content (%)	6.5
Relative density >5 mm	2.731
Relative density <5 mm	2.764

Four (4) determinations of native moisture content were carried out in the laboratory on till materials that met sieve specifications for impervious till. All results ranged between 6% and 10% with an average value near 8%.

Water Infiltration

Water infiltration was observed in the Test Pit TD-6-TP-1-10 between depths of 2.5 m and 2.9 m.

Estimated Volume

The till for use as impervious material in Borrow Area TD-6 covers an approximate area of 39,200 m^2. Based on an average investigated thickness of 2.1 m, a boulder content of 10% and considering a safety factor of 2, the estimated gross volume of available material is 37,000 m^3.

5.8.2.4 Borrow Area TD-7

General Description

Borrow Area TD-7 located approximately 9.2 km southeast of the Muskrat Falls dam site and 3.0 km south of the Churchill River (see Drawing no 503334-MF-1300-4GDD-0004 in Volume 6). The proposed project access road should cross the northern section of the deposit. The area can be divided in two sections. The main section stretches approximately 600 m in a southwest-northeast direction, with an average width of about 180 m. The eastern section of the area extends some 300 m to the north, at a somewhat lower level of a few meters, with an approximate width of 75 m.

The area is bounded at its south side by boggy lands and at its east side by a stream. The other sides are delimited by sloping terrain of variable steepness. The main section has a few lower spots where surface water is visible, while the eastern section is apparently well drained. The whole borrow area is densely wooded.

The layout of the area is shown on Figure 26.

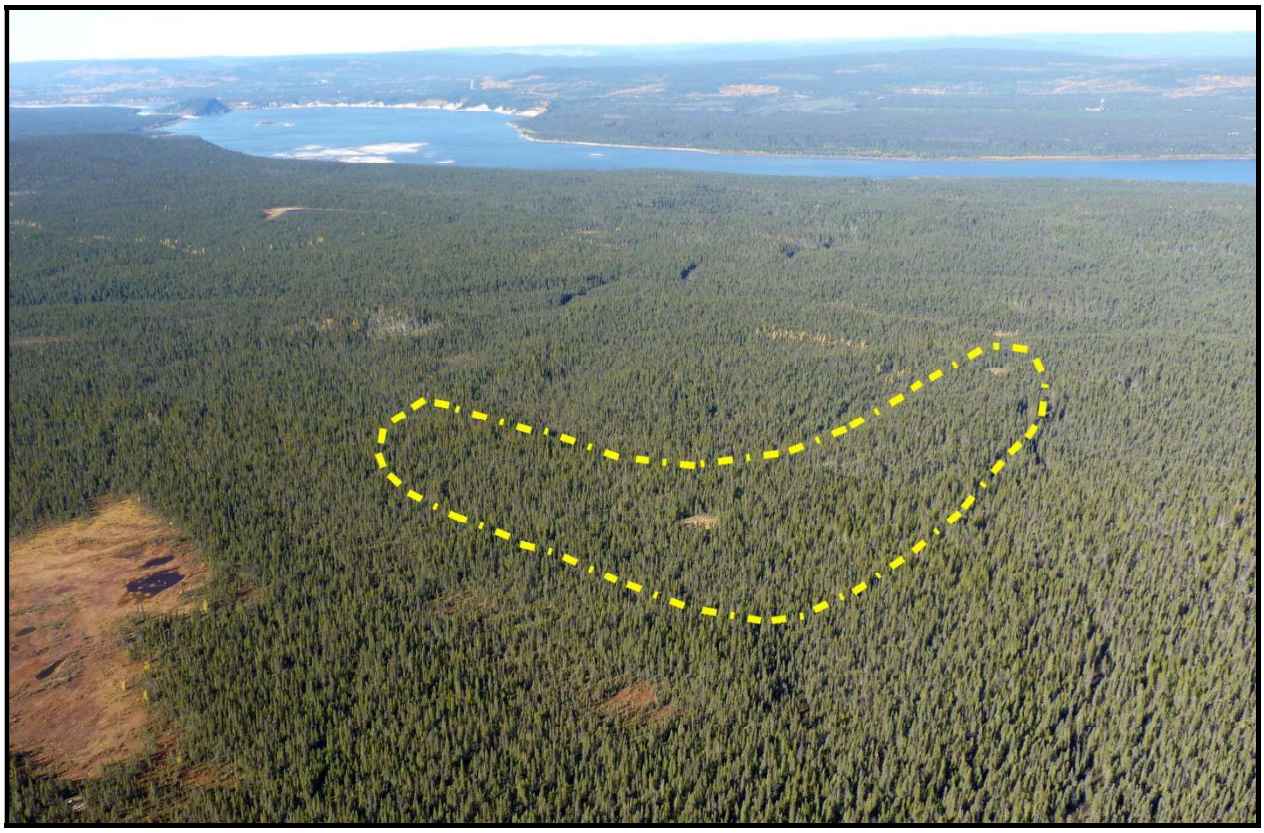


FIGURE 26: AERIAL PHOTOGRAPH OF BORROW AREA TD-7, VIEWING TO THE NORTHWEST

Summary of Investigations

The 2010 field program consisted of the excavation of 3 test pits numbered TD-7-TP-1-10 to TD-7-TP-3-10. Test pits were stopped in overburden between depths of 2.40 m and 3.35 m. Three (3) sieve analyses and 5 moisture content determinations were performed on samples retrieved from the test pits. The results of the grain size analyses are presented in a graphical format on a figure following the corresponding test pit report. The results of the water content determinations are given on test pit reports.

The locations of the test pits are shown on Drawing no 503334-MF-1300-4GDD-0007 in Volume 6.

Soils Description

From depths varying between 0.70 m and 0.80 m in Test Pits TD-7-TP-1-10 to TD-7-TP-3-10, underneath surficial organic and oxidized layers, the subsoil is composed of silty sand with traces or some gravel. Cobbles and boulders were encountered in test pits, in proportions of 0% to 5%.

Results of grain size analyses appear on Figure 27 in comparison with the impervious fill (till) specifications. The figure shows that samples recovered from Test Pits TD-7-TP-1-10 to TD-7-TP-3-10 meet impervious till specifications.

Complementary laboratory tests, namely hydrometer analysis, standard Proctor test and relative density determinations were carried out on sample BS-1 of Test Pit TD-7-TP-2-10. Table 23 gives a summary of the test results. Results of the standard Proctor test are presented in a graphical format on a figure following the corresponding test pit report. All others results are indicated on test pit report.

TABLE 23: BORROW AREA TD-7 - SUMMARY LABORATORY TEST RESULTS ON TILL SAMPLE

TEST	RESULT
	TD-7-TP-2-10 BS-1 1.0 – 3.1 m
Particle size	
Gravel (%)	10
Sand (%)	68
Silt (%)	20
Clay (%)	2
Standard Proctor (Method C)	
Maximum dry density (kg/ m^3)	1 988
Optimum water content (%)	5.6
Relative density >5 mm	2.698
Relative density <5 mm	2.7

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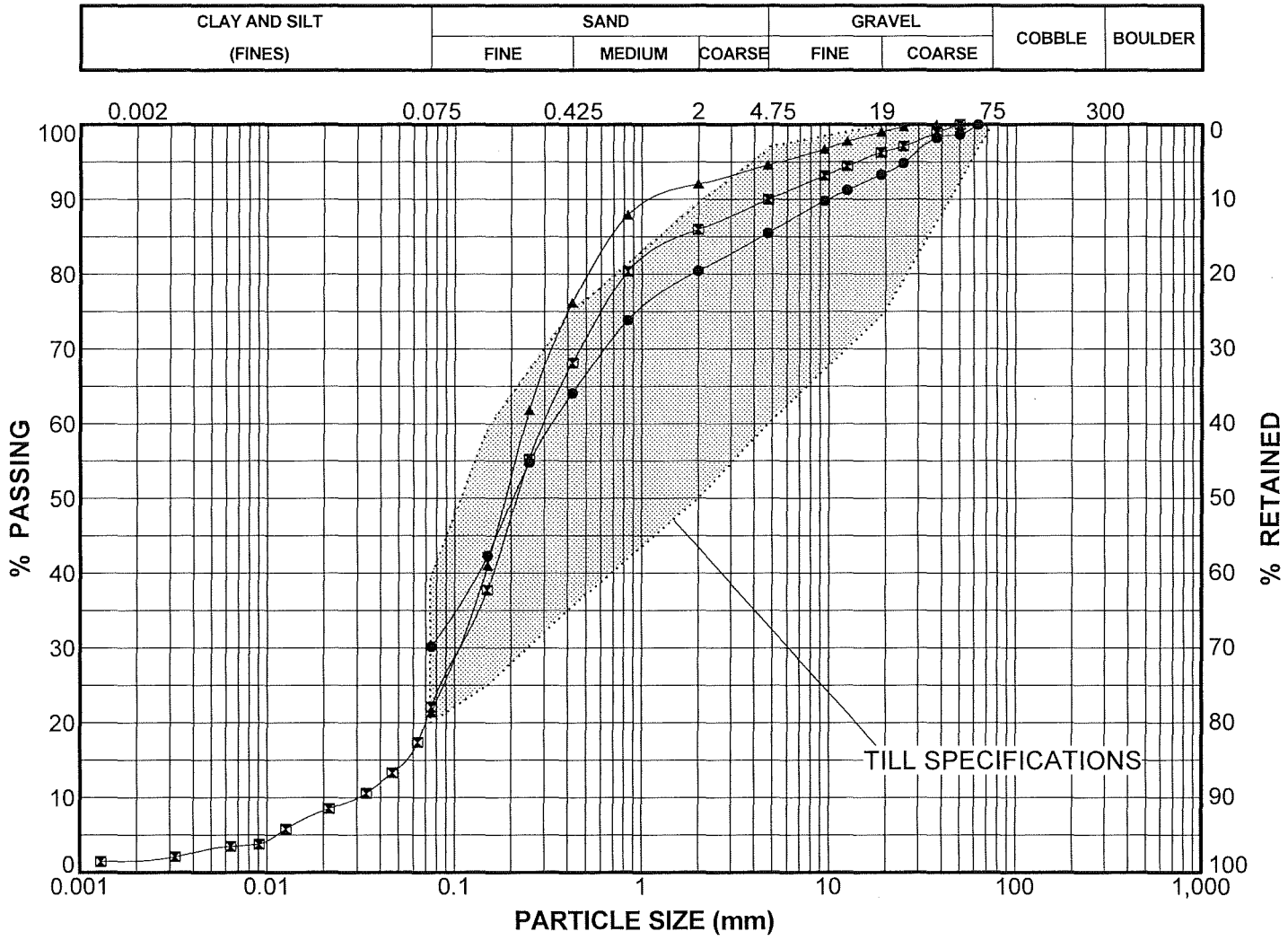
PARTICLE SIZE DISTRIBUTION

FIGURE 27

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area TD-7
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	TD- 7-TP-1-10	BS-1	1.10	2.30	15	55	30	**Silty sand** with some gravel.
⊠	TD- 7-TP-2-10	BS-1	1.00	3.10	10	68	20 2	**Silty sand** with some gravel and traces of clay.
▲	TD- 7-TP-3-10	BS-1	1.00	3.20	5	73	21	**Silty sand** with traces of gravel.

REMARKS :

Five (5) determinations of native moisture content were carried out in the laboratory on till materials that met sieve specifications for impervious till. Water content values ranged from 6% and 10% with an average value near 8%.

Water Infiltration

Water infiltrations were observed between depths of 1.0 m and 1.2 m in Test Pit TD-7-TP-1-10, and at the depth of 3.0 m in Test Pit TD-7-TP-2-10.

Estimated Volume

The till for use as impervious material in Borrow Area TD-7 covers an approximate area of 105,000 m^2. Based on an average investigated thickness of 2.2 m, a boulder content of 5% and considering a safety factor of 2, the estimated gross volume of available material is 110,000 m^3.

5.8.2.5 Borrow Area TD-8

General Description

Borrow Area TD-8 is located approximately 7.2 km southeast of the Muskrat Falls dam site and 1.6 km south of the Churchill River (see Drawing no 503334-MF-1300-4GDD-0004 in Volume 6). The proposed project access road should pass about 150 m north of the deposit. The area consists of a drumlinoid shaped deposit stretching approximately 600 m east-west, with a width of about 120 m on the western part, gradually narrowing to less than 80 m towards the east. The major part of the deposit is bounded on its south side by a lake, while the other sides are delimited by more or less gentle slopes. The area is densely wooded, and the topography is relatively even.

Summary of Investigations

The 2010 field program consisted of the excavation of 3 test pits numbered TD-8-TP-1-10 to TD-8-TP-3-10. All test pits were stopped in overburden at depths varying between 2.90 m and 3.10 m. Four (4) sieve analyses and 2 moisture content determinations were performed on samples retrieved from the test pits. Results of

the grain size analysis are presented in a graphical format on a figure following the corresponding test pit report. Results of the water content determinations are indicated on test pit reports.

The locations of the test pits are shown on Drawing no 503334-MF-1300-4GDD-0007 in Volume 6.

Soils Description

Underneath surficial organic and oxidized layers, from depths ranging from 0.5 m to 1.15 m, the subsoil in test pits consists of sand with some silt to silty sand, with traces or some gravel. Cobbles and boulders were encountered in Test Pits TD-8-TP-1-10 and TD-8-TP-3-10 in respective proportions of 0% to 10% and of 0% to 5%.

Results of grain size analyses are presented on Figure 28 in conjunction with the impervious fill (till) specifications. The figure shows that only materials recovered from Test Pit TD-8-TP-3-10 meet the sieve requirements for impervious till.

Water Infiltration

No water infiltration was observed during the excavation of the test pits.

Estimated Volume

Volume estimation for Borrow Area TD-8 was not pertinent since the materials from the area do not generally meet the sieve specifications for use as impervious fill.

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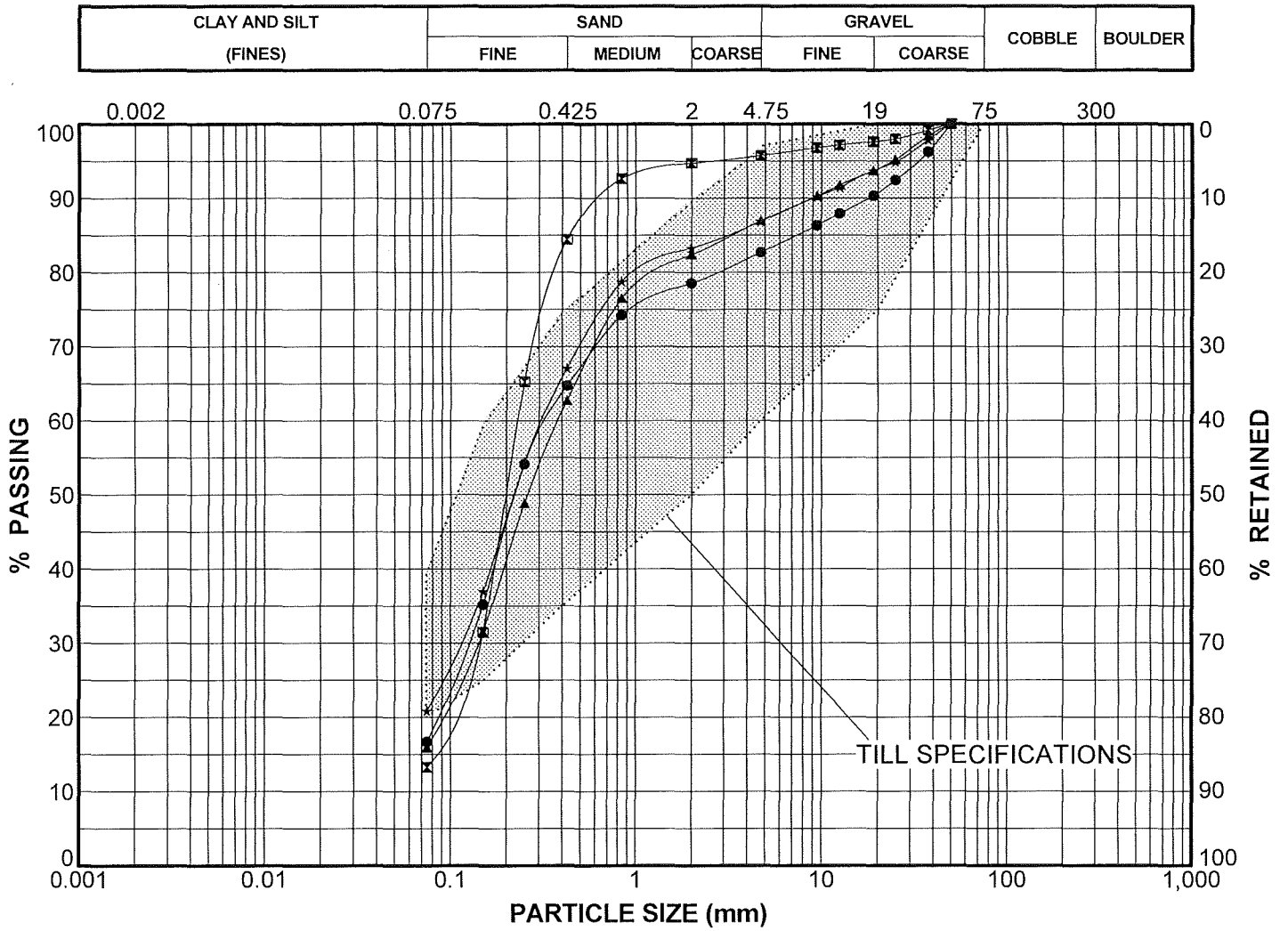
PARTICLE SIZE DISTRIBUTION

FIGURE 28

CLIENT : Nalcor Energy - Lower Churchill Project
PROJECT : Muskrat Falls 2010 Site Investigations
LOCATION : Borrow Area TD-8
FILE : G10192



	Sounding	Sample	Depth (m) from	Depth (m) to	Gravel (%)	Sand (%)	Silt and Clay (%)	Description
●	TD- 8-TP-1-10	BS-1	1.00	2.00	17	66	17	**Sand** with some gravel and some silt.
⊠	TD- 8-TP-1-10	BS-2	2.10	2.90	4	82	13	**Sand** with some silt and traces of gravel.
▲	TD- 8-TP-2-10	BS-1	1.30	3.00	13	71	16	**Sand** with some silt and some gravel.
★	TD- 8-TP-3-10	BS-1	1.10	2.80	13	66	21	**Silty sand** with some gravel.

REMARKS :

5.8.2.6 Borrow Area TD-11

General Description

Borrow Area TD-11 is located approximately 1.6 km southwest of the Muskrat Falls dam site (see Drawing no 503334-MF-1300-4GDD-0004 in Volume 6). The proposed area consists of a drumlinoid shaped deposit stretching approximately 800 m east-west, with an average width of about 200 m. It is bounded on its south side by a small stream, while the north side is delimited by a gentle slope. The area is densely wooded, and the topography is rather irregular. Numerous small rock outcrops were observed on the surface, mostly on the south side, indicating that the soil cover is generally thin. However, the soil cover seemed somewhat thicker on the south section.

Summary of Investigations

The 2010 field program consisted of the excavation of only 2 test pits numbered TD-11-TP-1-10 and TD-11-TP-2-10. Both test pits were stopped on bedrock at respective depths of 0.80 m and 0.40 m. No sieve analysis or moisture content determination was performed on samples retrieved from the test pits. Based on those results, the Borrow Area TD-11 was abandoned.

The locations of the test pits are shown on Drawing no 503334-MF-1300-4GDD-0007 in Volume 6.

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