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ASSINIBOINE RIVER & LAKE MANITOBA BASINS - FLOOD MITIGATION STUDY
LMB & LSM OUTLET CHANNELS
CONCEPTUAL DESIGN - STAGE 2

Manitoba
INFRASTRUCTURE AND TRANSPORTATION

KGS GROUP PROJECT
12-0300-011

DRAFT

August 2015

Manitoba
INFRASTRUCTURE AND TRANSPORTATION

Assiniboine River & Lake Manitoba Basins Flood Mitigation Study
Lake Manitoba & Lake St. Martin Outlet Channels
Conceptual Design – Stage 2

DRAFT

KGS Group 12-0300-011
August 2015

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August 17, 2015

File No. 12-0300-011

Manitoba Infrastructure and Transportation
200 Saulteaux Crescent
Winnipeg, Manitoba
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ATTENTION: Mr. Eugene Kozera
Director of Water Control System Management

RE: Assiniboine River & Lake Manitoba Basins Flood Mitigation Study
LMB & LSM Outlet Channels Conceptual Design – Stage 2 – Draft Report

Dear Mr. Kozera:

Please find enclosed six (6) copies of the Draft Report for the Lake Manitoba & Lake St. Martin Outlet Channels Conceptual Design – Stage 2, as well as one (1) electronic copy on a DVD. This report supersedes Section 13.0, which was previously issued as draft.

We are providing you with the full body of the report for your review. The executive summary has not been finalized, as it has not been decided whether it should be prepared for a technical audience or if it should be a more comprehensive summary for a public audience similar to what was prepared for the Assiniboine River & Lake Manitoba Basins Flood Mitigation Study. This can be discussed at our next TC meeting.

We appreciate the opportunity to have worked with MIT on this project and look forward to any future projects. If you have any questions or comments regarding the enclosed draft report, please contact the undersigned.

Yours truly,

<original signed by>

Dave MacMillan, P.Eng.
Principal

DBM/nf
Enclosures

cc: J.B. Smith, C. Siepman, P. Leclercq, T. Ng, B. Bodnaruk, KGS Group

EXECUTIVE SUMMARY

To be added in next version of report.

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1.0 INTRODUCTION

Kontzamanis Graumann Smith MacMillan Inc. (KGS Group) was retained by Manitoba Infrastructure and Transportation (MIT) to undertake a Conceptual Study to advance the design of the Lake Manitoba & Lake St. Martin Outlet Channels. This conceptual design was completed in two stages as outlined below.

Stage 1 (Refine Alternatives) of the study supplemented the work initiated in 2011 as part of the Analysis of Options for the Emergency Reduction of Lake Manitoba and Lake St. Martin Levels with consideration of the emergency works that were completed in 2011 and 2012. The Conceptual Design Stage 1 Draft Report (Deliverable LMB-01 Rev B) was issued on February 25, 2014. An Open House event was conducted on September 18, 2014 in Ashern to present the results of Stage 1 Study. A summary of the Open House event, as well as the final results of the Stage 1 Study, were included in the Assiniboine River & Lake Manitoba Basins Flood Mitigation Study Report.

Based on the results of the Stage 1 Study, the Province of Manitoba announced in the fall of 2014 that it was proceeding with the conceptual design of the preferred Lake Manitoba (LMB) and Lake St. Martin (LSM) outlet channel alternatives with a design capacity of 212 m^3/s (7,500 cfs) on LMB and 326 m^3/s (11,500 cfs) capacity on LSM. Stage 2 (Detailed Review of Preferred Alternatives) was then initiated in January 2015 to finalize the conceptual design of the preferred alternatives with the intent to expedite the design process by proceeding to the detailed design stage at the completion of Stage 2.

The Scope of work completed for the Stage 2 conceptual design is summarized as follows:

Lake Manitoba Outlet – Conceptual Level Designs and Cost Estimates

Specific basis of designs have been developed for the following preferred options identified in Stage 1 for a flow of 212 m^3/s (7,500 cfs):

- Lake Manitoba Outlet Channel Route C.
- Lake Manitoba Outlet Channel Route D.

A general site plan of the project area that shows the location of the proposed LMB Route C and Route D outlet channels is shown on Plate 1.

The conceptual design includes the hydraulic characterization of each of the preferred alternatives. The Stage 1 screening level designs for each preferred option have been further developed to complete the conceptual design. Cost estimates have been be prepared for each preferred alternative.

The following tasks have been completed for the LMB outlet options as part of the study:

- Flood routing for the period of record that extends from 1961 to the present, to determine the benefits of the LMB Outlet Channel on LMB water levels for the period since the Fairford River Water Control System (FRWCS) was put into operation.
- Confirmed and updated the hydraulic design of the outlet channel options, including channel width depth and slopes, as well as the design, size and location of all control, outlet, drop and bridge structures. HEC-RAS backwater models have been developed for each of the design alternatives. Winter ice conditions were also considered in the design as well as local drainage where necessary.
- Acquisition and processing of GIS data (survey, LiDAR, air photos, and sonar). The data for 2011 has been utilized wherever possible with minimal additional field surveying activities:
    - LiDAR data collected and processed in 2011 has been manipulated for incorporation into earth work models.
    - Previously collected air photos have been reviewed to provide a detailed validation of ground conditions, tree cover and erosion.
    - Geomatic support to geotechnical investigations has been provided (survey in locations of test holes, peat probes, wells, etc.).
- Geotechnical field investigations (peat probes, test pits, boreholes, monitoring wells, and laboratory testing) to estimate rock and overburden excavation quantities. The 2011 data has been utilized wherever possible and only minimal additional field investigation has been required, such as at the location of the proposed control structures and bridges.
- Costs and constructability for each of the alternatives (land acquisition, excavation, bridges, municipal roads, control structures, etc.) were assessed. Costs and quantities developed in Stage 1 have been re-evaluated and updated to include informal CAD sketches to assist with the project definition and cost estimates. Cost estimates have been based on “approximate” quantity takeoff with appropriate contingencies. Structure sketches have been developed to meet the hydraulic characteristics and have been sized on the basis of experience. No stability calculations have been undertaken at this level. Based on discussions with MIT, a gated / hoist option was considered for each control structure and included cursory consideration of power supply alternatives. Cost

estimates for the water control structures have been based on experience and previous similar structures designed by KGS Group. Geotechnical concept design has been based on experience as well, with sketches prepared outlining channel slopes and structure transitions.

- Assessed environmental impacts based on available existing data (water quality, terrestrial vegetation and wildlife, groundwater, etc.).
- Identified and screened potential adverse aquatic impacts based on available existing data. Evaluated the justification and methods for unrestricted fish passage between Lake Manitoba and Lake St. Martin.
- Identified and screened potential adverse social impacts including First Nations based on past experience, feedback received during the Stage 1 public consultation process and feedback received from landowners during the field investigation process.

Lake St. Martin Outlet – Conceptual Level Designs and Cost Estimates

Specific basis of designs have been developed for the following preferred options identified in Stage 1 for a flow of 326 m^3/s (11,500 cfs):

- Lake St. Martin Outlet Channel to Johnson Beach.
- Lake St. Martin Outlet Channel to Willow Point.

A general site plan that shows the location of the three reaches (Reach 1, Reach 2 and Reach 3) that form the LSM Outlet Channel, as well as the two preferred options identified above, is shown on Plate 1.

The conceptual design includes the hydraulic characterization of each of the preferred alternatives. The Stage 1 screening level designs for each preferred option have been further developed to complete Conceptual Design l. Cost estimates have been be prepared for each preferred alternative.

The following tasks have been completed for the LSM Outlet options as part of the study:

- Flood routing for the period of record that extends from 1961 to the present, to determine the capacity of the LSM Outlet Channel necessary to achieve the water level benefits that were defined by the Lake Manitoba Regulation Review Committee, for the period since the Fairford River Water Control System (FRWCS) was put into operation.
- Confirmed and updated the hydraulic design of the Reach 1 and Reach 3 channel options, including channel width depth and slopes, as well as the design, size and location of all control, outlet, drop and bridge structures. Requirements along Reach 2

have also been confirmed. HEC-RAS backwater models have been developed for each of the design alternatives. Winter ice conditions were also considered in the design as well as local drainage where necessary.

- Acquisition and processing of GIS data (survey, LiDAR, air photos, and sonar). The data from 2011 has been utilized wherever possible with minimal additional field surveying activities. However, an exception was the extension to the Willow Point Option, which has been investigated as part of the current scope.

    - Supplementary geomatic surveys have been performed in order to verify LiDAR data where necessary and to ground truth the condition of peat in areas of proposed excavation.

    - LiDAR data collected and processed in 2011 has been manipulated for incorporation into earth work models.

    - Previously collected air photos have been reviewed to provide detailed validation of ground conditions, tree cover and erosion.

    - Geomatic support to Geotechnical investigations has been provided (survey in locations of test holes, peat probes, wells, etc.).

- Geotechnical field investigations (peat probes, test pits, boreholes, monitoring wells, and laboratory testing) to estimate rock and overburden excavation quantities. The 2011 data has been utilized wherever possible and only minimal additional field investigation has been required, such as at the location of the proposed control structures. However, an exception is the extension to the Willow Point Option, which required additional field investigation as part of the current scope of work, as well as the access road routes. MIT has indicated that the detailed design of the access road will be handled internally; however, KGS Group collected additional geotechnical data along the existing winter road alignment previously used during the construction of Reach 3 in 2011/2012 as part of the current scope. The conceptual location of the proposed access road routes is shown on the General Site Plan on Plate 1.

- Costs and constructability for each of the alternatives (land acquisition, excavation, bridges, municipal roads, control structures, etc.) were assessed. Costs and quantities developed in Stage 1 have been re-evaluated and updated to include informal CAD sketches to assist with the project definition and cost estimates. Cost estimates have been based on “approximate” quantity takeoff with appropriate contingencies. Structure sketches have been developed to meet the hydraulic characteristics and have been sized on the basis of experience. No stability calculations have been undertaken at this level. Based on discussions with MIT, a gated / hoist option was considered for each control structure and included cursory consideration of power supply alternatives. Cost estimates for the water control structures have been based on experience and previous similar structures designed by KGS Group. Geotechnical concept design has been based on experience as well, with sketches prepared outlining channel slopes and structure transitions.

- Identified and screened potential environmental impacts based on available existing data (water quality, terrestrial vegetation and wildlife, groundwater, etc.).

- Identified and screened potential adverse aquatic impacts based on available existing data.
- Identified and screened potential adverse social impacts including First Nations based on past experience, feedback received by the independent 2011 flood review committees and feedback received during the Stage 1 public consultation process. Additional public engagement and / or consultation were not included in the current scope.

Stage 2 Conceptual Design Summary Report

This summary report has been prepared for the Lake Manitoba and Lake St. Martin Outlet Channels and describes the preferred alternatives, their hydraulic performance characteristics, estimated costs, constructability, potential environmental impacts and recommendations for the next steps in the design process. Requirements for implementation, including outstanding tasks to complete the detailed design and approval and licensing requirements under *The Environment Act*, have been described in detail for the preferred Lake Manitoba and Lake St. Martin Outlet options.

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2.0 BACKGROUND

2.1 2011 FLOOD

In 2011, record, widespread flooding occurred across much of southern Manitoba resulting in unprecedented high inflows into Lake Manitoba and Lake St. Martin. These high flows extended well into the summer and overwhelmed the capacity of the existing system. The result was that Lake Manitoba peaked at 249.1 m (817.1 ft), which was 1.4 m (4.6 ft) above the desirable range of 247.0 to 247.7 m (810.5 ft to 812.5 ft) and Lake St. Martin peaked at 245.6 m (805.5 ft), which was 1.7 m (5.5 ft) above the desirable operating range of 242.9 to 243.8 m (797.0 to 800.0 ft). Flooding on Lake Manitoba and Lake St. Martin prompted the emergency construction of dikes on both lakes. Road access was severely limited and widespread long-term evacuation was required.

In June 2011, the Province of Manitoba commissioned KGS Group and AECOM (the "2011 team") to explore options to bring the levels of Lake St. Martin and Lake Manitoba down to the desirable range on an emergency basis. The Province sought a broad review of potential options to achieve this objective in a timely and cost-effective manner, while also minimizing the potential impact on other areas of the Province. Based on the results of this assessment, summarized in a report titled, *Analysis of Options for Emergency Reduction of Lake Manitoba and Lake St. Martin Levels* (KGS Group/AECOM, 2014), the Lake St. Martin Emergency Outlet Channel was constructed.

The construction of Reach 1 of the Lake St. Martin Emergency Outlet Channel (LSMEOC) from Lake St. Martin to Buffalo Lake was completed on November 1, 2011 and has a measured capacity of 113 m^3/s (4,000 cfs) at a Lake St. Martin water level of 244.1m (801 ft). The Reach 3 Emergency Channel (Reach 3) from Buffalo Creek to Lake Winnipeg was partially constructed between January and March 2012 to divert flows away from the Dauphin River prior to spring break up. However, due to extremely mild winter conditions, operation of Reach 3 was not required; and, therefore, this channel currently remains in an incomplete condition, particularly with respect to some hydraulic structures.

The Reach 1 Emergency Outlet Channel was operated beginning in November 2011 and closed in November 2012, as required under the federal government terms and conditions for emergency operations. Reach 1 was operated again in July 2014 for a new emergency condition and remains open to this date.

As a follow-up to the 2011 emergency flood mitigation activities for the Assiniboine River & Lake Manitoba Basins, the Province of Manitoba commissioned two independent review groups: The Lake Manitoba and Lake St. Martin Regulation Review Committee (LM&LSMRC 2013) chaired by Harold Westdal, and The Manitoba 2011 Flood Review Task Force (FRTF, 2013) chaired by David Farlinger.

The LM&LSMRC 2013 made the following recommendations with respect to the LMB and LSM Outlet Channels:

"The Committee recommends that the Lake St. Martin Emergency Channel be made permanent.

- *The capacity should be sufficient such that Lake St. Martin can be maintained within the desirable range of 242.9 to 243.8 m (797 to 800 ft) at least 90 percent of the time;*
- *Consideration should be given to the inclusion of a control structure at the mouth of the permanent outlet channel to limit outflow at times of low lake levels; and*
- *The current Reach 3 should be redirected so that the channel outlets south of Willow Point on Lake Winnipeg.*

The Committee recommends that a second channel be constructed between Lake Manitoba and Lake St. Martin that would provide the total outlet capacity to meet the original design criteria for the Fairford Control Structure. If the Province builds a new outlet to Lake Manitoba as recommended, it should take that opportunity to design the new outlet in such a way as to provide unrestricted fish passage between Lake Manitoba and Lake St. Martin."

The FRTF (2013) made the following recommendations with respect to the LMB & LSM Outlet Channels:

"Adopt the recommendations of the Lake Manitoba and Lake St. Martin Regulation Review Committee regarding additional outlet capacity requirements for Lake Manitoba and Lake St. Martin, with due consideration for the engineering studies that are being conducted".

The results and recommendations of the LM&LSMRC 2013 and FRTF 2013 were adopted in principle by the Province of Manitoba and formed the basis of the current study by KGS Group.

2.2 STAGE 1 STUDY

The Lake Manitoba and Lake St. Martin Outlet Channels Conceptual Design - Stage 1 was completed as part of the Assiniboine River & Lake Manitoba Basins Flood Mitigation Study. The scope of Stage 1 was similar to the scope that was originally included in the Assiniboine River & Lake Manitoba Basins Flood Mitigation Study. However, additional effort was required to expedite this portion of the work, increase the level of detail due to the number of outlet options considered, prepare an interim report, and expand the public consultation process. The focus of Stage 1 was to reduce the number of preferred alternatives to a minimum, with the goal of selecting two preferred alternatives, if possible.

The scope of work and for Stage 1 included:

- Identify Outlet Options for Lake Manitoba & Lake St. Martin.
- Develop Screening Level Designs and Cost Estimates.
- Economic Assessment.
- Stage / Damage Relationships.
- Summary Report.
- Public Open House Event.

In the Stage 1 Study, six Lake Manitoba outlet channel options (Option A to Option F) and two Lake St. Martin outlet channel options (Option JB and Option WP) were developed:

- Option A – Twinning the Fairford River.
- Option B – Channel south of Pinaymootang First Nation.
- Option C – Channel slightly less south of Pinaymootang First Nation.

- Option D – Channel following Birch Creek.
- Option E – Bypass channel north of the Fairford River Water Control Structure (FRWCS).
- Option F – Expansion of the Fairford River and FRWCS.
- Option JB – Reach 1, Reach 2 and Reach 3 to Johnson Beach.
- Option WP – Reach 1, Reach 2 and Reach 3 east of Willow Point.

Discharge capacities for the outlet channels from Lake Manitoba to Lake St. Martin ranging from zero (do nothing) to 425 m^3/s (15,000 cfs) were assessed For the outlet channels from Lake St. Martin to Lake Winnipeg, discharges ranging from 113 m^3/s (4,000 cfs) to 540 m^3/s (19,000 cfs) were considered.

Based on the conceptual designs, estimated costs, environmental considerations, conclusions and recommendations specific to the LMB and LSM outlet channels were developed for incorporation into the Stage 2 Conceptual Design, including the key points listed below:

- On Lake Manitoba, Options C and D should be considered for further review as part of the Conceptual Design Stage 2 with a capacity of 212 m^3/s (7,500 cfs), as committed to by the Province of Manitoba in the fall of 2014.
- The Lake St. Martin Emergency Outlet Channel should be made permanent with a base capacity of 113 m^3/s (4,000 cfs) to control Lake St. Martin levels.
- The Lake St. Martin Outlet Channel capacity should be increased by 212 m^3/s (7,500 cfs), for a total capacity of 326 m^3/s (11,500 cfs), to match a Lake Manitoba Outlet Channel to ensure that flooding will not be aggravated on Lake St. Martin, as committed to by the Province of Manitoba in the fall of 2014.
- Options for the Reach 3 outlet at Johnson Beach and east of Willow Point have similar rankings and, therefore, both should proceed to Conceptual Design Stage 2 for further review.
- Each LMB and LSM outlet channel option should incorporate a control structure to regulate flows.
- Fish passage is not feasible within the outlet channels because they would not be continuously operated; therefore, all options should consider improvement of fish passage directly at the FRWCS.
- All LSM outlet channel options should incorporate a permanent access road to facilitate construction, maintenance and operation.

An Open House event was conducted on September 18, 2014 in Ashern to present the results of the Stage 1 Study. A summary of the Open House event as well as the final results of the Stage 1 Study were included in the Assiniboine River & Lake Manitoba Basins Flood Mitigation Study Report by KGS Group.

Based on the results of the Stage 1 Study, the Province of Manitoba announced in the fall of 2014 that it was proceeding with the conceptual design of the preferred Lake Manitoba (LMB) and Lake St. Martin (LSM) outlet channel alternatives with a design capacity of 212 m^3/s (7,500 cfs) and 326 m^3/s (11,500 cfs), respectively. The results of the Stage 1 Study formed the basis of scope of work for the Stage 2 Study as discussed in Section 1.0.

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3.0 2015 SUPPLEMENTARY GEOTECHNICAL FIELD INVESTIGATIONS

3.1 REGIONAL GEOLOGY AND HYDROGEOLOGY

The proposed LMB and LSM Outlet Channels are located within the Interlake area of the Manitoba lowland physiographic region (see Plate 1). The Manitoba lowland is a region of gentle relief situated east of the Manitoba Escarpment. The lowland is underlain by gently southwestward dipping Paleozoic and Mesozoic sediments consisting of carbonate rocks, with minor clastic and argillaceous units. The bedrock is predominantly overlain by tills, proglacial lacustrine sediments, and more recent organic deposits found in low-lying areas. The study area lies within the Lake Manitoba and Lake Winnipeg drainage basins. The lakes within the Manitoba lowland collect drainage from the southern portion of the Province, which is directed through Lake Winnipeg into the Nelson River system. Discharge of the drainage system ultimately occurs at Hudson Bay.

3.1.1 Surficial Geology

The regional surficial geology generally consists of a fluted calcareous silt diamicton (till) ground moraine, derived from Paleozoic aged dolomites and limestones (Matile and Keller, 2004). Recent organic deposits (i.e. swamp, marsh, or bog) are common in relatively low-lying troughs between streamlined and till surface flutes. Localized, discontinuous areas of glaciolacustrine silts and clays, or relict shoreline sands, gravels, and silty littoral sands may be found overlying the till surface.

Surficial sediments were deposited on an extensively eroded bedrock surface, which results in variability in overburden thicknesses in the region. Sediments overlying the bedrock are generally less than 10 m in thickness in most areas. Localized overburden areas along Watchorn Bay (i.e. Route D) and in the vicinity of the Fairford River are in excess of 20 m in thickness. In the area bound by Fairford, Grahamdale and the shores of Lake Manitoba sediments above bedrock are relatively thin; and there are numerous bedrock outcrops at surface consisting of glacially striated dolomites and limestones. There are several rock quarries in this area where the overburden thickness is minimal or non-existent (Geological Highway Map of Manitoba, 1994). Material Engineering Branch (MEB) of MIT could provide their rock quarry

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investigation records around this region for further investigations in the detail design stage and may provide assistance for the quarry and granular sources investigation.

3.1.2 Bedrock Geology

The regional bedrock geology consists of Paleozoic dolomites and limestones with the youngest (Devonian aged) rock units along the east shore of Lake Manitoba and the oldest (Ordovician aged) rock units situated between the east shore of Lake St. Martin and Lake Winnipeg. Near Steep Rock, along the east shore of Lake Manitoba, the bedrock consists of high-calcium limestone belonging to the Elm Point Formation. Westward, bedrock changes to dolomitic shale which belongs to the Ashern Formation. Between Faulkner and the east end of Lake St. Martin, the bedrock consists of Silurian aged dolomites (generally fossiliferous, but microcrystalline in places). East of Lake St. Martin there are dolomites and limestones belonging to the Stonewall Formation and Stony Mountain Formation.

The Silurian aged dolomites in the vicinity of Lake St. Martin have undergone structural deformation related to a meteorite impact centered on Gypsumville, Manitoba. Within the structural disturbance zone north of Lake St. Martin, the bedrock is highly variable with rocks varying in age from the Jurassic (relatively young) to Precambrian aged granites (relatively old).

The bedrock surface is found generally between El 220 m (721.8 ft) and El 260 m (853.0 ft) in most study areas, in particular between Lake Manitoba and Lake St. Martin. Regional bedrock contact elevation data northeast of Lake St. Martin is sparse, however, available regional information suggests bedrock surface elevations in the order of El 220 m (721.8 ft). In the area of structural deformation related to the Gypsumville meteorite impact, bedrock contact elevations are less than El 200 m (721.8 ft) in localized areas.

3.1.3 Hydrogeology

The bedrock aquifers in the study area are comprised of the Paleozoic rock sequence commonly referred to in Manitoba as the “Carbonate Aquifer System”. Pervious bedrock strata are separated by argillaceous (clayey or shaley) aquitards or aquicludes. Based on regional data, potentiometric surface maps, the locations of groundwater springs, and general

topography, a relatively fresh groundwater quality mound is found in the Interlake area. This area is a major zone of fresh water recharge to the carbonate aquifer, due to the relatively thin sediment cover comprised predominantly of till, with bedrock outcrops common.

Regional flow is easterly towards Lake Winnipeg, as well as westerly toward Lake Manitoba and Lake St. Martin (and also Lake Winnipegosis). Discharge from the aquifer occurs as seepage and flow into streams, marshes, and lakes found throughout the Interlake. Piezometric pressures in the aquifer are between approximately El 250 m to El 260 m (820 ft to 853 ft) in the Birch Creek (Route D) area, and between approximately El 240 m to El 250 m (787 ft to 820 ft) in the Fairford River area. Sparse data available in the northeast, near Dauphin River, show regional piezometric levels in the order of El 220 m to El 230 m (721 ft to 755 ft). Flowing artesian well conditions are somewhat common in the study area, in particular along Birch Creek (Route D), and in the vicinity of Lake St. Martin. Flowing artesian well conditions also occur in the Dauphin River area and are consistent with the 2011 and 2015 field investigation results where artesian flow conditions were encountered up to 1 m above ground surface.

Well yields are highly variable in the region, a direct result of the fractured rock conditions. Water yields depend on the number of fractures intersected by a well, their size (aperture), extent, and interconnection to other fractures. East of Lake Manitoba the water quality is generally fresh, with Total Dissolved Solids (TDS) <1,000 mg/L. Water quality is generally Mg-Ca-HCO_3 type, with TDS in the order of 400 mg/L to 650 mg/L. This water quality reflects the significant meteoric water, aquifer recharge zone noted within the Interlake area. Due to more complex geology and evaporate mineralogy in the Gypsumville area, water quality varies and is locally poorer with TDS concentrations up to 4,550 mg/L (Betcher, 1987).

3.2 LAKE MANITOBA (LMB) AND LAKE ST. MARTIN (LSM) OUTLET CHANNELS

In 2015, geotechnical field investigations were conducted between January and June 2015 along Route C and Route D of the Lake Manitoba (LMB) outlet channel and Reaches 1 through 3 (Willow Point Option) of the Lake St. Martin (LSM) outlet channel to supplement the investigations completed in 2011, as part of the following two projects:

1. Analysis of Options for Emergency Reduction of Lake Manitoba and Lake St. Martin Water Levels, and

2. Emergency Reduction of Lake Manitoba and Lake St. Martin Water Levels (KGS Group, 2013).

The purposes of the 2015 supplementary geotechnical field investigations were:

- To investigate the soil stratigraphic and groundwater conditions for foundation design of the LMB and LSM Outlet Channel control structures and the proposed bridge structures crossing the LMB Outlet Channels.
- To perform a groundwater impact study due to the construction of the LMB and LSM Outlet Channels.
- To determine the soil stratigraphic and groundwater conditions for the expansion of the Reaches 1 and 3 LSM Outlet Channels.
- To determine the soil stratigraphic and groundwater conditions for the proposed Reach 2 and Willow Point Option for the LSM Outlet Channels.
- To conduct a soil survey for the proposed access road to Reaches 1 through 3 and submit the results of the soil survey to MIT for access road design.
- To evaluate the existing quarry sites and potential gravel pit for borrow sources of riprap and granular materials for road construction and outlet channel construction.

The following Sections 3.3 to 3.6 present the 2015 supplementary geotechnical field investigation program for the LMB and LSM Outlet Channels.

3.3 LMB OUTLET CHANNEL – 2015 ROUTE C OPTION

The proposed 2015 Route C LMB Outlet Channel is envisioned to run from Portage Bay on LMB to LSM, in close proximity along the south boundary of the Fairford First Nation. As shown on Plate 2, a portion of the alignment runs along the west side of Provincial Trunk Highway No. 6 (PTH 6), then extends to the east and terminates at LSM. The proposed 2015 Route C is approximately 11.6 km (7.2 mi) long situated on private and crown leased lands. An outlet channel control structure (around Sta. 8+200) and two bridges crossing the outlet channel at approximately Sta. 0+500 and Sta. 4+600 are proposed for the 2015 Route C LMB Outlet Channel. Photo 3.1 provides an aerial view of conditions in 2011 along Route C.

Photo 3.1
Aerial view of conditions in 2011 along the Route C Alignment Looking towards Lake Manitoba



The 2011 geotechnical field investigation for Route C consisted of fifteen (15) test pits, six (6) boreholes, and approximately 2.7 kilometers of seismic survey. All the test pit, borehole and seismic survey locations are shown on Plate 2. Based on the 2011 geotechnical field investigation results, from approximately Station 0+000 to Sta. 6+000, the Route C Outlet Channel cuts through a rock ridge with the channel invert located in bedrock throughout this reach. The remainder of the channel cuts essentially through till materials with only the occasional occurrence of bedrock.

The 2015 supplementary geotechnical field investigation consisted of four (4) boreholes, TH15-RC-01, 02, 04 and 06, and their locations were shown on Plate 2. These boreholes were drilled for foundation design of the outlet channel control structure (TH15-RC-01) and the proposed

bridges structures (TH15-RC-02 and 04) and were extended to a depth of about 3 m below the proposed outlet channel invert or at least 3 m into the bedrock (see Plate 4). Standpipe piezometers (SP) and vibrating wire piezometers (VW) were installed in the boreholes for groundwater monitoring.

Soil and rock samples obtained from the boreholes were visually inspected in the field for material types. All soil samples were classified in accordance with the Unified Soil Classification System (USCS). Diagnostic laboratory testing was performed on selected soil samples to verify soil classifications including fourteen (14) moisture content analyses, six (6) grain size analyses and six (6) Atterberg Limits. Cored bedrock samples were examined and logged. Table 3.1 summarizes the 2015 supplementary geotechnical field investigation program for the proposed 2015 Route C LMB Outlet Channel. Detailed borehole logs, laboratory testing results and the rock core inspection report are included in Appendix D.

Table 3.1
2015 Route C Supplementary Geotechnical Field Investigation Program

Borehole	Station	Depth	Instrumentation	Remarks
TH15-RC-01	8+100	12.0 m	2 SP	Proposed Control Structure
TH15-RC-02	5+168	4.6 m	1 SP	Proposed Bridge Crossing
TH15-RC-04	0+464	11.1 m	2 SP	Proposed Bridge Crossing
TH15-RC-06	4+200	13.7 m	1 SP & 1 VW	

3.4 LMB OUTLET CHANNEL – 2015 ROUTE D OPTION

The proposed 2015 Route D LMB Outlet Channel is envisioned to run northwards from Watchorn Bay on LMB to Birch Creek on LSM as shown on Plate 5. The 2015 proposed Route D alignment generally follows low-lying terrain between LMB and LSM. In comparison to the 2011 alignment, the 2015 alignment was shifted northwards away from the major marshes and small lakes. As a result, the proposed 2015 Route D LMB Outlet Channel is approximately 24 km long (1 km longer than the 2011 alignment) and situated on private and crown leased lands. A bridge and outlet channel control structure (around Sta. 19+050) and four bridges crossing the outlet channel at approximately Sta. 2+600, Sta. 12+650, Sta. 16+750, and Sta.

21+250 are proposed for the Route D LMB Outlet Channel. Photo 3.2 provides an aerial view of conditions in 2011 along Route D.

Photo 3.2
Aerial View of Conditions in 2011 along the Route D Alignment Looking towards Birch Creek from Lake St. Martin



The 2011 geotechnical field investigation for Route D consisted of thirty-two (32) test pits, eighteen (18) boreholes, and approximately 3.7 km of seismic survey. All the test pit, borehole and seismic survey locations are shown on Plate 5. Based on the 2011 geotechnical field investigation results, the Route D Outlet Channel would cut through till materials and not intercept bedrock. The highest cut would be approximately 12 m high (see Plate 7).

The 2015 supplementary geotechnical field investigation consisted of six (6) boreholes: TH15-RD-01, 02, 03, 04, 05 and 10; and their locations are shown on Plate 5. These boreholes were

drilled for foundation design of the outlet channel control structure and the proposed bridge structures and were extended to depths ranging from 12.6 m to 22.3 m. Standpipe piezometers (SP) and vibrating wire piezometers (VW) were installed in the boreholes for groundwater monitoring.

Soil and rock samples obtained from boreholes were visually inspected in the field for material types. All soil samples were classified in accordance with the Unified Soil Classification System (USCS). Diagnostic laboratory testing was performed on selected soil samples to verify soil classifications including: sixty-six (66) moisture content analyses, twenty-eight (28) grain size analyses and twenty-nine (29) Atterberg Limits. Bedrock core samples were logged in detail and inspected. Table 3.2 summarizes the 2015 supplementary geotechnical field investigation program for the proposed 2015 Route D LMB Outlet Channel. Detailed borehole logs and the laboratory testing results are included in Appendix E.

Table 3.2
2015 Route D Supplementary Geotechnical Field Investigation Program

Borehole	Station	Depth	Instrumentation	Remarks
TH15-RD-01	2+670	22.3 m	2 SP	Proposed Bridge Crossing
TH15-RD-02 & 2A	12+750	15.7 m	2 SP	Proposed Bridge Crossing
TH15-RD-03 & 3A	17+030	15.2 m	2 SP & 1 VW	Proposed Bridge Crossing
TH15-RD-10A	17+800	18.7 m	1 SP & 1 VW	
TH15-RD-04	19+250	15.5 m	2 SP	Proposed Control Structure
TH15-RD-05	21+460	12.6 m	2 SP	Proposed Bridge Crossing

Bedrock samples were stored in core boxes in KGS Group's warehouse. KGS Group stores core samples for one (1) year prior to disposal.

3.5 LSM OUTLET CHANNELS – REACHES 1, 2 AND 3

The LSM Outlet Channel consists of Reaches 1, 2 and 3. Reach 1 Channel is envisioned to run northeast from LSM towards Lake Winnipeg through a wetland area connecting to the Buffalo Creek Drainage System as shown on Plate 8. The 2015 Reach 1 channel design plans to widen the existing 2011 Reach 1 emergency channel, as well as extend the channel towards Big

Buffalo Lake, and then capitalizing on the natural low lying ground conditions by allowing water to flow freely through the Big Buffalo Lake and the surrounding bog area into the Buffalo Creek Drainage System. The estimated length of the 2015 Reach 1 Channel is approximately 8 km long as shown on Plate 8.

The 2015 Reach 2 is a proposed diking system to be constructed along the top of the northwest bank of Buffalo Creek (only the upper portion as shown on Plate 10) as well as a containment dike along the rim of the bog to prevent overland flow to the north, that could bypass Reach 3, and travel downwards towards the lower reaches of Buffalo Creek and the Dauphin River.

The 2015 Reach 3 Channel design plans to widen and deepen the existing 2011 Reach 3 emergency channel and diking system to divert channel water flows from Buffalo Creek directly to Lake Winnipeg and away from the Dauphin River (see Plate 11). The 2011 Reach 3 Channel was designed to have an outlet at Johnson Beach (Johnson Beach Option). Another outlet option east of Willow Point (Willow Point Option) was considered for the 2015 Reach 3 Channel design. The total proposed flow path length from Lake St. Martin to Lake Winnipeg through Reaches 1, 2 and 3 is approximately 27.4 km. Photos 3.3 and 3.4 show the outlet location of the Johnson Beach and Willow Point options.

Photo 3.3
Location of the Reach 3 Johnson Beach Option Outlet at Lake Winnipeg



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Photo 3.4
Location of the Reach 3 Willow Point Option Outlet at Lake Winnipeg



The 2011 geotechnical field investigation for Reaches 1 and 3 consisted of forty-nine (49) test pits, nine (9) boreholes, thirty-four (34) hand auger test holes, four hundred twelve (412) peat probe measurements, fifty-four (54) lake sounding measurements, and approximately 33.1 km of seismic survey. All the 2011 geotechnical field investigation locations are shown on Plates 8, 10 and 12. Based on the 2011 geotechnical field investigation results, the LSM Outlet Channel of Reaches 1 and 3 mainly cut through till materials with the occasional occurrence of bedrock.

The 2015 supplementary geotechnical field investigation for the LSM Outlet Channels, access road soil survey and borrow sources consisted of nineteen (19) boreholes, seventy-one (71) test pits, and thirty-nine (39) peat probes. Their locations are shown on Plates 8 and 12. Standpipe piezometers (SP) and vibrating wire piezometers (VW) were installed in some of the boreholes for groundwater monitoring.

Soil and rock samples obtained from the boreholes were visually inspected in the field for material types. All soil samples were classified in accordance with the Unified Soil Classification System (USCS). Diagnostic laboratory testing was performed on selected soil samples to verify

soil classifications including 283 moisture content analyses, 217 grain size analyses and 201 Atterberg Limits. Bedrock core samples were logged in detail and inspected. Table 3.3 summarizes the 2015 supplementary geotechnical field investigation program for the proposed 2015 LSM Outlet Channels, access road soil survey and borrow sources. Detailed borehole logs, laboratory testing results and the rock core inspection report are included in Appendix F.

Table 3.3
2015 LSM Outlet Channel
Supplementary Geotechnical Field Investigation

Descriptions	Test Holes/Test Pits	Remarks
Reach 1 Channel	TH15-01	Proposed Control Structure
Reach 2	TP15-27 to TP15-31	Along the Bank of Buffalo Creek
Reach 3 Channel	TH15-02 to TH15-05 TP15-01 to TP15-20	Channel & Groundwater Investigation
Willow Point Channel	TH15-06 to TH15-12 TP15-21 to TP15-26 39 Peat Probes	Channel & Groundwater Investigation
Access Road Soil Survey	TP15-32 to TP15-71	Along the Alignment of the Existing Winter Road
Borrow Sources: • Reach 3 Quarry • Camp Site Quarry • Granular Borrow	 TH15-13 TH15-14 to TH15-16 TH15-17 to TH15-19	Investigation for Riprap Borrow and Granular Borrow

3.6 GROUNDWATER MEASUREMENTS

Besides the initial groundwater monitoring during the 2015 supplementary geotechnical field investigation, groundwater monitoring was conducted in May 2015 for the LSM Outlet Channels and in July 2015 for the LMB Outlet Channels. The results of the groundwater monitoring for the LMB and LSM Outlet Channels are presented in Tables 3.4 and 3.5, respectively.

Table 3.4
Groundwater Monitoring Results for LMB Outlet Channels Route C and D
(attached at end of report)

Table 3.5
Groundwater Monitoring Results for LSM Outlet Channels
(attached at end of report)

4.0 BASIS OF DESIGN OF CHANNELS

4.1 CHANNEL CAPACITY AND LAKE LEVELS

The design discharge for open water in the LMB and LSM outlet channels were based on a fixed water level on each lake as originally defined in 2011 as part of the *Analysis of Options for Emergency Reduction of Lake Manitoba and Lake St. Martin Levels* studies (KGS Group/AECOM, 2014). The reference water levels for the channel capacity are shown in Table 4.1. The capacity of the channels will be higher or lower than the design capacity depending on the water level of the Lakes.

Table 4.1
Reference Lake Levels for Outlet Channel Design

Lake	Reference Water Level
Lake Manitoba	248.1 m (814 ft)
Lake St. Martin	244.1 m (801 ft)

As discussed in Section 2.0, based on the results of the Stage 1 Study, the Province of Manitoba committed to a 212 m^3/s (7,500 cfs) outlet channel capacity on LMB. Accordingly, the design discharge that was used for the LMB outlet channels for Routes C and D was 212 m^3/s (7,500 cfs) with LMB at elevation El 248.1 m (El 814.0 ft).

On LSM, the Province of Manitoba committed to a 326 m^3s (11,500 cfs) outlet channel capacity, also based on the results of the Stage 1 Study. As discussed in Section 2.0, the 326 m^3s (11,500 cfs) capacity is based on the capacity of the existing LSM Emergency Outlet Channel of 113 m^3/s (4,000 cfs) plus the additional 212 m^3/s (7,500 cfs) from the proposed LMB outlet channel. Adopting the 113 m^3/s (4,000 cfs) capacity as the base condition to control Lake St. Martin levels was confirmed through the flood routing studies and has been summarized in Section 13.0 of the report. The additional 212 m^3/s (7,500 cfs) will ensure that flooding will not be aggravated on LSM due to a LMB outlet channel. Accordingly, the design discharge that was used for Reach 1, Reach 2 and Reach 3 of the LSM outlet channels was 326 m^3/s (11,500 cfs) with LSM at elevation El 244.1 m (El 801.0 ft).

The Province of Manitoba is also currently pursuing flood easements around LSM. Though not finalized, the flood easements are currently proposed at a level of El 245.7 m (El 806.0 ft) around the lake, based on a static water level of El 244.8 m (El 803.0 ft) plus 0.9 m (3 ft) for wind, waves and freeboard. As discussed with MIT, the preliminary LSM outlet channel design does not consider the potential flood easements. Optimization of the channel design could be considered at the next phase of design if the flood easements are finalized and may provide an opportunity to raise the reference water level above El 244.1 (El 801.0 ft) and make the channel more economical.

4.2 CHANNEL GEOMETRY

The hydraulic design of the outlet channels was based on an assumed uniform trapezoid shaped channel with a flat channel base. In till, the side slopes were assumed to be 4h:1v for channel depths of less than 8 m (26 ft) and 5h:1v for channel depths in excess of 8 m (26 ft). In rock, near vertical side slopes were assumed (1h:8v). Optimization of the hydraulic design based on a channel geometry that incorporates flatter slopes or a bench to address deep excavation cuts or the inclusion of dikes, or that incorporates a riparian channel, should be completed as part of the environmental approval process and once all other design components are being finalized. Optimization of the channel design considering costs, material types, and the bridge and control structures should also be undertaken following a process similar to what was done for the Red River Floodway expansion project.

4.3 CHANNEL VELOCITY

Maximum average flow velocities in the channel were based on the maximum permissible non-scouring velocity for the type of material that constitutes the channel bed. In till, the maximum permissible design velocity was 1.9 m/s (6.2 ft/s) based on engineering judgement and various references such as Ven Te Chow (Chow, 1959).

In a rock channel, there is no theoretical limit to the acceptable average flow velocity. However, in the winter, flow conditions of high velocity and turbulence produce frazil ice and form ice over, which reduces channel conveyance and exacerbates the flood condition upstream. As such, the

design velocity chosen for the rock channel considered the impact of frazil ice on the capacity of the outlet channel.

4.4 CHANNEL HEADLOSSES

The headloss for the channel excavations was estimated using the Manning's equation. Manning's "n" values selected for the channel design were based on typical values as defined by Ven Te Chow (Chow, 1959) and are listed in the Table 4.2.

Table 4.2
Typical Manning's "n" Values

Type of Channel Bed Material	n-value
Rock	0.045
Till	0.028
Ice Cover (2 ft or less)	0.015 to 0.020

4.5 DROP STRUCTURES

Excessive flow velocities in the channels that are greater than the maximum permissible were controlled using gradient control structures. This was only required for Reach 3 of the LSM Outlet Channels. The design of the gradient control structures were based on a detailed guide for a stone paved sloping channel in "Hydraulic Structures" by C.D. Smith, (1974). The design consists of rock lined drops in elevation of the channel bed with a weir at the crest of the drop structure. Details of the conceptual design of drop structures are provided in Section 9.2.2.

4.6 CONTROL STRUCTURES

Flow in the outlet channels would be controlled with gated control structures. The selected location of the control structures for the LMB outlet channel Routes C and D was PTH 6 to minimize the required size of the control structure, eliminate the need for a secondary drop or outlet structure, and to reduce impacts on groundwater and adjacent wetlands. On LSM, the control structure for Reach 1 would be located at the existing inlet location. Details of the conceptual design of the control structures are provided in Section 10.0 of the report.

4.7 EROSION PROTECTION

Erosion protection was incorporated into the design where necessary. The procedures for selection of the stone weight of the riprap were based on the guidelines of the USACE EM 110-2-1601, with the exception of the drop structures noted in Section 4.5, where the size of the stone riprap was based on C.D. Smith (1974).

4.8 RIPARIAN FLOW REQUIREMENTS AND FISH PASSAGE

Due to the intermittent occurrence of operation of the outlet channels from one year to the next, the difficulty of timing the opening and closure of the channel operation with fish migration windows, and the number of drop and control structures in the channels, it was assumed that the outlet channels and structures would not accommodate fish passage. Rather, improvement of fish passage directly at the FRWCS was considered in the design and is discussed in Section 12.0 of the report. Further discussion on potential environmental impacts of the project including fish habitat and resources is discussed in Section 15.0.

Although the LSM Reach 3 channel was designed to divert water away from its natural course on Buffalo Creek, riparian flow will be provided in Buffalo Creek downstream of the diversion point. As discussed in Section 9.2.3, an earth plug was incorporated into the design in conjunction with riparian flow culverts to maintain low flows in Buffalo Creek.

4.9 GEOTECHNICAL BASIS OF DESIGN

The basis of design for the LMB and LSM Outlet Channels from a geotechnical perspective is as follows:

- Long term condition (after construction): minimum estimated factor of safety (FS) of 1.5 for outlet channel and dike slope stability at steady state conditions, could be under full channel flow condition, no flow condition with water or no water (dry channel conditions).
- Short term condition (during construction): minimum estimated factor of safety (FS) of 1.3 for outlet channel and dike slope stability under dry channel conditions.
- Short term condition: minimum estimated factor of safety (FS) of 1.2 for outlet channel and dike slope stability under rapid drawdown conditions (during operation with Open or Closed Gate Conditions).

- A minimum 8 m width of peat stripping between the top of channel and side slope of dike.
- Dike fill would be silt and clay till materials from composite excavation.
- Final dike elevations at end of construction should be overbuilt by 0.3 m to overcome the long term estimated settlements (i.e. in addition to the recommended 1.0 m freeboard)

The criteria for minimum estimated FS were based on current Manitoba Provincial Guidelines for dike stability (MIT, 2012) and are consistent with the Canadian Dam Association (CDA) Dam Safety Guidelines (CDA, 2007).

The minimum 8 m of peat stripping requirement is to ensure a tight seal between the dike and foundation soils and to serve as a cut-off for seepage through the existing peat layer. Installing a cut-off in the peat would also assist in lowering the long term phreatic surface between the remaining saturated peat and open channel. A minimum 1.0 m freeboard of the dikes was recommended for the long term.

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5.0 LAKE MANITOBA OUTLET CHANNEL – ROUTE C

5.1 DESCRIPTION

Route C is an approximately 11.6 km (7.2 mi) long channel located immediately south of the Pinaymootang First Nation border and is situated on privately held lands and crown leased lands, joining LMB to LSM as shown on Plate 2. Its inlet is located approximately 2 km south of the existing FRWCS in Portage Bay on LMB. The alignment of the channel is generally to the east direction for 5 km (3.1 mi) before turning southeast along PTH 6 for approximately 3 km (1.9 mi). The channel then turns directly east to cross PTH 6 and enters LSM approximately 3.5 km (2.2 mi) downstream.

As shown on Plate 2, Route C would require construction of new bridge crossings at two municipal roads and at PTH 6, with the bridge at PTH 6 combined with a new control structure. The control and bridge structures have been combined into one structure to reduce construction costs. As discussed in Section 5.2.3, the control structure was located at PTH 6 to allow for a narrower and less costly structure than if it was located upstream near Lake Manitoba. The location of the control structure also helps reduce the potential groundwater impacts, as later discussed in Section 5.4.

Plate 2 also shows that the channel alignment cuts through the Manitoba Hydro Bi-pole Transmission Lines at about Station 2+400. This can be accommodated by shifting the channel alignment to fit between the base of the transmission line poles and with optimization of the spoil pile at the Detailed Design Phase.

Figure 5.1 shows a profile plot of the Route C channel from LMB to LSM. The land surface rises from LMB to El 256 m (El 839.9 ft) at approximately Station 3+500 and remains above El 253 m (830.1 ft) until PTH 6 when the ground surface falls quickly to El 246 m (El 807.1 ft) to LSM.

As discussed in Section 3.0, from LMB to approximately Station 6+000, the channel cuts through a rock ridge with the invert of the channel located in bedrock throughout this reach. The remainder of the channel to LSM cuts essentially through till material with only an occasional occurrence of bedrock.

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The channel has an invert of El 242.75 m (El 796.4 ft) at LMB and El 240.6 m (El 789.4 ft) at LSM. The depth of excavation below ground surface would vary between approximately 4 m (13 ft) and 14 m (46 ft), with the deepest cut located in the bedrock. Since the invert of the channel would be lower than water levels in LMB and LSM, there would be standing water in the channel when it is not in operation.

5.2 HYDRAULIC DESIGN

5.2.1 Channel Design

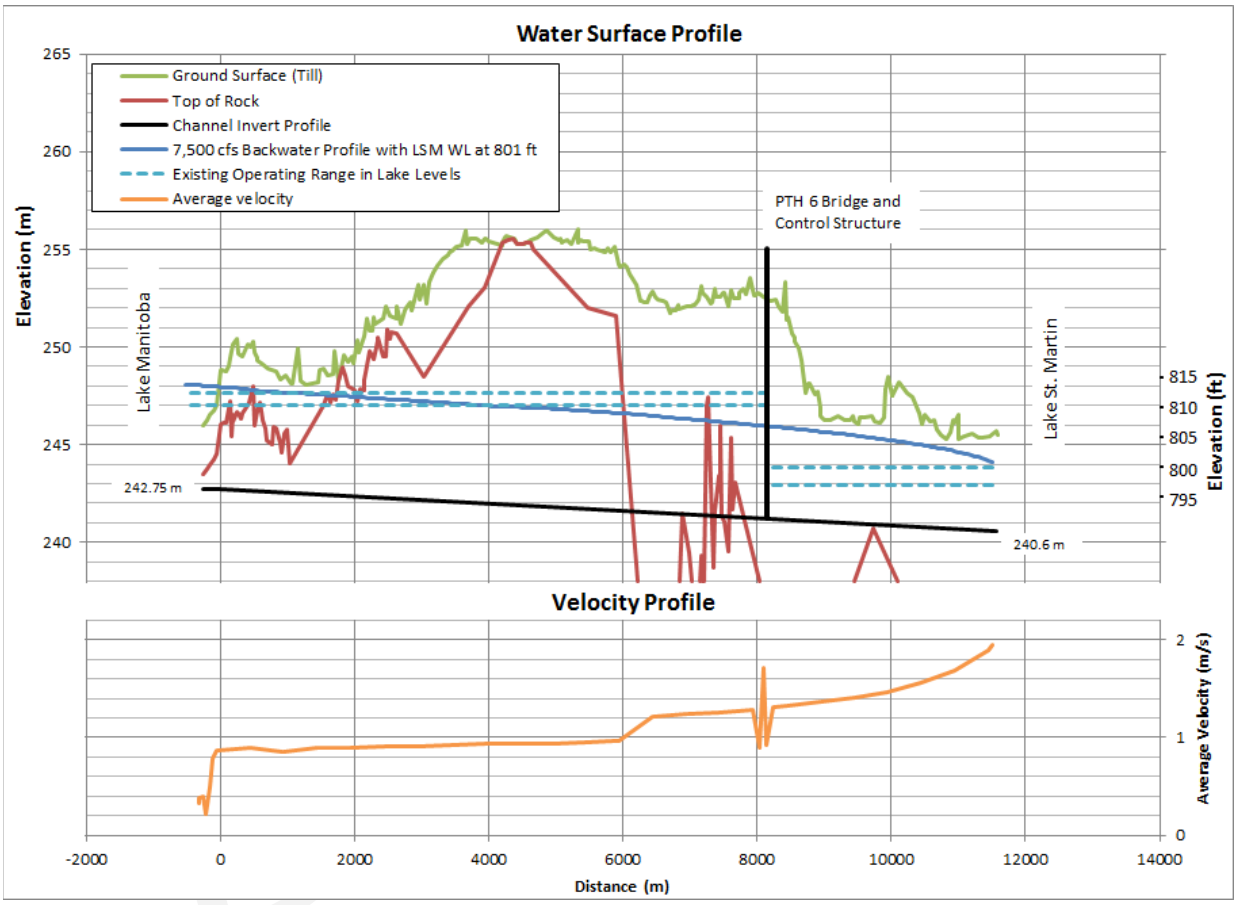
The channel design was based on Manning's equation to compute the base width using the channel design parameters listed in Table 5.1 with a design discharge of 212 m^3/s (7,500 cfs). The normal depth of flow of 5.25 m (17.2 ft) was based on the channel invert elevation at LMB and the design water level for LMB of El 248.1 m (El 814.0 ft). Table 5.1 summarizes the basis for the hydraulic design in the rock and till portions of the channel. A hydraulic profile of Route C based on a HEC-RAS backwater model of the channel and an assumed water level of El 244.1 m (El 801 ft) in Lake St. Martin as the downstream boundary condition is provided on Figure 5.1.

Table 5.1
Hydraulic Design Summary for Lake Manitoba Outlet Channel Route C

Channel Bed Material	Rock	Overburden / Unclassified
Station Range	-0+260 to 6+000	6+000 to 11+820
Design Flow	7,500 cfs	7,500 cfs
Channel Slope	0.086 %	0.086%
Normal Depth of Flow	5.25 m	5.25 m
Assumed Manning's 'n' Value	0.028	0.045
Base Width	44.4 m	16.6 m
Side Slopes	1H:8V	4H:1V

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Figure 5.1
Profile of Lake Manitoba Outlet Channel Route C



As shown on the profile, the average velocity in the channel ranges between approximately 1.2 m/s (4.0 ft/s) and 2.0 m/s (6.4 ft/s) in till and 0.8 m/s (2.8 ft/s) and 1.0 m/s (3.2 ft/s) in rock. In the till section, the average velocity is higher than under the normal depth of flow condition (velocity of 1.1 m/s (3.6 ft/s)). This is because the target water level on LSM of El 244.1 m (El 801.0 ft) is approximately 1.7 m (5.6 ft) lower than the design normal depth of flow. This results in the maximum average velocity in till of 2.0 m/s (6.4 ft/s) to exceed by 0.1 m/s (0.3 ft/s) the maximum allowable velocity that was identified in Section 4.3. To help reduce the velocities, the width of the downstream 500 m (1,640 ft) reach of the channel could be gradually increased up to its outlet into LSM to provide additional flow area as the water enters the lake. Riprap could also be considered to mitigate the risk of erosion.

The inlet to the channel for Option C must be designed to allow the flow to enter the channel with a minimum of loss. Based on bathymetric surveys of LMB conducted in the fall of 2014

near the entrance of Option C (Appendix C), the bottom elevation of the lake is approximately 246 m (807 ft) about 200 m (650 ft) from the shore. The conceptual configuration of the inlet includes a wide, shallow, bell-mouth entrance to achieve the desired hydraulic performance and is shown on Plate 2. The channel slopes from an approximately 300 m (1,000 ft) wide entrance at El 246.25 m (807.9 ft) down gradually to the invert level of the channel at approximately El 242.75 m (796.4 ft) over a distance of approximately 600 m (2,000 ft). The entrance would be excavated in the dry behind temporary cofferdams that would be designed for moderately high lake levels and moderate wind events. Should an extreme windstorm occur and cause overtopping of the cofferdam, the intent would be to permit temporary flooding of the construction area and rehabilitation of the cofferdam after the event. The height of the cofferdam would be selected in final design but is expected to reflect a probability of overtopping and failure of about 1:20 to 1:50 for the duration of the construction period at the channel entrance.

There will be many years when the channel will be inoperative. There is a concern that the natural shoreline processes in Lake Manitoba would eventually lead to infilling of the entrance to the channel with sediment. This is not a certainty and would require more careful examination during final design. For the purposes of the conceptual design described herein, however, it has been assumed that it will prove necessary to construct a groin at the north side of the channel entrance that would project into the lake approximately 100 m (330 ft) beyond the mouth of the channel. This would prevent the migration of sand and silt into the channel and minimize the risk of infill. This groin would have to be a substantial structure, built to withstand the severe wind effects on Lake Manitoba. Detailed analyses in final design would be required to develop a robust configuration. The groin concept is shown on Plate 2.

5.2.2 Winter Ice Considerations

The backwater model results showed that the computed Froude number for the flow under normal operating conditions is greater than 0.12 for all locations in the channel. Since the critical Froude number for an ice cover to advance in flowing water by juxtaposition must be no greater than 0.08, an ice cover on the channel is unlikely. Significant staging in the water level in the channel at LSM in the range of 4.5 m (15 ft) would be required to lower the flow velocity to reduce the Froude number before the cover could advance upstream from LSM. Based on experience and observations of ice conditions in the Fairford River, as well as in the existing

emergency Reach 1 channel since the flood of 2011, it is unlikely that there would be a sufficient amount of frazil ice production for staging to occur for an ice cover to advance sufficiently upstream and impede the capacity of the channel at LMB.

In addition, the flood routing studies discussed in Section 13.0 showed that the outlet channel would typically begin operation in early summer and end operation by late fall. Operation of the channel in the winter normally will not be required. As discussed in Section 13.3.1, in the 54 years that were simulated, the channel would have been operated 7 times in the month of December but only 4 times in the month of January, 3 times in February and 2 times in March. Winter operation is, therefore, only expected during very large flood events such as in 2011, 2012 and 2014.

While an ice cover is unlikely to occur during operation of the Route C outlet channel, it is possible that, given the convenience of operating the automated gates, these gates would be used during winter for lake regulation to supplement the FRWCS fixed stoplog gates. If used for flow regulation, it is possible that the gates could be opened and flow would be initiated after a stable ice cover had already formed in the channel. This type of ice cover would be similar to lake ice, which typically has a low Manning's n-value.

An ice covered rating curve was, therefore, computed for this condition using the HEC-RAS backwater model with an assumed smooth ice cover (n-value of 0.015) with a thickness of 0.6 m (2 ft). The winter ice covered rating curve provided in Section 5.2.3 shows that the ice cover would reduce the channel discharge by approximately 57 m^3/s (2,000 cfs) from the equivalent open water condition at El 248.1 m (El 814.0 ft) of 212 m^3/s (7,500 cfs) to approximately 155 m^3/s (5,500 cfs).

In the channel, the water levels at the flow of 155 m^3/s (5,500 cfs) with the 0.6 m (2 ft) ice cover would at most be 0.3 m (1.0 ft) higher than under open water conditions at the 212 m^3/s (7,500 cfs) flow. Due to the very deep cut of the excavation, this slight increase to water levels is still well within the channel banks and does not impact the hydraulic design of the channel. For the rare case where significant staging occurs at the channel outlet due to the formation of an ice cover by juxtaposition, the water levels risk overtopping the channel banks near LSM.

However, this could be addressed by constructing dikes using the spoil material from the channel excavation if this risk is considered to be significant enough.

5.2.3 Control Structure and Rating Curve

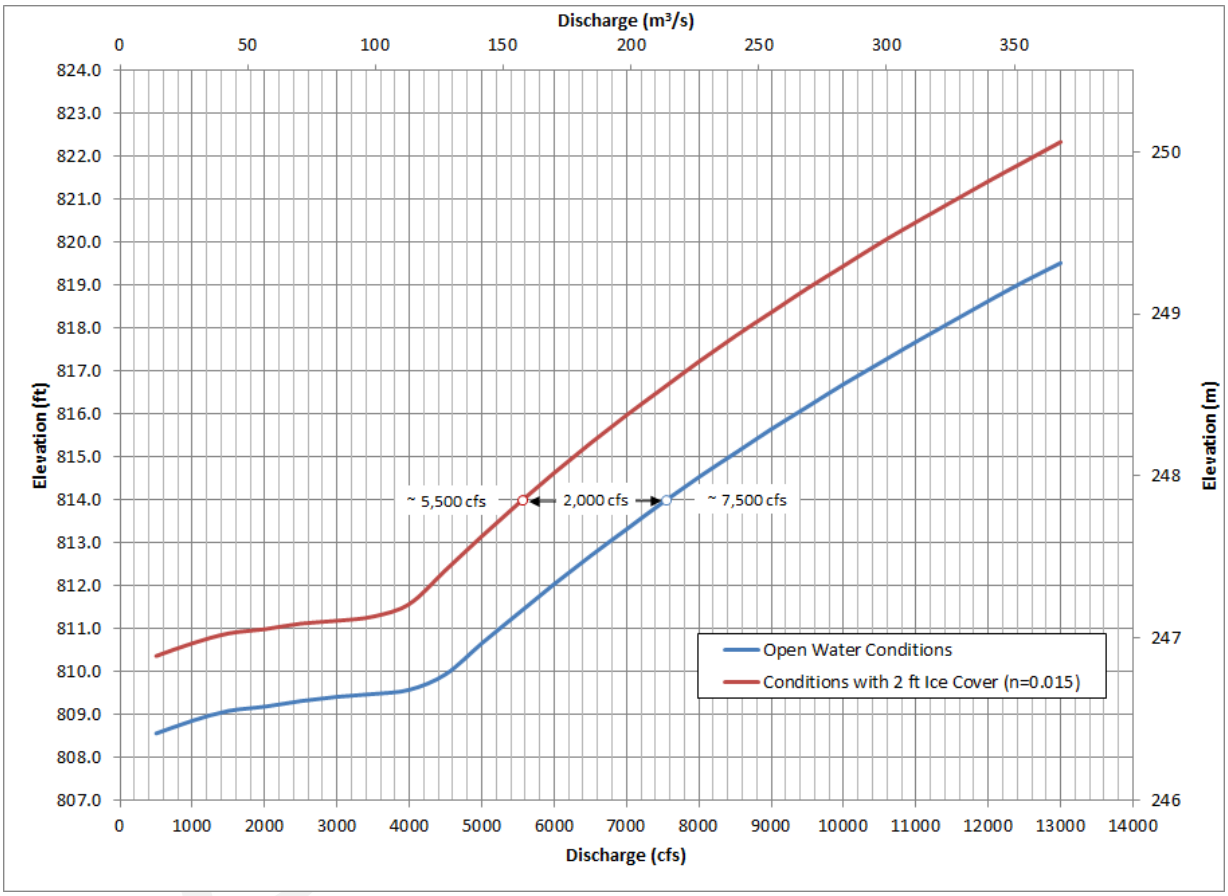
A gated control structure, which would be located at PTH 6 as shown on Plate 2, will be used to control flow in the channel. The control structure will be comprised of three bays each 9 m (29.6 ft) wide with an invert of El 241.24 m (El 791.5 ft). Design details of the control structure concept are provided in Section 10.0 of the report.

Having the control structure located about 8 km into the channel allows for a narrower structure than if located near the LMB outlet. This is due to the long channel length upstream of the structure, which "dampers" the additional head loss from having a narrower structure. The downstream location of the structure also helps reduce potential groundwater impacts along the channel upstream of the structure when it is closed, as discussed in Section 5.4. The selected location also allows the control structure and the PTH 6 Bridge to be combined into a single structure to save on construction costs, and provides good access for operation and maintenance purposes.

When the structure is closed, the water level in the channel on the upstream side of the structure will be the water level on LMB and on the downstream side of the structure will be the water level on LSM.

When the structure is fully open, flows in the channel will depend on LMB water levels. Based on the results of the HEC-RAS backwater model with an assumed LSM water level of El 244.1 m (El 801.0 ft) and with open water conditions on the channel, a stage-discharge relationship (Figure 5.2) was prepared for the Route C channel at LMB. As shown on the figure, the channel design can convey the 212 m^3/s (7,500 cfs) flow criteria at a LMB water level of El 248.1 m (El 814.0 ft). The winter ice covered rating curve discussed in Section 5.2.2 is also included on the figure.

Figure 5.2
Stage-Discharge Relationship for Lake Manitoba Outlet Channel Route C



5.3 GEOTECHNICAL DESIGN

The borehole drilling and sampling program for the geotechnical field investigation along Route C at the LMB Outlet Channel was completed by Hatch Ltd. as a sub-consultant of KGS Group, from June 8 to 19, 2015. Maple Leaf Drilling Ltd. of Winnipeg, Manitoba provided the drilling services using 125 mm solid stem augers and HQ coring. Standard Penetration Tests (SPT) were performed in 1.5 m (5 ft) intervals in till deposits to determine the relative density of the soil. Quality representative soil samples were obtained for soil logging and laboratory testing with the selected drilling and excavating methods. The geotechnical investigation was completed under the continuous supervision of Hatch Ltd. personnel and at the direction of KGS Group.

As mentioned in Section 3.3, a total of four (4) boreholes (TH15-RC-01, 02, 04 and 06) were drilled to investigate the subsurface conditions of Route C for foundation and channel design. A total of six (6) standpipe piezometers and one (1) vibrating wire piezometer were installed within the till deposits to monitor piezometric pressures. The location of these boreholes are shown in plan on Plate 2.

5.3.1 Stratigraphy of LMB Outlet Channel Route C Option

In general, the stratigraphy at Route C consisted of a thin layer of topsoil overlying till materials including silt and clay till, silt till, clay till, and then bedrock.

Topsoil – A thin layer of topsoil was encountered at the surface of each borehole and extended to approximate depths of 0.3 to 0.9 m. The topsoil was black to grey in colour, moist, firm and contained organics.

Silt and Clay Till / Clay Till / Silt Till – Varying till deposits were encountered beneath the topsoil containing varying amounts of clay, silt, sand and gravel. The predominant grain size within the till varied spatially and with depth. The till extended to bedrock at approximate depths of 6.1 m, 1.4 m and 1.6 m in Borehole 15-RC-01, 02 and 06, respectively and to approximate completion depths of 11.1 m in Borehole 15-RC-04 where this borehole was terminated prior to reaching bedrock. The till was grey in colour, moist to wet, hard and contained occasional cobbles and boulders. Based on twelve (12) SPT tests performed in the till, the uncorrected SPT blow counts (N) in the till ranged from a minimum of 16 in Borehole 15-RC-04 to greater than 100. A total of six (6) of the 12 SPT tests performed in the till encountered refusal. Thin sand and cobble layers were encountered in Borehole 15-RC-01 and 02 separating the till and bedrock.

Bedrock – Limestone bedrock was encountered in all boreholes at approximate depths ranging from 1.4 m to 6.1 m. Jointing observed in the bedrock core was composed predominately of sub-horizontal fractures, which varied in weathering degree, iron staining, or had calcite and iron minerals precipitate out along groundwater flow pathways formed by the bedrock fracture network. The majority of the cored limestone and dolomite showed signs of weathering outside

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of the joint faces. The limestone and dolomite exhibit a vuggy porosity where voids vary between 2 mm to 10 mm and up to 60 mm in diameter.

Structurally, the limestone appears to be highly fractured, shows karstic characteristics, and recoveries of the individual core runs are between approximately 0% and 100 %. The bedrock overall, based on core recoveries and Rock Quality Designation (RQD), appeared to be in poor condition. RQD rankings varied between approximately 0% and 61%, ranging from very poor to fair classification. Broken core zones and broken lost core zones were identified in all cored boreholes, with estimated core losses ranging from approximately 0.02 m to 1.52 m.

Detailed borehole logs, the laboratory testing results and the rock core inspection report are included in Appendix D.

Plate 3 shows the profile of the 2015 Route C LMB Outlet Channel. This profile included the ground surface, the soil profile of the 2011 and 2015 test pits and boreholes, the 212 m^3/s (7,500 cfs) flow water surface profile and the design channel invert. This profile was used to estimate the excavation volume of topsoil and composite excavation materials for channel construction.

5.3.2 Groundwater Conditions

Groundwater readings were obtained on July 16, 2015, approximately one month after the completion of the 2015 supplementary geotechnical field investigation program. Results of the July 16 readings showed the groundwater levels were generally approximately 1 m below ground surface. No artesian condition was observed in the 2015 drilling program. Table 3.4 summarizes the groundwater monitoring results. Section 5.4 discusses the groundwater conditions in detail and provides the preliminary results of the groundwater impact study.

5.3.3 Route C LMB Outlet Channel Slope Stability

A slope stability analysis was conducted to establish the side slope requirements for the Route C LMB Outlet Channel excavation and the dike (spoil piles) linings along the channel. Four conditions were examined to determine the side slope requirements:

1. Long Term Condition (after construction) with a minimum estimated factor of safety (FS) of 1.5: under full channel flow condition or no flow condition with water at lake levels.

2. Short Term Condition (during construction) with a minimum estimated factor of safety (FS) of 1.3: under dry channel condition.

3. Short Term Condition with a minimum estimated factor of safety (FS) of 1.2: under rapid drawdown conditions during channel operation with Open Gate Upstream conditions.

4. Short Term Condition with a minimum estimated factor of safety (FS) of 1.2: under rapid drawdown conditions during channel operation with Closed Gate Downstream conditions.

The stability analyses were conducted using the two-dimensional computer model SLOPE/W, developed by GeoSlope International Ltd. from Calgary, Alberta. The model is capable of analyzing numerous iterations of both circular and composite slip surfaces to identify analytically the worst-case slip surface. The Morgenstern-Price Method of Slices with a half sine wave inter-slice force function was applied to all calculations reported herein.

5.3.4 Channel Configuration

As mentioned in Section 5.1, the channel has an invert of El 242.75 m (El 796.4 ft) at LMB and El 240.6 m (El 789.4 ft) at LSM. The depth of excavation below ground surface would vary between approximately 4 m (13 ft) and 14 m (46 ft), with the deepest cut located in the bedrock. Since the invert of the channel would be lower than water levels in LMB and LSM, there would be standing water in the channel when it is not in operation.

Section 3.3 indicated that from approximately Station 0+000 to Sta. 6+000, the Route C Outlet Channel cuts through a rock ridge with the channel invert located in bedrock (limestone) throughout this reach. The remainder of the channel cuts essentially through till materials with only the occasional occurrence of bedrock. For the Stage 2 Study, the channel slopes cutting through the limestone bedrock would have a side slope of 1H:8V. The channel slopes cutting through till materials would be determined with the following slope stability analysis.

For the slope stability analysis, two (2) slope configurations were analyzed in respect to the height of excavation (H) of 6 m, 8 m, 10 m and 12 m in overburden. These slope configurations were:

1. For height of excavation (H) up to 8 m, channel side slopes = 4H:1V.
2. For height of excavation (H) over 8 m, channel side slopes = 4H:1V with a 4 m bench at a height of excavation of 8 m.

Typical cross sections of the Route C channel design are provided on Plate 3.

5.3.5 Material Parameters

The general soil stratigraphy in the vicinity of the Route C LMB Outlet Channel within the overburden soil portion consisted of topsoil overlying till materials including silt and clay till, clay till and silt till. All types of till materials were modeled as "composite till".

KGS Group completed a review of similar previous projects and determined that the shear strength parameters cohesion of c' = 4 kPa with an internal friction angle of Φ' = 27° would be a conservative estimate for the 'composite fill'. This combination of material parameters is on the conservative end of empirical correlations between Atterberg Limit test results and shear strength parameters for similar types of soil. Sensitivity shear strength parameter analyses were also conducted using a higher internal friction angle of Φ' = 32° and 35°.

5.3.6 Groundwater Conditions

High groundwater level conditions were observed from the July 16, 2015 groundwater monitoring results. Two (2) groundwater conditions were, therefore, assumed in the slope stability model. These groundwater conditions were:

1. For height of excavation (H) up to 8 m – groundwater at surface, total saturated conditions.
2. For height of excavation (H) over 8 m – Groundwater level at 1.5 m below ground surface in excavations greater than 8 m.

5.3.7 Results of Slope Stability Analysis

Based on the above, the results of the slope stability analysis for the Route C LMB Outlet channel are presented in the matrix table of Table 5.2. The channel configurations as described in Section 5.3.4 meet the geotechnical basic design criteria as stated in Section 5.3.3 with the

above noted soil shear strength parameters (Section 5.3.5) and assumed groundwater conditions (Section 5.3.6).

Table 5.2
Route C LMB Outlet Channel Slope stability Summary
(attached at end of report)

For the LMB Outlet Channels Conceptual Design – Stage 2, the following are recommended for the Route C Option:

- For channel excavation in bedrock, a slope of 1H:8V is required (see Plate 3).
- For channel 'height of excavation' in overburden less than 8 m, channel side slopes of 4H:1V are recommended (see Plate 3).
- For channel 'height of excavation' in overburden between 8 m to 12 m, channel side slopes of 4H:1V with a 4 m bench at height of excavation of 8 m is recommended (see Plate 3).
- For channel excavation within a combination of bedrock and overburden, a channel side slope of 1H:8V within the bedrock portion is recommended, then a 4 m wide bench, and then a 4H:1V slope within the overburden.
- Continuous groundwater monitoring (one in spring, one in fall, and after heavy rainfall conditions) is recommended to obtain long term groundwater conditions and to provide more detailed information for the de-watering design, if required.
- De-watering during construction may be required. De-watering to 1 m below the proposed channel invert is recommended.
- If sand layers are encountered on the side slopes of the outlet channel, reverse filter design will be required to prevent channel water from seeping into the groundwater system.
- Topsoil to be removed from the footprint of the outlet channel should be stockpiled and reused by dressing on the side slopes of the channel and on the spoil pile/dike.
- Spoil pile/dike or topsoil stockpile should be placed a minimum distance of 25 m from the top of the outlet channel.

5.3.8 Foundation Considerations for Control Structure and Bridge Structure

Control Structure Foundations

The Control structure will be founded on limestone bedrock. The bedrock conditions around the proposed invert elevation (El 241.2 m) varied from 'Fair' with a Rock Quality Designation (RQD)

of 53% at El 243.5 m to 'Poor' with a Rock Quality Designation (RQD) of 32% at El 242.0 m. For preliminary design, a factored Ultimate Limit State (ULS) bearing capacity of 800 kPa for intact competent limestone bedrock may be assigned for the Limit State Design (LSD) with no settlement concerns. Seepage control measures such as grouting of the upper fractured bedrock should be considered in the next stage of design.

Bridge Structure Shallow Foundations

Shallow foundations may be considered to support the structures at the site with the provision that all footings are to be placed at 2.4 m (8 ft) or deeper below the finished grade, which is the recommended design depth for frost penetration. For shallow footings at 2.4 m or deeper below grade, a factored ultimate limit state (ULS) bearing capacity of 280 kPa for stiff till and 800 kPa for intact competent limestone bedrock may be assigned for limit state design (LSD). The minimum concrete footing dimension should be 900 mm.

Bridge Structure Cast-in-Place Concrete Friction Piles

Cast-in-place (CIP) concrete friction piles may be used to support the proposed structures depending on the design structural loads. Suitable CIP piling methods for the site include the continuous flight auger (CFA) method and the plain bored method depending on the pile diameters. Temporary casing may be required for bored piles due to the potential caving of the overburden soils along the depth. The Factored Ultimate Limit State (ULS) skin friction value of 22 kPa may be assigned for limit state design (LSD).

Bridge Structure Driven Steel Piles

Based on the above, driven steel piles (H-piles or pipe piles) to practical refusal could occur within the very hard till layers. Due to limitations on the drivability of the pile imposed by the yield strength of the pile, as a guide to initial design and selection of pile wall thickness and steel grade, it is recommended that the maximum design 'SLS' compressive resistance value of a steel pile be limited to 0.25FyAs (i.e. a fraction of the unfactored structural yield capacity of the pile), where: Fy is the nominal yield stress of the steel, and As is the cross-sectional area of steel in the pile. The purpose of this restriction is to mitigate the risk of statically designing a pile

that cannot be driven with enough energy or force to overcome dynamic soil resistance and subsequently develop the design static load resistance without yielding or damaging the pile.

Dynamic pile testing using pile driving analyzer (PDA Testing) and CAPWAP analysis should be performed during pile installation to verify the pile capacity. Driving shoes should be used for all types of driven steel piles. The steel pipe pile may be left open or filled with concrete. The pile filled with concrete will have higher bending capacity and lower potential for local buckling of the thin wall.

5.3.9 Future Work for Detail Design

If the Route C Option is chosen for the LMB Outlet Channel for the next stage of design (detail design), the following geotechnical/groundwater study works are recommended:

- Conduct water well survey in the vicinity areas along proposed Route C.
- Develop a groundwater monitoring program to measure the existing piezometers. This will provide historical groundwater records prior to the construction of the channel and provide a better understanding on the artesian groundwater conditions.
- Conduct laboratory testing such as direct shear tests, flexible wall permeability tests from remolded proctor samples to verify the soil strength parameters.
- Perform an investigation program for the detail design of inlet and outlet of the channel.

5.4 GROUNDWATER IMPACTS

5.4.1 Summary of Hydrogeological Field Program

The hydrogeology field program involved monitoring of water levels along the Route C channel alignment at instrumentation installed at test pit and borehole locations during the geotechnical program. The test pit and borehole locations are shown on Plate 2. A summary of measured till and bedrock piezometric pressures is shown on Table 5.3.

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Table 5.3
Summary of Piezometric Pressures along Route C Alignment

Station	Test hole	Approx. Ground Elevation (m)	Approx. Top of Bedrock Elev. (m)	Piezometer Stratigraphic Unit (Tip Depth)	Date Monitored	Piezometric Pressure Elevation (m)
0+464	15-RC-04	249.69	< 238.6	Upper clay till (5.5 m depth)	04/08/2015	249.08
				Lower clay till (10.7 m depth)	04/08/2015	248.92
4+200	15-RC-06	254.97	253.3	Upper limestone bedrock (5.2 m depth)	04/08/2015	253.62
				Lower limestone bedrock (13.5 m depth)	04/08/2015	253.31
5+168	15-RC-02	255.46	254.1	Upper limestone bedrock (1.5 m depth)	04/08/2015	254.63
8+100	15-RC-01	252.62	246.4	Silt (4.6 m depth)	04/08/2015	251.25
				Lower limestone bedrock (11.9 m depth)	04/08/2015	251.20
8+575	BH-BC4	248.27	229.3	Limestone bedrock (18.97 m depth)	07/2011	251.17
9+650	BH-BC6	245.54	241.0	Limestone bedrock (5.54 m depth)	08/2011	247.58
10+225	BH-BC5	246.07	236.1	Limestone bedrock (11.07 m depth)	08/2011	246.87

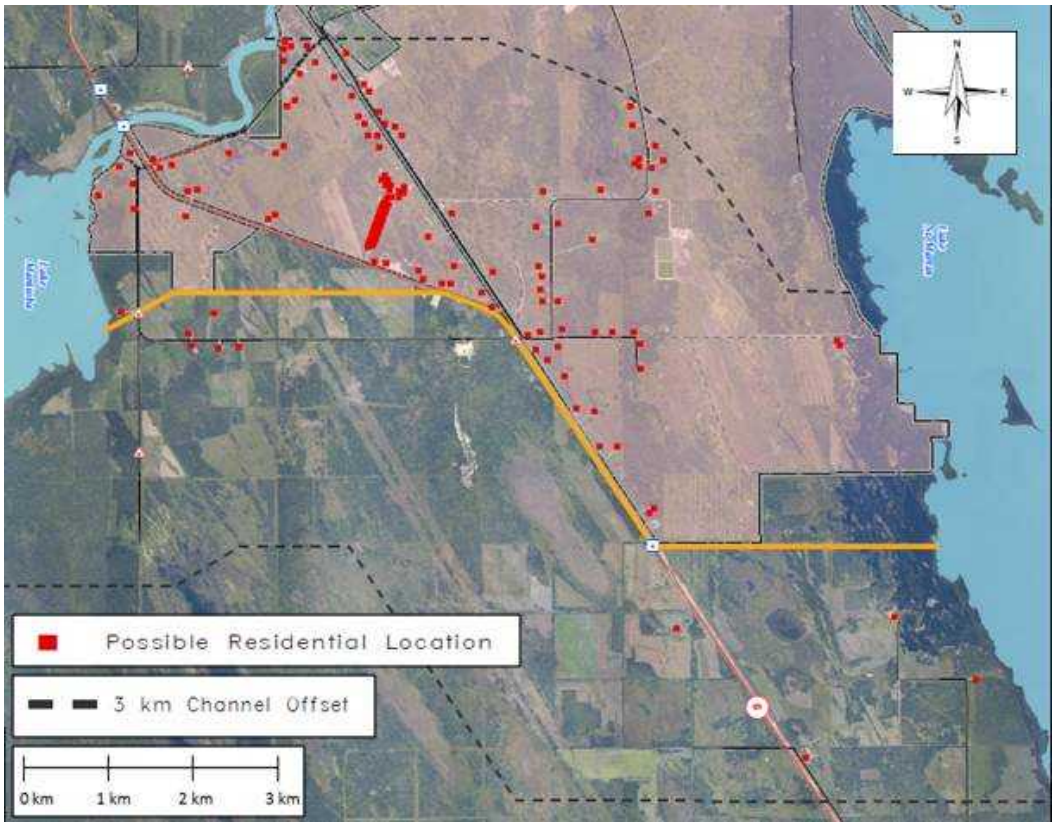
Piezometric pressures range from confined pressure near ground surface to flowing artesian conditions nearer to the Lake Manitoba side of the proposed channel alignment (e.g. BH-BC4, BH-BC5, BH-BC6). This reflects a decreasing ground surface elevation toward this end of the proposed Route C alignment.

5.4.2 Summary of GWDRILL Records

A search of the Provincial well record database (GWDrill) within the vicinity of the proposed Route C channel option identified a recorded 309 wells drilled within 3 km of the channel alignment. A number of these wells are not necessarily utilized for domestic purposes (e.g. livestock wells, monitoring wells, test holes without well installations). Additionally, a number of these wells may have been decommissioned or abandoned. Based on a preliminary review of the area, there are up to 145 possible residential locations within the 3 km Route C channel offset, which is likely a more accurate estimate of the number of active domestic wells of interest (Figure 5.3). The offset of 3 km is somewhat arbitrary and was selected as a reasonable

distance for this scale of project, and for assessment of any potential associated groundwater impacts.

Figure 5.3
Route C Alignment and Possible Domestic Well Locations



The brief review of the GWDrill records was conducted including assessment of: depth to groundwater, depth to bedrock, casing depth, total well depth, and estimated well capacity. Based on well capacities, an approximate aquifer transmissivity was also calculated. The review of the GWDrill records is summarized on Table 5.4.

Table 5.4
Summary of GW Drill Database within 3 km Offset of Route C Alignment

Total GWDrill well records =	309
Total well records included in review =	62 (approx. 20%)
Depth to bedrock range =	0.3 m to 50.3 m
Median depth to bedrock =	3.4 m
Well depth range =	9.1 m to 60.0 m
Median well depth =	23.9 m
Casing depth range =	0.6 m to 52.3 m
Median casing depth =	7.8 m
Depth to groundwater range =	4.0 m (above ground) to 9.8 m (below ground)
Median depth to groundwater =	3.7 m
Well capacity range =	0.07 USgpm/ft to >21.6 USgpm/ft
Median well capacity =	0.9 USgpm/ft
Calculated transmissivity range =	144 USgpd/ft to >43,200 USgpd/ft
Median calculated transmissivity =	1,800 USgpd/ft

Based on this review, the local geological and hydrogeological conditions show a significant amount of variability, but some general observations include:

- Depth to bedrock is generally shallow (median overburden depth of 3.4 m).
- Water supply generally drawn from upper carbonate aquifer (8 m to 24 m well depth range). The channel excavation for Route C would occur within this aquifer zone.
- Flowing artesian conditions observed at 3 of the 62 wells reviewed.
- Depth to groundwater is generally shallow (median groundwater depth of 3.7 m below grade).
- Well capacities and aquifer transmissivity are generally low. A range of 1,000 to 10,000 USgpd/ft is a reasonable estimate of bulk aquifer transmissivity, based on the available data. Transmissivities >10,000 USgpd/ft were calculated at 6 of 62 wells reviewed. It should be noted that these transmissivity calculations are very approximate, and do not include variables such as well efficiency losses.

5.4.3 Excavation Basal Heave and Groundwater Blowout Assessment

The Route C profile (Figure 5.1) shows the base of the proposed excavation profile relative to underlying bedrock surface elevations. The initial 6 km of the channel will require excavation into the bedrock, with direct connection to the upper carbonate aquifer. The channel invert is underlain by till from approximately Sta. 6+000 km to Sta. 7+000 km, where bedrock is again exposed within the proposed channel base. Beyond Sta. 8+000 km, the channel is generally underlain by till, varying in thickness from 0 m to >10 m, based on the estimated bedrock elevation along this channel reach.

Blowout/basal heave conditions may occur within the channel excavation during the construction phase of the project (unless mitigated by an aquifer depressurization system), if the bedrock aquifer groundwater piezometric pressures exceed the confining overburden mass that remains between the channel excavation invert, and bedrock surface elevation during excavation. During channel operations, blowout or basal heave/seepage would be expected if these bedrock aquifer pressures exceed the operating channel surface water profile, and where not confined by sufficient overburden thicknesses. Where the channel is excavated within the bedrock, on-going groundwater discharge from the bedrock aquifer will occur in most areas, since the channel water level will be below the surrounding aquifer piezometric surface.

To assess the blowout and groundwater discharge potential, an assessment of anticipated groundwater aquifer pressures, overburden depths, and operational channel surface water profiles is required. During the operational stage, a minimum Lake Manitoba level (El 246.9 m) is assumed for the upstream section of the channel (i.e. upstream of the control structure) and a minimum Lake St. Martin level (El 242.6 m) is assumed for the downstream section of the channel (i.e. downstream of the control structure).

Table 5.5 summarizes the assessment of blowout and basal heave conditions, utilizing the geotechnical information available from previous studies, for both the construction phase and channel operational phase. Based on the available information, factors of safety against blowout/basal heave were calculated at two locations, for the construction and operational phases of the project (at geotechnical investigation locations BH-BC4 and BH-BC5).

Table 5.5
Factors of Safety against Blowout along Route C Alignment

Borehole	Channel Invert Elevation (m)	Minimum Operating Water Level (m)	Bedrock Elevation (m)	Bedrock Groundwater Piezometric Elevation (m)	Factor of Safety - Construction	Factor of Safety - Channel Operation
BH-BC4	241.2	242.9	229.3	251.17	1.1	1.2
BH-BC5	240.9	242.9	236.1	246.87	0.9	1.1

The calculated factors of safety range from approximately 0.9 to 1.1 during construction and 1.1 to 1.2 during channel operation. As such, there is certainly the potential for blowout/basal heave in channel areas with overburden underlying the channel invert during the construction phase, particularly in the downstream channel area (i.e. beyond the Control Structure at Sta. 8+000) of the proposed alignment, or in areas where limited basal soils will remain in place between the base of the channel excavation and the top of the underlying bedrock aquifer. It is also estimated that blowout/basal heave, and/or seepage could occur from the aquifer into the channel during operational conditions, based on the factors of safety that are nominally above unity for the operational case. The design Factor of Safety against blowout would be 1.3 during the construction phase and 1.5 during the operational phase.

5.4.4 Aquifer Drawdown during Channel Construction

Drawdown of aquifer groundwater piezometric pressures would be anticipated during construction, as well as during channel operation, given the shallow depth to groundwater, and deep excavation into bedrock (up to 13 m) along the proposed Route C. The largest drawdowns would occur during the construction phase depressurization, with drawdown to a level at or below the invert of the channel in the immediate vicinity of the excavation; these drawdowns would decline with distance away from the excavation, the relative magnitude controlled by aquifer transmissivity, and total groundwater discharge to the excavation (which is a function of the area of the bedrock aquifer exposed during construction and/or discharging groundwater through fractured overburden tills to the channel excavation). Potential aquifer drawdown could also occur during channel operation, when operating surface water levels within the channel are less than the piezometric pressures within the surrounding bedrock aquifer. The bedrock aquifer piezometric pressure condition would be expected to re-equilibrate to an elevation nominally

above the normal channel surface water operational levels, with continued discharge to the excavated channel from the bedrock aquifer.

A review of groundwater elevations was based on previous KGS Group geotechnical investigations, as well as a review of the Provincial Groundwater Availability Map Series. For the purposes of this assessment, a groundwater piezometric pressure elevation of El 250 m was utilized as a reasonable estimate for nearby residential well groundwater levels. During construction, the minimum channel excavation elevation is approximately El 241 m. During operation, water levels in the channel are assumed to be equal to minimum Lake Manitoba levels upstream of the control structure (El 246.9 m), and equal to minimum Lake St. Martin levels downstream of the control structure (El 242.6 m). Based on these assumptions, the approximate maximum aquifer drawdowns at the channel are 9 m (during construction phase), 3 m (upstream of the Control Structure, during normal channel operation), and 7 m (downstream of the Control Structure, during normal channel operation).

To assess potential drawdowns at distance, a calculation for radial flow to a well was utilized as an approximation. Additionally, aquifer transmissivities were assumed in the range of 1,000 to 30,000 USgpd/ft based on the preliminary GWDrill records assessment. An aquifer storativity of 0.0001 was also assumed, and a duration of 300 days (10 months) was used. Three hundred (300) days was selected as a reasonable timeframe between annual aquifer recharge events and is the conservative case. The calculated aquifer drawdowns are shown on Figure 5.4 for the construction phase and Figure 5.5 for the operations phase.

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Figure 5.4
Route C - Cross Section of Estimated Aquifer Drawdown with Distance during the Construction Phase

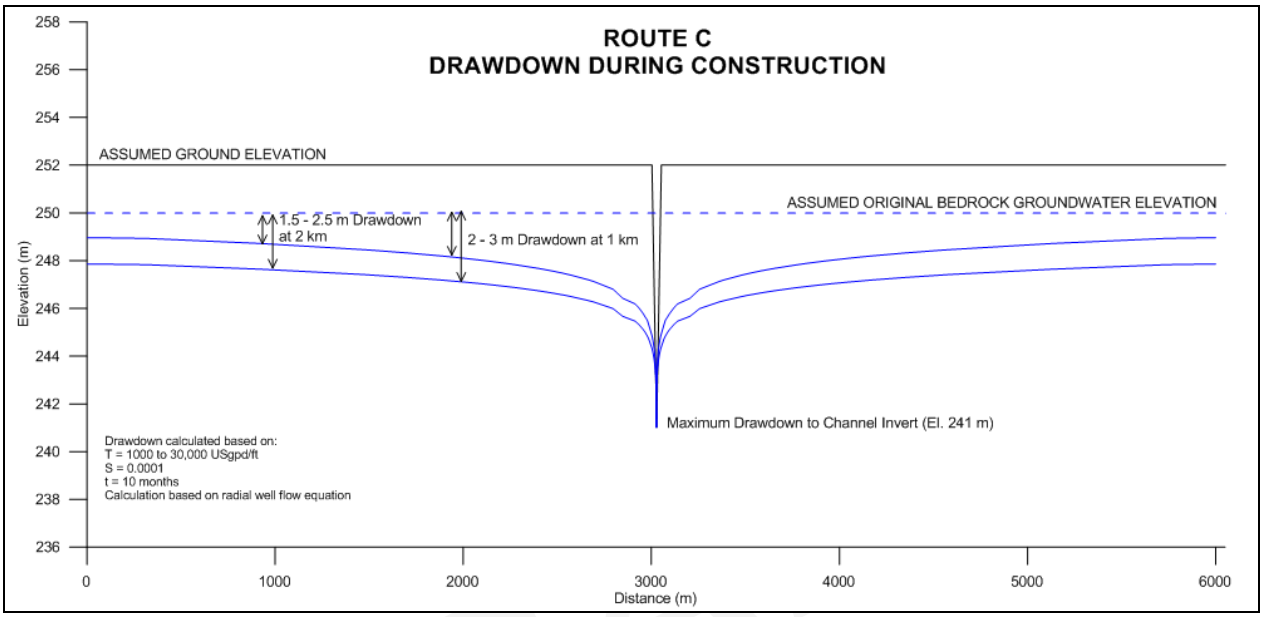
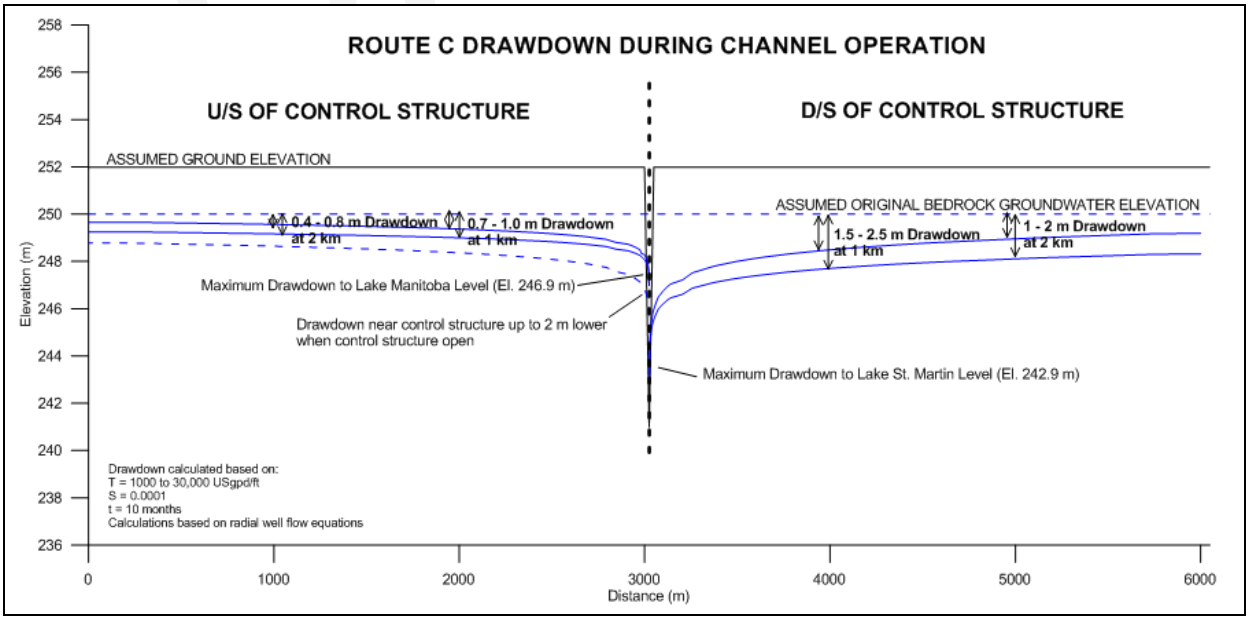


Figure 5.5
Route C – Cross Section of Estimated Aquifer Drawdown with Distance during the Normal Channel Operational Phase



This estimation of potential aquifer drawdown demonstrates a potential maximum of 2 m to 3 m of drawdown at 1 km from the channel during construction, equating to as much as 5 m to 6 m

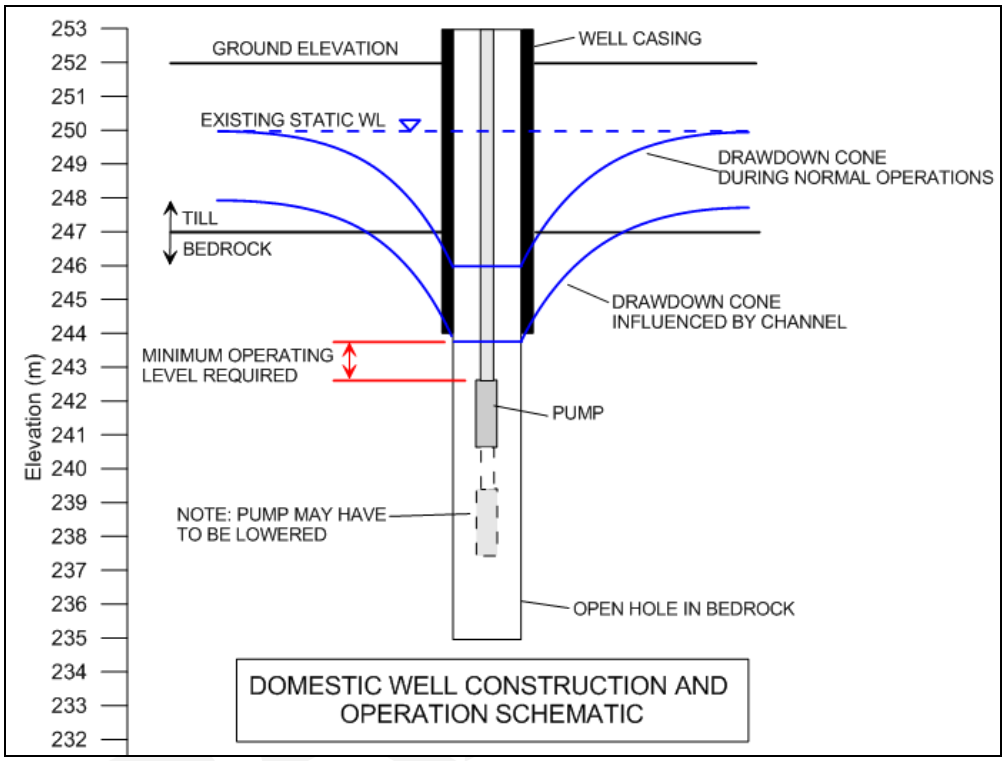
in the immediate vicinity of the channel excavation. During channel operation upstream of the Control Structure, aquifer drawdown in the range of 1 m could be anticipated at 1 km from the channel, and in the range of 2.5 m downstream of the Control Structure at a distance of 1 km from the channel. These drawdowns are greater in close proximity to the channel and associated channel control structures.

Line source drawdown and well superposition methods were also utilized to estimate regional drawdowns (versus the radial well calculations provided above). These methods resulted in greater drawdowns than estimated using the radial well method, by up to 2 to 3 times (e.g. up to 7 to 8 m drawdown calculated at 1 km from the channel during construction). It should be noted that these methods, like the radial well method, do not include consideration of recharge boundaries, aquifer fracture discontinuities, and other aquifer heterogeneity and are likely overly conservative. Unlike the radial well method, line source methods also assume a linear relationship between distance and drawdown, which is not expected based on site testing and the nature of fracture flow and aquifer heterogeneity within the relatively low transmissivity regional aquifer. As such, these larger drawdowns are expected to be over-estimations of what could reasonably be anticipated. To more accurately assess the anticipated drawdowns, additional well drilling and aquifer testing, combined with a regional hydrogeological model would be required, with sensitivity analysis to capture a realistic drawdown profile at the final design stage. All preliminary calculations, however, indicate that up to several meters of drawdown could be expected at local supply wells and assessment of these local third party wells relative to these drawdowns would be required.

The well construction, pumping rates, and available drawdown at individual domestic wells are unknown at this time. However, given the large number of wells within close proximity to the channel, it can be anticipated that a large number of these wells would require some level of mitigation (e.g. lowering pumps, drilling new wells, alternate water supply, etc.) to accommodate the imposed drawdowns estimated during the construction and operational phases of the project. A schematic of a domestic well construction and possible impacts from the channel is shown on Figure 5.6.

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Figure 5.6
Domestic Well Schematic and Potential Drawdown Impacts



This preliminary assessment indicates that aquifer drawdowns within close proximity to the channel can be anticipated to be significant immediately adjacent to the channel excavation, and somewhat less at a distance (e.g. a minimum of 2 m to 3 m during construction, as far as 1 km from the channel) and may have an impact on available capacity (i.e. available drawdown, or minimum operating water levels) of the local supply wells. A field program to establish residential well capacities and available drawdown would be required prior to construction, as well as development of a mitigation plan for any anticipated impacts to local users (e.g. provision of an alternate water supply, lowering pumps, etc.). This type of program could include ±145 residences based on an area encompassed by a 3 km channel offset.

5.4.5 Groundwater under the Direct Influence of Surface Water (GUDI) Assessment

Seepage connections to the Route C channel will exist where the channel is excavated into the bedrock, and where the remaining overburden tills below the channel and above the bedrock have fractured due to blowout/basal heave conditions. In general, groundwater discharge

conditions are anticipated along the channel, with surrounding groundwater piezometric pressures sustained above normal operational surface water levels within the channel. Under these conditions, an upward gradient favoring exfiltration of aquifer groundwater to the channel would be in effect.

However, GUDI conditions with a temporary reversal of the upward gradient along the channel may occur periodically during conditions of a sudden increase in surface water elevation in the channel (such as during channel operations due to spring flood conditions), or separately during events of increased and sustained pumping and/or drawdown of local wells at any time of year, and especially in relatively close proximity to the channel. The sudden increase in channel surface water levels would be of concern primarily downstream of the control structure, with an increase in channel water level profile of up to 2 m immediately downstream of the control structure. This type of flood stage increase could result in a plume of surface water infiltration to the bedrock aquifer. This plume could become available to migrate some distance within the aquifer from the channel entrance point, for a duration of time until the aquifer piezometric pressure condition re-equilibrates to the new channel surface water elevations, again favoring groundwater discharge to the channel. Pumping of domestic wells in close proximity to the channel could capture a localized plume of surface water within the bedrock fracture flow system, thus drawing it away from the channel entrance point, regardless of the re-equilibration of the aquifer piezometric pressure condition.

The concerns associated with GUDI are related to a change in the aquifer water quality (e.g. infiltration of channel surface water and bacteria) within the fractured bedrock aquifer, which may be transmitted through the fracture system to local well users, with impacts including potential bacterial contamination of these wells. Actual surface water flows into the local aquifer would be affected by aquifer properties including fracture connectivity, fracture continuity, overall bulk bedrock transmissivity, and storativity conditions. The connection of the channel to the fractured bedrock aquifer, and of the aquifer to the local domestic wells, will require evaluation accordingly.

Sufficient investigation would be required to properly assess and verify these kinds of aquifer conditions, and to quantify possible impacts to the aquifer system. Ultimately, a long-term risk

management program to monitor and assess impacts to the local groundwater regime would include at a minimum, but would not be limited to:

- Detailed physical and chemical hydrogeological assessment.
- Domestic well inventory.
- Installation of sentry wells.
- A long term water quality monitoring program. Monitoring and assessment of aquifer quality would continue for the duration of the operational life of the channel.

5.4.6 Changes to Lake St. Martin Water Quality

Discharge of groundwater to the channel is anticipated given the channel excavation depth, aquifer piezometric pressure conditions, interconnection to the carbonate aquifer, and construction and operational channel conditions. Based on a review of groundwater quality compiled in the Provincial Groundwater Availability Map Series, the groundwater quality appears to be relatively fresh (TDS = 390 to 550 mg/L, Chloride = 2 to 19 mg/L). Groundwater baseflows under maximum drawdown conditions are calculated in the range of 450 USgpm (construction) to 250 USgpm (operation) for an aquifer transmissivity of 10,000 USgpd/ft. These baseflows may increase significantly if aquifer transmissivity proves to be higher than this initial estimate (e.g. >2,000 USgpm for T = 50,000 USgpd/ft during construction).

Although the available water quality data (TDS, chloride) does not raise any initial concerns for discharge into an aquatic environment, the dissolved oxygen level of the groundwater is anticipated to be much lower than the receiving surface water. As such, some discussion may be required with the Department of Fisheries and Oceans based on any anticipated alteration to the aquatic environment (Lake St. Martin). It should be noted, however, that the groundwater system naturally discharges to Lake Manitoba and Lake St. Martin, and as such the volume of groundwater discharge to the surface water bodies should not be greatly increased. Also, based on channel and control structure design and operations, some volume of surface water baseflow will be included. This baseflow is not estimated at this time, however, it can be assumed that some degree of dilution of groundwater will occur prior to discharge to Lake St. Martin and can be quantified during the final design stage.

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6.0 LAKE MANITOBA OUTLET CHANNEL – ROUTE D

6.1 DESCRIPTION

The Route D outlet channel connects Watchorn Bay on Lake Manitoba to the outlet of Birch Creek on Lake St. Martin as shown in Plate 5. The proposed route is approximately 24.0 km (14.9 mi) long and situated on privately held and crown leased lands.

This proposed route alignment is adjacent to low-lying terrain between Lake Manitoba and Lake St. Martin along which numerous marshes and small lakes exist. Local land drainage in the area generally travels from the west to the east. Construction of outside drains on either side of the channel will help convey local land drainage that may be impeded by the channel. Construction of the channel to the west of the marshes and lakes rather than through the middle is preferred to minimise environmental impacts and also to minimise the costs of having to excavate the channel in wet conditions.

As shown on Plate 5, this option would require construction of new bridge crossings at three municipal roads, Provincial Road (PR) 239 and PTH 6. While the channel crosses a fourth municipal road just south of Lake St. Martin, a minor road realignment is proposed rather than constructing another bridge crossing. It may also be possible to re-align PR 239 slightly north to avoid crossing the channel, however, the bridge crossing has been assumed at this stage.

The bridge at PTH 6 would be combined with a new control structure. The control and bridge structures have been combined into one structure to reduce construction costs. The control structure was located at PTH 6, which is near the mid-point of the channel length to allow for a narrower and less costly structure than if it was located upstream near Lake Manitoba as discussed in Section 6.2.3. The location of the control structure also helps reduce the potential groundwater impacts, as later discussed in Section 6.4.

Plate 5 also shows that the channel alignment cuts through the Manitoba Hydro Bi-pole Transmission Lines at about Station 13+500. This can be accommodated by shifting the channel alignment to fit between the base of the transmission lines poles and with optimization of the spoil pile at the Detailed Design phase. A similar optimization process will be required at

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about Station 22+000 to accommodate the municipal road realignment discussed above, as well as Birch Creek and a private homestead on opposite sides of the channel.

Figure 6.1 shows a profile plot of the Route D channel from LMB to LSM. Upstream of PTH 6, the land surface ranges from about El 248 m (El 813.7 ft) to about El 252 m (El 826.8 ft) near PTH 6. The ground surface then falls quickly to about El 245.5 m (El 805.4 ft) to LSM. As discussed in Section 3.0, the channel essentially cuts through till material and does not intercept rock.

The channel has an invert of El 242.0 m (El 793.0 ft) at LMB and El 239.0 m (El 784.1 ft) at LSM. The depth of excavation below ground surface would vary between approximately 6 m (20 ft) and 12 m (39 ft), with the deepest cut located near PTH 6. Since the invert of the channel would be lower than water levels in LMB and LSM, there would be standing water in the channel when it is not in operation.

6.2 HYDRAULIC DESIGN

6.2.1 Channel Design

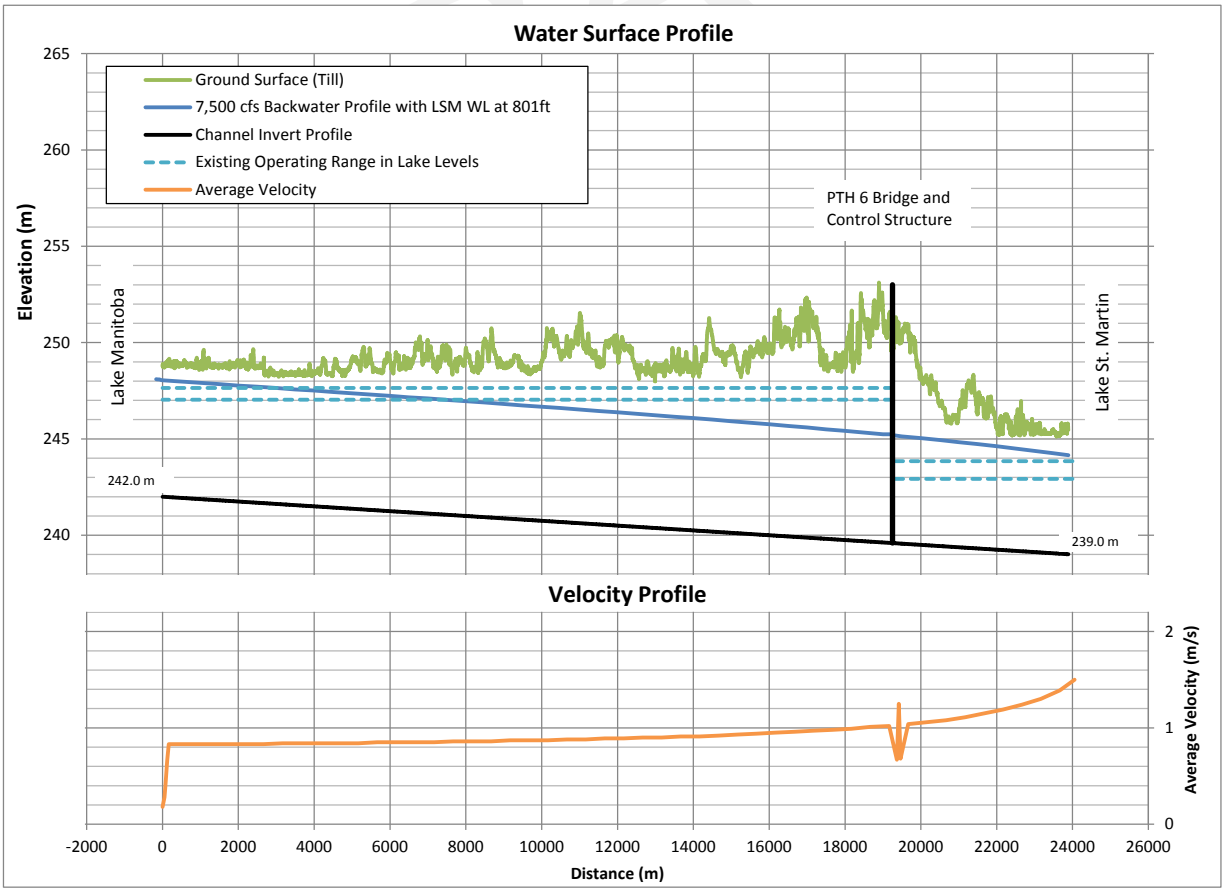
The channel design was based on the Manning's equation to compute the base width using the channel design parameters listed in Table 6.1 with the design discharge of 212 m^3/s (7,500 cfs). The normal depth of flow of 6.1 m (20.0 ft) was based on the channel invert elevation at LMB and the design water level for LMB of El 248.1 m (El 814.0 ft). Table 6.1 summarises the basis of the hydraulic design of the channel. A hydraulic profile of Route D, based on a HEC-RAS backwater model of the channel, and an assumed water level of El 244.1 m (El 801 ft) in Lake St. Martin as the downstream boundary condition is provided on Figure 6.1

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Table 6.1
Hydraulic Design Summary for Lake Manitoba Outlet Channel Route D

Channel Bed Material	Overburden / Unclassified
Design Flow	7,500 cfs
Channel Slope	0.0125%
Normal Depth of Flow	6.1 m
Assumed Manning's 'n' value	0.028
Base Width (< 8m channel depth)	12.7 m
Side Slopes (< 8m channel depth)	4H:1V
Base Width (> 8m channel depth)	8.3 m
Side Slopes (> 8m channel depth)	5H:1V

Figure 6.1
Profile of Lake Manitoba Outlet Channel Route D



As shown on the profile, the average velocity in the channel ranges between approximately 0.95 m/s (3.1 ft/s) and 1.3 m/s (4.3 ft/s). This is slightly higher than under the normal depth of flow condition (velocity of 1.0 m/s (3.3 ft/s)). This is because the target water level on LSM of El 244.1 m (El 801.0 ft) is approximately 1.0 m (3.3 ft) lower than the design normal depth of flow. However, the average velocity is still well below the maximum allowable design velocity in till discussed in Section 4.3.

The inlet to the channel for Option D would be similar in concept to that described for Option C in Section 5.2.1. Based on bathymetric surveys of LMB conducted in the fall of 2014 near the entrance of Option D (Appendix C), the bottom elevation of the lake is approximately 245 m (803.8 ft) about 500 m (1,600 ft) from the shore. The conceptual configuration of the inlet includes a wide, shallow, bell-mouth entrance to achieve the desired hydraulic performance and is shown on Plate 5. The channel slopes from the wide entrance at El 246 m (807.1 ft) down gradually to the invert level of the channel at approximately El 242 m (794.0 ft) over a distance of approximately 500 m. The entrance would be excavated in the dry behind temporary cofferdams that would be designed for moderately high lake levels and moderate wind events. Should an extreme windstorm occur and cause overtopping of the cofferdam, the intent would be to permit temporary flooding of the construction area, and rehabilitation of the cofferdam after the event. The height of the cofferdam would be selected in final design but is expected to reflect a probability of overtopping and failure of about 1:20 to 1:50 for the duration of the construction period at the channel entrance.

There will be many years when the channel will be inoperative. There is a concern that the natural shoreline processes in Lake Manitoba would eventually lead to infilling of the entrance to the channel with sediment. This is not a certainty and would require more careful examination during final design. For the purposes of the preliminary design described herein, however, it has been assumed that it will prove necessary to construct groins on each side of the channel entrance that would project into the lake approximately 100 m (330 ft) beyond the mouth of the channel. This would prevent the migration of sand and silt into the channel and minimize the risk of infill. These groins would have to be substantial structures, built to withstand the severe wind effects on Lake Manitoba. Detailed analyses in final design would be required to develop a robust configuration. The groin concept is shown on Plate 5.

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6.2.2 Winter Ice Considerations

The backwater model results showed that the computed Froude number for the flow under normal operating conditions is greater than 0.12 for all locations in the channel. Since the critical Froude number for an ice cover to advance in flowing water by juxtaposition must be no greater than 0.08, an ice cover on the channel is unlikely. Significant staging in the water level in the channel at LSM in the range of 4.5 m (15 ft) would be required to lower the flow velocity to reduce the Froude number before the cover would advance upstream from LSM. Based on experience and observations of ice conditions in the Fairford River as well as in the existing emergency Reach 1 channel since the flood of 2011, it is unlikely that there would be a sufficient amount of frazil ice production for staging to occur for an ice cover to advance sufficiently upstream and impede the capacity of the channel at LMB.

In addition, the flood routing studies discussed in Section 13.0 showed that the outlet channel would typically begin operation in early summer and end operation by late fall. Operation of the channel in the winter normally will not be required. As discussed in Section 13.3.1, in the 54 years that were simulated, the channel would have been operated 7 times in the month of December but only 4 times in the month of January, 3 times in February and 2 times in March. Winter operation is, therefore, only expected during very large flood events such as in 2011, 2012 and 2014.

While an ice cover is unlikely to occur during operation of the Route D outlet channel, it is possible that given the convenience of operating the automated gates, these gates would be used during winter for lake regulation to supplement the FRWCS fixed stoplog gates. If used for flow regulation, it is possible that the gates could be opened and flow would be initiated after a stable ice cover had already formed in the channel. This type of ice cover would be similar to a lake ice, which typically has a low Manning's n-value.

An ice covered rating curve was, therefore, computed for this condition using the HEC-RAS backwater model with an assumed smooth ice cover (n-value of 0.015) with a thickness of 0.6 m (2 ft). The winter ice covered rating curve, provided in Section 6.2.3 shows that the ice cover would reduce the channel discharge by approximately 71 m^3/s (2,500 cfs) from the equivalent open water condition at El 248.1 m (El 814.0 ft) of 212 m^3/s (7,500 cfs) to approximately

142 m^3/s (5,000 cfs). In the channel, the water levels at the flow of 142 m^3/s (5,000 cfs) with the 0.6 m (2 ft) ice cover would be similar to open water conditions at the 212 m^3/s (7,500 cfs) flow.

6.2.3 Control Structure and Rating Curve

A gated control structure, which would be located at PTH 6, as shown on Plate 5, will be used to control flow in the channel. The control structure will be comprised of three bays each 9 m wide (29.6 ft) with an invert of El 239.6 m (El 786.1 ft). Design details of the control structure concept are provided in Section 10.0 of the report.

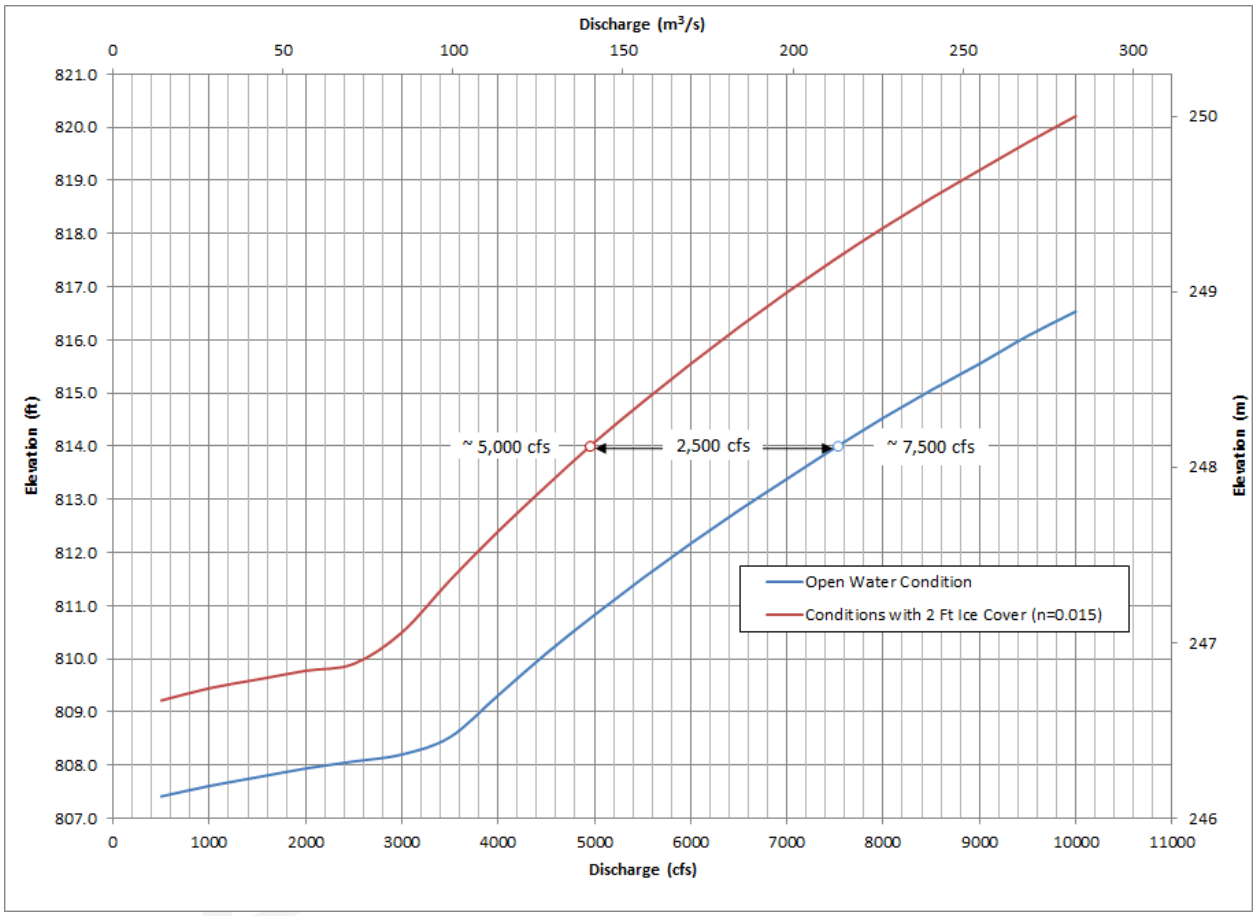
Having the control structure located about 19 km into the channel allows for a narrower structure than if located near the LMB outlet. This is due to the long channel length upstream of the structure, which "dampers" the additional headloss from having a narrower structure. The downstream location for the structure also helps reduce potential groundwater impacts along the channel upstream of the structure when it is closed, as discussed in Section 6.4. The selected location also allows the control structure and the PTH 6 Bridge to be combined into a single structure to save on construction costs, and provides good access for operation and maintenance purposes.

When the structure is closed, the water level in the channel on the upstream side of the structure will be the water level on LMB and on the downstream side of the structure will be the water level on LSM.

When the structure is fully open, flows in the channel will depend on LMB water levels. Based on the results of the HEC-RAS backwater model with an assumed LSM water level of El 244.1 m (El 801.0 ft), and with open water conditions on the channel, a stage-discharge relationship (Figure 6.2) was prepared for the Route D channel at LMB. As shown on the figure, the channel design can convey the 212 m^3/s (7,500 cfs) flow criteria at a LMB water of 248.1 m (814.0 ft). The winter ice covered rating curve discussed in Section 6.2.2 is also included on the figure.

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Figure 6.2
Stage-Discharge Relationship for Lake Manitoba Outlet Channel Route D



6.3 GEOTECHNICAL DESIGN – ROUTE D

The borehole drilling and sampling program for the geotechnical field investigation along Route D at the LMB Outlet Channel was completed by Hatch Ltd. as a sub-consultant of KGS Group, from June 8 to 19, 2015. Maple Leaf Drilling Ltd. of Winnipeg, Manitoba provided the drilling services using 125 mm solid stem augers and HQ coring. Standard Penetration Tests (SPT) were performed in 1.5 m (5 ft) intervals in till deposits to determine the relative density of the soil. Quality representative soil samples were obtained for soil logging and laboratory testing with the selected drilling and excavating methods. The geotechnical investigation was completed under the continuous supervision of Hatch Ltd. personnel and at the direction of KGS Group.

As mentioned in Section 3.4, a total of six (6) boreholes (TH15-RD-01 to TH15-RD-05, and TH15-RD-10) were drilled to investigate the subsurface conditions of Route D for foundation and channel design. A total of eleven (11) standpipe piezometers and two (2) vibrating wire piezometers were installed within the till deposits to monitor piezometric pressures. The location of these boreholes are shown in plan on Plate 5.

6.3.1 Stratigraphy of LMB Outlet Channel Route D Option

In general, the stratigraphy at Route D consisted of a thin layer of topsoil overlying till materials including clay till, silty clay till, silt till, or sandy clay till with layers of sand, and then bedrock.

Topsoil – A thin layer of topsoil was encountered at the surface of each borehole and extended to approximate depths of 0.3 to 1.2 m. The topsoil was black in colour, moist, firm and contained organics.

Clay Till / Silty Clay Till / Silt Till – Varying till deposits were encountered beneath the topsoil containing varying amounts of clay, silt, sand and gravel. The predominant grain size within the till varied spatially and with depth. The till extended to bedrock at an approximate depth of 20.7 m in Borehole 15-RD-01 and to approximate completion depths of 12.6 m to 18.7 m in other boreholes, where these boreholes were terminated prior to reaching bedrock. The till was grey in colour, moist to wet, hard and contained occasional cobbles and boulders. Based on 50 SPT tests performed in the till, the uncorrected SPT blow counts (N) in the till ranged from a minimum of 2 in Borehole 15-RD-10 to greater than 100. A total of 14 of the 50 SPT tests performed in the till encountered refusal or had a blow count (N) greater than 100. In general, till (lower till) had refusal or with a blow count (N) greater than 100 was encountered at depths below 8 m to 10 m or below the layers of Sand/Silty Sand.

Sand / Silty Sand – Layers of sand or silty sand with a thickness of up to 3.9 m was encountered in 15-RD-01, 15-RD-02, 15-RD-03 and 15-RD-04. The sand was grey to brown in colour, wet, compact to very dense, fine to medium grained and contained varying amounts of silt. Some clay was encountered in the silty sand in Borehole 15-RD-04. Based on 5 SPT tests performed in the sand and silty sand, the uncorrected SPT blow counts (N) ranged from 19 to

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71 with an overall average of 36. Note that some of the Sand/Silty Sand layers could be located just above or near the proposed channel invert elevations.

Bedrock – Limestone bedrock was encountered in Borehole 15-RD-01 at an approximate depth of 20.7 m and extended to the end of the borehole at an approximate depth of 22.3 m. However, no bedrock core samples were obtained in Borehole 15-RD-01. All other 2015 boreholes were terminated prior to reaching bedrock.

Plate 7 shows the profile of the 2015 Route D LMB Outlet Channel. This profile included the ground surface, the soil profile of the test pits and boreholes, the 212 m^3/s (7,500 cfs) flow water surface profile and the channel invert. This profile was used to estimate the excavation volume of topsoil and composite excavation materials for channel construction.

6.3.2 Groundwater Conditions

Groundwater readings were obtained on July 16, 2015, approximately one month after the completion of the 2015 supplementary geotechnical field investigation program. Results of the July 16 readings showed the groundwater levels were ranged from 1m above to 1 m below ground surface. Artesian conditions were observed upon completion drilling in Boreholes 15-RD-01, 15-RD-02 and 15-RD-04 within the lower till below the layers of Sand/Silty Sand and in Boreholes 15-RD-01, 15-RD-02, 15-RD-03 and 15-RD-04 in July 16, 2015 groundwater monitoring. This is consistent with the 2011 geotechnical field investigation results. Note that the artesian conditions, in general, were encountered in the very hard till (about 10 m below ground surface) and/or below the Sand/Silty Sand layers. Section 6.4 discusses the groundwater conditions in detail and provides the preliminary results of the groundwater impact study.

6.3.3 Route D LMB Outlet Channel Slope Stability

A slope stability analysis was conducted to establish the side slope requirements for the Route D LMB Outlet Channel excavation and the dike (spoil piles) linings along the channel. Four conditions were examined to determine the side slope requirements:

1. Long Term Condition (after construction) with a minimum estimated factor of safety (FS) of 1.5: under full channel flow condition or no flow condition with water at lake levels.

2. Short Term Condition (during construction) with a minimum estimated factor of safety (FS) of 1.3: under dry channel condition.

3. Short Term Condition with a minimum estimated factor of safety (FS) of 1.2: under rapid drawdown conditions during channel operation with Open Gate Upstream conditions.

4. Short Term Condition with a minimum estimated factor of safety (FS) of 1.2: under rapid drawdown conditions during channel operation with Closed Gate Downstream conditions.

The stability analyses were conducted using the two-dimensional computer model SLOPE/W, developed by GeoSlope International Ltd. from Calgary, Alberta. The model is capable of analyzing numerous iterations of both circular and composite slip surfaces to identify analytically the worst-case slip surface. The Morgenstern-Price Method of Slices with a half sine wave inter-slice force function was applied to all calculations reported herein.

6.3.4 Channel Configuration

As mentioned in Section 6.1, the channel has an invert of El 242.0 m (El 793.0 ft) at LMB and El 239.0 m (El 784.1 ft) at LSM. The depth of excavation below ground surface would vary between approximately 6 m (20 ft) and 12 m (39 ft), with the deepest cut located near the control structure at PTH 6. Since the invert of the channel is lower than water levels in LMB and LSM, there would be standing water in the channel when it is not in operation.

For the slope stability analysis, two (2) slope configurations were analyzed in respect to the height of excavation (H) of 6 m, 8 m, 10 m and 12 m. These side slope configurations were:

1. 2 - 4H:1V of 1/2 height (H) slope with a bench for an effective slope of 5H:1V, where H is the height of excavation.

2. 2 - 5H:1V of 1/2 height (H) slope with a bench for an effective slope of 6H:1V, where H is the height of excavation.

Typical cross sections of the Route D channel design are provided on Plate 6.

6.3.5 Material Parameters

The general stratigraphy in the vicinity of the Route D LMB Outlet Channel within the channel excavation consisted of topsoil overlying till materials including clay till, silty clay till, silt till, or

sandy clay till with layers of sand. All types of till materials were modeled as “composite till”, but separated into upper and lower till materials for different groundwater conditions.

KGS Group completed a review of similar previous projects and determined that a shear strength parameter cohesion of c’ = 4 kPa with an internal friction angle of Φ’ = 27° would be a conservative estimate for the ‘composite fill’. This combination of material parameters is on the conservative end of empirical correlations between Atterberg limit test results and shear strength parameters for similar types of soil. Sensitivity shear strength parameter analyses were also conducted using higher internal friction angles of Φ’ = 32° and 35°.

6.3.6 Groundwater Conditions

Due to the artesian groundwater conditions that were observed in the very hard till below the Sand/Silty Sand layers, three groundwater conditions were assumed in the slope stability model for the upper and lower till. These groundwater conditions were:

1. For upper till, the groundwater level was assumed to be about 3 m below the groundwater.
2. Artesian conditions for lower till (the very hard till below the sand layers) with 2 m of head above ground surface were assumed.
3. De-watering conditions for lower till with water a level 1 m below the channel invert were assumed during construction (dry channel condition).

6.3.7 Results of Slope Stability Analysis

Based on the above, the results of the slope stability analysis for the Route D LMB Outlet channel are presented in the matrix of Table 6.2. The channel configurations as described in Section 6.3.4 meet the geotechnical basic design criteria as stated in Section 6.3.3 with the above noted soil shear strength parameters (Section 6.3.5) and assumed groundwater conditions (Section 6.3.6).

Table 6.2
Route D LMB Outlet Channel Slope stability Summary
(attached at end of report)

Note that under artesian conditions, the Route D LMB Outlet Channel over 6 m of excavation with "2 - 4H:1V of 1/2 height (H) slope with a bench for an effective slope of 5H:1V" channel configuration would not meet the geotechnical basic design criteria, and over 8 m of excavation with "2 - 5H:1V of 1/2 height (H) slope with a bench for an effective slope of 6H:1V" channel configuration would not meet the geotechnical basic design criteria if de-watering were not provided. De-watering for Route D LMB Outlet channel would be required during construction stage.

For the LMB & LSM Outlet Channels Conceptual Design – Stage 2, the following are recommended:

- For channel 'height of excavation' between 6 m to 8 m, the channel configuration of "2 - 4H:1V of 1/2 height (H) slope with a bench for an effective slope of 5H:1V" is recommended (see Plate 6).
- For channel 'height of excavation' between 8 m to 12 m, the channel configuration of "2 - 5H:1V of 1/2 height (H) slope with a bench for an effective slope of 6H:1V" is recommended (see Plate 6).
- A further groundwater impact study is recommended to verify the artesian groundwater conditions and to provide more detailed information for the de-watering design.
- De-watering during construction will most likely be required. De-watering to 1 m below the proposed channel invert is recommended.
- If sand layers are encountered on the side slopes of the outlet channel, reverse filter design would be required to prevent channel water from seeping into the groundwater system.
- Topsoil to be removed from the footprint of the outlet channel should be stockpiled and reused by dressing on the side slopes of the channel and on the spoil pile/ dike.
- Spoil pile/dike or topsoil stockpile should be placed at a minimum distance of 25 m from the top of the outlet channel.

6.3.8 Foundation Considerations for Control Structure and Bridge Structure

Control Structure Foundations

The Control structure will be founded on the stiff till deposit at the proposed invert elevation of El 239.5 m. The uncorrected SPT blow count (N) values were greater than 100 at El 244.0 m and El 242.2 m and refusal was encountered at El 239.5 m (at proposed invert elevation). Based on the SPT blow count results, a factored Ultimate Limit State (ULS) bearing capacity of

280 kPa for stiff till may be assigned for the Limit State Design (LSD). Minor settlement is anticipated and should be investigated further as part of the next stage of design. Final design of the structure should also incorporate seepage control measures.

Bridge Structure Shallow Foundations

Shallow foundations may be considered for lightly loaded structures at the site with the provision that all footings are to be placed at 2.4 m (8 ft) or deeper below finished grade, which is the recommended design depth for frost penetration. For shallow footings at 2.4 m or deeper below grade, a factored ultimate limit state (ULS) bearing capacity of 280 kPa for stiff till may be assigned for limit state design (LSD). The minimum concrete footing dimension should be 900 mm.

Bridge Structure Cast-in-Place Concrete Friction Piles

Cast-in-place (CIP) concrete friction piles may be used to support the proposed structures depending on the design structural loads. Suitable CIP piling methods for the site include the continuous flight auger (CFA) method and plain bored method depending on the pile diameters. Temporary casing may be required for bored piles due to the potential caving of the overburden soils along the depth. The Factored Ultimate Limit State (ULS) skin friction value of 22 kPa may be assigned for the limit state design (LSD).

Bridge Structure Driven Steel Piles

Based on the above, driven steel piles (H-piles or pipe piles) to practical refusal could occur within the very hard till layers. Due to limitations on the drivability of the pile imposed by the yield strength of the pile, as a guide to initial design and selection of pile wall thickness and steel grade, it is recommended that the maximum design ‘SLS’ compressive resistance value of a steel pile be limited to 0.25FyAs (i.e. a fraction of the unfactored structural yield capacity of the pile), where: Fy is the nominal yield stress of the steel, and As is the cross-sectional area of steel in the pile. The purpose of this restriction is to mitigate the risk of statically designing a pile that cannot be driven with enough energy or force to overcome dynamic soil resistance and subsequently develop the design static load resistance without yielding or damaging the pile.

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Dynamic pile testing using pile driving analyzer (PDA Testing) and CAPWAP analysis should be performed during pile installation to verify the pile capacity. Driving shoes should be used for all types of driven steel piles. The steel pipe pile may be left open or filled with concrete. The pile filled with concrete will have higher bending capacity and lower potential for local buckling of the thin wall.

6.3.9 Future Work for Detail Design

If the Route D Option is chosen for the LMB Outlet Channel, for the next stage of design (Detailed Design), the following geotechnical/groundwater study works are recommended:

- Conduct water well survey in the vicinity of areas along the proposed Route D.
- Develop a groundwater monitoring program to measure the existing piezometers. This will provide historical groundwater records prior to the construction of the channel and provide a better understanding of the artesian groundwater conditions.
- Perform laboratory testing such as direct shear tests, flexible wall permeability tests from remolded proctor samples to verify the soil strength parameters.
- Conduct an investigation program for the detailed design of inlet and outlet of the channel.

6.4 GROUNDWATER IMPACTS

6.4.1 Summary of Hydrogeological Field Program

The hydrogeology field program involved monitoring of water levels along the Route D channel alignment at instrumentation installed during the geotechnical program, as well as a pumping test conducted at the 15-RD-04 location (St. 19+256, proposed Control Structure) to determine aquifer properties at this location. The instrumentation locations were at test hole locations, which are shown on Plate 5.

A summary of measured till and bedrock piezometric pressures along Route D are shown on Table 6.3.

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Table 6.3
Summary of Piezometric Pressures along Route D Alignment

Station	Test hole	Approx. Ground Elevation (m)	Approx. Top of Bedrock Elev. (m)	Piezometer Stratigraphic Unit (Tip Depth)	Date Monitored	Piezometric Pressure Elevation (m)
1+590	BH-D109	249.72	< 237.5	Silt till (10.5 m depth)	08/2012	250.68
2+672	15-RD-01	248.3	227.6	Silty clay (10 m depth)	04/08/2015	249.37
				Clay till (20 m depth)	04/08/2015	251.31
3+500	BH-D101	249.25	< 238.6	Silty clay till (7.5 m depth)	07/2012	248.09
7+780	BH-D106	249.92	< 239.2	Silty clay till (9 m depth)	07/2012	248.06
10+920	BH-D107	249.81	< 239.1	Silty clay till (6 m depth)	07/2012	248.97
12+776	15-RD-02/15-RD-02A	248.65	< 233.0	Silty clay (7 m depth)	04/08/2015	248.33
				Silty clay till (14.5 m depth)	04/08/2015	254.44
13+460	BH-D9	249.49	< 237.3	Silty clay till (11.5 m depth)	07/2012	248.96
17+032	15-RD-03/15-RD-03A	251.84	< 236.6	Silty clay till (7 m depth)	04/08/2015	251.06
				Sand (10 m depth)	04/08/2015	251.18
				Clay till (14.5 m depth)	04/08/2015	252.42
19+256	15-RD-04/15-RD-04A	251.76	235.6	Silty clay (7 m depth)	04/08/2015	250.26
				Silty clay till (14 m depth)	04/08/2015	253.53
				Bedrock (16.2 m depth)	04/08/2015	253.75
17+800	15-RD-10A	248.87	< 230.1	Silty clay (7.5 m depth)	04/08/2015	-
				Silt till (18 m depth)	04/08/2015	-
21+464	15-RD-05	247.09	< 234.4	Silty clay (7 m depth)	04/08/2015	246.15
				Silty clay (11.5 m depth)	04/08/2015	248.02
22+730	BH-D4	246.46	< 235.8	Sand (10 m depth)	07/2011	252.5 (estimated)

Piezometric pressure within the bedrock was measured at one location (15-RD-04A), with flowing artesian conditions observed (piezometric pressure El = 253.75 m, ground El = 251.76 m). Piezometric pressures in the lower till zone ranged from El 251.73 m

(15-RD-01) to El 254.45 m (15-RD-02), with flowing artesian conditions observed along the entire alignment, within this lower till zone. Piezometric pressures generally decreased with increasing elevation within the overburden, demonstrating a headloss from the bedrock zone, and confirming an upward groundwater gradient along the proposed Route D alignment. An inter-till sand zone was observed at two locations, 15-RD-03 and 15-RD-04. The piezometric pressure within the sand zone at 15-RD-03 was observed at El 251.18 m, also demonstrating an upward pressure gradient from the underlying bedrock aquifer.

A pumping test program was conducted at investigation location 15-RD-04 (Sta. 19+256) on August 4, 2015. This site was selected based on it being the probable location of the proposed Route D Control Structure. The program included installation of a 125 mm diameter pumping well, completed with 6 m of open hole into the bedrock aquifer. Two monitoring wells were also installed within the upper limestone bedrock at distances of approximately 5 m and 100 m from the pumping well. Bedrock pumping well and monitoring well logs are included in Appendix D. Additionally, the two nearby till piezometers, installed during the geotechnical investigation program at 15-RD-04, were monitored during testing to assess piezometric response within the till.

The pumping test was conducted for a duration of 4 hours at a pumping rate of 0.44 L/s (7 USgpm). A summary of the installation is provided in Table 6.4 and a summary of drawdown during the pumping test is provided in Table 6.5.

Table 6.4
Summary of Pumping Well and Piezometer Installations for Pumping Test

Well	Monitored Stratigraphic Unit	Elevation of Monitored Zone (m)	Static Piezometric Pressure (m)
PW-1	Bedrock	228.9 - 235.45	253.75
15-RD-04A	Bedrock	232.56 - 235.45	253.75
15-RD-04B	Bedrock	233.47 - 236.52	253.78
15-RD-04 – lower till	Lower till	237.26 - 238.16	253.53
15-RD-04 – upper till	Upper till	244.16 - 245.06	250.26

Table 6.5
Summary of Pumping Test Observations

Well	Lateral Distance from Pumping Well	Maximum Drawdown After 4 hours Pumping
PW-1	-	17.7 m
15-RD-04A	5 m	5.3 m
15-RD-04B	100 m	0.4 m
15-RD-04 – lower till	5 m	5.3 m
15-RD-04 – upper till	5 m	0 m

The analysis of pumping test data is presented in Appendix G. Based on this analysis, the estimated aquifer transmissivity at this location is <500 USgpd/ft. The calculated storativity ranged from 0.00033 to 0.00005, typical of carbonate bedrock aquifers in the Province.

The pumping test results at this test location demonstrate the low transmissivity of the local bedrock aquifer, consistent with findings of a review of Provincial well records in the area (see Section 6.4.2). The review of Provincial well records showed that approximately 50% of wells in the area had transmissivities in the range of <1000 USgpd/ft. It should be noted, however, that this transmissivity is based on a single localized pumping test, and regional variability in transmissivity is anticipated along the Route D alignment.

A few of the other key observations made during the pumping test include:

- The bedrock zone was characterized by a fractured upper contact zone, located at the top of the bedrock, immediately below the till overburden soils. The bedrock was overall competent with depth below this uppermost fractured zone, yielding little groundwater production. The upper fracture zone appeared to be reasonably continuous within the areas of investigation (i.e. within approximately 100 m of the pumping well), and generally interconnected, based on the observed piezometric pressure responses at 5 m and 100 m distance from the pumping well.
- A negative aquifer boundary condition appeared following approximately 150 minutes of pumping. Piezometric pressures within the pumping well decreased at an increased rate during this time, in comparison to earlier periods of the pumping test. This is likely a function of the aquifer drawdown zone encountering the limits of, or a change in, the localized upper aquifer fracture system. The result is increased headlosses, demonstrated by reduced water flow toward the well, with increasing size of the drawdown cone.

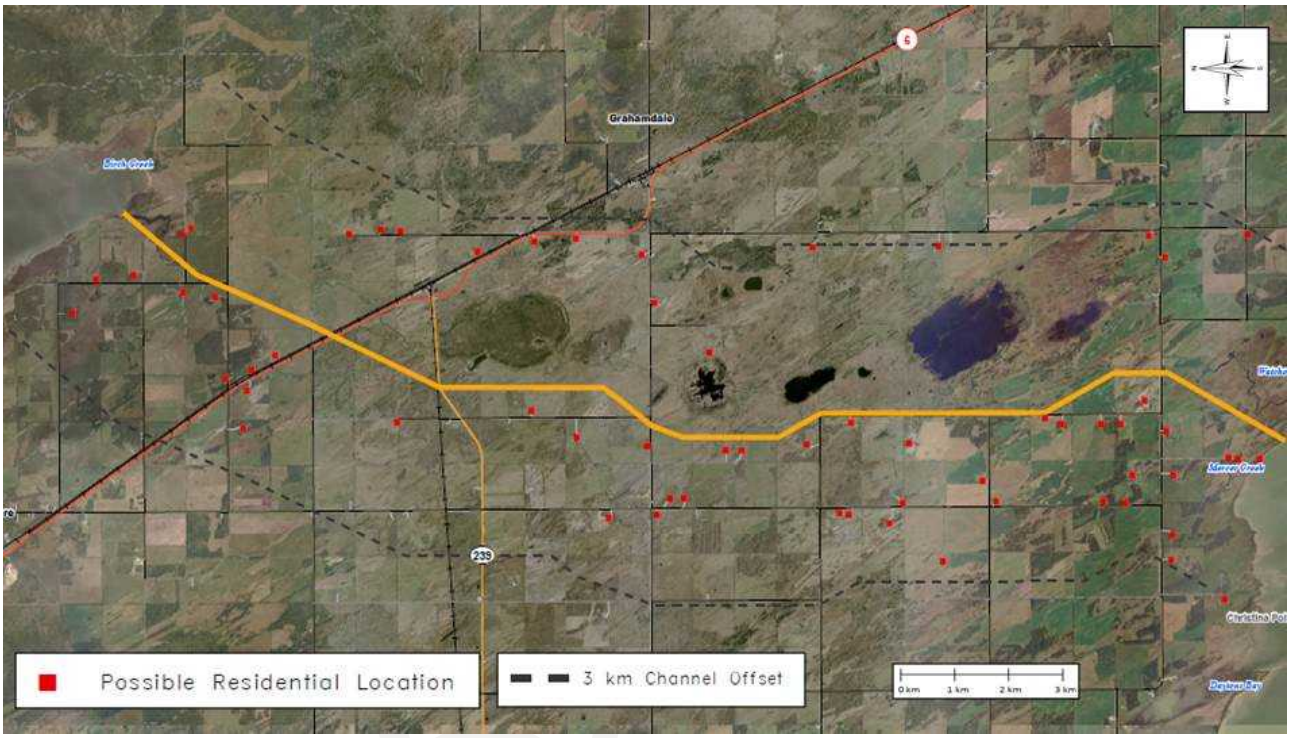
- Well efficiency losses were observed during the pumping test, with drawdown within the pumping well at 17.7 m, versus 5.3 m of drawdown observed within the aquifer at a distance of 5 m from the pumping well.
- The lower till zone appears to be directly connected to the bedrock aquifer, with immediate piezometric pressure response within the deep till piezometer.
- The upper till zone did not respond to pumping during the 4 hour pumping test. This observation does not mean that the upper till is disconnected from the bedrock aquifer, but more likely will require a longer duration of drawdown/pumping before a response could be observed. This observed response is typically a function of the low permeability of the till soils.
- Recovery of piezometric pressures occurred rapidly, with >80% recovery of static piezometric pressures within 1.5 hrs following pump shut-off.

6.4.2 Summary of GWDRILL Records

A search of the Provincial well record database (GWDrill) within the vicinity of the proposed Route D channel option identified a recorded 140 wells drilled within 3 km of the channel alignment. A number of these wells are not necessarily utilized for domestic purposes (e.g., livestock wells, monitoring wells, test holes without well installations). Additionally, a number of these wells may have been decommissioned or abandoned. Based on a preliminary review of the area, there are up to 70 possible residential locations within the 3 km Route D channel offset, which is likely a more accurate estimate of the potential number of active domestic wells of interest (Figure 6.3). The offset of 3 km is somewhat arbitrary and was selected as a reasonable distance for this scale of project, and for assessment of any potential associated groundwater impacts.

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Figure 6.3
Route D Alignment and Possible Domestic Well Locations



A brief review of the GWDrill records was conducted including assessment of: depth to groundwater, depth to bedrock, casing depth, total well depth, and estimated well capacity. Based on well capacities, an approximate aquifer transmissivity was also calculated. The review of the records is summarized on Table 6.6.

Table 6.6
Summary of GW Drill Database within 3 km Offset of Route D Alignment

Total GWDrill well records =	140
Total well records included in review =	126 (approx. 90%)
Depth to bedrock range =	0.3 m to 32.3 m
Median depth to bedrock =	12.2 m
Well depth range =	4.6 m to 79.2 m
Median well depth =	25.6 m
Casing depth range =	2.7 m to 32.0 m
Median casing depth =	12.6 m
Depth to groundwater range =	3.7 m (above ground) to 7.9 m (below ground)

Median depth to groundwater =	0.9 m (below ground)
Well capacity range =	0.02 USgpm/ft to 36 USgpm/ft
Median well capacity =	0.5 USgpm/ft
Calculated transmissivity range =	78 USgpd/ft to 72,000 USgpd/ft
Median calculated transmissivity =	1,008 USgpd/ft

Based on this review, the local geological and hydrogeological conditions show a significant amount of variability, but some general observations include:

- Water supplies are generally drawn from upper carbonate aquifer (13 m to 25 m range).
- Flowing artesian conditions observed at 28 of the 140 wells reviewed.
- Depth to groundwater is generally shallow (median depth to groundwater of 0.9 m below grade).
- Well capacities and aquifer transmissivity are generally low, with approximately 50% of the wells with a calculated transmissivity of <1000 USgpd/ft, although these calculations do not account for well efficiencies. A range of 1,000 to 10,000 USgpd/ft is a reasonable estimate of bulk aquifer transmissivity, based on the available data. Transmissivity >10,000 USgpd/ft were calculated at 8 of 140 wells reviewed. It should be noted that these transmissivity calculations are very approximate, and do not include variables such as well efficiency losses.

6.4.3 Excavation Basal Heave and Groundwater Blowout Assessment

The Route D profile (Figure 6.1) shows the base of the proposed excavation profile relative to the existing ground elevation and channel operational water elevations. Based on the current channel design and available geotechnical investigations, the channel invert is above the bedrock, and excavated within the tills, for the entire length of the channel. During the recent geotechnical and hydrogeological investigations, bedrock was encountered at two borehole locations, 15-RD-01 and 15-RD-04A. Bedrock at 15-RD-01 was encountered at approximately 14.2 m below the channel invert at El 227.6 m. Bedrock at 15-RD-04A was encountered at approximately 3.89 m below the channel invert at El 235.61 m. At other borehole locations where bedrock was not encountered, bedrock elevations are assumed below approximately El 230 m to El 236 m, based on the borehole completion elevations reached during drilling. These hole completion depth elevations are generally lower than the bedrock surface shown locally on the available Provincial Groundwater Availability Map Series drawings (bedrock elevations in the range of 224 m to 250 m). Additionally, a review of domestic well records

demonstrates typical bedrock depths in the range of 12 m from ground surface (estimated El 238 m), although large variability in bedrock elevation is demonstrated locally based on these records. It is possible that the channel alignment generally follows a natural bedrock depression within this area. The existence of a topographically low bedrock surface elevation was identified during a seismic refraction survey completed at two locations along the channel alignment in 2011. The seismic refraction survey identified bedrock elevations potentially as low as El 220 m to El 225 m in the vicinity of the Route D channel alignment.

Blowout/basal heave conditions may occur within the channel excavation during the construction phase of the project (unless mitigated by an aquifer depressurization system), if the bedrock aquifer groundwater piezometric pressures exceed the confining overburden mass that remains between the channel excavation invert, and bedrock surface elevation during excavation. During channel operations, blowout or basal heave/seepage would be expected if these bedrock aquifer pressures exceed the operating channel surface water profile, and where not confined by sufficient overburden thicknesses.

Table 6.7 summarizes the assessment of blowout, utilizing the geotechnical information available from field studies for both the construction phase and operational phase.

Table 6.7
Factors of Safety against Blowout along Route D Alignment

Borehole	Channel Invert Elevation (m)	Minimum Operating Water Level (m)	Bedrock Elevation (m)	Bedrock Piezometric Pressure (m)	Factor of Safety - Construction	Factor of Safety - Channel Operation
15-RD-01	241.8	246.9	227.6	251.73**	1.2	1.4
15-RD-02	240.4	246.9	230*	254.45**	0.9	1.1
15-RD-03	240.0	246.9	230*	252.39**	0.9	1.2
15-RD-04	239.5	242.9	235.6	253.75	0.4	0.6
15-RD-05	239.2	242.9	230*	248.02**	1.0	1.2

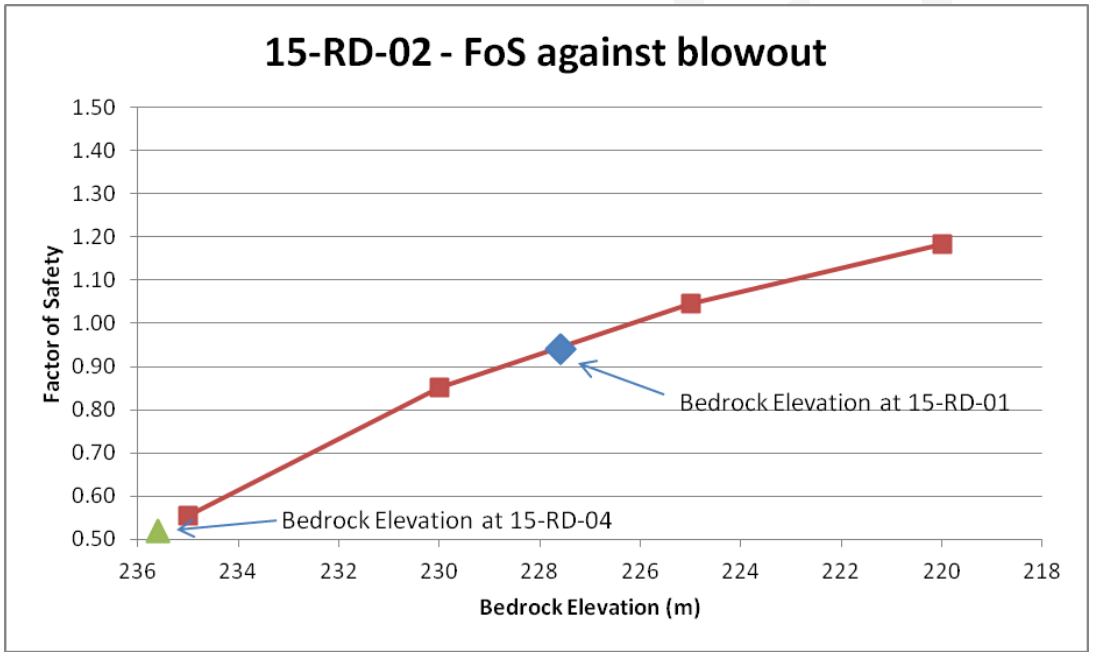
* Bedrock not encountered during drilling and for the purposes of this assessment is assumed at a level between 15-RD-01 and 15-RD-04.
** Bedrock piezometric pressure assumed as similar to pressure in lower till zone.

The calculated factors of safety range from 0.4 to 1.2 during construction and 0.6 to 1.4 during channel operation. As such, based on the available information, blowout/seepage conditions are

anticipated along the entire length of the channel during the construction phase. Additionally, Factors of Safety during the operational phase would be less than the required design Factor of Safety. The design Factors of Safety against blowout are 1.3 during the construction phase, and 1.5 during the operational phase.

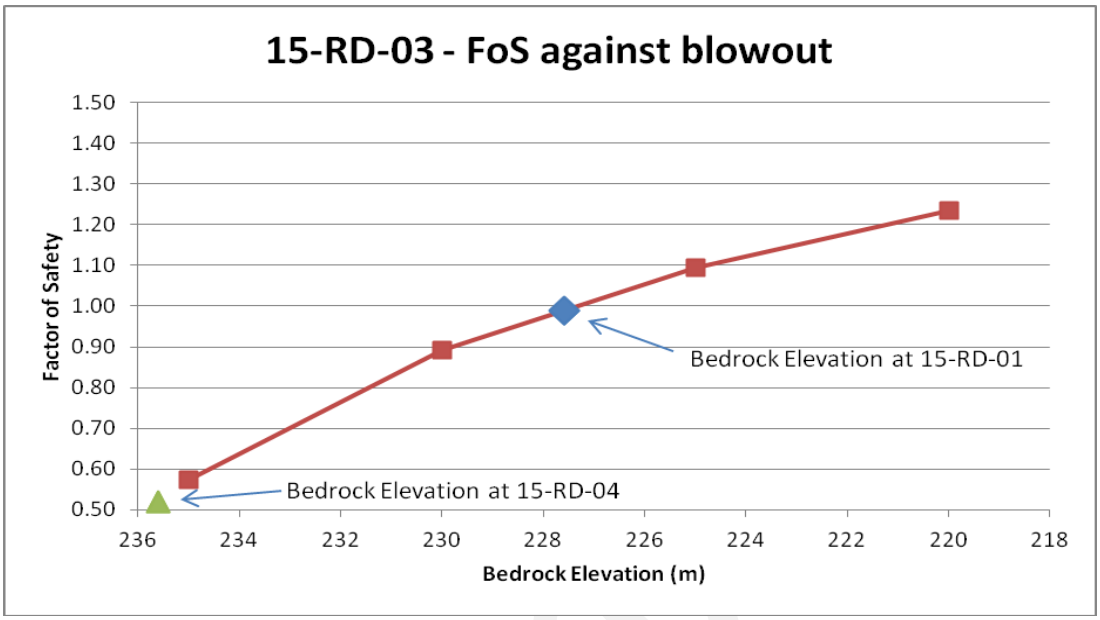
It should be noted that these Factors of Safety for 15-RD-02, 15-RD-03, and 15-RD-05 are based on an assumed bedrock elevation of 230 m and piezometric pressures measured within the till. A sensitivity analysis on the Factor of Safety related to bedrock elevation was conducted at these locations with results shown on Figures 6.4 to 6.6.

Figure 6.4
Sensitivity Analysis for Blowout during Construction Phase – 15-RD-02



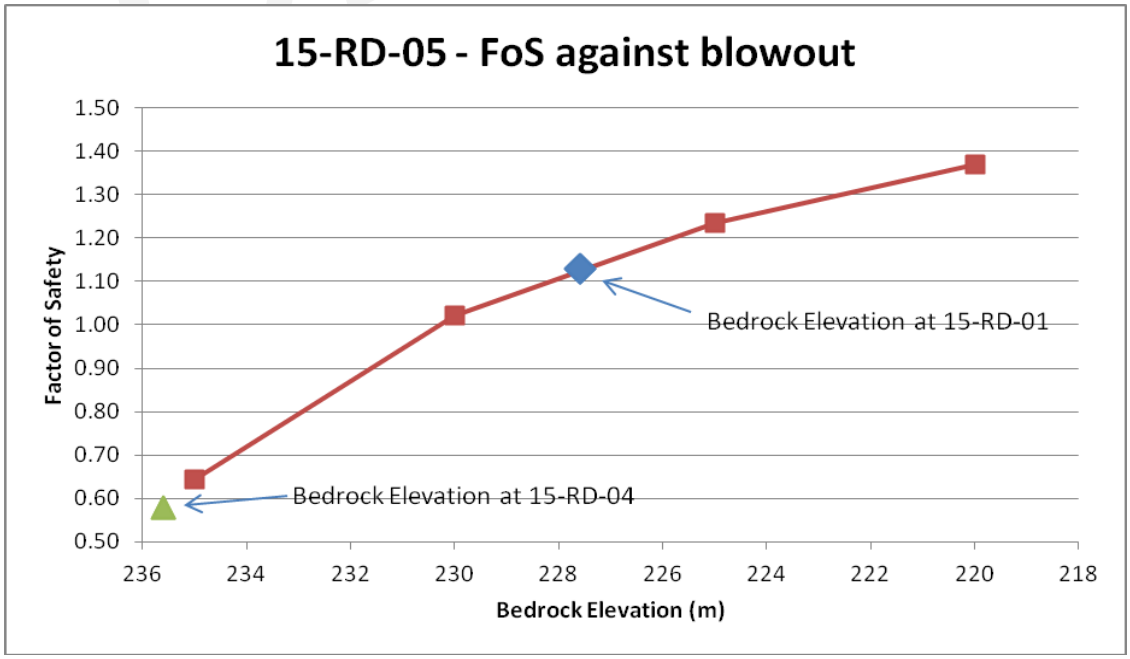
Note: Piezometric elevation assumed to be El 254.45 m, as measured in the till at tip El 233.7 m.

Figure 6.5
Sensitivity Analysis for Blowout during Construction Phase – 15-RD-03



Note: Piezometric elevation assumed to be El 252.39 m, as measured in the till at tip El 236.8 m.

Figure 6.6
Sensitivity Analysis for Blowout during Construction Phase – 15-RD-05



Note: Piezometric elevation assumed to be El 248.02 m, as measured in the till at tip El 235.2 m.

As a result of the potential for blowout conditions, a depressurization program, or other construction-based method of accommodating the high aquifer piezometric pressures and associated basal heave/blowout conditions, would be required during the construction and operational phases of the project. Based on the low bedrock transmissivities anticipated along the channel alignment, utilizing bedrock wells for depressurization may be inefficient (due to the small radius of influence associated with an individual well), and thus cost-prohibitive, due to the length of channel involved and large number of wells that could be necessary. There is potential to excavate sumps for pumping within the main excavation, periodically along the channel alignment, allowing for discharge of groundwater through the sump. This would require channel excavation from the downstream end and working upstream, with sumps installed as necessary. Groundwater discharge would be pumped to discharge from the sumps, and/or flow along the under-construction channel toward Lake St. Martin. These sumps would be maintained into the operational stage of the channel to provide continued depressurization of the aquifer. These sumps could also be constructed with graded sand filters to allow for exfiltration of groundwater seepage, while providing some level of aquifer water quality protection by limiting infiltration during possible infiltration periods and connectivity with surface water within the channel. This reverse sand filter method was utilized on the Winnipeg Floodway Expansion to mitigate some of the concern with infiltration/exfiltration groundwater/surface water exchanges that were active from the original floodway channel construction phase in the 1960s.

It should also be noted that raising the channel invert within reasonable levels (1 to 2 m) does not provide the required design Factors of Safety during the construction phase. A groundwater depressurization/piezometric pressure relief program would also be required for this alternate design.

6.4.4 Aquifer Drawdown during Channel Construction

Drawdown of aquifer groundwater piezometric pressures would be anticipated during construction as well as during channel operation, given the flowing artesian piezometric pressure conditions, and potential direct connection to the bedrock aquifer, via seepage through fractured till due to groundwater blowout. The largest aquifer drawdowns would occur during the construction phase, with drawdown to a level at or below the invert of the channel excavation. Potential aquifer drawdown could also occur during channel operation, with surface water levels

within the channel lower than the surrounding aquifer piezometric pressures, thus maintaining groundwater exfiltration conditions to the channel, should a connection be formed (e.g. fracturing or blowout of the confining till unit). The bedrock aquifer piezometric pressure condition would be expected to re-equilibrate to an elevation nominally above the normal channel surface water operational levels, with continued seepage to the excavated channel from the bedrock aquifer.

A review of groundwater piezometric pressure elevations was based on recent KGS Group geotechnical investigations, as well as from a review of the Provincial Groundwater Availability Map Series. For the purposes of this assessment, a groundwater elevation of El 252 m was utilized as a reasonable estimate for domestic well water levels. During construction, the minimum channel invert elevation is approximately El 239 m. During operation, water levels in the channel are assumed to be equal to Lake Manitoba levels upstream of the control structure (El 246.9 m), and equal to Lake St. Martin levels downstream of the control structure (El 242.6 m). Based on these assumptions, the approximate maximum aquifer drawdowns at the channel are approximately 13 m (during construction phase), 5 m (upstream of the Control Structure, during normal channel operation), and 9 m (downstream of the Control Structure, during normal channel operation).

To assess potential drawdowns at a distance, a calculation for radial flow to a well was utilized as an approximation. Additionally, aquifer transmissivities were assumed in the range of 1,000 to 30,000 USgpd/ft, based on the preliminary GWDrill records assessment as well as the current pumping test program. An aquifer storativity of 0.0001 was also assumed, and a duration of 300 days (10 months) was used. Three hundred (300) days was selected as a reasonable timeframe between annual aquifer recharge events and is considered the conservative case. The calculated aquifer drawdowns are shown on Figure 6.7 for the construction phase and Figure 6.8 for the operations phase.

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Figure 6.7
Route D – Cross-Section of Estimated Aquifer Drawdown with Distance during the Construction Phase

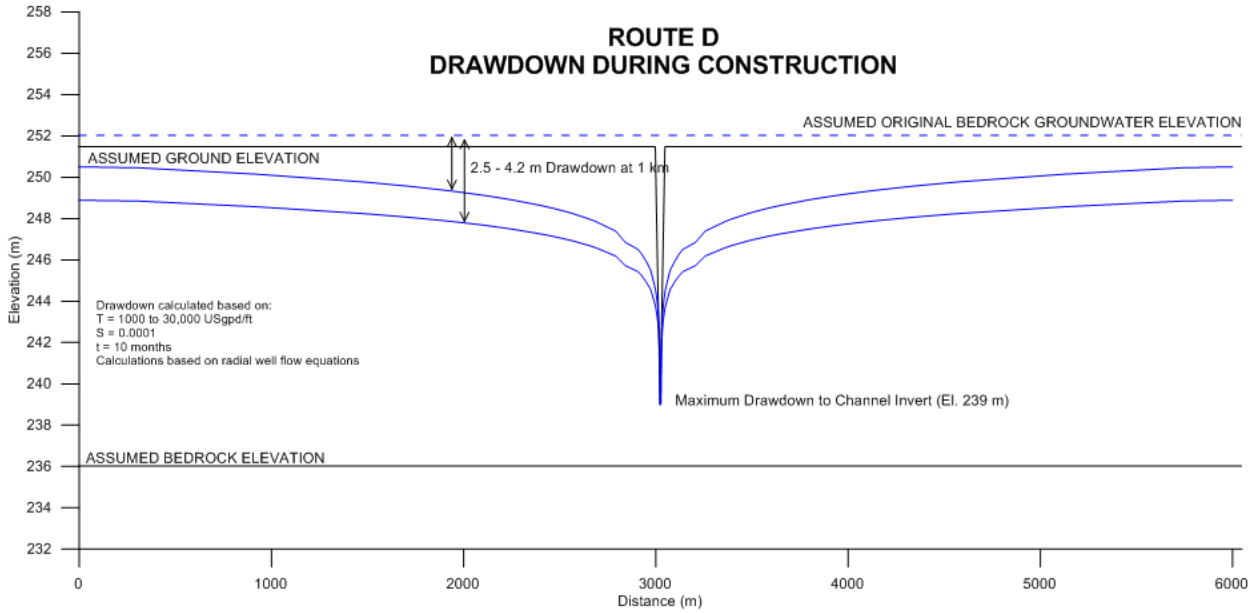
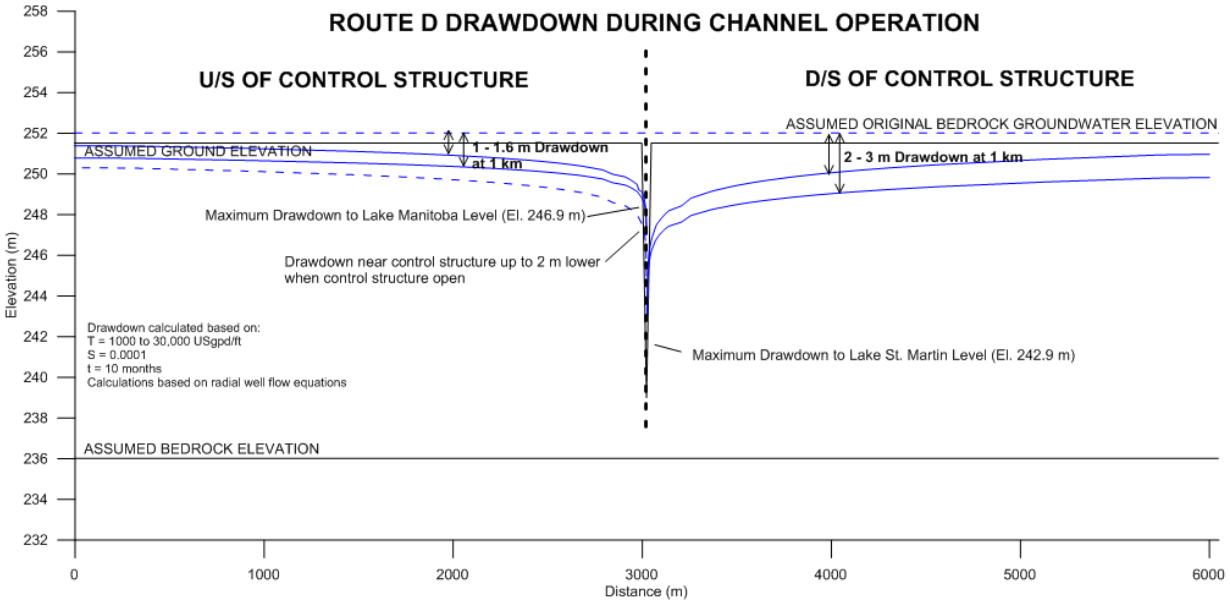


Figure 6.8
Route D – Cross-Section of Estimated Aquifer Drawdown with Distance during the Normal Channel Operational Phase



This estimation demonstrates a potential maximum of 2.5 m to 4.2 m of drawdown at a 1 km distance from the channel during construction, and as much as 6 m to 8 m in the immediate vicinity of the channel excavation. During normal channel operation upstream of the Control Structure, aquifer drawdown in the range of 1.5 m could be anticipated at 1 km from the channel, and in the range of 3 m downstream of the Control Structure at a distance of 1 km. These drawdowns are greater in close proximity to the channel and associated channel control structures. In this scenario, a direct interconnection to the bedrock aquifer is assumed (i.e. via fracturing of the confining till during blowout of the basal soils in the channel, and/or due to construction of depressurization sumps). However, if the integrity of the channel basal soils is maintained along the length of the channel, or with limited interconnection through the depressurization sumps, the assessment of groundwater impacts would change, and would be proportionately less.

Line source drawdown and well superposition methods were also utilized to estimate regional drawdowns (versus the radial well calculations provided above). These methods resulted in greater drawdowns than estimated using the radial well method, by up to 2 to 3 times (e.g. up to 8 to 10 m drawdown calculated at 1 km from the channel during construction). It should be noted that these methods, like the radial well method, do not include consideration of recharge boundaries, aquifer fracture discontinuities, and other aquifer heterogeneity and are likely overly conservative. Unlike the radial well method, line source methods also assume a linear relationship between distance and drawdown, which is not expected based on site testing and the nature of fracture flow and aquifer heterogeneity within the relatively low transmissivity regional aquifer. As such, these larger drawdowns are expected to be over-estimations of what could reasonably be anticipated. To more accurately assess the anticipated drawdowns, additional well drilling and aquifer testing, combined with a regional hydrogeological model would be required, with sensitivity analysis, to capture a realistic drawdown profile at the final design stage. All preliminary calculations, however, indicate that up to several meters of drawdown could be expected at local supply wells and assessment of these local third party wells relative to these drawdowns would be required.

The well construction, pumping rates, and available drawdown at individual domestic wells are unknown at this time. However, given the number of wells within close proximity to the proposed channel alignment, it is reasonable to anticipate that a portion of these wells would require some

level of mitigation (lowering pumps, drilling new wells, alternate water supply, etc.) to accommodate the imposed drawdown.

This preliminary assessment indicates that aquifer drawdowns within close vicinity to the channel can be anticipated to be greatest immediately adjacent to the channel excavation, and decreasing at distance (e.g. a minimum of 2 m to 4 m during construction, as far as 1 km from the channel) and would likely have an impact on the available capacity of some local water supply wells. As with Route C, a field program to establish residential well capacities, and available drawdown would be required prior to construction, as well as development of a mitigation plan for any anticipated impacts to local users (e.g. alternate water supply, lowering pumps, etc.). This type of program could include ±70 residences based on a 3 km offset from the proposed channel alignment.

6.4.5 Groundwater under the Direct Influence of Surface Water (GUDI) Assessment

Seepage connections to the Route D channel will exist where the remaining overburden tills below the channel and above the bedrock have fractured due to blowout/basal heave conditions. In general, groundwater discharge conditions are anticipated along the proposed Route D channel, with surrounding groundwater piezometric pressures sustained above normal operational surface water levels within the channel. Under these conditions, an upward gradient favouring exfiltration of aquifer groundwater to the channel would be in effect.

However, GUDI conditions (with a temporary reversal of the upward gradient) along the channel may occur periodically during conditions of a sudden increase in surface water elevation in the channel (such as during channel operations due to spring flood conditions), or separately during sustained pumping and drawdown of local wells, at any time of year, and especially in relatively close proximity to the channel. The sudden increase in channel surface water levels would be of concern primarily downstream of the control structure, with an increase in channel water level profile of up to 1.5 m immediately downstream of the control structure during flood stage. This type of flood stage increase could result in a plume of surface water infiltration to the bedrock aquifer. This plume could become available to migrate some distance within the aquifer from the channel entrance point for a duration of time until the aquifer piezometric pressure condition re-equilibrates to the new channel surface water elevations, again favoring groundwater discharge

to the channel. Pumping of domestic wells in close proximity to the channel could capture the localized plume of surface water within the bedrock fracture flow system, thus drawing it away from the channel entrance point, regardless of the re-equilibration of the aquifer piezometric pressure condition.

The concerns associated with GUDI are related to a change in the aquifer water quality (e.g. infiltration of channel surface water and bacteria) within the fractured bedrock aquifer, which may be transmitted through the fracture system to local well users, with impacts including potential bacterial contamination of these wells. Actual surface water flows into the local aquifer would be affected by aquifer properties including fracture connectivity, fracture continuity, overall bulk bedrock transmissivity, and storativity conditions. However, the connection of the channel to the fractured bedrock aquifer, and of the aquifer to the local domestic wells, cannot be ignored.

A varying depth of till will be maintained beneath the invert of the channel and the bedrock aquifer along Route D, although a connection between the bedrock aquifer and the channel is anticipated either due to blowout, or with possible installation of depressurization sumps. These sumps could be constructed with reverse sand filters to help protect the local aquifer from infiltration of surface water contaminants. This method was utilized along the Manitoba Floodway.

Sufficient investigation would be required to properly assess and verify these kinds of aquifer conditions and to quantify possible impacts to the aquifer system. A limited program including a pumping well installation and pumping test was completed during late July, 2015, at location 15-RD-04. Results of this program and assessment of aquifer conditions will be compiled as an addendum, and will be included within the Final report.

Ultimately, a long-term risk management program to monitor and assess impacts to the local groundwater regime would include at a minimum, but would not be limited to:

- Detailed physical and chemical hydrogeological assessment.
- Domestic well inventory.
- Installation of sentry wells.

- A long term water quality monitoring program. Monitoring and assessment of aquifer quality would continue for the duration of the operational life of the channel.

6.4.6 Changes to Lake St. Martin Water Quality

Discharge of groundwater to the channel is anticipated given the channel excavation depth, aquifer piezometric pressure conditions, interconnection to the carbonate aquifer, and construction and operational channel conditions. Based on a review of groundwater quality compiled in the Provincial Groundwater Availability Map Series, the groundwater quality appears to be relatively fresh (TDS = 370 to 660 mg/L, Chloride = 3 to 39 mg/L). Groundwater baseflows under maximum drawdown conditions are calculated in the range of 1,000 USgpm (construction period) to 550 USgpm (operational period) for an aquifer transmissivity of 10,000 USgpd/ft. These baseflows may increase significantly if aquifer transmissivity proves to be higher than this initial estimate (e.g. >5,000 USgpm for T = 50,000 USgpd/ft during construction). Additionally, these baseflow estimates are based on a direct connection of the excavated channel to the carbonate aquifer via fractured tills along the entire length of the channel.

Although the available water quality data (TDS, chloride) does not raise any initial concerns for discharge into an aquatic environment, the dissolved oxygen level of the groundwater is anticipated to be much lower than the receiving surface water. As such, some discussion may be required with the Department of Fisheries and Oceans based on any anticipated alteration to the aquatic environment (Lake St. Martin). It should be noted, however, that the groundwater system naturally discharges to Lake Manitoba and Lake St. Martin, and as such the volume of groundwater discharge to the surface water bodies should not be greatly increased. Also, based on channel and control structure design and operations, some volume of surface water baseflow will be included. This baseflow is not estimated at this time, however, it can be assumed that some degree of dilution of groundwater will occur prior to discharge to Lake St. Martin and can be quantified during the final design stage.

6.4.7 Drainage of Surface Water Bodies near the Channel Alignment

A number of ponds, sloughs, and lakes (e.g. Reed Lake, Clear Lake, Goodison Lake) are located within the vicinity of the proposed Route D channel alignment. It is assumed, based on

the high groundwater piezometric pressures in the area, that there may be some connection of the groundwater aquifer to these water bodies, depending on the total depth of the water body, underlying soil stratigraphy, and depth to bedrock surface. Available topographic information indicates surface water elevations of these water bodies to be in the range of El 249 m, relative to bedrock piezometric pressures in the range of El 250 to 252 m. As such, drawdown of the groundwater aquifer may impact the water levels within these water bodies. It is estimated that the current upward gradient of flow between the groundwater and surface water bodies could reverse with drawdown induced by the Route D channel, with possible drainage of the surface water bodies, or more likely, a drop in lake levels due to the reduction in groundwater baseflow contribution. Lacustrine fine grained sediments that have formed within these basins would likely limit the drainage of the surface water system through the basin bottom, even with a drop in groundwater piezometric pressures. This assessment assumes that there is a connection between the groundwater and surface water bodies via the underlying fractured till, and associated seepage pathways.

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7.0 LAKE ST. MARTIN OUTLET CHANNEL – REACH 1

7.1 DESCRIPTION

The LSM outlet channel extends approximately 27 km from Lake St. Martin to Lake Winnipeg and consists of three reaches as shown on Plate 1. The first reach (Reach 1) extends approximately 8 km (5 mi) from LSM to Big Buffalo Lake. As discussed in Section 2.0, the Reach 1 emergency outlet channel was constructed in 2011 in response to high water levels on LMB and LSM as recommended in the Analysis of Options for Emergency Reduction of Lake Manitoba and Lake St. Martin Levels (KGS Group/AECOM, 2011). The existing Reach 1 Emergency Outlet Channel is about 6 km long (3.7 mi), extending from LSM to the bog area surrounding Big Buffalo Lake. It has a 45 m (147.6 ft) base width and has a measured capacity of approximately 113 m^3/s (4,000 cfs) at a LSM water level of El 244.1m (801.0 ft). Record drawings of the Lake St. Martin Reach 1 Emergency Outlet Channel construction are provided in Appendix A. Photo 7.1 shows the Reach 1 Emergency Channel during operation in 2012.

Photo 7.1
Reach 1 Emergency Chanel Looking Downstream



As discussed in Section 4.1, the proposed permanent Reach 1 outlet channel would consist of upgrading the existing emergency outlet channel to a permanent status with additional capacity to provide a net increase in flow to LSM above the base condition of the existing Reach 1 channel. On this basis, the design capacity of the LSM outlet channel is 326 m^3/s (11,500 cfs) at a LSM water level of El 244.1m (El 801.0 ft) (i.e. 113 m^3/s (4,000 cfs) of the existing channel plus the additional 212 m^3/s (7,500 cfs) from the proposed LMB outlet channel). To achieve the 326 m^3/s (11,500 cfs) capacity, the existing channel would have to be widened, and extended by about 2 km downstream to Big Buffalo Lake, as shown on Plate 8.

A control structure would be constructed at the inlet of Reach 1 that would also act as a bridge to provide access to the north west side of the channel. An all season access road would also be constructed to access Reach 1 as shown on Plate 1. Reach 1 is located entirely on crown land and would therefore not require any land acquisition.

Figure 7.1 shows a profile plot of the Reach 1 channel from LSM to Big Buffalo Lake. The land surface rises slightly from LSM to El 246 m (El 807.1 ft) at approximately Station 2+500 and then drops to El 241.5 m (El 792.3 ft) at Station 6+000, where the channel enters the Big Buffalo Lake Bog area. The land surface then falls gradually to El 241 m (El 790.7 ft) at Big Buffalo Lake.

The proposed channel will have an invert of El 241.1 m (El 791.0 ft) at LSM and El 239.6 m (El 786.1 ft) at Big Buffalo Lake, based on the slope and invert of the existing Reach 1 channel. The depth of excavation below ground surface would vary between approximately 1.5 m (5 ft) and 4.5 m (15 ft). As discussed in Section 3.0, the channel essentially cuts through peat and till material and does not intercept rock. Since the invert of the channel would be lower than the normal water level in Buffalo Creek, there would be standing water in the channel when it was not in operation.

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7.2 HYDRAULIC DESIGN

7.2.1 Channel Design

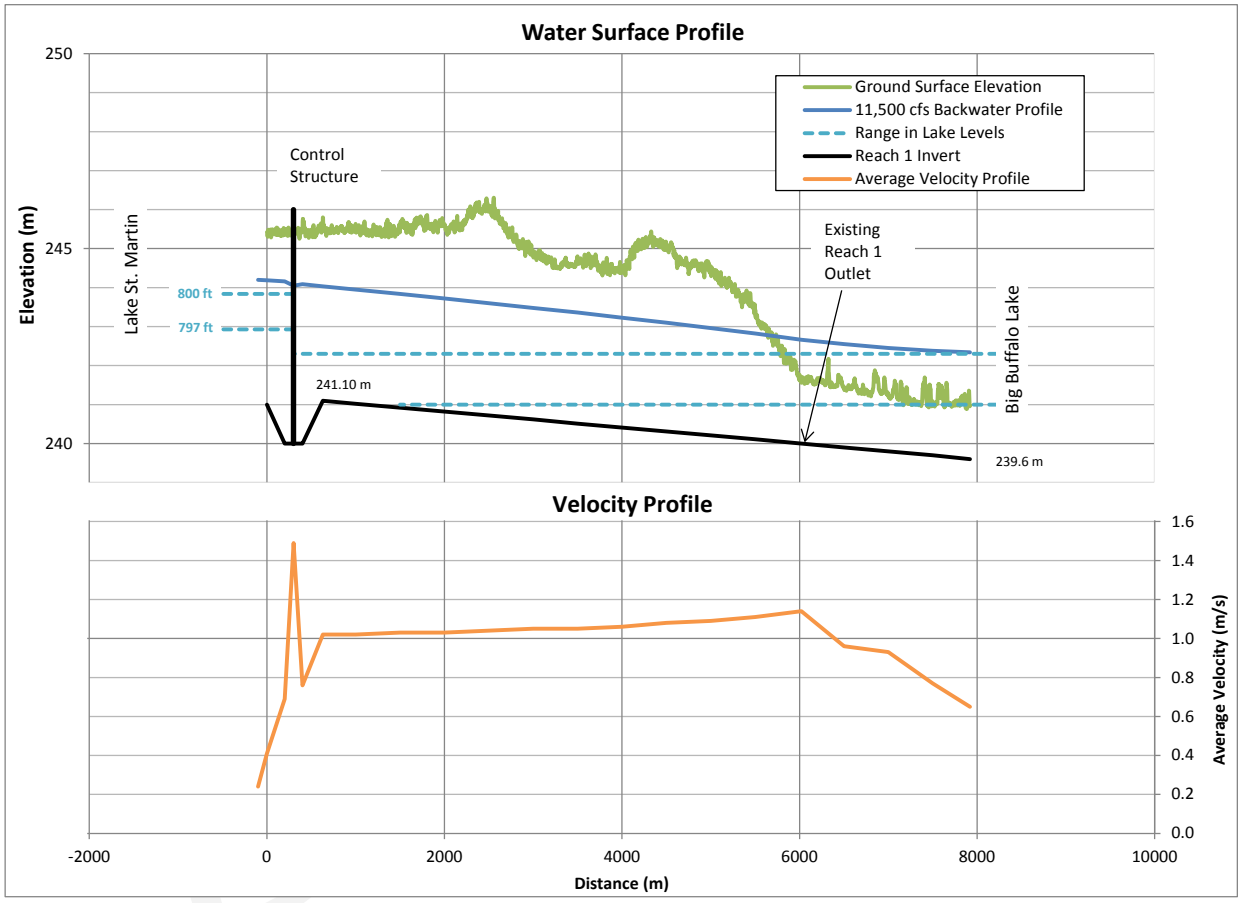
The channel design of Reach 1 was based on the Manning's equation to compute the base width using the channel design parameters listed in Table 7.1 and a discharge of 326 m^3/s (11,500 cfs). The normal depth of flow of 3.0 m (9.8 ft) was assumed based on the channel invert elevation at LMB and the design water level for LSM of El 244.1 m (El 801.0 ft). Table 7.1 summarizes the hydraulic design parameters for the channel. A hydraulic profile of Reach 1, based on a HEC-RAS backwater model of the channel, and an assumed water level of El 242.3 m (El 794.9 ft) in Big Buffalo Lake as the downstream boundary condition is provided on Figure 7.1.

Table 7.1
Hydraulic Design Summary for Reach 1 of the Lake St. Martin Outlet Channel

Design Flow	11,500 cfs
Channel Slope	0.0204%
Normal Depth of Flow	3.0 m
Assumed Manning's 'n' value	0.028
Base Width	95.8 m
Side Slopes	4H:1V

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Figure 7.1
Profile of Reach 1 of the Lake St. Martin Outlet Channel



As shown on the profile, the proposed Reach 1 channel has been extended 2 km (1.6 mi), 1.5 m (5 ft) deep, into the bog area to Big Buffalo Lake. This is necessary to reduce the backwater effects due to the headlosses that occur when water is flowing over the bog area that surrounds Big Buffalo Lake. Based on a HEC-RAS backwater profile of Reach 2 (discussed in Section 8.0), there would be a significant headloss through the bog area upstream of Big Buffalo Lake if the channel was not extended, which would increase the water levels in Reach 1 by more than 0.7 m (2.3 ft) above the normal depth of flow, reducing the channel capacity by about 85 m^3/s (3,000 cfs).

Rather than extending the channel through the bog, increasing the width of the proposed Reach 1 channel was also considered; however, this option was dismissed since the width increase would be disproportionately large to compensate for the backwater.

Extending the channel to Big Buffalo Lake will not eliminate flow over the bog as the design water level would still be higher than the top of the peat. However, by spoiling the excavated material in the bog on the north west side of the channel only, most of the water would flow within the channel, with only a portion of the water flowing over the peat on the south east side.

The inlet to the channel for Reach 1 would be similar in concept to that described for LMB Options C and D discussed in Sections 5.2.1 and 6.2.1. However, due to the sheltered position of the channel entrance at Lake St. Martin, the need for a groin to prevent the migration of sand and silt into the channel and minimize the risk of infill would be unlikely. Detailed bathymetric surveys are needed to fully develop the concept and would be conducted at the Detailed Design Phase of study.

7.2.2 Winter Ice Considerations

The backwater model results showed that the computed Froude number for the flow under normal operating conditions is greater than 0.12 for all locations in the channel. Since the critical Froude number for an ice cover to advance in flowing water by juxtaposition must be no greater than 0.08, an ice cover on the channel is unlikely. Significant staging in the water level in the channel at Big Buffalo Lake in the range of 2 m (15 ft) could be required to lower the flow velocity to reduce the Froude number before the cover would advance upstream from Big Buffalo Lake. Based on experience and observation of ice conditions in the existing emergency Reach 1 channel since the flood of 2011, it is unlikely that there would be a sufficient amount of frazil ice production for staging to occur for an ice cover to advance sufficiently upstream and impede the capacity of the channel at LSM.

In addition, the flood routing studies discussed in Section 13.0 showed that the outlet channel typically begins operation in early summer and ends operation by late fall. Operation of the channel in the winter normally will not be required. As discussed in Section 13.3.1, in the 54 years that were simulated, the channel would have been operated 7 times in the month of December but only 4 times in the month of January, 3 times in February and 2 times in March. Winter operation is, therefore, only expected during very large flood events such as in 2011, 2012 and 2014.

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While an ice cover is unlikely to occur during the operation of Reach 1, the possibility that the channel must be operated during winter for lake regulation after a stable ice cover had already formed in the channel cannot be completely ruled out. An ice covered rating curve was, therefore, computed for this condition using the HEC-RAS backwater model with an assumed smooth ice cover (n-value of 0.015) with a thickness of 0.6 m (2 ft). The winter ice covered rating curve, provided in Section 7.2.3 showed that the ice cover would reduce the channel discharge by approximately 50% from the equivalent open water condition at El 244.1 m (El 801.0 ft) of 212 m^3/s (11,500 cfs) to approximately 156 m^3/s (5,500 cfs).

In the channel, the water levels at the flow of 156 m^3/s (5,500 cfs) with the 0.6 m (2 ft) ice cover would at most be 0.5 m (2.0 ft) higher than under open water conditions at the 326 m^3/s (11,500 cfs) flow. This slight increase to water levels is still well within the channel banks and does not impact the hydraulic design of the channel. Although the chance of an ice cover in the channel is very unlikely and winter operation is also remote, the operation procedures and possible effects of an ice cover should be reviewed at the detailed design stage.

7.2.3 Control Structure and Rating Curve

A gated control structure, which would be located at the channel inlet at LSM, as shown on Plate 8, will be used to control flow in the channel. Since headlosses at the structure will directly impact on the capacity of the channel, the structure was sized purposely large to minimize headlosses. Based on the rating curve developed for the channel, it is estimated that a headloss of 0.1 m would reduce the capacity of the channel by 5% – 10%, depending on the LSM water level.

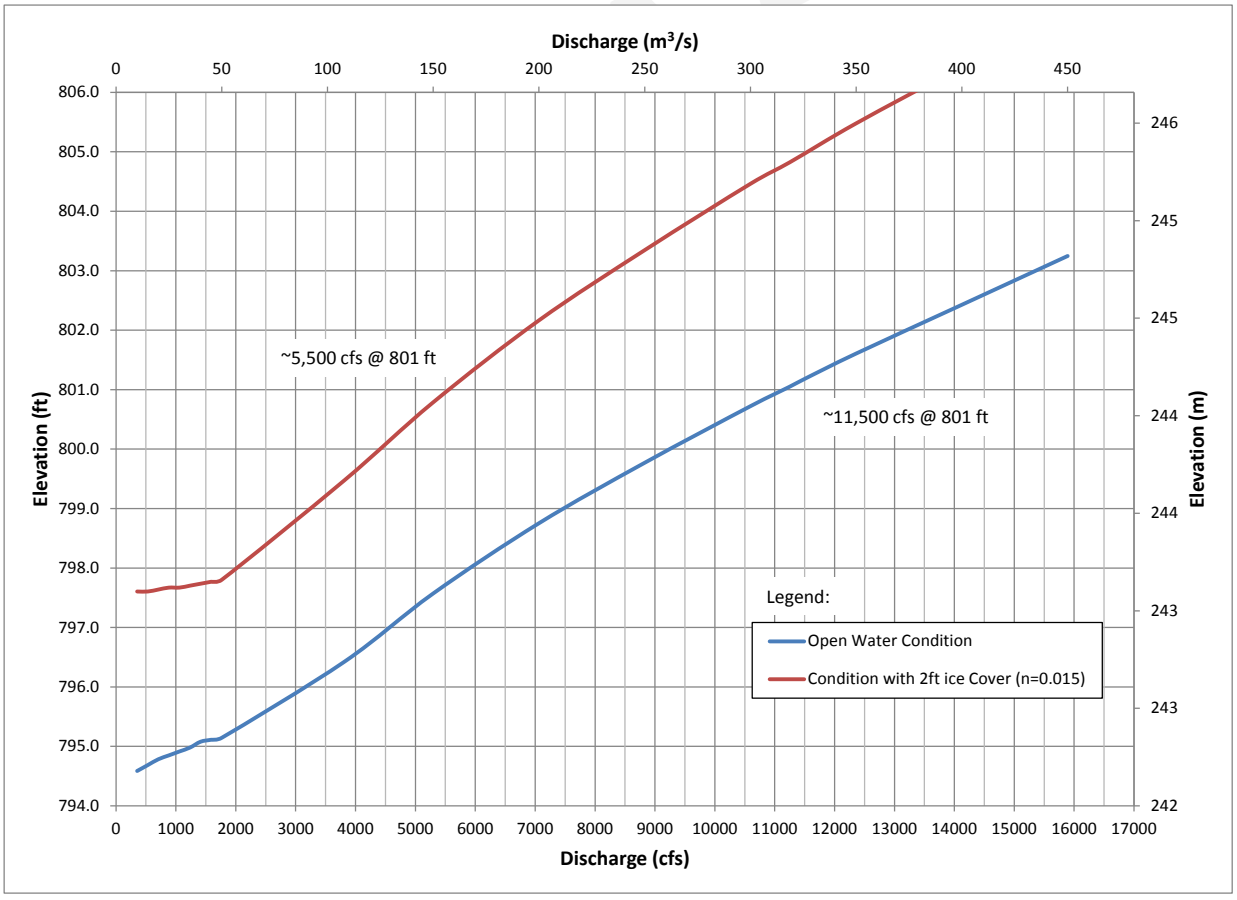
A 6-bay structure with bay widths of 9 m (29.6 ft) each was chosen for the control structure, which would limit the headloss to 0.07 m. As well, the invert of the base slab was also lowered by 1 m below the channel invert to El 240.0 m (El 787.4 ft) to increase the flow area and reduce headlosses. Design details of the control structure concept are provided in Section 10.0 of the report.

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When the structure is closed, the water level upstream of the structure will be the same as the water level on LSM and on the downstream side of the structure the water level will be the same as the water level in Big Buffalo Lake.

When the structure is fully open, the flow in the channel will depend on LSM water levels. Based on the results of the HEC-RAS backwater model and with open water conditions on the channel, a stage-discharge relationship (Figure 7.2) was prepared for Reach 1. As shown on the figure, the channel design meets the 326 m^3/s (11,500 cfs) flow criteria at a LSM water level of 244.1 m (801.0 ft). The winter ice covered rating curve discussed in Section 7.2.2 is also included on the figure.

Figure 7.2
Stage-Discharge Relationship for Reach 1 of the Lake St. Martin Outlet Channel



7.3 GEOTECHNICAL DESIGN – REACH 1

In 2011, seven (7) boreholes, two hundred and forty-two (242) peat probes, fifty-four (54) lake sounding measurements (LS), and approximately 8.0 km of seismic survey lines were conducted for the Reach 1 Emergency channel. The proposed 2015 Reach 1 channel design was planned to widen the existing 2011 Reach 1 emergency channel and to extend the existing dikes towards Big Buffalo Creek.

The 2015 supplementary geotechnical field investigation for Reach 1 of the LSM Outlet Channels consisted of one (1) borehole (TH15-01) near the inlet of the Reach 1 channel and its location is shown on Plate 8. Three standpipe piezometers (SP) were installed in this borehole for groundwater monitoring.

The borehole drilling and sampling program for the geotechnical field investigation of Reach 1 at the LSM Outlet Channel was completed by KGS Group in February 2015. Maple Leaf Drilling Ltd. of Winnipeg, Manitoba provided the drilling services using 150 mm hollow stem augers and HQ coring. Standard Penetration Tests (SPT) were performed at 1.5 m (5 ft) intervals in till deposits to determine the relative density of the soil. Quality representative soil samples were obtained for soil logging and laboratory testing. The drilling investigation was completed under the continuous supervision and direction of KGS Group personnel.

7.3.1 Stratigraphy of Reach 1 LSM Outlet Channel

Based on the 2011 and 2015 geotechnical field investigation results, the stratigraphy at Reach 1 consisted of a thin layer of topsoil overlying till materials including silt till, silty clay till, and then bedrock. Dike fill (silty clay till) was encountered in TH15-01 for a depth of 2.1 m in the inlet area.

Peat and Organic Clay – Peat and organic clay (topsoil) was encountered at the surface and extended to approximate depths of 0.4 to 0.9 m. The topsoil was dark brown in colour and contained organics.

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Silt Till / Silty Clay Till – Varying till deposits were encountered beneath the topsoil containing varying amounts of clay, silt, sand and gravel. The predominant grain size within the till varied spatially and with depth. The till extended to bedrock at approximate depths of 26.7 m in Borehole TH15-01. All 2011 boreholes were drilled to depths ranging from 2.0 m to 12.8 m and were terminated prior to reaching bedrock. The till was grey in colour, moist to wet, hard and contained occasional cobbles and boulders. Based on twelve (12) SPT tests performed in the till from TH15-01, the uncorrected SPT blow counts (N) in the till ranged from 12 to 65.

Bedrock – Limestone bedrock was encountered in TH15-01 at an approximate depth of 26.7 m. Jointing observed in the bedrock core is mainly composed of sub-horizontal fractures, some of which had been slightly weathered and iron stained, or had had iron minerals precipitate out along groundwater flow pathways formed by the bedrock fracture network. The majority of the cored limestone showed some degree of weathering.

The bedrock overall, based on core recoveries and Rock Quality Designation (RQD), appears to be in fair to good condition. Core recovery was about 94% to 98%. RQD rankings varied between approximately 72% and 84%, ranging from a fair to good classification.

Detailed borehole logs, the laboratory testing results and the rock core inspection report are included in Appendix F.

Figure 7.1 shows the profile of the 2015 Reach 1 LSM Outlet Channel. This profile included the ground surface, the 326 m^3/s (11,500 cfs) flow water surface profile and the design channel invert. This profile was used to estimate the excavation volumes of topsoil and composite excavation materials for channel construction.

7.3.2 Groundwater Conditions

Groundwater readings were obtained in May 2015, approximately three months after the completion of the 2015 supplementary geotechnical field investigation program. Table 3.5 (attached at end of report) summarizes the groundwater monitoring results. Section 7.4 discusses the groundwater conditions in detail and provides the preliminary results of the groundwater impact study.

7.3.3 Reach 1 LSM Outlet Channel Slope Stability

A slope stability assessment was conducted to establish the side slope requirements for the Reach 1 LSM Outlet Channel excavation and the dikes (spoil piles) lining along the channel. Three conditions were examined to determine the side slope requirements:

1. Long Term Condition (after construction) with a minimum estimated factor of safety (FS) of 1.5: under full channel flow condition or no flow condition with water at Buffalo Lake levels.
2. Short Term Condition (during construction) with a minimum estimated factor of safety (FS) of 1.3: under dry channel condition.
3. Short Term Condition with minimum estimated factor of safety (FS) of 1.2: under rapid drawdown conditions with 'Closed Gate' conditions after the channel operation.

7.3.4 Channel Configuration

As mentioned in Section 7.1, the channel has an invert of El 241.1 m (El 791.0 ft) at LSM and El 239.6 m (El 786.1 ft) at Big Buffalo Lake, based on the slope and invert of the existing Reach 1 channel. The depth of excavation below ground surface would vary between approximately 1.5 m (5 ft) and 4.5 m (15 ft). The channel essentially cuts through peat and till material and does not intercept rock. Since the invert of the channel is lower than the normal water level El 241.1 m (El 791.0 ft) in Buffalo Creek, there would be standing water in the channel when it is not in operation.

The proposed channel configuration concept consists of widening the existing, 6km long, Reach 1 emergency channel, as shown on the typical cross sections provide on Plate 9, and then extending the channel approximately 2km into the bog area up to Big Buffalo Lake. To excavate the 2km long channel extension, it has been assumed that spoil material from the channel widening section would be pushed into the peat to form a cofferdam on either side of the proposed channel extension section. Based on 2011 field investigations, the depth of peat in the area ranges between 2 and 3m. At this stage of design, it has therefore been assumed that the cofferdam would be 3m high with 4:1 side slopes. Photo 7.2 shows the bog area at the outlet of the Reach 1 Emergency Channel, taken in the fall of 2013 when the outlet channel was closed.

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Photo 7.2
Bog Area Downstream of Reach 1 Emergency Channel



A slope stability assessment was conducted for the Reach 1 LSM Outlet Channel. Based on the slope stability parameter assumed for Route C and Route D, the slope stability assessment assumed the till materials of the Reach 1 channel are similar to the till materials of Route C and Route D, with a shear strength parameter cohesion of c' = 4 kPa and an internal friction angle of Φ' = 27°, which would be a conservative estimate for 'till materials'. Totally saturated groundwater conditions (worst conditions) were assumed.

7.3.5 Results of Slope Stability Assessment

Based on the above, slope stability assessment results indicated that the proposed Reach 1 channel side slope and cofferdam slope of 4H:1V is adequate for the channel excavation ranging from 1.5 m to 4.5 m deep and for the cofferdam system up to 3 m high.

For the LSM Outlet Channels Conceptual Design – Stage 2, the following are recommended for Reach 1:

- For channel 'height of excavation' less than 4.5 m, channel side slopes of 4H:1V are recommended.

- For height of cofferdam less than 3 m, dike slopes of 4H:1V are recommended.
- Topsoil to be removed from the footprint of the outlet channel should be stockpiled to be reused for dressing on the side slopes of the channel and on the spoil / dike.
- Spoil piles or topsoil stockpiles should be placed a minimum distance of 25 m from the top of the outlet channel.

7.3.6 Foundation Considerations for Control Structure

Shallow Foundations

Shallow foundations may be considered for lightly loaded structures at the site with the provision that all footings are to be placed at 2.4 m (8 ft) or deeper below finished grade, which is the recommended design depth for frost penetration. For shallow footings at 2.4 m or deeper below grade, a factored ultimate limit state (ULS) bearing capacity of 280 kPa for stiff till may be assigned for limit state design (LSD). The minimum concrete footing dimension should be 900 mm.

Cast-in-Place Concrete Friction Piles

Cast-in-place (CIP) concrete friction piles may be used to support the proposed structures depending on the design structural loads. Suitable CIP piling methods for the site include the continuous flight auger (CFA) method and the plain bored method depending on the pile diameters. Temporary casing may be required for bored piles due to the potential caving of the overburden soils along the depth. The Factored Ultimate Limit State (ULS) skin friction value of 22 kPa may be assigned for limit state design (LSD).

7.3.7 Future Work for Detailed Design

For the next stage of design (Detailed Design), the following geotechnical/groundwater study works are recommended:

- Develop a groundwater monitoring program to measure the existing piezometers. This will provide historical groundwater records prior to the construction of the channel.
- Perform laboratory testing such as direct shear tests, flexible wall permeability tests from remolded proctor samples to verify the soil strength parameters.

- Conduct an investigation program for the detailed design of the inlet and outlet of the channel. At this stage, there is limited geotechnical information for the channel extension areas of Reach 1 from the existing channel to Big Buffalo Lake.

7.4 GROUNDWATER IMPACTS

Groundwater impacts along Reach 1 were assessed based on 2011 and 2015 geotechnical investigations conducted by KGS Group, as well as a review of available Provincial data for the area. The stratigraphy along Reach 1 generally consists of 0.9 to 1.5 m of peat overlying silt till. Bedrock was identified at the Reach 1 inlet at an approximately El 221 m (TH15-01). The nearest data from the Provincial Groundwater Availability Map Series indicated bedrock at approximately El 224 m. The invert for the proposed widened Reach 1 channel ranges from El 240 to El 241 m. As such, an approximate overburden depth above the bedrock and below the channel invert in the range of 15 to 20 m should be maintained along the channel alignment. Groundwater piezometric pressure elevations were recorded at TH15-01 at approximately El 247.2 m, or about 0.6 m below ground surface.

The potential for blowout of basal soils along the Reach 1 alignment is low based on this assessment, unless there is a naturally occurring zone of more pervious connection from the bedrock aquifer through the tills into channel excavation areas via an inter-till granular zone, for example. Accounting only for intact and homogeneous till conditions, a Factor of Safety against blowout/basal heave of approximately 1.5 was calculated for the construction phase in the Reach 1 area, based on the limited available information.

There is minimal connectivity anticipated between the channel surface water and groundwater aquifer based on the overburden thickness and bedrock aquifer piezometric pressures. Additionally, there are no residential wells identified in close proximity to the channel. As such, no concerns related to aquifer drawdown or GUDI are associated with Reach 1 construction or operation.

Based on Reach 1 channel design, including the utilization of till for the channel sideslopes and to mitigate the drainage of the perched water table present within the overlying peat into the channel excavation, it is not anticipated that the channel will result in drainage of local wetlands.

The till is estimated to have a maximum hydraulic conductivity in the range of 1 x 10^{-6} m/s and should provide a barrier to any significant groundwater inflow to the channel.

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8.0 LAKE ST. MARTIN OUTLET CHANNEL – REACH 2

8.1 DESCRIPTION

The LSM outlet channel extends about 27 km from Lake St. Martin to Lake Winnipeg and consists of three reaches as shown on Plate 1. The second reach (Reach 2) extends approximately 8.6 km (5.3 mi) from Big Buffalo Lake and the outlet of Reach 1 to the Inlet of Reach 3. The first half of Reach 2 is located within the bog area that surrounds Big Buffalo Lake, which becomes inundated with operation of the LSM outlet channel. Water then follows the natural drainage path into Buffalo Creek up to its diversion point into Reach 3.

Excavation of a channel within Reach 2 was contemplated as part of the emergency measures in 2011. However, it was determined that excavation would not be required in Reach 2 to obtain a capacity equal to the capacity of the Reach 1 Emergency Outlet Channel of approximately 113 m^3/s (4,000 cfs). The need for channel improvements in Reach 2 was then re-examined during the Stage 1 studies. Based on the limited data available at the time, a combination of dike construction and the widening and deepening of a natural segment of the upstream end of Buffalo Creek was proposed for design discharges of 255 m^3/s (9,000 cfs) or more.

For the current study, additional hydraulic analyses were conducted, as discussed in Section 8.2. As a result, the proposed concept for Reach 2 has evolved to include the construction of dikes only, without the need of deepening or widening the existing natural channel.

The proposed alignment of the Reach 2 dike would extend approximately 8 km (5 mi) and follow the high ground north of the bog area that surrounds Buffalo Lake and west of Buffalo Creek. The purpose of the dikes would be to contain the inundation within the bog area and the flow within Buffalo Creek. Without the dikes, uncontrolled overland flow could occur to the north, bypassing Reach 3, and travel downwards towards the lower reaches of Buffalo Creek and the Dauphin River. Plate 10 shows the extent of the inundation in the bog area that surrounds Big Buffalo Lake and the proposed alignment of the LSM Reach 2 Dike.

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Though channel excavation would not be required for Reach 2, installation of riprap on the Buffalo Creek channel banks in sharp bends and other vulnerable areas would be required to limit erosion when the LSM Outlet Channel is in operation. Observations of conditions in the Buffalo Creek channel during the emergency operation have identified several areas which are potentially subject to erosion. These are shown on Plate 10.

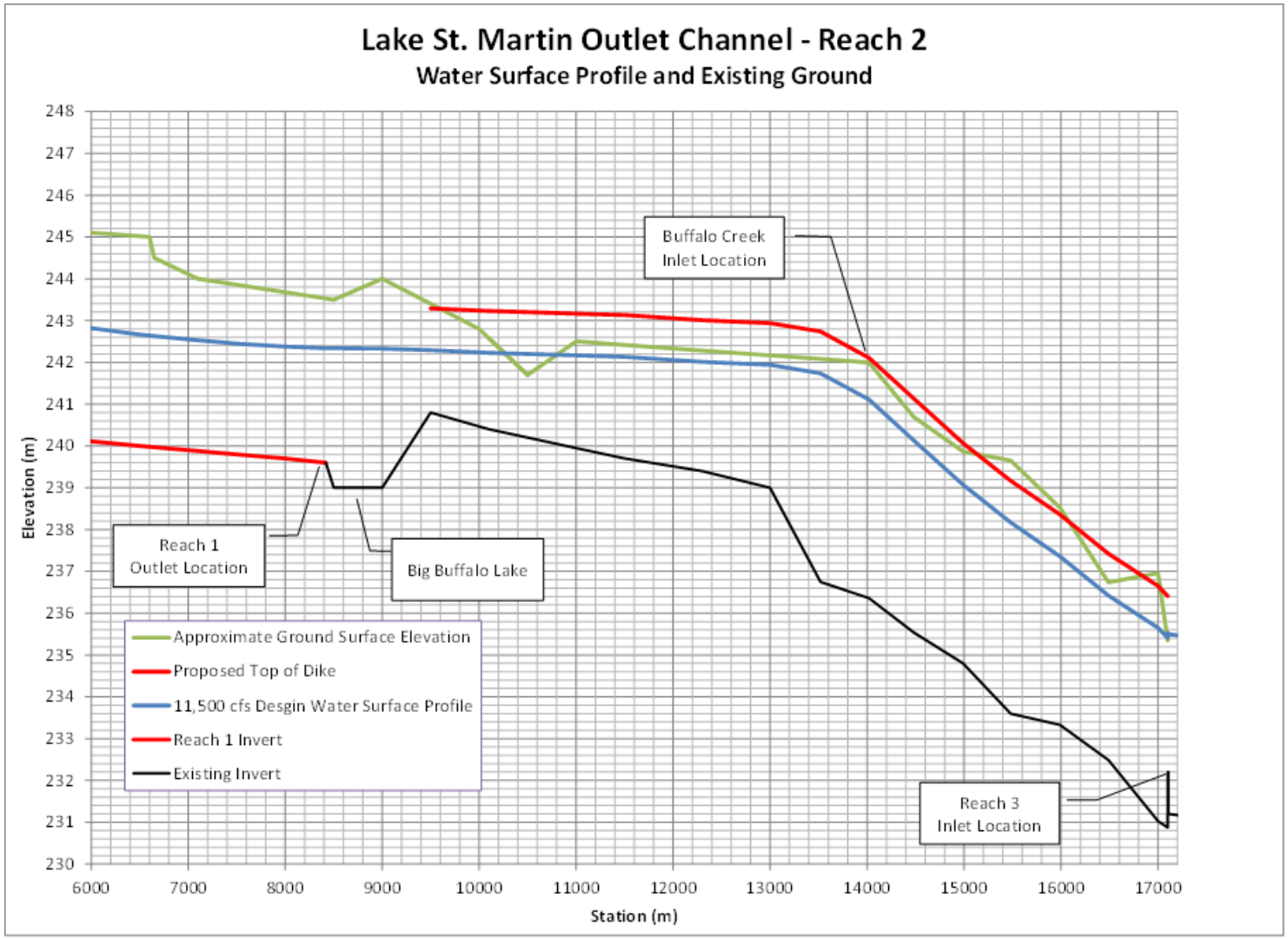
Access to the Reach 2 dike, which is across Buffalo Creek, would occur via the Reach 3 Diversion Structure, as discussed in Section 9.2.3, but only when the LSM outlet channel is not in operation. High water levels and flows in Buffalo Creek and in Reach 3 would impede access when the channel is in operation.

8.2 HYDRAULIC DESIGN

A previous HEC-RAS backwater model of Buffalo Creek was updated for the current study based on data collected as part of the Lake St. Martin Emergency Relief Channel Monitoring and Development of Habitat Compensation Project. The model, which includes Buffalo Creek and the bog area that surrounds Big Buffalo Lake, was updated with cross sections of Buffalo Creek that were collected in 2013 after the 2011/2012 operation of the Emergency Channel. Surveyed cross sections were not available within the bog area surrounding Big Buffalo Lake, therefore, the original cross sections that were based on LiDAR were maintained.

The model was calibrated based on a limited amount of water level data that was also collected as part of the Lake St. Martin Emergency Relief Channel Monitoring and Development of Habitat Compensation Project at flows of about 113 m^3/s (4,000 cfs). Manning's n-values of 0.037 for the main channel and 0.14 for the overbank section of the channel were selected as the final values for the calibration. It should be noted that, though the calibration was successful for the conditions noted above, more detailed surveys of the Buffalo Creek channel and within the bog area will be necessary at the detailed design stage to define with more accuracy the hydraulic conditions within Reach 2 at the design flow of 326 m^3/s (11,500 cfs). A profile of Buffalo Creek and the bog area within Reach 2 is provided on Figure 8.1.

Figure 8.1
Water Surface Profile along Buffalo Creek and the Buffalo Lake Bog Area



The results of the backwater analysis formed the basis to define the proposed dike height. An inundation map within the bog area that surrounds Big Buffalo Lake and along Buffalo Creek was prepared and is shown on Plate 10. The dike height was based on the water surface adjacent to the dike plus 1 m (3.3 ft) of freeboard.

As discussed in Section 13.3.2, peak flows in the LSM outlet channel could exceed the design capacity if the control structure remained fully open during an extreme flood event such as in 2011. This could aggravate flooding within the bog area and encroach on the dike freeboard or possibly even overtop the dikes. Higher dikes could be constructed to address this however, further field investigations and additional surveys within the bog area would be necessary to determine whether this is a practical solution. Limiting the peak flows on the LSM outlet channel or alternatively allowing the dikes to overtop could also be considered as further discussed in Section 13.3.2.

8.3 GEOTECHNICAL DESIGN OF DIKES, REACH 2

The 2015 Reach 2 is a diking system to be constructed along the top of the banks of Buffalo Creek (only the upper portion) as shown on Plate 10 to prevent channel water overtopping this reach of Buffalo Creek and the containment dikes along the rim of the bog.

The 2015 supplementary geotechnical field investigation for Reach 2 of the LSM Outlet Channels consisted of five (5) test pits (TP15-27 to TP15-31) near the top of the bank of Buffalo Creek. These locations are shown on Plate 10.

8.3.1 Stratigraphy of Reach 2 LSM Outlet Channel

Based on the 2015 geotechnical field investigation results, the stratigraphy at Reach 2 consisted of a layer of peat overlying silty clay and till materials.

Peat – Peat was encountered at the surface and extended to approximate depths of 0.4 to 0.9 m. The topsoil was black to brown in colour, wet and soft, with traces of sand and gravel.

Silty Clay – Silty clay layers were encountered separating between the peat and till materials and extended to approximate depths of 1.8 to 3.1 m. The silty clay was brown in colour, moist and firm, with traces of sand and gravel. Cobbles and boulders were also located.

Silt Till – Silt till deposits were encountered beneath the silty clay containing varying amounts of clay, silt, sand and gravel. The predominant grain size within the till varied spatially and with depth. The till extended to depths ranging from 3.4 m to 5.5 m and were terminated prior to reaching bedrock. The till was brown in colour, moist and dense and contained occasional cobbles and boulders.

Bedrock – Bedrock was not encountered in the Reach 2 investigation.

Detail borehole logs and the laboratory testing results are included in Appendix F.

Plate 10 shows the alignment of the 2015 Reach 2 LSM Outlet Channel. For the LSM Outlet Channel Stage 2 design, it is assumed that the height of dike would be less than 3 m high. This alignment was used to estimate the excavation volume of topsoil and the dike fill materials.

8.3.2 Dike Slope Stability, Reach 2 Dike and Containment Dikes

A slope stability assessment was conducted to establish the side slope requirements for the Reach 2 dike and the containment dikes along the rim of the bog. Three conditions were examined to determine the side slope requirements:

1. Long Term Condition (after construction) with a minimum estimated factor of safety (FS) of 1.5: under full channel flow condition or no flow condition.
2. Short Term Condition (during construction) with a minimum estimated factor of safety (FS) of 1.3: under dry condition.
3. Short Term Condition with a minimum estimated factor of safety (FS) of 1.2: under rapid drawdown conditions after channel operation.

8.3.3 Dike Configuration

A slope stability assessment was conducted for the Reach 2 dike and the containment dikes along the rim of the bog of the LSM Outlet Channel. Based on the assumed parameters for the

slope stability analysis of Route C and Route D, slope stability assessment assumed that the dike would be constructed with the till materials, which were similar to the till materials of Route C and Route D with a shear strength parameter cohesion of c' = 4 kPa and an internal friction angle of Φ' = 27°, which would be a conservative estimate for 'till materials'. Totally saturated groundwater conditions (worst conditions) were assumed.

8.3.4 Results of Slope Stability Assessment

Based on the above, slope stability assessment results indicated that the proposed Reach 2 dike side slope of 4H:1V was adequate for a diking system up to 3 m high.

For the LSM Outlet Channels Conceptual Design – Stage 2, the following are recommended for the Reach 2 dike:

- For height of dike less than 3 m, a dike slope of 4H:1V is recommended.
- Topsoil to be removed from the footprint of the outlet channel should be stockpiled and reused as dressing on the side slopes of the channel and on the spoil pile/dike.
- Spoil pile/dike or topsoil stockpile should be placed about 25 m to 30 m away from the top of bank of Buffalo Creek or the rim of the bog.

8.3.5 Future Work for Detailed Design

For the next stage of design (Detailed Design), the following geotechnical/groundwater study work is recommended:

- Conduct an investigation program for the detailed design of the Reach 2 containment dikes. At this stage, there is limited geotechnical information for the proposed Reach 2 containment dikes areas.

8.4 GROUNDWATER IMPACTS

Groundwater impacts along Reach 2 were assessed based on the 2015 geotechnical investigations conducted by KGS Group. The stratigraphy along Reach 2 generally consists of 0.5 to 1.5 m of peat overlying 2 to 3 m of clay, underlain by silt till. Bedrock was not identified along Reach 2. Limited seepage from the silt till layer was observed during test-pitting. The

design for Reach 2 includes stripping of peat (up to 2 m depth) for the construction of containment berms 2 m to 4 m in height, with minimal channel excavation.

No concerns related to groundwater impacts during construction, or relative to longer-term aquifer vulnerability were identified with the proposed Reach 2 construction and operations.

8.5 ALTERNATIVE CHANNEL CONCEPT THROUGH BOG

As previously discussed, prior to entering Buffalo Creek, flows within Reach 2 travel through Big Buffalo Lake and the surrounding bog area. Field surveys conducted in 2011 showed that the depth of peat in some areas within the bog was in excess of 3 m (10 ft). The current LSM outlet channel concept assumes that flow over the bog will occur without significant problems as it did during the 2011/2012 and 2014/2015 emergency operations. None the less, there is a risk that "chunks" of bog releasing and plugging the entrance to Buffalo Creek could occur under different circumstances such as during higher flow conditions or during an unusually long period of operation. Past experience in other areas such as on Lake of the Woods in 2014, and with Manitoba Hydro Rat/Burntwood River 1970's Observation Program (Churchill River Diversion), indicate that though this problem appears unlikely, it cannot be ruled out.

The effect of a bog release plugging the entrance of Buffalo Creek would be to increase water levels within the bog area, potentially increasing the extent of flooding and backwater into Reach 1. An alternative Reach 2 concept was, therefore, considered and consisted of a 200 m wide, 7 km long channel through the bog area. All of the peat within the channel would be removed, and the depth of excavation would vary between approximately 2 and 3 m depending on the depth of peat at an estimated cost of approximately $60 million.

This alternative bog channel concept was not considered as the base assumption for the current study. However, further assessment and contingency plans would be required at the next phase of design to fully address the risk once other aspects of the LSM outlet channel design such as operating rules and the environmental approval process were being finalized. Detailed field investigations and surveys in the bog area would likely be necessary as part of the analyses.

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9.0 LAKE ST. MARTIN OUTLET CHANNEL – REACH 3

9.1 DESCRIPTION

The LSM outlet channel extends about 27 km from Lake St. Martin to Lake Winnipeg and consists of three reaches as shown on Plate 1. The third reach (Reach 3) extends approximately 10 km (6.2 mi) from Big Buffalo Creek to Lake Winnipeg. As discussed in Section 2.1, the Reach 3 Emergency Channel was partially constructed between January and March 2012 to divert flows away from the Dauphin River. However, due to extremely mild winter conditions, operation of the Reach 3 channel was not required; therefore, this channel currently remains in an incomplete condition. The existing Reach 3 Emergency Channel starts at Buffalo Creek and extends about 6 km (3.7 mi) where it exits into a forested and bog area where the land slopes downwards to Lake Winnipeg. It has a base width that varies between 21 and 28 m (68.9 and 91.9 ft) and has a design capacity of approximately 120 m^3/s (4,250 cfs). Tender drawings developed for the 2012 construction of the Lake St. Martin Reach 3 Emergency Channel are provided in Appendix B. Photo 9.1 shows the Reach 3 Emergency Channel in the fall of 2013.

Photo 9.1
Reach 3 Emergency Channel Looking Upstream



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As part of the current project, the proposed Reach 3 Channel will require deepening, widening and lengthening the existing Reach 3 Emergency Channel. The design capacity of Reach 3 will be consistent with those of Reach 1 and Reach 2: 326 m^3/s (11,500 cfs) at a LSM water level of El 244.1 m (El 801.0 ft).

There are two alignment options to lengthen Reach 3 to Lake Winnipeg: extending the existing channel straight to Johnson Beach, or extending the existing channel to the east side of Willow Point. The two options are shown on Plate 11. Both routes are located entirely on crown land and would, therefore, not require any land acquisition.

A diversion structure would be constructed in Buffalo Creek near the inlet of Reach 3 to divert flood flows into Reach 3. The construction of an inlet weir on Reach 3 and of culverts through the diversion structure would be utilized to maintain riparian flow in Buffalo Creek as discussed in Section 9.2.3. Access across Reach 3 would only be available when the LSM Outlet Channel was not in operation via a low flow crossing over the inlet weir. An all season access road would also be constructed to access Reach 3 and as shown on Plate 1.

Figures 9.1 and 9.2 show profile plots of both Reach 3 channel options from Buffalo Creek to Lake Winnipeg. The land surface generally falls gradually along the common reach for both channel alignment options, from El 236 m (El 774.3 ft) at Buffalo Creek (Station 16+600) to El 232 m (El 761.2 ft) at approximately Station 21+000. The land surface then drops rapidly for both channel alignment options to El 218 m (El 715 ft) at approximately Station 27+000, where both channels outlet into Lake Winnipeg.

The proposed channels have an invert of El 231.2 m (El 758.5 ft) at Buffalo Creek and El 213.0 m (El 699.5 ft) at Lake Winnipeg. The large head drop where the land surface falls rapidly would be accommodated with rockfil drop structures. The depth of excavation below ground surface would vary between approximately 2 m (7 ft) and 6 m (20 ft). As discussed in Section 3.0, the channel essentially cuts through peat and till material with a minor area of fragmented rock near Station 21+500.

Local land drainage in the area generally occurs from south to north or east to west and would be intercepted by the channel. However, the construction of outside drain ditches on either side

of the channel will be designed to convey local land drainage that may be impeded by the channel. A low flow channel has not been incorporated into the design of Reach 3 at this phase of study to convey riparian flow; however, this could be considered during the environmental approval process, if necessary.

9.2 HYDRAULIC DESIGN

9.2.1 Channel Design

Both Reach 3 channel alignment options have the same hydraulic design and were based on the Manning's equation to compute the base width using the channel design parameters listed in Table 9.1. The normal depth of flow of 4.3 m (14.1 ft) was assumed based on the channel invert elevation at Buffalo Creek of El 231.2 m (El 758.5 ft) and the design water level for Buffalo Creek of El 235.5 m (El 772.6 ft) at the design discharge of 326 m^3/s (11,500 cfs). Table 9.1 summarizes the hydraulic design of the two channel options. Hydraulic profiles for both Reach 3 options, assuming normal depth of flow are provided on Figures 9.1 and 9.2.

Table 9.1
Hydraulic Design Summary for Lake St. Martin Reach 3 Channel

Design Flow	11,500 cfs
Channel Slope	0.0326 %
Normal Depth of Flow	4.3 m
Assumed Manning's 'n' Value	0.028
Base Width	35.8 m
Side Slopes	4H:1V
Average Velocity	1.4 m/s

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Figure 9.1
Profile of Lake St. Martin Reach 3 Channel with Outlet at Johnson Beach

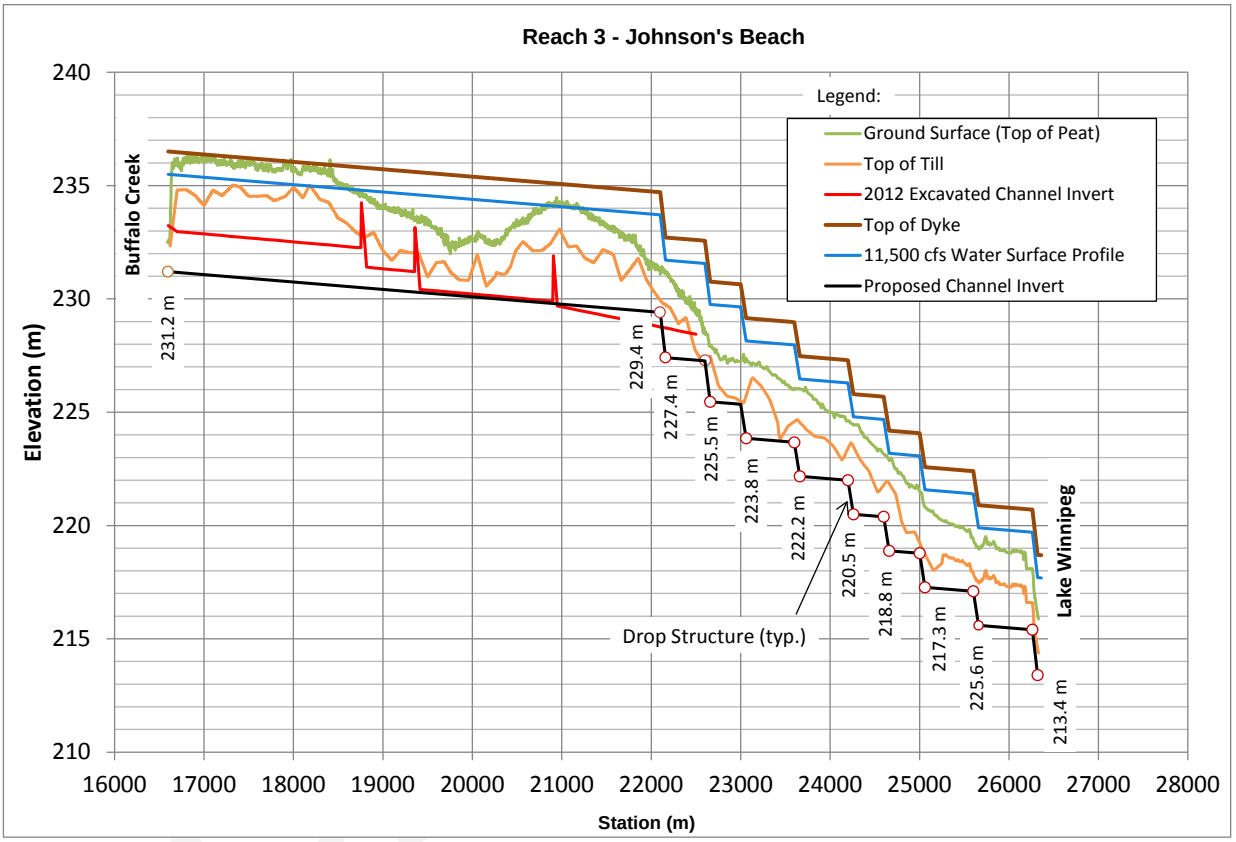
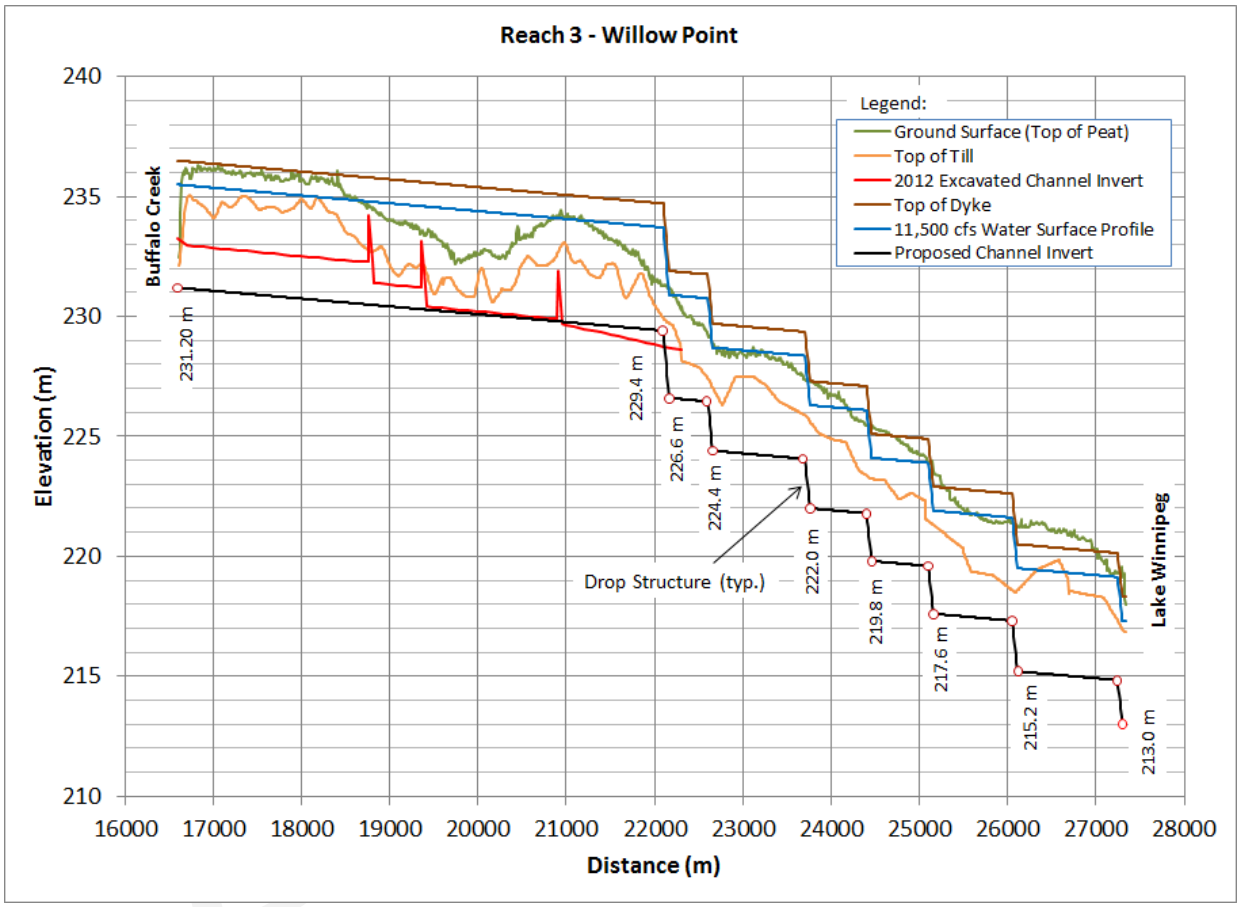


Figure 9.2
Profile of Lake St. Martin Reach 3 Channel with Outlet East of Willow Point



As shown on the profiles, the design water level exceeds the ground elevation at several locations. Furthermore, as discussed in Section 13.0 of the report (Flood Routing Analysis), flows in the channel could exceed design conditions during extreme flood events if the control structure on Reach 1 remained fully open. For the computed 2011 peak flow of 420 m^3/s (14,820 cfs), water levels in the channel would increase by about 0.7 m (2.3 ft). To contain flows within the Reach 3 channel, dikes have been incorporated into the design and are shown on Figures 9.1 and 9.2. The proposed dike height is based on the design water surface profile of 326 m^3/s (11,500 cfs) plus 1 m (3.3 ft) of freeboard. As such, the dike design would also accommodate the increase in water levels and flows during a 2011 type flood event.

It should be noted that the location and number of drop structures can be optimized to reduce the depth of excavation for both Reach 3 channel options. For example, the Reach 3 channel option with an outlet at Johnson's Beach (Figure 9.1) has 9 drop structures with an average

channel invert of about 3 m (10 ft) below the ground surface, whereas the Reach 3 channel option with outlet east of Willow Point (Figure 9.2) has 7 drop structures with an average channel invert of about 4.5 m (15 ft) below the ground surface. The shallower cut has the advantage of reducing excavation quantities. However, it also results in a water surface profile further above the existing ground surface and, therefore, requires higher dikes. At the current phase of design, this difference between the two options can be neglected as it does not impact the hydraulic design of the channels.

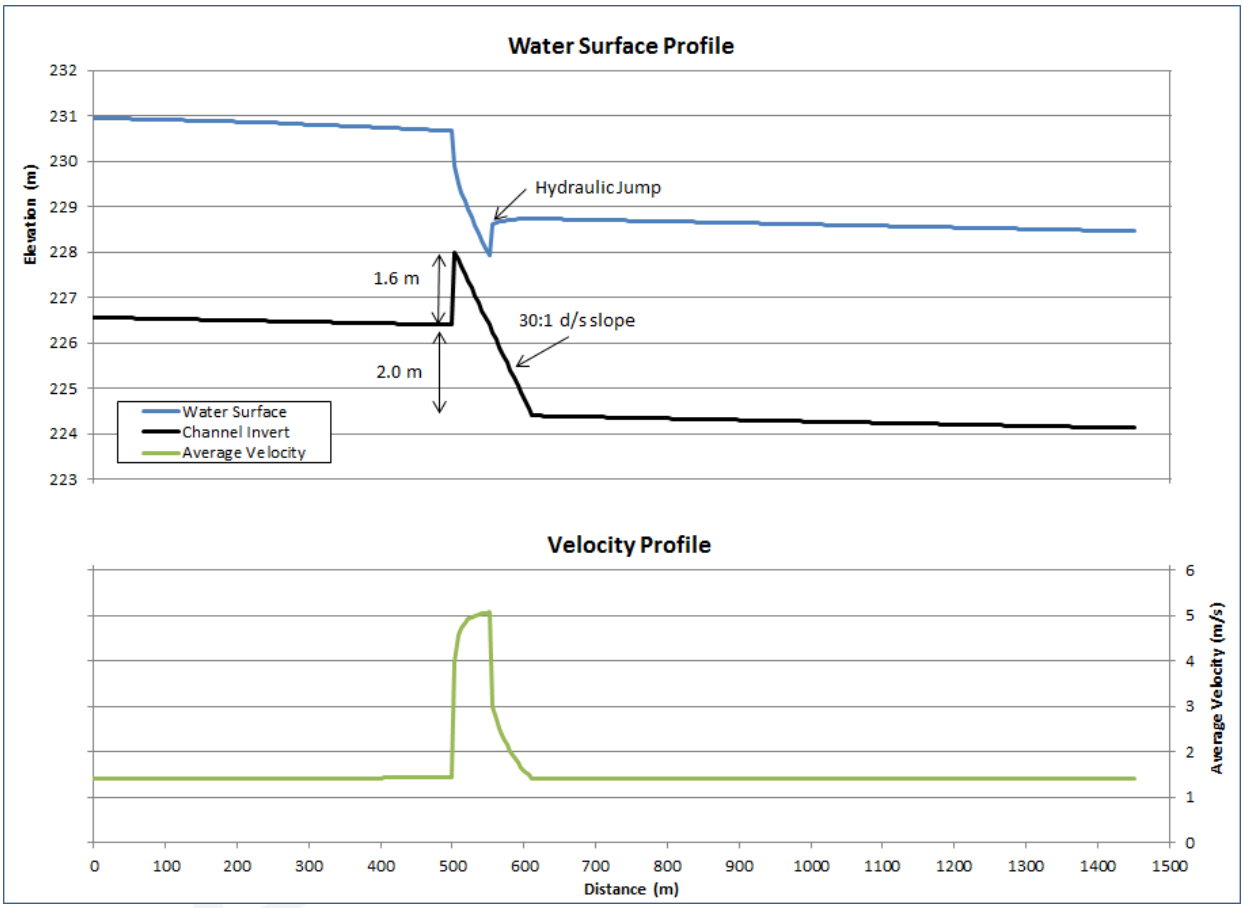
9.2.2 Drop Structures

As previously discussed and shown on Figures 9.1 and 9.2, drop structures have been incorporated into the design of Reach 3 to address the steep sloping terrain from Buffalo Creek to Lake Winnipeg. The design of the drop structures was based on the design guide for a stone paved sloping channel in “Hydraulic Structures” by C.D. Smith (1974). The design consists of rock lined drops in elevation of the channel bed, with a weir at the crest of the drop structure about 1.6 m (5.2 ft) higher than the channel bed upstream. Plate 14 shows a typical plan and profile of the drop structure concept. For a 2 m (6.6 ft) head differential, a design flow of 325 m^3/s (11,500 cfs), and a downstream slope of 30H:1V, each structure would require approximately 11,000 m^3 of rockfil with a d50 of 0.5 m (1.6 ft) and a thickness of twice the d50.

The structures have been designed to maintain the normal depth of flow of 4.3 m (14.1 ft) in the channel upstream of each structure. A typical structure was modeled in HEC-RAS and the water surface and average velocity profiles have been shown on Figure 9.3.

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Figure 9.3
Water Surface and Velocity Profile of Typical Reach 3 Drop Structure



As shown on the figure, a hydraulic jump occurs on the downstream slope of the structure. The highest velocity occurs immediately upstream of the jump and peaks at approximately 5.1 m/s (17 ft/s). Upstream and downstream of the structure, the water depth in the channel is approximately 4.3 m (14.1 ft) with average velocities of about 1.4 m/s (4.6 ft/s), which is consistent with conditions under normal depth of flow.

Due to the presence of a weir at the crest of the structures, water would pond in the channel upstream of each structure when the LSM outlet channel is closed. This might pose an issue associated with fish release after channel use or make it difficult to revegetate the channel. To address this, one or more small culverts could be incorporated into the design through the weir to allow the pool upstream to drain. This would have to be considered further as part of the environmental approval process of the project if deemed necessary.

9.2.3 Diversion Structure at Buffalo Creek

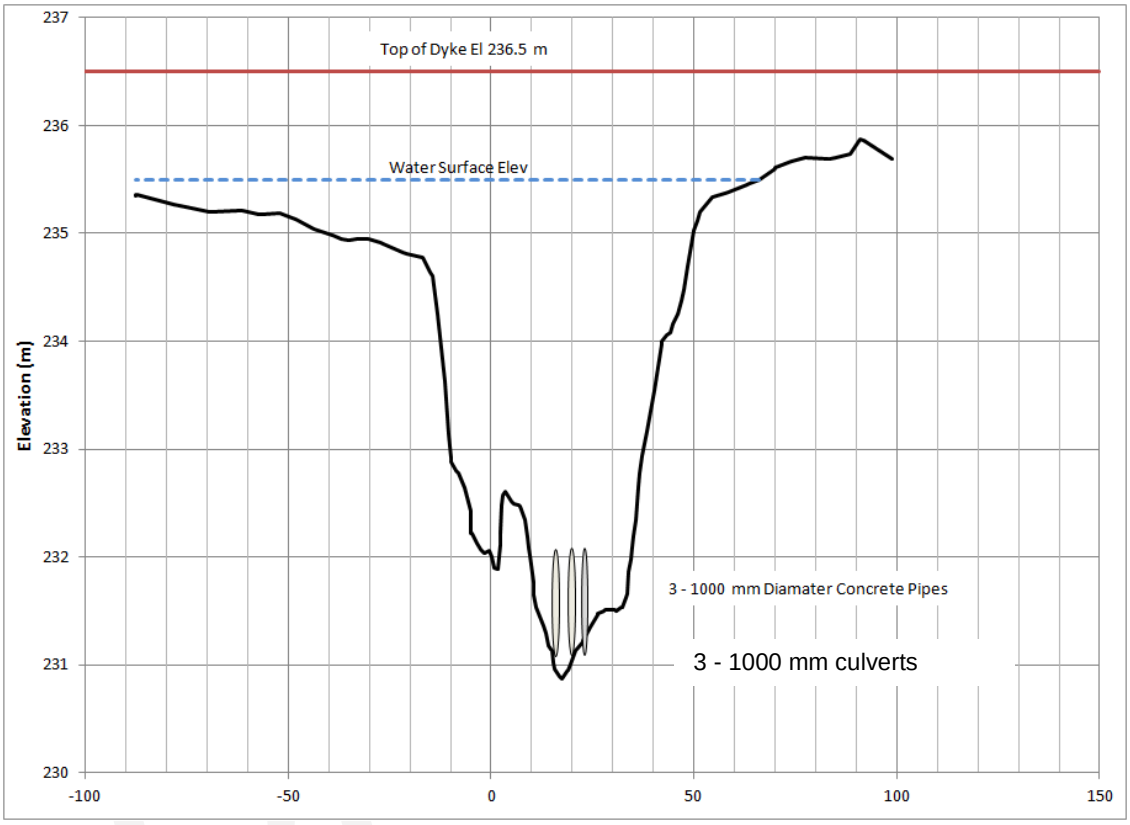
A diversion structure will be used as a cutoff dam on Buffalo Creek to divert the flow to the Reach 3 channel. The location of the diversion structure is just downstream from the Reach 3 inlet location as shown on Plate 11. The proposed structure would be an earth dam with a crest at El 236.5 m (El 775.9 ft) based on the design water level in the Reach 3 channel with 1 m (3.3 ft) freeboard to prevent overtopping from flows possible during a 2011 type flood event in the LSM outlet channel. Photo 9.2 shows the inlet location of the Reach 3 Emergency Channel at Buffalo Creek where the diversion structure would be constructed. At the time of the photo, flows in Buffalo Creek were approximately 113 m^3/s (4,000 cfs).

Photo 9.2
Reach 3 Emergency Channel Inlet Location at Buffalo Creek



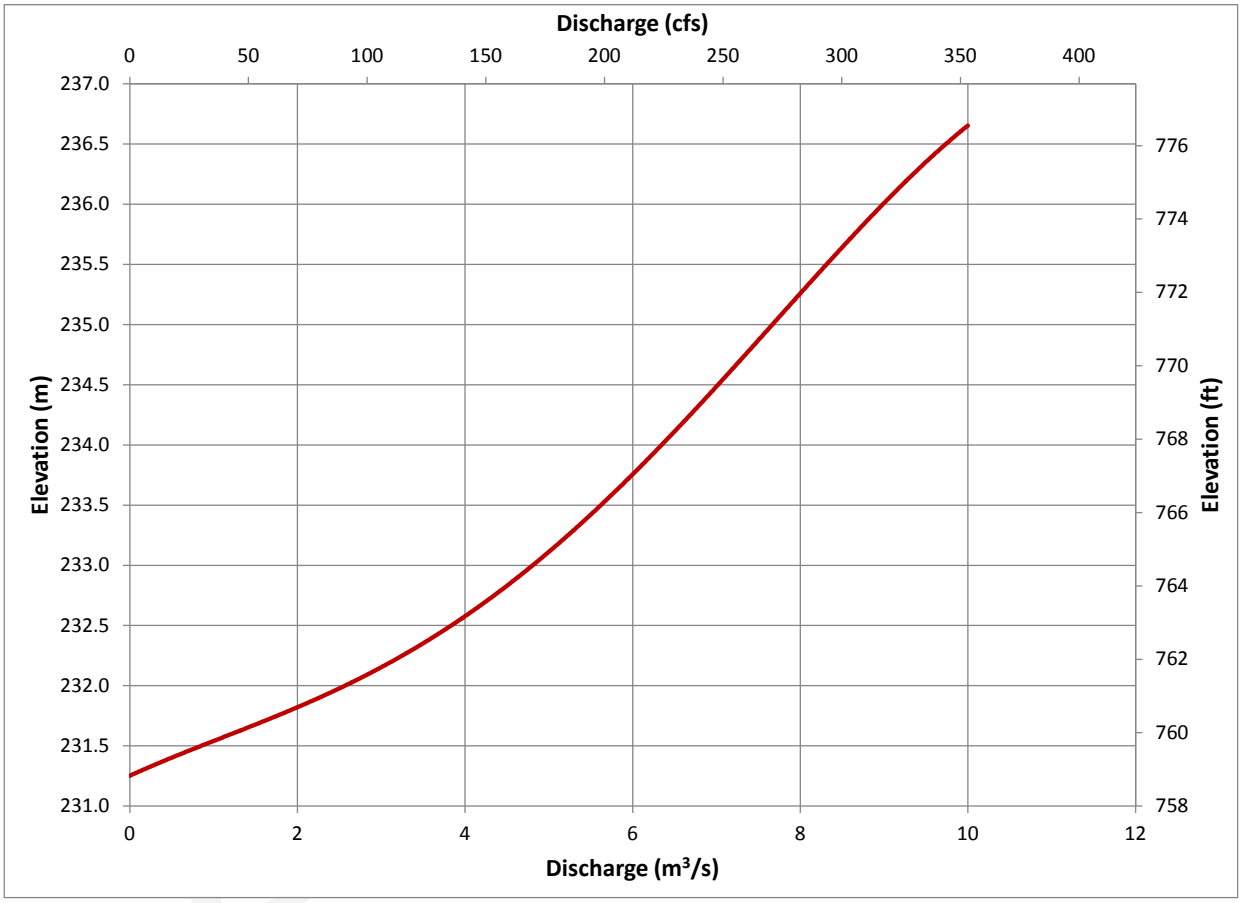
In addition, riparian flow passage for Buffalo Creek would be accommodated with 3-1.0 m diameter culverts constructed through the diversion structure. The invert of the culverts would be about El 231.1 m (758.2 ft) based on the Buffalo Creek invert level and would span about 45 m in length based on an assumed 4:1 side slopes to the diversion structure. Figure 9.4 shows a cross section of the diversion structure and culverts.

Figure 9.4
Cross Section of Diversion Structure and Riparian Flow Culverts on Buffalo Creek



A stage-discharge relationship for the riparian flow culverts is provided on Figure 9.5.

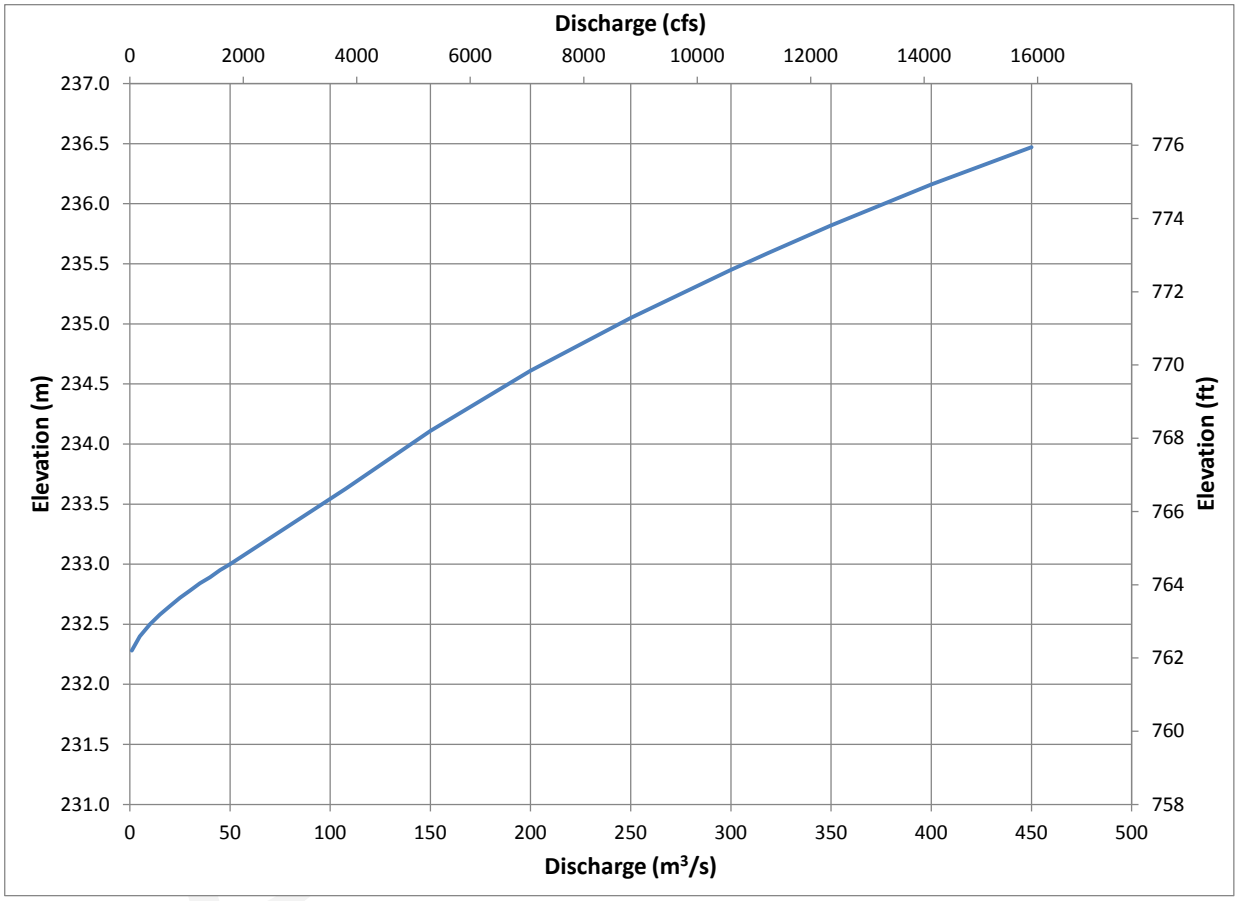
Figure 9.5
Stage-Discharge Relationship for Riparian Flow Culverts



An inlet weir would also be constructed on Reach 3 to help maintain riparian flow in Buffalo Creek when the LSM outlet channel is not in operation. The weir would also provide intermittent access across Reach 3 via a low flow crossing when the LSM outlet channel is not in operation and during periods of normal local runoff on Buffalo Creek. The location of the inlet weir is shown on Plate 11.

The crest level of the weir would be El 232.2 m (El 761.8 ft) or 0.1 m (0.3 ft) above the obvert of the riparian flow culverts. As shown on Figure 9.5, this would allow riparian flows of approximately 3 m^3/s (105 cfs) or less to remain entirely within Buffalo Creek downstream of the diversion control structure. Above 3 m^3/s (105 cfs), the water level would exceed the crest elevation of the weir and at that level the flow would be split between Buffalo Creek and Reach 3. A stage-discharge relationship for Reach 3 is provided on Figure 9.6.

Figure 9.6
Stage-Discharge Relationship for Reach 3



9.3 GEOTECHNICAL DESIGN – REACH 3

The 2015 supplementary geotechnical field investigation for Reach 3 of the LSM Outlet Channels consisted of eleven (11) boreholes (TH15-02 to TH15-12), twenty-six (26) test pits and thirty-nine (39) peat probes. Their locations are shown on Plate 11. Four (4) boreholes (TH15-02 to TH15-05) were drilled along the existing Reach 3 Channel. Seven (7) boreholes (TH15-06 to TH15-012) were drilled along the alignment of the Willow Point Channel. All test pits and peat probes were performed along the alignment of the Willow Point Channel. Standpipe piezometers (SP) were installed in some of the boreholes for groundwater monitoring.

The borehole drilling, test pitting and sampling program for the geotechnical field investigation of Reach 3 at the LSM Outlet Channel were completed by KGS Group in February 2015. Maple Leaf Drilling Ltd. of Winnipeg, Manitoba provided the drilling services using 150 mm hollow stem augers and HQ coring. Standard Penetration Tests (SPT) were performed in 1.5 m (5 ft) intervals in till deposits to determine the relative density of the soil. Test pitting was performed by an Hitachi 270 excavator. Quality representative soil samples were obtained for soil logging and laboratory testing. The drilling and test pitting investigations were completed under the continuous supervision and direction of KGS Group personnel.

9.3.1 Stratigraphy of Reach 3 LSM Outlet Channel

The stratigraphy of the alignment generally consisted of peat overlaying silty clay and silt till. The till was generally found at depths ranging from 1.37 to 5.49 m below grade.

Peat – The peat was black to brown in colour, moist to wet, soft, with rootlets and roots. The thickness of the peat ranged from 0.35 to 1.68 m. Seepage conditions were observed ranging from minor to excessive and requiring the abandonment of the test pits during investigation.

Silty Clay – Silty clay was encountered beneath the peat varying in thickness from 0.76 to 4.12 m. The silty clay was grey to brown in colour, damp to moist, soft to stiff in consistency, of low to intermediate plasticity and contained trace to some sand and gravel. Sand and gravel content typically increased with depth. The undrained shear strength, estimated from the field Torvane ranged from 20 to 100 kPa and typically increased with depth.

Silt Till – Silt till was encountered at depths ranging from 1.37 to 5.49 m. The silt till was generally brown, moist, compact to dense, contained some sand and gravel, and trace to some cobbles and boulders. The density of the till increased with depth.

Bedrock – Limestone bedrock was encountered in TH15-02 to TH15-06 at approximate depths ranging from 6.2 m to 16.5 m. Jointing observed in the bedrock core was mainly composed of sub-horizontal fractures some of which were slightly weathered and iron stained, or had iron minerals precipitate out along groundwater flow pathways formed by the bedrock fracture

network. The majority of the cored limestone showed some degree of weathering beyond the joint faces.

The bedrock overall, based on core recoveries and Rock Quality Designation (RQD), appeared to be in fair to good condition. Core recovery was about 94% to 98%. RQD rankings varied between approximately 72% and 84%, ranging from fair to good classification.

Detailed borehole logs, laboratory testing results and the rock core inspection report are included in Appendix F.

Figure 9.1 shows the profile of the 2015 Reach 3 LSM Outlet Channel. This profile included the ground surface, the 326 m^3/s (11,500 cfs) flow water surface profile and the design channel invert. This profile was used to estimate the excavation volume of topsoil and composite excavation materials for channel construction.

9.3.2 Groundwater Conditions

Groundwater readings were obtained in May 2015, approximately three months after the completion of the 2015 supplementary geotechnical field investigation program. Table 3.5 summarizes the groundwater monitoring results. The artesian groundwater condition in bedrock was encountered in borehole TH15-02 (near Buffalo Creek). This is consistent with the 2011 geotechnical field investigation results. Section 9.4 discusses the groundwater conditions in detail and provides the preliminary results of the groundwater impact study.

9.3.3 Reach 3 LSM Outlet Channel Slope Stability

A slope stability assessment was conducted to establish the side slope requirements for the Reach 3 LSM Outlet Channel excavation and the dike (spoil piles) linings along the channel. Three conditions were examined to determine the side slope requirements:

1. Long Term Condition (after construction) with a minimum estimated factor of safety (FS) of 1.5: under full channel flow condition or no flow condition (dry channel condition).
2. Short Term Condition (during construction) with a minimum estimated factor of safety (FS) of 1.3: under dry channel condition.

3. Short Term Condition with minimum estimated factor of safety (FS) of 1.2: under rapid drawdown conditions with 'Closed Gate' conditions after channel operation.

9.3.4 Channel Configuration

As mentioned in Section 9.1, the proposed channels have an invert of El 231.2 m (El 758.5 ft) at Buffalo Creek and El 213.0 m (El 699.5 ft) at Lake Winnipeg. The large head drop where the land surface falls rapidly would be accommodated with rockfil drop structures. The depth of excavation below ground surface would vary between approximately 2 m (7 ft) and 6 m (20 ft). The channel essentially cuts through peat and till material with a minor area of fragmented rock near Station 21+500. A diking system up to 4 m high would be required for the low lying ground surface areas (see Figures 9.1 and 9.2). Typical cross sections of the Reach 3 channel are provided on Plate 12.

A slope stability assessment was conducted for the Reach 3 LSM Outlet Channel. Based on the assumed parameters for the slope stability analysis of Route C and Route D, the slope stability assessment assumed the till materials of the Reach 3 channel would be similar to the till materials of Route C and Route D with a shear strength parameter of cohesion of c' = 4 kPa and an internal friction angle of Φ' = 27°, which would be a conservative estimate for 'till materials'. Totally saturated groundwater conditions (worst conditions) were assumed.

9.3.5 Results of Slope Stability Assessment

Based on the above, slope stability assessment results indicated that the proposed Reach 3 channel side slope and dike slope of 4H:1V was adequate for the channel excavation ranging from 2 m to 6 m deep and for the diking system up to 4 m high.

For the LSM Outlet Channels Conceptual Design – Stage 2, the following are recommended for Reach 1:

- For channel 'height of excavation' less than 6 m, channel side slopes of 4H:1V are recommended.
- For height of dike less than 4 m, dike slopes of 4H:1V are recommended.
- Topsoil to be removed from the footprint of the outlet channel should be stockpiled, and reused as dressing on the side slopes of the channel and on the spoil pile/ dike.

- Spoil pile/dike or topsoil stockpile should be placed a minimum distance of 25 m from the top of the outlet channel.
- De-watering conditions with water level 1 m below the channel invert would be required during construction.

9.3.6 Reach 3 Cutoff Dam at Buffalo Creek

As mentioned in Section 9.2.3, a diversion structure will be used as a cutoff dam on Buffalo Creek to divert the flow to the Reach 3 channel. The location of the diversion structure is just downstream from the Reach 3 inlet location as shown on Plate 11. The Reach 3 cutoff dam would have a crest elevation of El 236.5 m (El 775.9 ft) based on the design water level in the Reach 3 channel with 1 m (3.3 ft) freeboard to prevent overtopping from flows possible during a 2011 type flood event in the LSM outlet channel. The Reach 3 cutoff dam will be found on Buffalo Creek with the creek bottom at approximately El 231.0 m. The height of the cutoff dam would range from 1.0 m to 5.5 m (see Figure 9.4).

A slope stability assessment was conducted for the Reach 3 LSM Outlet Channel. Based on the assumed parameters for the slope stability analysis of Route C and Route D, the slope stability assessment assumed the till materials of the Reach 3 cutoff dam would be similar to the till materials of Route C and Route D with a shear strength parameter of cohesion of c' = 4 kPa and an internal friction angle of Φ' = 27°, which would be a conservative estimate for 'till materials'. Totally saturated groundwater conditions (worst conditions) were assumed.

Slope stability assessment results indicated that the proposed Reach 3 cutoff dam with a side slope of 4H:1V would be adequate for the dam height ranging from 1 m to 5.5 m high.

9.3.7 Future Work for Detailed Design

For the next stage of design (detail design), the following geotechnical/groundwater study works are recommended:

- Develop a groundwater monitoring program to measure the existing piezometers. This will provide historical groundwater records prior to the construction of the channel and enable a better understanding of the artesian groundwater conditions.

- Perform laboratory testing such as direct shear tests, flexible wall permeability tests from remolded proctor samples to verify the soil strength parameters.
- Conduct an investigation program for the detailed design of the inlet and outlet of the channel.
- Further investigation for the quarry and granular sources as borrows during construction.

9.4 GROUNDWATER IMPACTS

The Reach 3 profile (Figure 9.1) shows the base of the Reach 3 channel profile relative to bedrock and design channel surface water elevations. Based on this assessment, the channel invert contacts bedrock in the area of Sta. 21+000 to Sta. 22+500. Additionally, the proposed channel invert is very close to bedrock at the location of TH15-03 (approximately Sta. 17+311). During the 2015 investigations, bedrock was encountered at test holes TH15-02 to TH15-06, and at TH15-13 (all upstream of approximately Sta. 23+200), and was not encountered in downstream areas beyond Sta. 23+200 (i.e. at TH-07 to TH-12) along the Willow Point alignment. In all cases, borehole advancement was to approximately 3.5 to 6.5 m below the proposed channel invert.

Blowout/basal heave conditions may occur within the channel excavation during the construction phase of the project (unless mitigated by an aquifer depressurization system), if the bedrock aquifer groundwater piezometric pressures exceed the confining overburden mass that remains between the channel excavation invert and bedrock surface elevation during excavation. During channel operations, blowout or basal heave/seepage would be expected if these bedrock aquifer pressures exceed the operating channel surface water profile, and where not confined by sufficient overburden thicknesses.

To assess the blowout and groundwater seepage potentials, an assessment of anticipated groundwater aquifer pressures, overburden depths, and operational channel surface water profiles will be required.

Table 9.2 summarizes the assessment of blowout and basal heave conditions, utilizing the geotechnical information available from field studies for both the construction phase and channel operational phase.

Table 9.2
Factors of Safety against Blowout along Reach 3 Alignment

Borehole	Channel Invert Elevation (m)	Design Operating Water Level (m)	Bedrock Elevation (m)	Bedrock Piezometric Pressure (m)	Factor of Safety - Construction	Factor of Safety - Channel Operation
TH15-02	231.2	234.9	218.7	236.11	1.4	1.7
TH15-03	231	234.8	230.8	235.14	0.1	1.0
TH15-04	230.6	234.4	224.2	237.22	1.0	1.3
TH15-05	230.3	234	227.6	233.33	0.9	1.6
TH15-06	224.3	228.1	219.7	225.42	1.6	2.3
TH15-07	224.2	228	218.9*	227.85**	1.2***	1.6***
TH15-08	224.1	227.9	217.8*	227.22**	1.3***	1.7***
TH15-09	224	227.8	220.7*	226.47**	1.1***	1.8***
TH15-10	219.7	223.5	214.7*	224.22**	1.1***	1.5***
TH15-11	217.5	221.3	213.6*	221.68**	1.0***	1.4***
TH15-12	217.3	221	213.5*	220.96**	1.0***	1.5***

* Bedrock was not encountered during drilling and for the purposes of this assessment is assumed as being equal to the elevation at the end of drilling.
** Bedrock piezometric pressure assumed as similar to pressure in lower till zone.
*** Calculated Factors of Safety are approximate and based on assumptions of bedrock elevation and bedrock piezometric pressure.

The calculated factors of safety range from 0.1 to 1.4 during construction and 1.0 to 2.3 during channel operation. The wide range of Factors of Safety demonstrate the variable bedrock elevations along the alignment, and relative proximity to the base of channel excavation. As such, blowout conditions may be anticipated at various locations of the channel during the construction phase, particularly in the vicinity of TH15-03 (Sta. 17+311) and TH15-04 (Sta. 18+459), as well as between TH15-05 and TH15-06 (Sta. 19+424 to Sta. 24+144) where relatively high bedrock elevations had previously been identified with the 2011 investigations. Factors of Safety during the design water level would be at a typical design Factor of Safety (FoS = 1.5) along most of the channel with exceptions in the area of TH15-03 and TH15-04, as well as the aforementioned high bedrock zone.

The Factors of Safety for the Willow Point alignment at TH15-07 to TH15-12 (Sta. 23+540 to Sta. 26+544) are based on assumed bedrock elevations estimated to be equivalent to the total

depth of drilling advanced into the till, and with bedrock groundwater elevations assumed similar to those observed in the lower silt till zone, which would be the conservative base case condition. In many cases, the bedrock piezometric pressure condition within the upper carbonate aquifer is essentially equivalent to the measured deep silt till piezometric pressures. In this area (TH15-07 to TH15-12, Sta. 23+540 to Sta. 26+544) a minimum of approximately 3.5 m to 6.5 m of overburden will remain between the channel invert and the bedrock surface. Further investigations may be required to better define bedrock elevations and piezometric pressures to confirm the current assumptions and refine the Factors of Safety for blowout/basal heave.

As a result of the potential for blowout conditions, a depressurization program may be required during the construction phase of the program at select locations. The upper bedrock was noted to be lightly to moderately fractured during geotechnical drilling. Falling head tests conducted within the upper bedrock zone also indicated hydraulic conductivity at TH15-03 (Sta. 17+311) of approximately $5.7x10^{-6}$ m/s. A second falling head test at TH15-05 (Sta. 19+424) demonstrated a rapid dissipation of injected water (i.e. a headloss of 2 m in less than 15 seconds). An assessment of bedrock transmissivities has not been completed at this time, with a general assessment that the bedrock may be moderately to highly transmissive, based on the falling head tests. Further hydrogeological testing (e.g. pumping test) in the sensitive areas (e.g. areas of relatively high bedrock elevations) may be required to better define depressurization requirements.

As a result of the potential for blowout conditions, a depressurization program, or other construction-based method of accommodating the high aquifer piezometric pressures and associated basal heave/blowout conditions would be required during the construction and operational phases of the project. There is potential to excavate sumps for pumping within the main excavation periodically along the channel alignment allowing for discharge of groundwater through the sump. This would require channel excavation from the downstream end and working upstream, with sumps installed as necessary. Groundwater discharge would be pumped to discharge from the sumps, and/or flow along the under-construction channel towards Lake Winnipeg. These sumps would be maintained into the operational stage of the channel to provide continued depressurization of the aquifer. Should the bedrock aquifer be found to be

highly transmissive, the potential for groundwater depressurization wells may require investigation.

There are no residential wells identified in close proximity to the channel alignment. As such, no concerns related to aquifer drawdown or GUDI are associated with Reach 3 construction or operation.

Based on the Reach 3 channel design, including the utilization of till for the channel sideslopes and to mitigate the drainage of the perched water table present within the overlying peat into the channel excavation, it is not anticipated that the channel will result in drainage of local wetlands. The till is estimated to have a maximum hydraulic conductivity in the range of 1×10^{-6} m/s and should provide a barrier to any significant groundwater inflow to the channel.

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10.0 LAKE MANITOBA AND LAKE ST. MARTIN CONTROL STRUCTURES

10.1 GENERAL

The layout and design of each of the concrete control structures to be constructed as part of the Project, including structural steel and embedments in primary concrete for supporting gates and stoplogs are described in the following sections. The specifics of the gates, stoplogs and any embedments in secondary concrete, are provided in Section 10.3.

Two control structures are envisioned as a part of the overall project – one each for the Lake Manitoba and Lake St. Martin Outlet Channels. The structures will be similar in design and function with nominal difference in pier heights. As described in Sections 5.2.3 and 6.2.3, at this level of design, the Lake Manitoba Channel Control Structure will consist of three 9 m wide bays and will be very similar for Route C or D. Since the hydraulic capacity of the Lake St. Martin Channel is significantly greater, this structure will consist of six 9 m wide bays. With these exceptions, the function, construction and gate operation of the structures will be very similar as described below. The three-bay and six-bay spillway concepts are shown on Plates 16 and 17. Photo 10.1 shows the new Manitoba Hydro Pointe du Bois control structure which is similar in concept to the proposed structures for the Lake Manitoba and Lake St. Martin Outlet Channels.

Photo 10.1
Manitoba Hydro Pointe du Bois Control Structure



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The structural design and stability analysis of the new concrete structures will be consistent with MIT requirements and CDA Guidelines where relevant. In general, the structures will be designed for the most unfavorable possible combination of the loads due to water, earth, environmental conditions and dead loads to meet temporary and final operating conditions. The required service life for the concrete structures will be planned for a minimum of 65 years. During this period, it is expected that the only maintenance required will be that which can be categorized as routine, and that major repairs or rehabilitation will be unnecessary.

The control structure will be located in the middle of the channel and will be comprised of either three or six 9 m wide sluice bays, guides and sill beams for upstream stoplogs, vertical lift gates and downstream stoplogs. A stilling basin or apron slab will not be required due to the relatively low velocities and the soundness of the rock or till in the discharge channel. The spillway gates will be operated by individual dedicated wire rope hoists located in a heated hoist housing supported on steel towers founded on the spillway piers.

The upstream pier noses are tapered to reduce the headloss. The piers include downstream stoplog slots to isolate the rollway and gates from backwater effects to allow for routine inspection and maintenance of the spillway.

As shown on Plate 15, the control structure bridge deck will be located downstream of the main gates and will consist of individual, precast, concrete beams, laterally post-tensioned. The width of the deck will provide sufficient space for positioning a mobile crane with outriggers extended. The bridge deck will be designed to enable a crawler crane to lift the hoist housing onto the columns.

Upstream stoplogs will be provided to close off all six spillway bays for construction and maintenance purposes. One set of upstream stoplogs will be procured to facilitate future maintenance during operation.

A permanent upstream structural steel walkway will be provided to allow uninterrupted access to the upstream side of the upstream stoplogs. This will facilitate operation of a monorail hoist with pendant control for handling the stoplogs. A cable tray will run along the upstream side of the walkway for electrical services. A movable inspection platform will be provided to enable

inspection of the main spillway gates from the upstream side. The inspection platform will be handled with the monorail crane and will be stored in the monorail extension area.

A pressure relief system is assumed to not be required underneath the base slab. The benefits associated with this type of system have been judged to be outweighed by the additional costs associated with their installation. A grout curtain will be provided underneath the spillway base slab to control seepage.

Concrete gravity transition structures will be located immediately east and west of the spillway. The structures will be sized to minimize total concrete and to meet the requirements for tying into the structures.

An ancillary building will be constructed near the spillway to house mechanical and electrical services. It is likely the building will either be a pre-engineered steel building erected on site or be composed of pre-assembled modules fabricated off-site and assembled on site.

10.2 STANDBY DIESEL GENERATOR FACILITY

A stand-alone standby diesel generator will be installed on a concrete pad near the ancillary building with protection bollards and in proximity of the roadway for refueling and maintenance. The standby diesel generator will likely be skid-mounted and equipped with an outdoor winterized enclosure. No separate HVAC systems are required, as the winterized enclosure will be equipped with built-in ventilation systems (dampers and heaters). Potential spills will be contained by a double-walled, belly diesel tank supplied with the generator. Bollards will be provided for physical protection.

10.3 GATES, GUIDES AND HOIST REQUIREMENTS

The control structure will consist of three or six 9 m wide spillway bays. Each bay will be equipped with a spillway gate and guides, an upstream stoplog check, a downstream stoplog check and a dedicated wire rope hoist. The hoists are located in a hoist housing that spans the length of the structure. The hoist housing is supported by a tower and bridge arrangement. An upstream monorail crane will also be provided for the handling of stoplogs.

The spillway gates will be approximately 9 m wide by 5 or 9 m high fabricated single leaf, vertical lift spillway gates. The gates will have an upstream skinplate and downstream cladding. Sufficient weight will be provided in each gate leaf so that it closes readily under conditions of maximum head. Brass staunching rod type seals will be used on the sides, and moulded rubber sill seals will be provided. It is assumed that each gate will be equipped with two electric forced air heaters, and each gate guide will be provided with gain heating.

The embedded gate guides will be fabricated from steel sections and will be placed in either primary or secondary concrete (both options are acceptable, and the most cost effective method will be selected in consultation with MIT). The roller path, vertical seal path, and sill seal face will be machined, corrosion-resistant steel. All gate guides will be provided with vertical embedded piping of sufficient size to allow for the installation of electric heating elements adjacent to the seal and main and side roller paths. To minimize the potential for cavitation, the gate slots will be designed with a downstream tapered offset. Additionally, steel armouring of the floor and pier face near the gate guides and sill beams will be provided as required to protect against cavitation damage.

Each gate will have two lifting points and will be raised and lowered by dedicated spillway gate hoists that are a double-drum, wire rope design, complete with motor, electro-mechanical brake, fan brake and gearbox, typical of many Manitoba Hydro structures. Because of the availability of emergency power from the diesel generator, a portable gas engine to raise the gates will not be required.

The insulated and heated hoist housing will be supported by a tower and bridge structure. The height of the structure will be sufficient to allow the gates to be raised to the maintenance position with the bottom of the gate 500 mm from above deck level. Enclosed, but unheated stairwells will be provided at each end of the hoist housing with a service space for electrical / mechanical services provided in the east tower. The hoist housing will enclose the spillway gate hoists, gate hoist control panel, gate guide heating control panel and electrical distribution panels. Consideration of a service maintenance hoist along the length of the hoist house and sized to handle a hoist drum and ring gear will be discussed with MIT at the detailed design stage. The service hoist would connect with a monorail beam that extends over the roadway.

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This arrangement would enable the complete removal of a hoist drum and spur gear without the need to open the hoist housing roof or require the use of a mobile crane.

Upstream stoplogs will be provided to close off all Spillway bays for construction and to allow maintenance and inspection of the gates. The upstream stoplogs will be handled by a monorail crane of the double drum design, providing two lifting points with permanent attachment to the follower and supported on the upstream side of the steel towers. The monorail will extend beyond the deck to enable the installation and removal of the stoplogs without the need for a mobile crane. A monorail extension will be supported on a concrete pier to the west of the primary spillway. The length and arrangement of the monorail extension will accommodate flatbed trucks to deliver and remove stoplogs from the spillway location. The monorail crane will be operable by a remote radio control station and back-up pendant controls. Two downstream stoplogs will be provided for use under certain flow conditions to isolate the spillway for maintenance and inspection. Placing and removing the downstream stoplogs will be done with a downstream crane as illustrated in Plate 15. Due to the infrequent use anticipated for use of the downstream stoplogs, consideration could be given to the periodic use of a mobile crane. However, MIT was reluctant to commit to this approach due to interference on the associated PTH.

10.4 FIRE PROTECTION SYSTEM

Fire protection for the spillway will be a combination of passive measures and active fire protection systems. This will involve the installation of clean agent fire extinguishing systems, two standpipes, a dry manual sprinkler arrangement and fire extinguishers. The buildings are normally unoccupied buildings and sprinkler systems are not required by building codes. Fire protection systems will be provided as a means of asset protection, and not to fulfill a life safety requirement of the building code.

10.5 HEATING AND VENTILATING SYSTEMS

Heating will be provided by heavy duty electric unit heaters in the Primary Spillway hoist housing. The unit heaters to meet the 90 kW heating load required for the hoist housing will be wall mounted at a high level with wall mounted thermostats provided for each heater. Both the

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stairwells to the hoist housing will be enclosed, but no heating will be provided, since there are no facilities within them that would be damaged by freezing. The minimal ventilation requirements of the hoist housing will be provided by infiltration.

Each room in the ancillary building will be heated by two heavy-duty electric unit heaters to meet the heating load of 16 kW and controlled by wall-mounted thermostats. This will maintain indoor temperatures within the design range to ensure proper/reliable equipment operation, to minimize maintenance requirements and to provide an acceptable working environment for operation and maintenance staff.

10.6 ANCILLARY BUILDING

The ancillary building located directly near the Spillway will house electrical distribution equipment, communications equipment and fire protection systems. It is anticipated that the Ancillary Building will likely consist of three rooms, two electrical rooms and one communications / fire protection room.

10.7 STANDBY DIESEL GENERATOR

The standby generator will be a 600 V 3 phase generator with a turbocharged diesel engine for quick response time to provide emergency backup power, should both 12.47 kV lines fail to provide service. The final size of the generator will be determined once all electrical and mechanical designs have been completed including final loads designed by the successful Gate Guide and Hoist supplier. However, preliminary load estimates for the Ancillary Building and Spillways indicate that 750 kW would be required. For a 750 kW generator, a 1,000 liter fuel tank would be required to supply 4 hours of runtime at full load.

10.8 COMMUNICATION, ALARM AND SECURITY SYSTEMS

There is no requirement for cyber security as part of the Project. Physical security features that will be provided as part of the Project include a road access gate, as well as an intrusion alarm and door control for the Ancillary Building and Primary Spillway stairwell access.

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The public will be able to access the structures by foot or by boat; and, therefore, there will be some public safety equipment, such as warning signs and booms both upstream and downstream that will be required.

There is no requirement for CCTV cameras for security purposes at the Spillway. There will, however, likely be CCTV cameras for operational reasons at the Spillway. A number of cameras are anticipated to be required to cover the site. One at each end of the Spillway on both upstream and downstream sides, and directed towards the Spillway. One camera will observe the standby generator area. These cameras will be fixed mounted and wide angle. This will allow operators should MIT pursue some form of remote operation to observe the Spillway before changing gate status or in response to alarms.

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11.0 PERMANENT AND CONSTRUCTION POWER SUPPLY

11.1 GENERAL

Electrical power will be required for the permanent control structure(s), as well as for their construction.

As discussed in Section 10.0, one six-bay concrete spill structure will be located near the new outlet from Lake St. Martin to control the water discharging on Reach 1 from Lake St. Martin towards Lake Winnipeg. There are two options for the location of the second three-bay concrete spill structure controlling the water discharge from Lake Manitoba to Lake St. Martin (Option C and Option D).

Both the LMB and LSM structures will require permanent power to electrically raise and lower the gates, as well as to heat an appropriate number of gates to maintain winter operation capability.

11.2 LAKE ST. MARTIN CONTROL STRUCTURE

11.2.1 General

The control structure at Lake St. Martin is based on a six-bay concrete structure as shown on Plate 17. It is located remotely from existing Manitoba Hydro electrical power sources.

The control structure site is also located remotely from adequate sources of concrete, rock and aggregate and construction staff accommodation. Accordingly, during construction of the control structure, it is likely that a camp with sleeping and meal facilities will be required. Our cost estimate assumes that a rock crushing and a concrete batch plant will also be required, as well as offices, carpentry shops, and vehicle maintenance facilities.

11.2.2 Permanent Power Requirements

The permanent power planning requirements to operate the facility are estimated as follows:

Gate Guide Heating

Although the gates are not anticipated to be operated significantly during the winter months, provisions have been included for each of the six gates to be provided with electric gate guide heaters to keep the gate slots and rollers free from ice. This is required primarily to prevent ice from damaging the gate slot components. It will also keep the gate slots operational and free from ice. Each gate requires an estimated 21 kW of installed gain heating. These requirements will be reviewed at the detailed design stage when operational constraints and needs are defined.

Gate Body Heating

Operation of the control structure is expected to be required approximately once every two years. In many years, the structure would only be required to operate in the spring when there is no significant risk of ice. However, there are years when the gates could be required to operate throughout the winter to drain Lake Manitoba in anticipation of high flows entering Lake Manitoba during spring melt.

Under conditions of no flow, the control structure will have approximately two meters of tailwater on the downstream side. While this tailwater could possibly not have an ice cover when passing water, this cannot always be guaranteed. Accordingly, the downstream skin plate on each gate needs to be equipped with heating to prevent ice from binding the gate in and also possibly damaging the gate body.

This operational requirement, as well as the significant risk of structural damage to the gate if water enters the lower section of the gate and then freezes, would require that all six gates be heated throughout the winter each year. This will include heating the downstream submerged section to prevent the gate from being frozen in and becoming inoperable. These operational requirements will be reviewed with MIT at the detailed design stage.

For purposes of the electrical system, all gates will be provided with gate body heating to keep the upstream gate face free from ice. Each gate will also be equipped with downstream skin

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plate heating to a height of 2 m. The functional requirements for potential damage, due to ice during operation, to the gates will be reviewed at the detailed design stage.

Gate Hoist Motor(s)

The gates are not required to move quickly as there is ample time to adjust them. Nor is more than one gate required to operate at one time. A 15 to 25 HP motor is likely more than adequate.

Gate Hoist House Heating

An allowance of 25 kW of heater(s) for each bay has been provided.

Lighting and Incidentals

An allowance of 15 kW for incidentals has been allowed provided.

Based on the above electrical demands, the permanent power requirements are estimated at:

Gate guide heating	6 gates at 21 kW	=	126 kW
Gate body heating			
Upstream	6 gates at 22.5 kW	=	135 kW
Downstream	6 gates at 10 kW	=	60 kW
Hoist motor	1 gate at 25 HP	=	25 kW
Hoist house heating	6 bays at 25 kW	=	125 kW
Hoist house Lighting			15 kW
Incidentals			15 kW
Total			526 kW

A 750 kVA supply transformer is an appropriate size at this stage of study. Power supply requirements and the status of discussions with Manitoba Hydro to supply this power to the site are described in Section 16.0.

11.2.3 Construction Power Requirements

As indicated in Section 11.1 General, the site of the control structure is at a remote location with no nearby infrastructure available to support its construction. The April 10, 2015 memorandum entitled, Diesel Generated Electricity for Construction – 6-Bay Spillway, in Appendix H outlines the extent of services required to support the construction activities and estimates the electrical loads that would need to be accommodated. These include the following major components:

Construction Camp

A camp capable of supporting 100 to 150 people has been assumed. This would be dependent on the construction schedule to be adopted. A faster schedule would require more workers and a larger camp. This electrical load is estimated at 1500 KVA.

Concrete Batch Plant

There are no concrete facilities with adequate capacity nearby. Facilities to support the largest pour, including chilled water system to pre-cool the concrete and adequate redundancy to support the construction schedule, would be required. This electrical load is estimated at 750 MVA.

Rock crushing Facilities

There are no rock crushing and aggregate facilities within reasonable trucking distances and with adequate capacity to support the construction. Accordingly, rock crushing facilities will be required. The source of materials is not known at this time. It is reasonable to assume this equipment will not be grid connected and will come with its own generation facilities.

General Construction Needs

The Contractor will also require electrical power for general construction purposes, including major pumps to manage water on the site, temporary heating during construction, carpentry

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shops, indoor material storage sheds, cranes, offices, fire protection, and water supply. This electrical load has been estimated at 750 MVA.

Based on these component load estimates, a reasonable estimate for construction power is 3,000 KVA.

11.3 LAKE MANITOBA OUTLET CONTROL STRUCTURE

11.3.1 General

The control structure, which controls the release from Lake Manitoba into Lake St. Martin, is a three-bay concrete structure. The sizes of the three bays are similar to the Lake St. Martin control structure. Two potential locations (labelled 'C' and 'D') are possible as shown on Plate 1. For purposes of electrical power requirements, both options may be considered to be the same. Both control structures would be located on PTH 6 and include a bridge component to allow PTH 6 to cross the control structure.

The two optional locations are both close to existing Manitoba Hydro electrical service infrastructure for permanent power requirements. Manitoba Hydro has a power line, which runs adjacent to PTH 6.

There is no obvious source for concrete to construct the concrete structure. The closest source of concrete for the two locations is Ashern. At this level of design, it has been assumed that these facilities are inadequate. The largest pour would be the base slab and is estimated at approximately 500 m^3. Facilitating a pour of this magnitude would require approximately 70 truckloads over a 15 hour period. Accordingly, we have assumed a batch plant would be required for this structure as well.

At half the size of the Lake St. Martin Control Structure, it will be easier to construct with a shorter construction schedule and a smaller workforce. Accommodation for construction staff would either need to be made at existing facilities in the area or a construction camp would need to be established. The need for a camp would be determined by the final project schedule and the associated staffing, as well as a more detailed estimate of the available local resources.

This will require further investigation in the final design phase. For purpose of the preliminary design, a 50 to 75 person camp that will require sleeping and meal facilities has been assumed.

Both sites are located in the vicinity of Ashern. Aggregate sources and rock crushing, if required, would have independent electrical power sources.

11.3.2 Permanent Power Requirements

As described in Section 13.0, at this level of design, it has been assumed that the gates will be required to be operated in the winter. The permanent power requirements to operate the facility are estimated as follows:

Gate Guide Heating

Each of the three gates will be provided with electric gate guide heaters to keep the gate slots and rollers free from ice. This is required primarily to prevent ice from damaging the gate slot components. It will also keep the gates operational and free from ice. Each gate requires 21 kW of installed gain heating.

Gate Body Heating

As with the Lake St. Martin control structure, operation of the control structure is expected to be required, on average, once every two years. For many years the structure would only be required to operate when there is no risk of ice. However, there are years when the gates could be required to operate throughout the winter to drain Lake Manitoba in anticipation of high flows entering Lake Manitoba during spring melt.

Under conditions of no flow, the control structure will have approximately one meter of tailwater on the downstream side. While this tailwater could possibly not have an ice cover, this cannot always be guaranteed. Accordingly, the downstream skin plate on each gate needs to be equipped with heating to prevent ice from binding the gate in, and also possibly damaging the gate body.

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For purposes of the electrical system, all gates will be provided with gate body heating to keep the gate upstream face free from ice. Each gate will also be equipped with downstream skin plate heating to a height of 1 m. Each gate will require 22.5 kW of gate body heating and 5 kW of downstream skin plate heating.

Gate Hoist Motor(s)

The gates are not required to move quickly as there is ample time to adjust them. Nor is more than one gate required to operate at one time. A 15 to 25 HP motor is likely more than adequate.

Gate Hoist House Heating

An allowance of 25 kW of heater(s) for each bay has been provided.

Lighting and Incidentals

An allowance of 15 kW for incidentals has been provided.

The permanent power requirements are estimated at:

Gate Guide Heating	3 Gates at 21 Kw	63 Kw
Gate Body Heating		
Upstream	3 gates at 22.5 kW	68 kW
Downstream	3 gates at 5 kW	15 kW
Hoist Motor	1 Gate at 25 HP	25 Kw
Hoist House Heating	3 Bays at 25 Kw	75 Kw
Hoist House Lighting		5 Kw
Incidentals		15 kW
Total		266 kW

A 300 kVA supply transformer is an appropriate size at this stage of study, and associated “tie-in” costs. Power supply requirements are discussed in Section 16.0.

11.3.3 Construction Power Requirements

The current construction schedule calls for both structures to be constructed at the same time. The construction power requirements at the Lake Manitoba Control Structure are similar to those required at the Lake St. Martin Control Structure, with the following differences:

- Lake Manitoba Structure will likely require a smaller camp or no camp at all. At the present time, a camp is proposed at approximately ⅔ the size.

As with the Lake St. Martin Control Structure, the construction power requirements are still in the order of 3,000 KVA and at this preliminary phase can be considered equivalent. Manitoba Hydro has indicated that they cannot accommodate a 3 MVA load at reasonable cost or appropriate schedule. Accordingly, a prime power diesel generator power system will be required for this location as well.

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12.0 FAIRFORD RIVER WATER CONTROL STRUCTURE FISHWAY

The Lake Manitoba and Lake St. Martin Regulation Review Committee recommended that: *"If the Province builds a new outlet to Lake Manitoba as recommended, it should take that opportunity to design the new outlet in such a way as to provide unrestricted fish passage between Lake Manitoba and Lake St. Martin".* However, the Stage 1 Conceptual Design Study indicated that fish passage is not feasible within the outlet channels because they would not be continuously operated; therefore, all options should consider improvement of the fish passage directly at the Fairford River Water Control Structure (FRWCS). A conceptual design for the replacement of the Fairford Dam fish passage structure has now been developed as part of the proposed project.

The Fairford Dam, also known as the Fairford River Water Control Structure (FRWCS), is located along the Fairford River, approximately 1.0 km downstream from the river outlet from Lake Manitoba as shown in Photo 12.1. The FRWCS was originally constructed in 1961 and later rehabilitated in 2005. The 72.29 m (237'-2") long combination dam and bridge structure consists of 11 bays each measuring 5.482 m (19'-2").

Photo 12.1
FRWCS (June 27, 2011) Looking East



Although two concrete weirs were integrated during the construction of the dam in 1961 in one of the bays to facilitate fish passage, there is no evidence that these weirs were ever effective in facilitating upstream fish passage. In 1984, a Denil fishway was constructed in the third bay from the south (Bay #9). Further studies confirmed the effectiveness of the fishway for species and sizes of fish found in the Fairford River. In 2005, portions of the existing Denil fishway structure timber and structural steel components were rehabilitated.

For the proposed conceptual design of the replacement fishway, Walleye (Sander vitreus), Sauger (Sander Canadensis), Lake Whitefish (Coregonus clupeaformis) and Northern Pike (Esox Lucius) were considered as target fish species. Each component of the fishway should be designed to allow for hydraulic conditions that would provide the opportunity for the successful passage of each of the identified target fish species. The proposed fishway is designed at a conceptual level to provide adequate conditions for upstream fish passage for Lake Manitoba levels ranging from El 246.89 m (810 ft) to El 247.50 (812 ft), assuming a minimum discharge at the Fairford Dam of 23 m^3/s (800 cfs), and up to El 247.80 m (813 ft) assuming that the Fairford Dam is fully open. The corresponding tailwater level during operation of the fishway would range from El 245.1 m (804 ft) to El 247.2 m (811ft). The proposed fishway would be designed for a maximum head difference of 2.4 m (7’ 10.5”). Based on the annual duration curve of historical Lake Manitoba levels shown in Figure 13.11 (Section 13.0), the fishway would then provide upstream fish passage approximately 95% of the time. At lake levels exceeding El 247.80 m (813 ft), the fishway would be closed.

The proposed concept consists of a pool and riffle fishway located on the north bank of the Fairford River as shown on Plate 18. One of the benefits of the decommissioning of the existing Denil Fishway in Bay #9 is to allow for additional discharge capacity at the Fairford River Water Control Structure. The fishway entrance would be located approximately 10 to 20 m to the north of the north abutment of the Fairford Dam. It is anticipated that some excavation in the wet will be required to reach the required minimum invert at El 244.5 m (736.5 ft). The proposed fishway channel would be excavated into the north riverbank along PTH6 at a 20:1 slope for a fish passage structure, which has been considered appropriate for this application. Relocation of the existing drainage system along PTH 6 and through the access roads north of the proposed location may be required and should be reviewed during the next stage of the design. The top width of the fishway channel is expected to be approximately 10 m. Further topographic data

would be required in the area to confirm channel dimensions, as well as excavation and material placement volumes. The fishway channel will be lined with an impermeable liner under rockfil. The Lower Fishway would include approximately six V-notch rockfil riffles. These nature-like riffles would allow for a maximum of a 0.3 m drop in water level between each riffle, therefore creating a succession of resting pools and riffles. The riffles would be designed to maintain the maximum velocity at the crest below the maximum swimming speed of the target fish species. For the proposed design, the riffles are designed for maximum velocities ranging from 1.0 m/s to 1.5 m/s, which are anticipated to be below the maximum burst speed of Northern Pike.

The proposed fish passage structure is constituted of two channels, namely the Upper Fishway and the Lower Fishway, to accommodate for the natural variation and range in Lake Manitoba levels. The proposed concept includes a concrete control structure at the top of the Lower Fishway (operated with timber stoplogs or a steel gate), which would allow the passage of the fishway flow through the upper section of the fishway channel for the upper range of the Lake St. Martin level. A galvanized steel platform would be required on top of the control structure for access during its operation. The Upper Fishway includes two additional riffles, which would raise the water level in the fishway by an additional 0.6 m, to reach the required level at the fishway exit without exceeding the swimming capabilities of the target fish species. During low lake levels, the concrete stoplog structure would be fully open and the entirety of the fishway flow would pass through the Lower Fishway while the Upper Fishway would remain dry. Operation of the fishway structure would be required in conjunction with the operation of the Fairford River Water Control Structure and when the Lake Manitoba levels reach approximately El 247.2 m.

Passage of the fishway under PTH 6 would require the installation of a concrete box culvert, or alternate culvert structure acceptable to MIT. A 2400 mm x 1800 mm structure with beveled-end sections was considered for this concept. The invert elevation of the box culvert would be set at El 246.0 m, to maintain sufficient water depth inside. The box culvert would also include a 600 mm wide stoplog structure at the upstream end to minimize the range of flows going through the fishway with variable Lake Manitoba levels, and also to allow for complete dewatering of the structure for maintenance or repairs, if required. Placement of the culvert will require a staged construction sequence and temporary traffic control to ensure traffic is maintained on PTH 6, as there are no alternate crossing locations along the Fairford River.

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13.0 FLOOD ROUTING ANALYSES

Following the flood of 2011, the Province commissioned the Lake Manitoba and Lake St. Martin Regulation Review, chaired by Mr. Harold Westdal (Regulation Review, 2013). Amongst other items, the purpose of the Regulation Review was to provide recommendations on:

- The need for additional water control works.
- The most acceptable and practical range of regulation within which the levels of Lake Manitoba and Lake St. Martin (LSM) might be controlled.

KGS Group has considered the recommendations of the Regulation Review in the assessment of the various channel options studied in the Stage 2 study. One recommendation that pertained to the design and operation of the outlet channels was that the capacity of the LSM outlet channel should be sufficient that the LSM water level could be controlled within the desirable range of El 797 to El 800 feet at least 90% of the time.

Accordingly, KGS Group undertook flood routing studies to determine whether the channel operation satisfied the Regulation Review recommendation in terms of maintaining LSM water levels within the desirable range. Additionally, the flood routing studies were performed to:

- Demonstrate the benefits of the channel to reducing water levels on LMB and LSM.
- Determine the peak discharges in the channels.
- Determine when the channel is operated during any year and the frequency of use of the channel during the period of record.

13.1 OPERATING RULES

The flood routing of inflows through LMB and LSM with and without outlet channels has been based on assumed operating rules for the existing Fairford River Water Control Structure (FRWCS) and the outlet channels. While the rules of operation for the channels have not been resolved by the Province, the rules of operation that have been considered in the flood routing analyses are based on a combination of the existing rules for the FRWCS, recommendations from the Regulation Review and discussion with the Study Technical Committee.

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It should be noted that a separate initiative by the Province of Manitoba, the Provincial Flood Control Infrastructure Review of Operating Guidelines, was initiated in the fall of 2013 and was mandated to review the operating rules and guidelines of the Red River Floodway, Portage Diversion and FRWCS as a system. Results from this review were not available at the time of the flood routing analyses conducted by KGS Group for the current study. However, based on information provided at the Review's Open House events, as well as discussions with Rick Bowering who is a member of the Review Panel, no significant changes to the FRWCS operating rules are anticipated at this time. Nevertheless, the review may recommend changes to the Portage Diversion operating guidelines, which could in turn impact inflows to Lake Manitoba. As such, though the flood routing results presented in Section 13.3 are representative of the most current available information and data for Lake Manitoba and Lake St. Martin, the results of the Review Panel should be considered at the next stage of design when the operating rules for the outlet channels are being finalized.

Additionally, upgrades to the Lower Assiniboine River Capacity, including the Provincial Dike system, as well as to the Portage Diversion are being proposed as part of the Assiniboine River and Lake Manitoba Basins Flood Mitigation Study, which could also impact inflows to Lake Manitoba. This should also be considered at the next stage of design if the Province adopts the recommendations of the Flood Mitigation Study.

As discussed in Section 4.1, another initiative by the Province of Manitoba has been to pursue flood easements around Lake St. Martin. Though not finalized, the flood easements are currently proposed at a level of El 245.7 m (El 806 ft) around the lake, based on a static water level of El 244.8 m (El 803 ft) plus 0.9 m (3 ft) for wind, waves and freeboard. As discussed with MIT, the preliminary LSM outlet channel design and the assumed operating rules defined in the sections that follow do not consider the potential flood easements. Optimization of the channel design could be considered at the next phase of design if the flood easements are finalized.

13.1.1 Lake Manitoba

It was assumed that the proposed LMB outlet channel will be operated in conjunction with the existing FRWCS to control water levels on LMB and LSM. For LMB, the LMB outlet channel will be used to augment the discharge on the Fairford River. For simplicity in the model, the control

structure on the outlet channel was assumed to be operated either fully opened or fully closed whereas the existing FRWCS will be used to provide controlled discharges to maintain the lake level within the prescribed operating range and to maintain the existing flow pattern in the Fairford River and Lake Pineimuta when the outlet channel is closed. The gate systems on the outlet channel would still be designed to operate at partial opening to limit peak flows for example, however, the preferred method of operation should be considered further at the next phase of design as part of the environmental approval process when specific conditions such as minimum flow requirements are identified.

The following rules of operation for the LMB outlet channel were assumed:

- The operating range for LMB has been assumed as El 246.9 m to 247.5 m (El 810.0 ft to El 812.0 ft) for the entire period of analysis. This range is 0.5 ft lower than the existing range of operation and is based on the Regulation Review recommendation that the lower range be used for a period of five years (starting in 2013 when they issued their report). The lower range was adopted for the entire period of analysis to best represent the ability of the outlet channel to reduce water levels on LMB.
- For simplicity in the model, the gates in the LMB outlet channel are assumed to be either fully opened or fully closed. The gate systems would still be designed to operate at partial opening, however, at this stage of study only the fully open or closed assumptions have been considered in the routing.
- Partial stoplog settings in the FRWCS will be used to regulate discharges from LMB.
- The stoplogs in the FRWCS and the gates in the new outlet channel will be fully opened when the LMB water level is above the top of the desirable operating range El 247.5 m (El 812.0 ft).
- During recovery from a flood condition on LMB (i.e. when LMB water levels are decreasing), the stoplogs in the FRWCS and the gates in the LMB outlet channel will remain open until LMB has receded to the middle of the operating range for LMB El 247.2 m (El 811.0 ft).
- When the LMB water level has receded to the middle of the operating range, the outlet channel gates will be closed completely and the stoplogs in the FRWCS will be closed to 60% of the fully opened condition.
- No further adjustment in the FRWCS stoplog settings will take place until the LMB water level falls below the bottom of the operating range El 246.9 m (El 810.0 ft).
- For LMB water levels below the bottom of the desirable operating range (drought condition), outflow from the FRWCS will be reduced to a maximum of 22.6 m^3/s (800 cfs) until the LMB water level increases to the middle of the operating range El 247.2 m (El 811.0 ft).

- Gate and stoplog setting changes are assumed to occur only on the first day of a month to limit the frequency of operations.

13.1.2 Lake St. Martin

For LSM, it was assumed that the proposed outlet channel will be used to augment the existing LSM outlet capacity provided by the Dauphin River and the existing Emergency Channel, such that the additional flow from the LMB outlet channel will not cause additional flooding on LSM. Consequently, the capacity of the LSM outlet channel has been sized to provide additional capacity equal to the discharge capacity from the LMB outlet channel, as previously discussed in Section 7.0.

The following rules for operation of the LSM outlet channel were assumed:

- The operating range for LSM was assumed as El 243.2 m to El 243.8 m (El 798.0 ft to El 800.0 ft).
- For simplicity in the model, the gates in the LSM outlet channel control structure were assumed to be operated either fully opened or fully closed. The gate systems would still be designed to operate at partial opening to limit peak flows for example, however, at this stage of study only the fully open or closed assumptions have been considered in the routing. The preferred method of operation should be considered further at the next phase of design as part of the environmental approval process when specific conditions such as minimum flow requirements are identified.
- The gates in the Lake St. Martin outlet channel will be fully opened if the lake water level is above the assumed top of the operating range El 243.8 m (El 800 ft).
- When the Lake St. Martin water level has receded to the bottom of the operating range El 243.2 m (El 798 ft), the outlet channel gates will be closed completely.

13.2 FLOOD ROUTING PROGRAM

The determination of water levels on LMB and LSM was accomplished by flood routing inflows and outflows through LMB and LSM using a daily flood routing program applying the assumed operating rules from Section 13.1.

As per the terms of reference for the study, the historic period of 1961 to 2014 was selected for the analysis. This 54-year period corresponds to the period since the existing FRWCS was put into operation and contains both periods of wet and dry conditions.

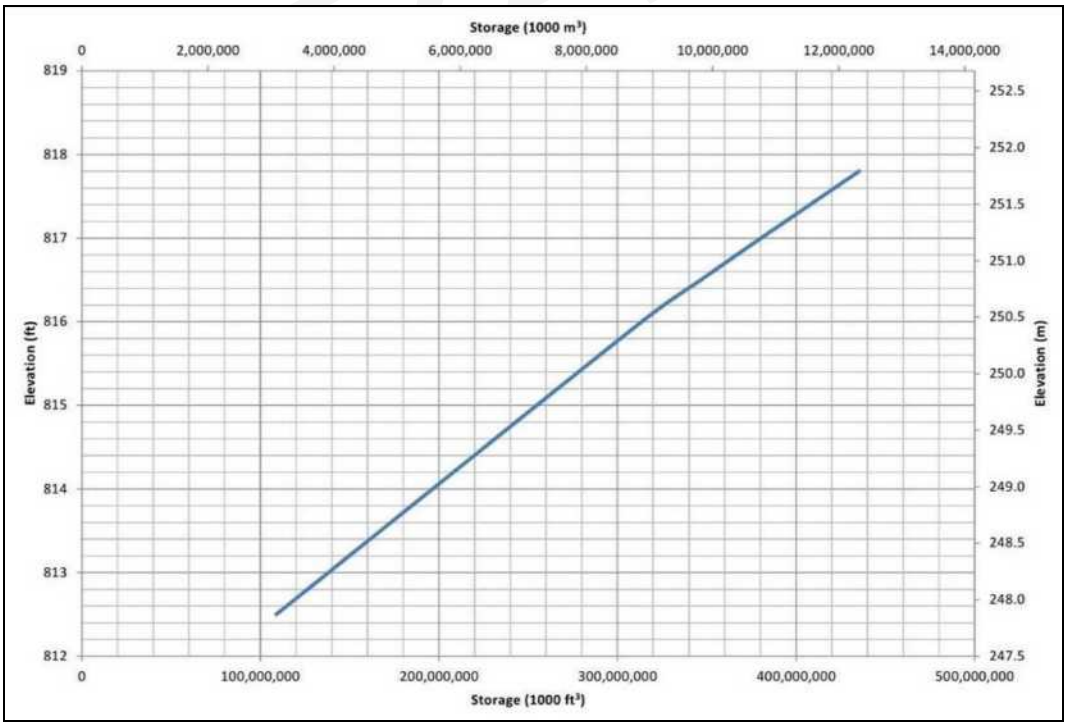
Daily inflows to LMB were determined as Inflow Available for Outflow (IAO) computed from observed daily water levels on LMB using the continuity equation:

Daily Inflow = Outflow + Change in Storage.

The following data was used to determine inflows to LMB:

- Daily water levels taken from recorded daily water levels from the Water Survey of Canada (WSC) gauge at Steep Rock (WSC Station 05LK002) and Lake Manitoba near Westbourne (WSC Station 05LL012), and smoothed to reduce the effects of wind setup using a 5-day moving average adjustment.
- Daily outflow from recorded discharges for the WSC gauge on the Fairford River near Fairford (WSC Station 05LM001).
- A stage-storage relationship of LMB (Figure 13.1).

Figure 13.1
Lake Manitoba Stage-Storage Relationship



The Portage Diversion contribution is included in the period from 1970 to 2014 and therefore is included in the LMB daily inflows from the IAO analysis. For the period 1961 to 1969, it was

assumed that the Portage Diversion would not have contributed to LMB inflows since flood conditions did not occur on the Assiniboine River during this period.

LMB water levels and outflows were computed for conditions with an outlet channel based on the following data:

- Daily inflows from the IAO analysis.
- Stage-discharge rating curve for the FRWCS calibrated for 2011 conditions based on 2011 recorded discharges for the WSC Gauge Station 05LM001 (Fairford River near Fairford) and observed water levels on LMB at WSC Gauge Station 05LK002 (Lake Manitoba near Steep Rock) (Figure 13.2).
- Stage-discharge rating curve for Lake Manitoba outlet channel Option C (Figure 13.3). This curve is also representative of conditions for Route D since the basis of design for both channel alternatives is to provide a 212 m^3/s (7,500 cfs) capacity when the LMB water level is at El 248.1 m (El 814.0 ft).
- A stage-storage relationship of LMB (Figure 13.1).

Figure 13.2
Fairford River Stage-Discharge Relationship at Lake Manitoba

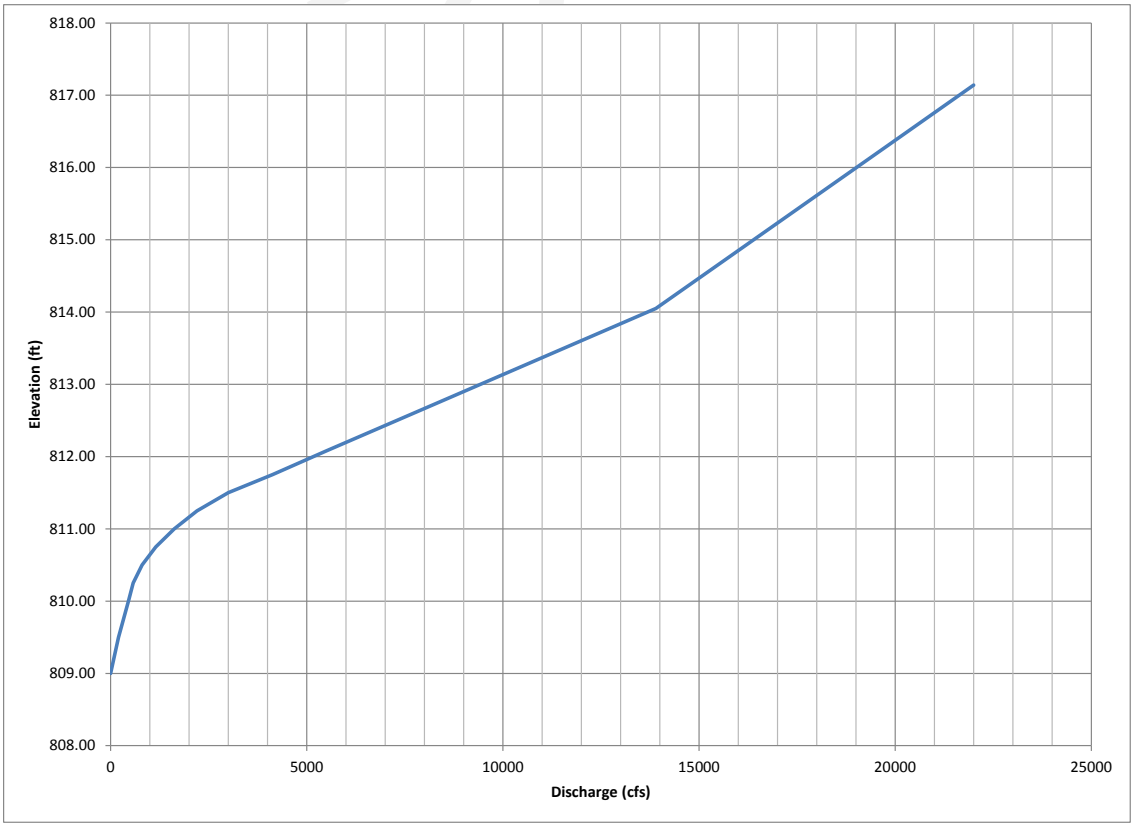
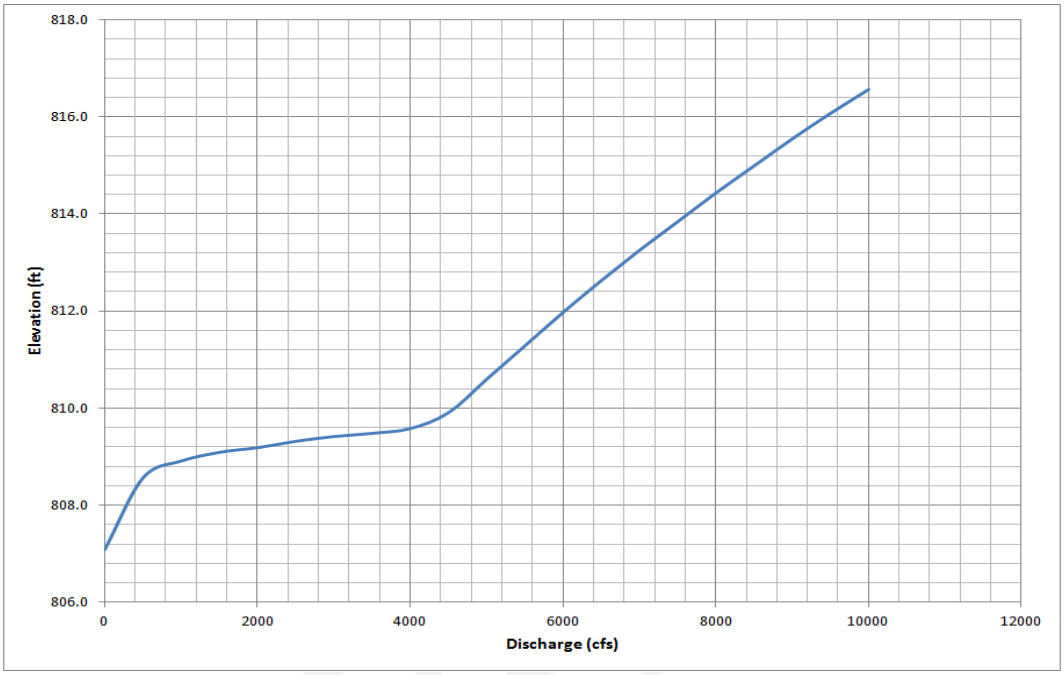


Figure 13.3
Stage-Discharge Relationship for Lake Manitoba Outlet Channel Option C



LSM outflows were computed for conditions with an outlet channel based on the following data:

- Daily inflows based on the LMB outflows described above.
- Stage-discharge rating curve for Dauphin River open water and ice conditions (Figure 13.4). Open water conditions were assumed to occur from April 1 to November 31.The open water rating curve was developed from observed LSM water levels as recorded at the WSC Gauge Station 05LM005 (Lake St. Martin near Hilbre) and daily discharges recorded at WSC Gauge Station 05ML006 (Dauphin River near Dauphin River) during 2011. The ice condition rating curve (assumed to occur from December 1 to March 31) was developed from ice modeling conducted by KGS Group in 2011 and 2012 (KGS Group, 2014), and observed winter conditions from 2011 to 2014.
- Stage-discharge rating curve for the LSM Outlet Channel (Figure 13.5)
- A stage-storage relationship of LSM (Figure 13.6).

Figure 13.4
Dauphin River Stage-Discharge Relationship at Lake St. Martin

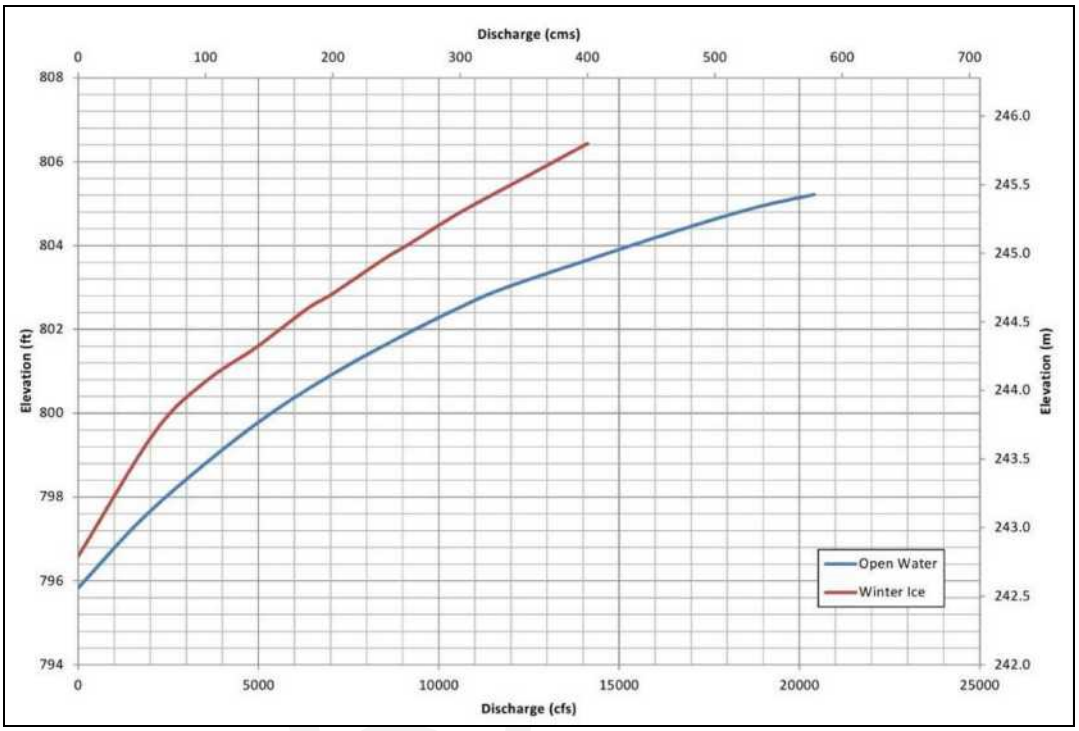


Figure 13.5
Stage-Discharge Relationship for Lake St. Martin Reach 1 Outlet Channel

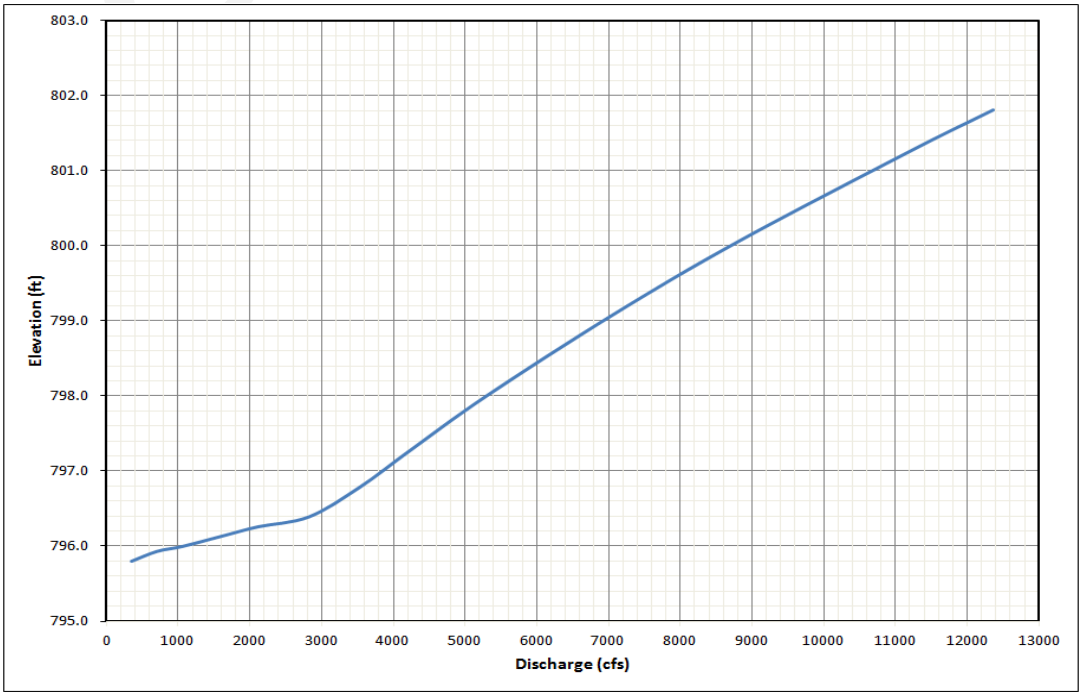
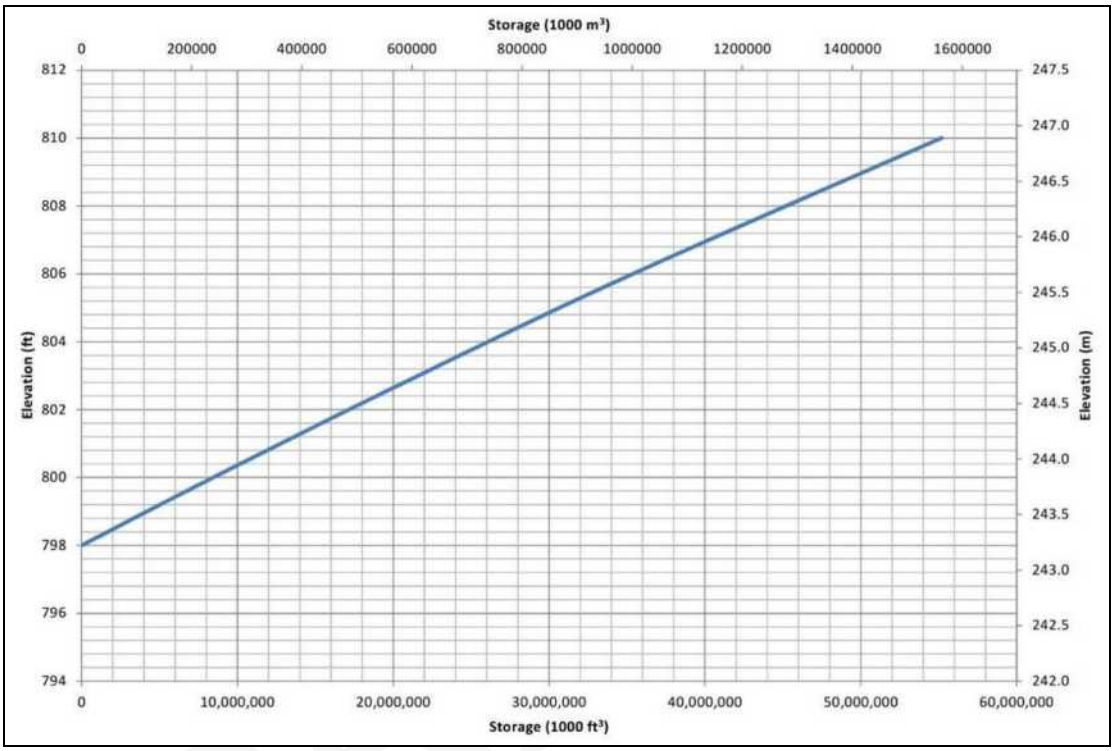


Figure 13.6
Lake St. Martin Stage-Storage Relationship



As discussed in Section 5.0, the formation of an ice cover in the outlet channels has the potential of reducing outflows from the lakes. However, as also discussed in Section 5.0, an ice cover is unlikely to occur in the outlet channels during operation. On this basis, only open water conditions in the outlet channels have been considered for the routings. Further discussion on the assumptions and potential effects of ice in the channels has been included in Section 5.0.

13.3 FLOOD ROUTING RESULTS

13.3.1 Lake Manitoba

Water levels on LMB for the period from 1961 to 2014 are shown on Figures 13.7, 13.8, 13.9 and 13.10 for the following conditions:

- Historic (recorded) conditions on LMB with the existing FRWCS and Portage Diversion, without an outlet channel on LMB.
- Computed conditions on LMB with the existing FRWCS and Portage Diversion with a 212 m^3/s (7,500 cfs0 outlet channel on LMB.

Outflows from LMB are also shown on the figures. As discussed in Section 13.2, these results are representative of conditions for both LMB outlet channel options C and D.

It should be noted that immediately prior to 1961, there was a wet period in the 1950s, which caused high water levels on LMB. Though this wet period was not specifically included in the analysis, the effects that the outlet channels would have had in reducing the peak water levels on LMB were considered in the flood routing. As such the starting water level on LMB is lower for the condition with outlet channels.

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Figure 13.7
Lake Manitoba Hydrographs – 1961 to 1973

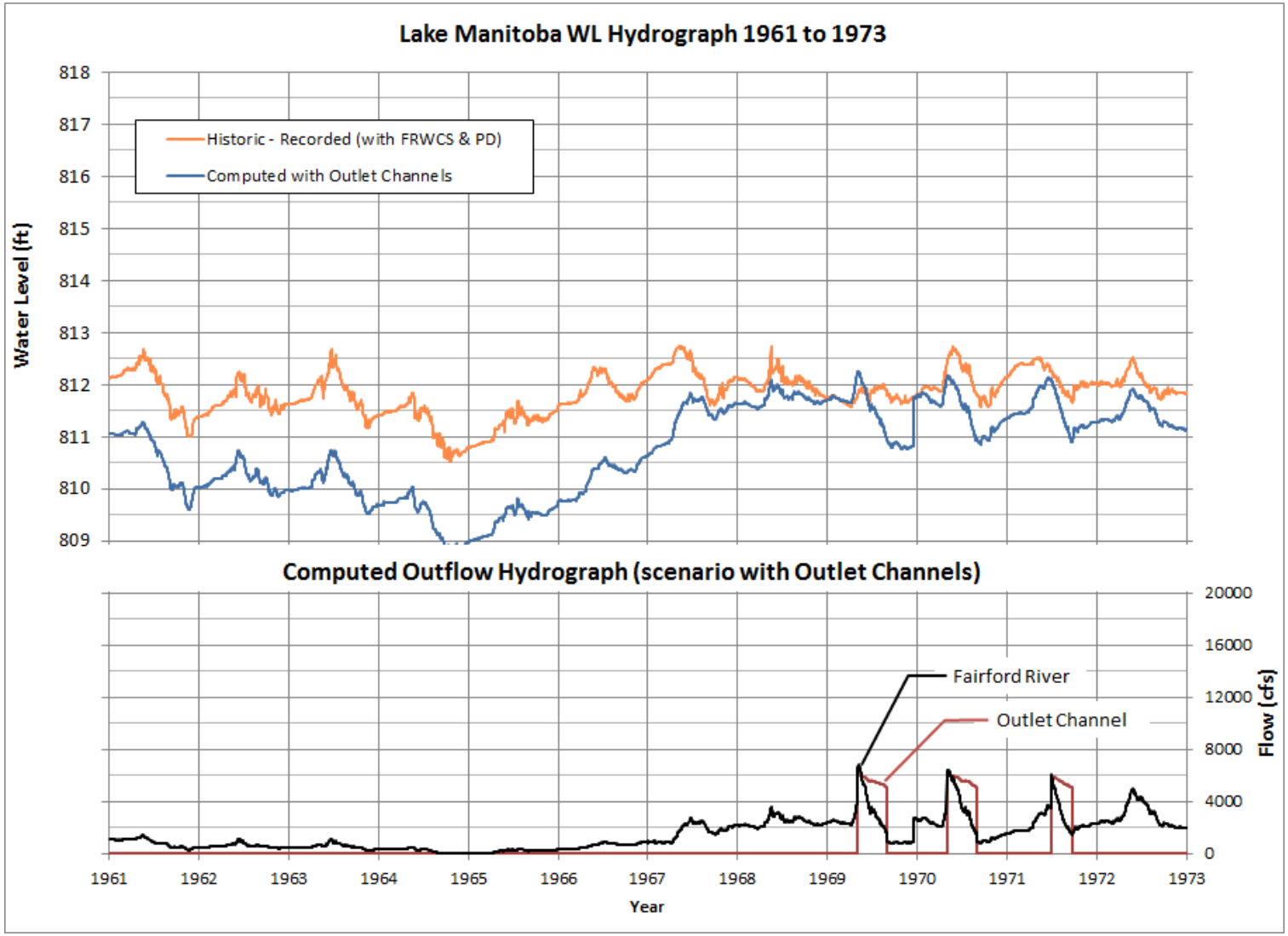


Figure 13.8
Lake Manitoba Hydrographs – 1973 to 1987

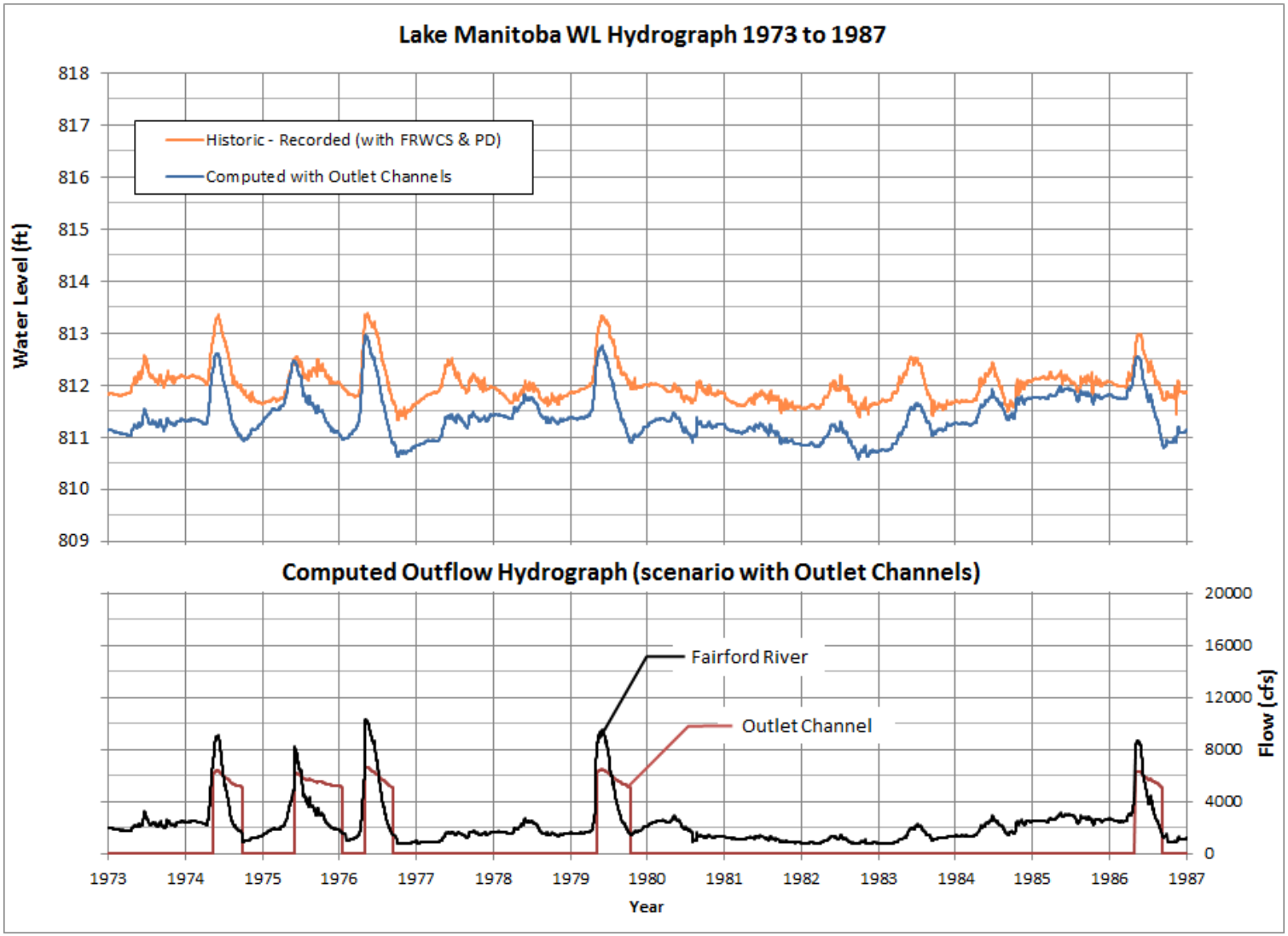


Figure 13.9
Lake Manitoba Hydrographs – 1987 to 2001

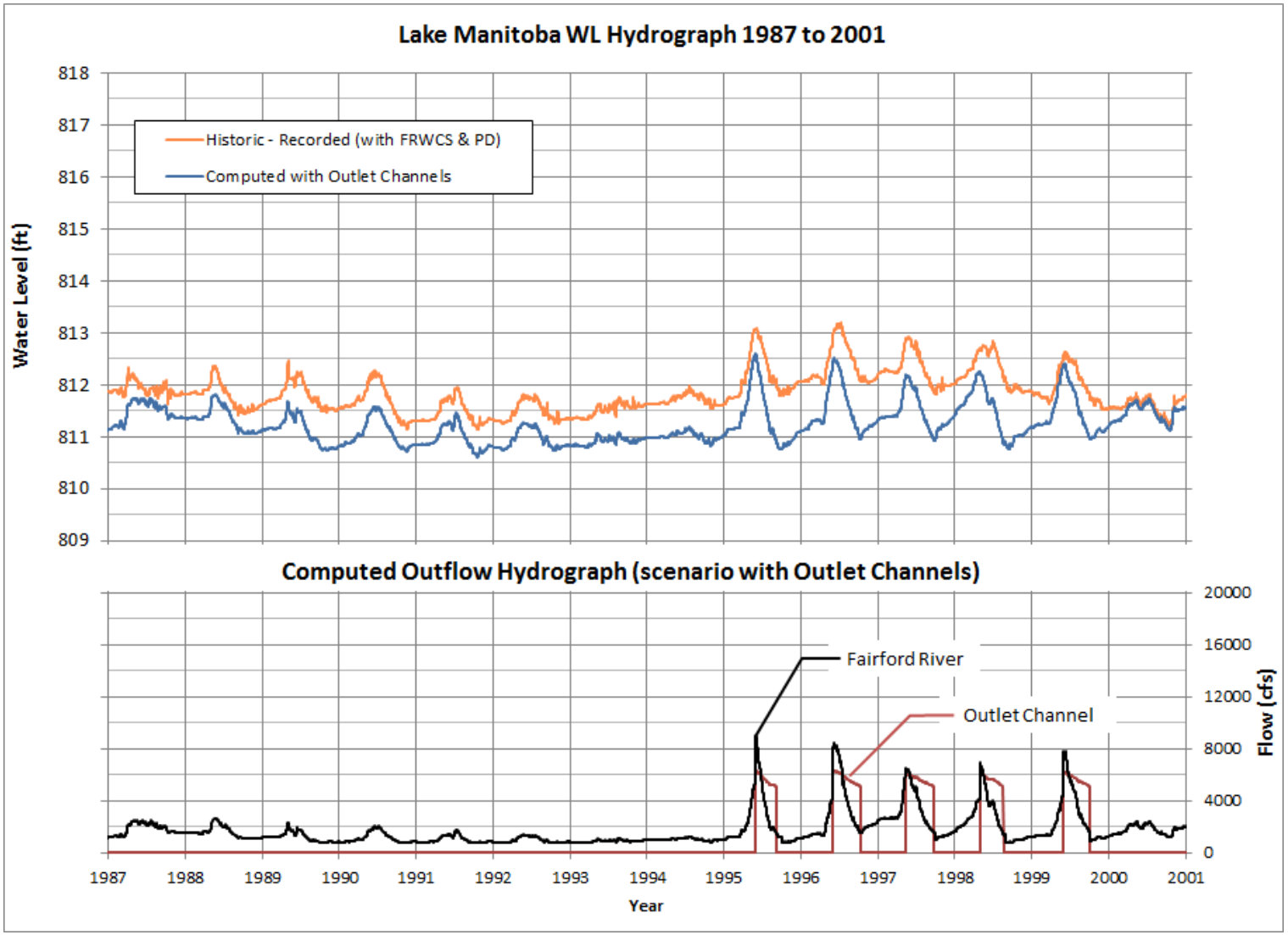
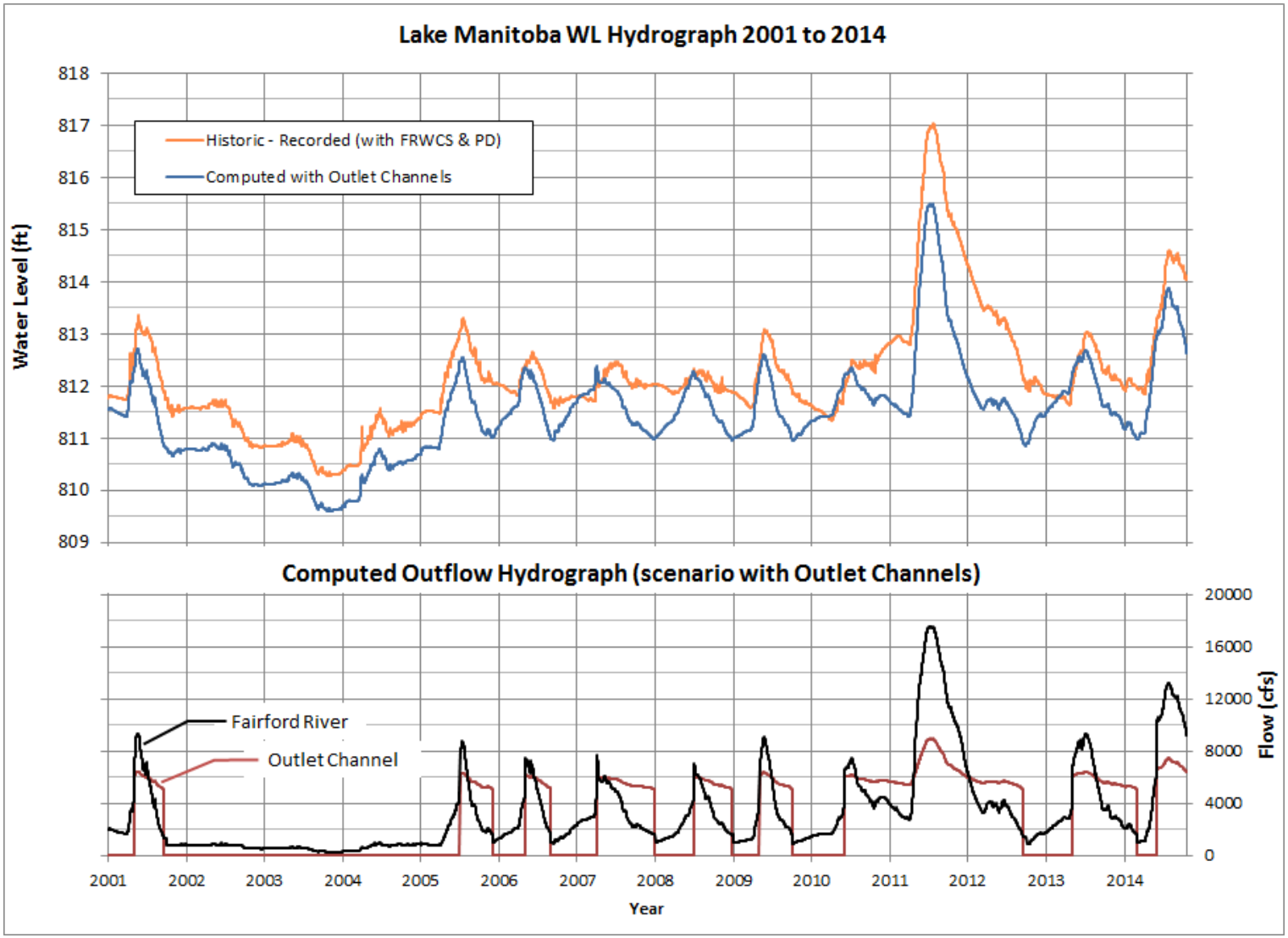


Figure 13.10
Lake Manitoba Hydrographs – 2001 to 2014



The operation of the LMB outlet channel, with the assumed El 246.9 m to El 247.5 m (El 810.0 ft to El 812.0 ft) operating range, is shown to maintain the LMB water level below El 247.8 m (El 813 ft) (0.3 m [1 ft]) below the flood stage of El 248.1 m (El 814.0 ft) in all but one year (2011) of the 54 years of simulation. In comparison, historic conditions exceeded the level of El 247.8 m (El 813.0 ft) on 12 of the 54 years. These results clearly show the ability of the outlet channel to maintain water levels below flood stage in all years except during extreme flood events such as 2011.

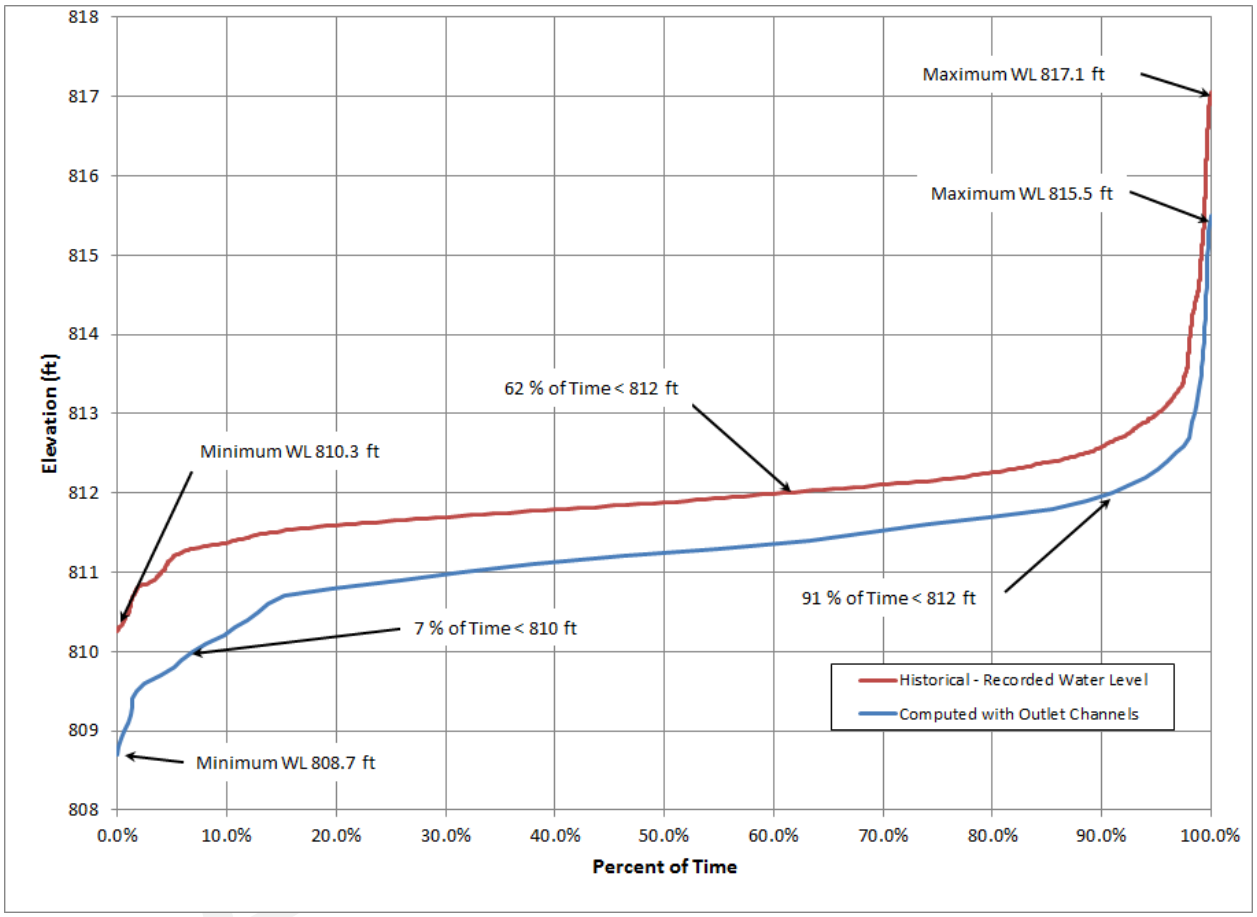
During the 2011 Flood, the recorded peak water level was shown to be approximately El 249.1 m (El 817.1 ft). The simulation demonstrates that this can be reduced by 0.5 m (1.6 ft) to a peak water level of El 248.6 (El 815.5 ft) with the operation of the 212 m^3/s (7,500 cfs) outlet channel.

The peak channel outflow during the period of analysis also occurred in 2011 and was computed at 250 m^3/s (8,835 cfs) at El 248.6 m (El 815.5 ft), which is greater than the design condition of 201 m^3/s (7,500 cfs) at El 248.1 m (El 814.0 ft). As discussed in Sections 5.0 and 6.0, the design of the LMB outlet channels can accommodate this additional flow; however, the outlet control structure gates can be operated to limit the flow to 212 m^3/s (7,500 cfs), if necessary.

The comparison of LMB water levels with and without the outlet channel is also shown on the water level duration curve on Figure 13.11.

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Figure 13.11
Lake Manitoba Duration Curve



As shown on Figure 13.11, the operation of the LMB outlet channel based on the El 246.9 m to El 247.5 m (El 810.0 ft to El 812.0 ft) operating range will reduce the percentage of time that the LMB water level exceeds El 247.5 m (El 812.0 ft) to 9% of the time compared to 38% of the time under historic conditions. The maximum calculated water level over the simulation period is reduced by 0.5 m (1.6 ft).

With the outlet channel and the assumed El 246.9 m to El 247.5 m (El 810.0 ft to El 812.0 ft) operating range, the minimum computed water level is also reduced by 0.5 m (1.6 ft), and the water levels fall below the assumed bottom of operating range of El 246.9 m (El 810.0 ft) 7% of the time, which may not be desirable. Refinement of the operating rules to minimize impacts on LMB during dry periods should be considered at the next stage of design when the operating rules for the outlet channels are being finalized.

The results of the analysis also show that the LMB outlet channel would have been operated a total of 24 times in the 54-year period of analysis from 1961 to 2014. The frequency of use and the months that the channel would have been operated is shown on Figure 13.12.

Figure 13.12
Lake Manitoba Outlet Channel Period of Operation
1961 to 2014 (54 Years of Simulation)

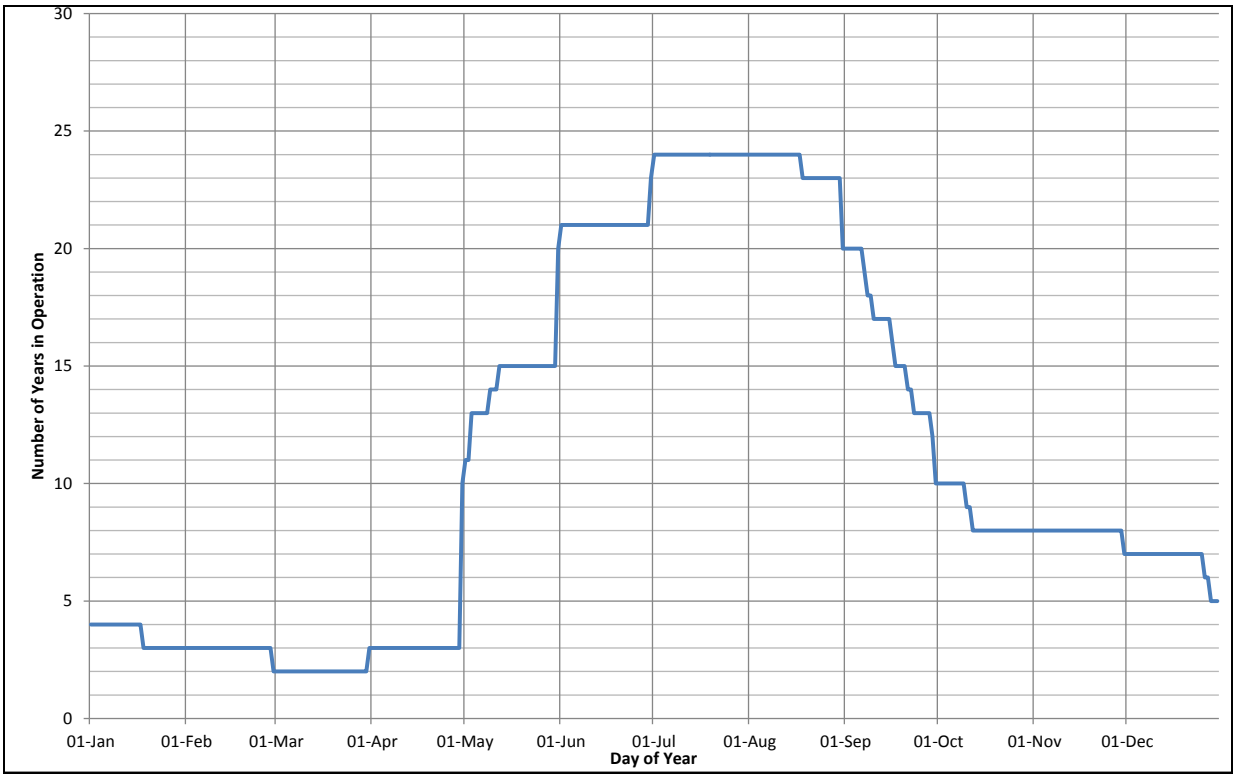


Figure 13.12 shows that for the 24 years the channel would have been operated, the channel was usually opened in the spring or early summer months of April, May or June, and closed in the late summer or early fall in the months of August or September. The channel would have been operated 7 times in the month of December but only 4 times in the month of January, 3 times in February and 2 times in March. Winter operation is, therefore, only expected during very large flood events such as in 2011, 2012 and 2014. The assumptions associated with the winter rating curve discussed in Section 5.2.2 will, therefore, not have a significant effect on the simulation levels. Nonetheless, further consideration of the effects of an ice cover could be undertaken during the environmental approval process if necessary.

13.3.2 Lake St. Martin

Water levels on LSM for the period from 1961 to 2014 are shown on Figures 13.13, 13.14, 13.15 and 13.16 for the following conditions:

- Historic (recorded) conditions on LSM with the existing FRWCS and Portage Diversion, without outlet channels on LMB and LSM (except in 2011-2014 when the 113 m^3/s (4,000 cfs) emergency outlet channel was constructed on LSM).
- Computed conditions on LSM with the existing FRWCS and Portage Diversion, with a 212 m^3/s (7,500 cfs) outlet channel on LMB and 326 m^3/s (11,500 cfs) channel on LSM.

It should be noted that for the condition with outlet channels, the computed water level on LSM at the beginning of the simulation was higher than historic conditions, even if the computed LMB water levels were higher than the historic condition for the same period and the simulation did not require operation of the outlet channels. This was because the assumed operating guidelines for the FRWCS (based on the existing guidelines) were different than those that were first established when the structure was put into operation in 1961. As discussed in Section 13.1.1, a minimum outflow of 800 cfs from Lake Manitoba was included in the simulations, which resulted in a computed inflow to LSM that was greater than historic conditions, and as such resulted in a higher water level.

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Figure 13.13
Lake St. Martin Hydrographs 1961 to 1973

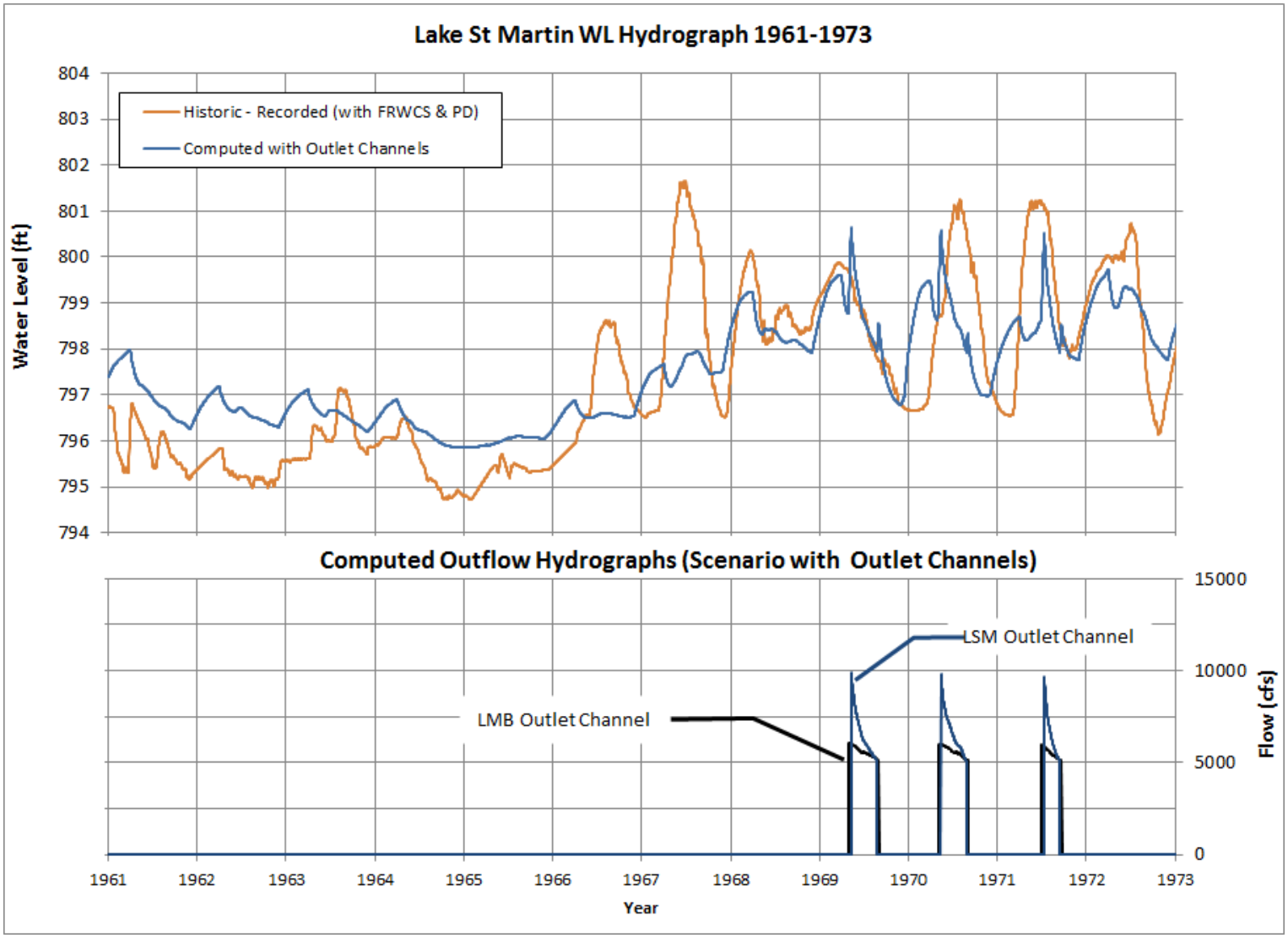
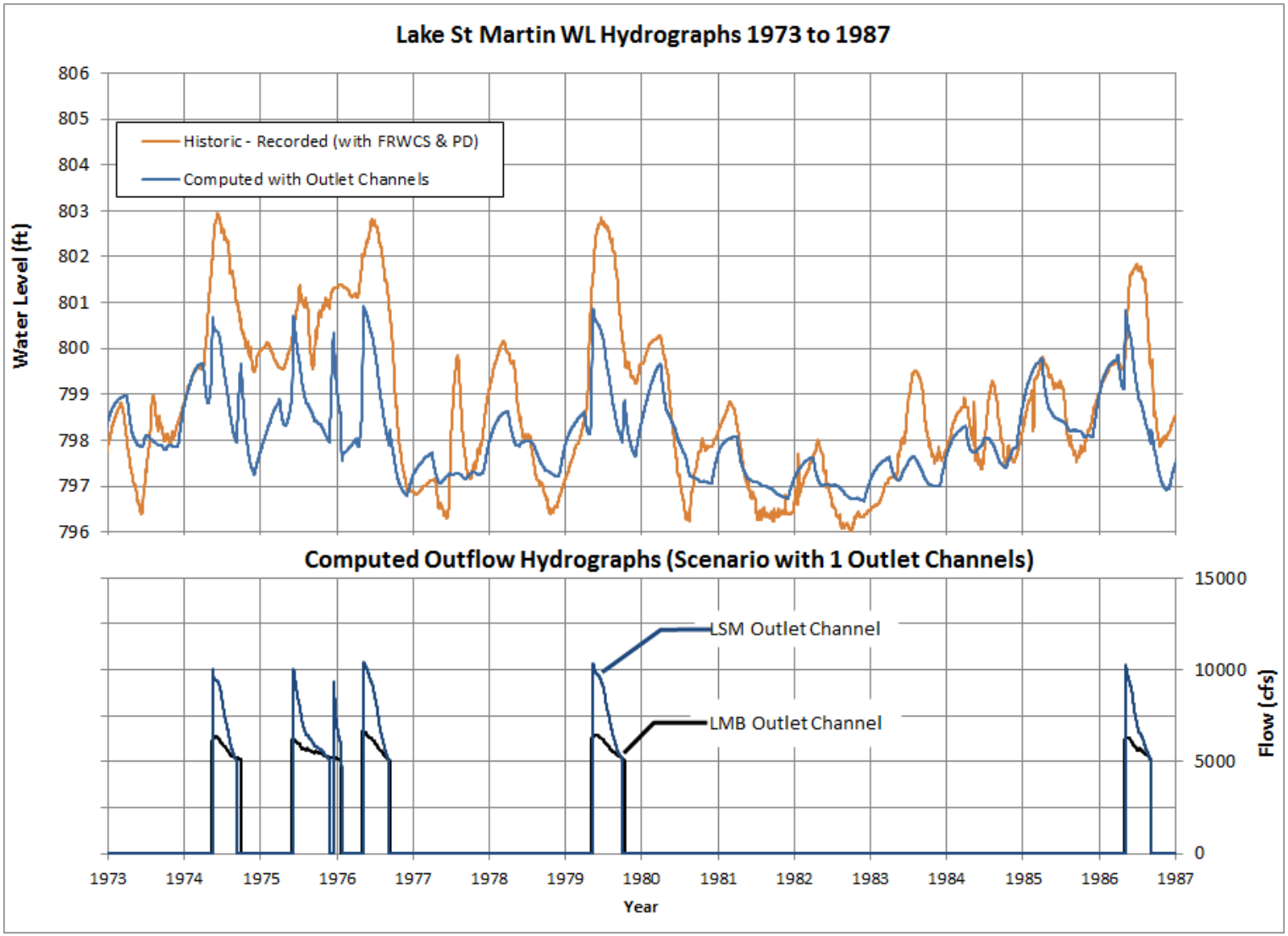
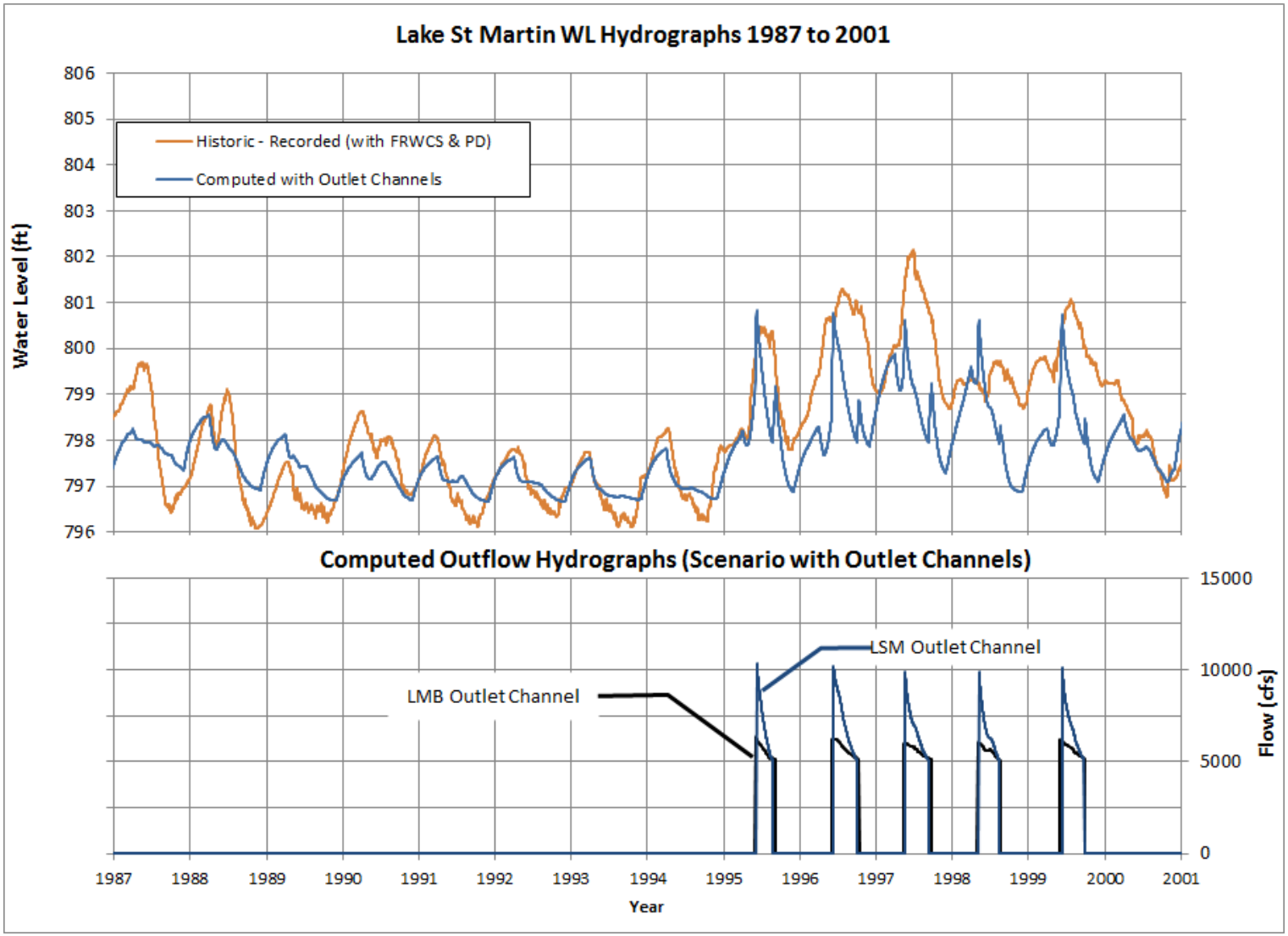


Figure 13.14
Lake St. Martin Hydrographs 1973 to 1987



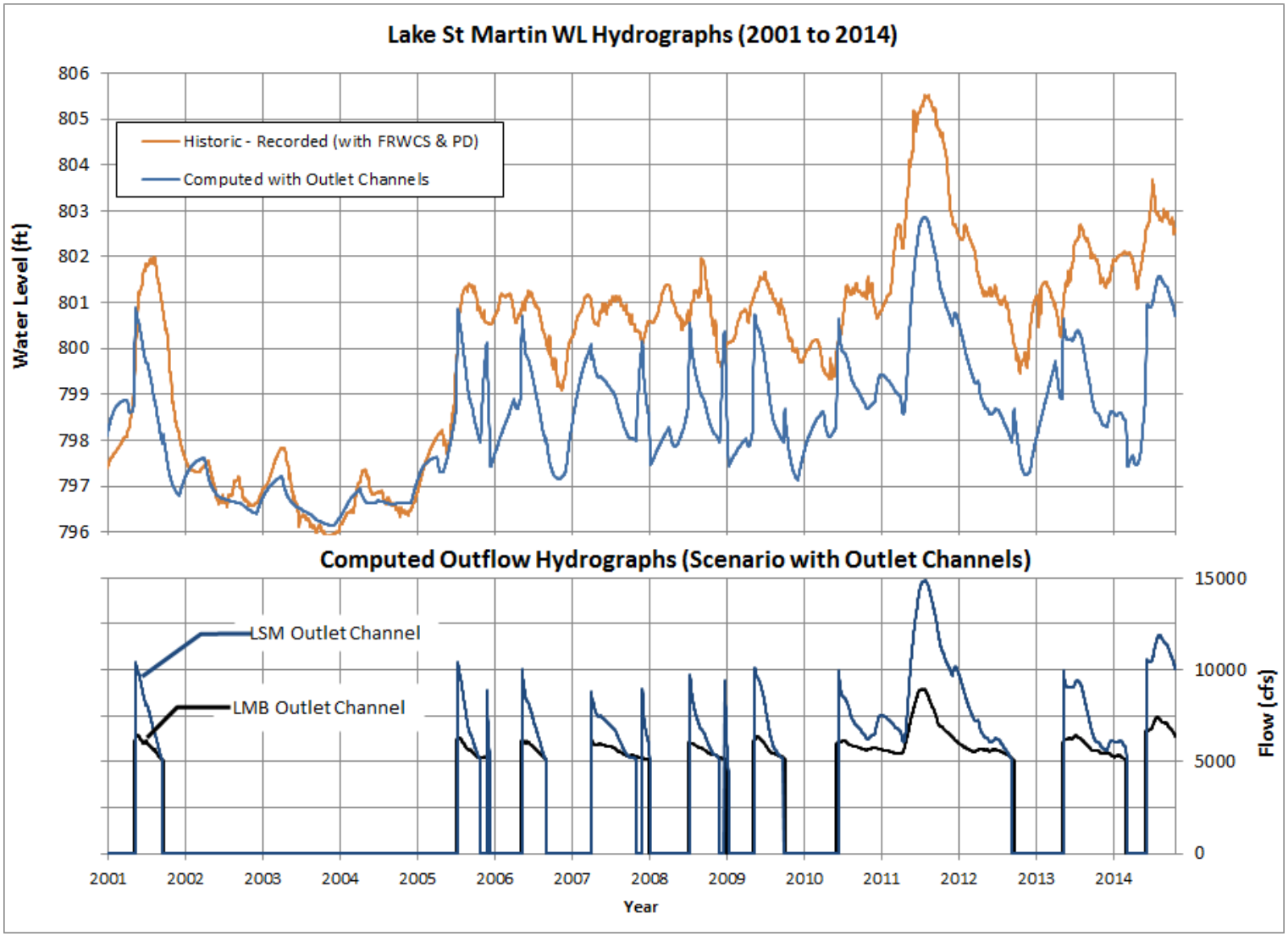
KGS GROUP

Figure 13.15
Lake St. Martin Hydrographs 1987 to 2001



KGS GROUP

Figure 13.16
Lake St. Martin Hydrographs 2001 to 2014



KGS GROUP

The operation of the LSM outlet channel, with the assumed El 243.2 m to El 243.8 m (El 798.0 ft to El 800.0 ft) operating range, is shown to maintain the LSM water level below the flood stage of El 244.4 m (El 801.7 ft) defined by MIT in all but one year (2011) of the 54 years of simulation. In comparison, historic conditions exceeded the level of El 244.4 m (El 801.7 ft) in 12 of the 54 years. These results clearly show the ability of the outlet channel to maintain water levels below flood stage in all years except during extreme flood events such as 2011.

During the 2011 Flood, the recorded peak water level was shown to be approximately El 245.5 m (El 805.5 ft) but it was reduced by 0.8 m (2.6 ft) to a peak water level of El 244.7 m (El 802.9 ft) with the operation of the 11,500 cfs outlet channel.

The peak outflow during the period of analysis occurred in 2011 and was computed at 420 m^3/s (14,820 cfs) at El 244.7 m (El 802.9 ft). This is more than the design condition of 326 m^3/s (11,500 cfs) at El 244.1 m (El 801.0 ft). As discussed in Section 7.0, Reach 1 can accommodate this increased flow; however, the increased flow would require the construction of higher dikes in Reach 3, as discussed in Section 9.0. In Reach 2, there were three options that could be considered to address the increase flows:

1. Higher dikes could be constructed in this reach to accommodate the increased flow. However, further field investigations and additional surveys within the bog area would be necessary to determine whether this was a practical solution, as discussed in Section 8.0.
2. In lieu of constructing a dike in this area, the excess water could be allowed to overtop the low lying area, which would then flow overland in a north-east direction towards Buffalo Creek, bypassing Reach 3.
3. Alternatively, limiting the flows to 326 m^3/s (11,500 cfs) could be achieved by operating the LSM outlet control structure. A sensitivity analysis was conducted to determine the impact on LSM of limiting the outflow to 326 m^3/s (11,500 cfs) and it was determined that the peak water level on LSM in 2011 would increase to El 245.0 m (803.8 ft), which would be approximately 0.3 m (0.9 ft) higher than the calculated water level with the control structure fully opened. Limiting peak flows to 212 m^3/s (7,500 cfs) in the LMB outlet channel could offset some of the impacts on LSM levels.

For the current study for such a rare event, it was assumed that allowing the water to overtop the low lying area was an acceptable strategy for Reach 2. However, the other two options should be considered further during the environmental approval process and during the next phase of design when the operating rules for the outlet channels are being finalized.

The comparison of LSM water levels with and without outlet channels is shown on the water level duration curve on Figure 13.17.

Figure 13.17
Lake St. Martin Duration Curve

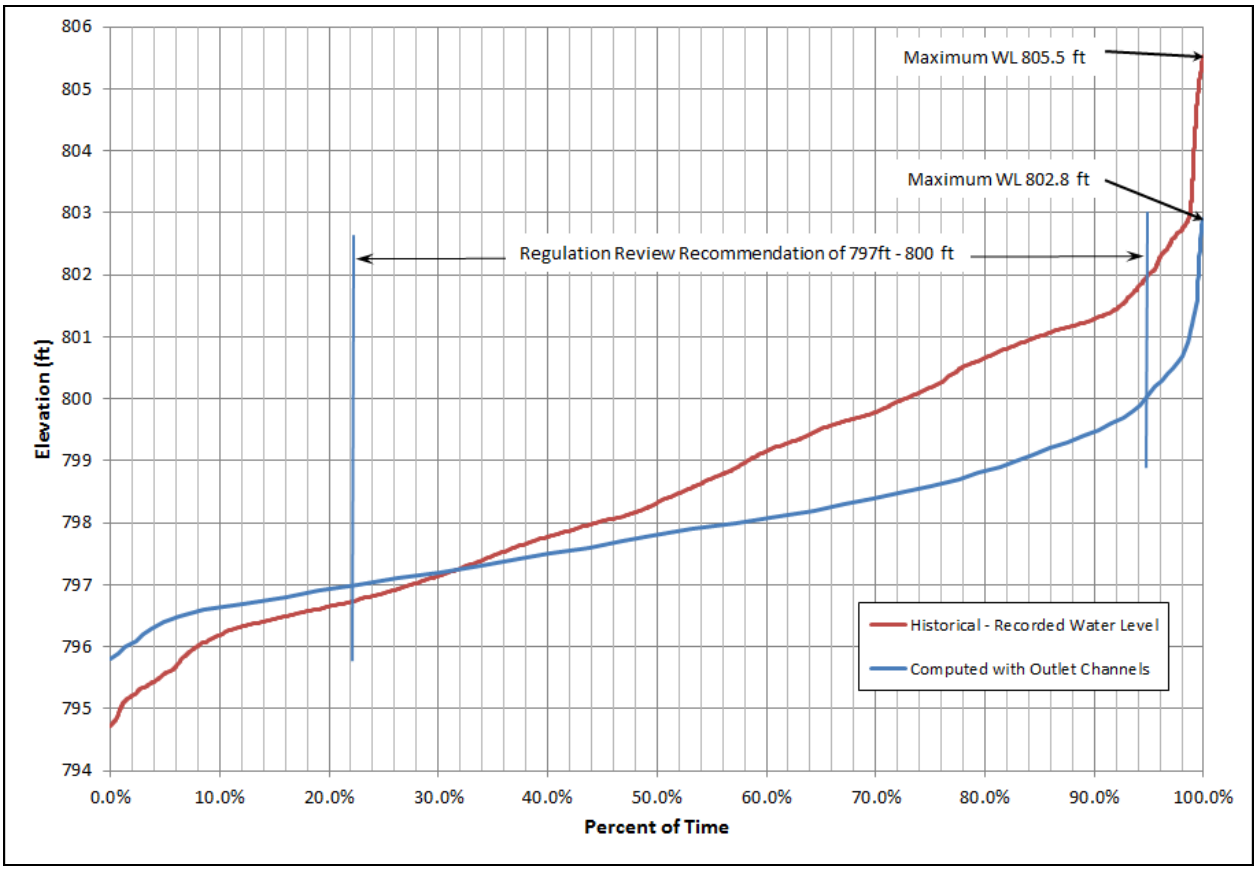


Figure 13.17 shows the percentage of time that the LSM water levels are controlled within a given range. The 326 m^3/s (11,500 cfs) capacity outlet channel is shown to control the maximum water level at or below the flood stage of El 244.4 m (EL 801.7) ft approximately 99% of the time.

As previously discussed at the beginning of Section 13.0, the Lake Manitoba and Lake St. Martin Regulation Review recommended that the LSM outlet channel should have sufficient capacity to control LSM water levels within the desirable range of El 242.9 to El 243.8 m (El 797 ft to El 800 ft) at least 90% of the time. As shown on Figure 13.17, the LSM outlet channel, is able to maintain water levels below El 243.8 m (El 800 ft) 95% of the time; however,

it is also below El 242.9 m (El 797 ft) 22% of the time. On this basis, the water levels in LSM with the outlet channels and the assumed operating rules discussed in Section 13.1 would be within the El 242.9 m to El 243.8 m (El 797 ft to El 800 ft) range 73% of the time. This is a significant improvement over historic conditions shown on the figure when the water levels were within the recommended range only 56% of the time.

In spite of the significant improvement over historic conditions, the simulation results do not achieve the Regulation Review recommendation of maintaining the water levels within the desirable range of El 242.9 to El 243.8 m (El 797 ft to El 800 ft) at least 90% of the time. To achieve this recommendation, the percentage of time when water levels fall below El 242.9 m (El 797 ft) would have to be reduced. However, water levels in LSM at El 242.9 m (El 797 ft) are not influenced by the operation of the LSM outlet channel, since the gates are closed when the LSM water level falls below El 243.2 m (798 ft). Rather, the low lake levels occur due to low inflows into LSM provided from LMB, and the minimum channel bottom elevation in the Dauphin River, which allows LSM water levels to fall below El 242.9 m (797 ft).

The concerns associated with low lake levels could be addressed by modifying the operating rules and increasing the riparian discharge from LMB. Increasing the riparian flow from LMB would, however, be difficult since the water level on LMB coincidentally would also be below the minimum level. Should the Regulation Review recommendation of controlling LSM water levels within the desirable range of El 242.9 to El 243.8 m (El 797 ft to El 800 ft) at least 90% of the time be identified as a strict guideline for future operation on LSM, this would have to be considered further during the environmental approval process and during the next phase of design when the operating rules for the outlet channels will be finalized.

The results of the analysis have shown that the LSM outlet channel was generally operated coincidently with the LMB outlet channel. However, as shown on Figures 13.13 to 13.16, there were several years where the LSM outlet channel was opened and closed more than once in the same year. This was due to the LMB outlet channel remaining open after the LSM outlet channel was closed when the water levels receded below El 243.2 m (798 ft). The inflows from the LMB channel would then contribute to a rapid rise in water levels on LSM, which would then exceed El 243.8 m (El 800 ft) and trigger the re-opening of the LSM outlet channel. Addressing this concern could be achieved by modifying the operating rules of the LSM outlet channel such

that they also considered whether the LMB outlet channel was in operation. Additionally, a partial closure of the LSM outlet channel control structure at low lake levels could also be considered instead of the assumed full closure. These different scenarios should be considered further during the next phase of design when the operating rules for the outlet channels are being finalized.

13.3.3 Comparisons to Unregulated Conditions

To further assess the effects of the outlet channels on LMB and LSM, the results of the flood routing analyses were also compared to unregulated conditions on the two lakes. Unregulated conditions are defined as conditions without the Portage Diversion, FRWCS and outlet channels and have been computed by R.J. Bowering for the Province of Manitoba (Bowering, 2013) for the historic period of 1924 to 2012.

As discussed in Section 13.3.1, water levels on LMB exceeded the level of El 247.8 m (El 813.0 ft) (0.3 m (1 ft) below the flood stage of El 248.1 m [El 814 ft]) only once for the computed conditions with outlet channels. With unregulated conditions, water levels on LMB were computed by R.J. Bowering to exceed El 247.8 m (El 813.0 ft) 28 times during the 54-year period. Additionally, during the 2011 flood, the unregulated peak water level on LMB was computed to be El 249.0 m (El 816.8 ft). This level is approximately 0.4 m (1.3 ft) higher than the computed water level of El 248.6 m (El 815.5 ft) for conditions with the FRWCS, Portage Diversion and outlet channels. These results clearly demonstrate the ability of the outlet channels, in conjunction with the FRWCS, to significantly reduce the occurrences of floods on LMB and also to maintain peak water levels below flood stage during large flood events such as a 2011 type flood.

On LSM, historic water levels have fluctuated much more widely than those which would have occurred under unregulated conditions since construction of the FRWCS in 1961. In 2011, the peak water level for unregulated conditions was computed by R.J. Bowering to be approximately El 244.8 m (El 803.2 ft). This water level was 0.1 m (0.3 ft) higher than the computed water level of 244.7 m (El 802.9 ft) discussed in Section 13.3.2 for conditions with the FRWCS, Portage Diversion and outlet channels. This demonstrates that the 326 m^3/s (11,500 cfs) capacity of the LSM outlet channel, which is 113 m^3/s (4,000 cfs) more than the

capacity of the LMB outlet channel, is capable of reducing water levels on LSM below unregulated conditions during extreme flood events such as in 2011.

As discussed in Section 13.3.2, water levels on LSM for conditions with outlet channels were computed to be within the range of El 242.9 m to El 243.8 m (El 797 ft to El 800 ft) 73% of the time during the 1961 to 2014 period. Though this falls short of achieving the Regulation Review recommendation of maintaining the water levels within the desirable range of El 242.9 m to El 243.8 m (El 797 ft to El 800 ft) at least 90% of the time, it is a significant improvement over unregulated conditions. Unregulated water levels computed by R.J. Bowering were shown to be within the El 242.9 m to El 243.8 m (El 797 ft to El 800 ft) range 61% of the time during the 1924 to 2012 period, which is 12% less often than the conditions with the FRWCS, Portage Diversion and outlet channels.

13.3.4 Comparison to the 1:100 Year Water Level on Lake St. Martin

In a Flood Mitigation Study for First Nations along the Fairford River, Lake St. Martin, and Lake Pineimuta, AECOM (2012) reported that the 1:100 year water level on LSM, with the emergency outlet channel that was constructed in 2011, was El 244.7 m (802.8 ft). This water level was compared to the results of the flood routing analyses conducted by KGS Group in the current study since the results from the AECOM report were being considered by the Province of Manitoba in their initiative to pursue flood easements around LSM.

As discussed in Section 13.3.2, the recorded peak water level of El 245.5 m (El 805.5 ft) in 2011 was reduced by 0.8 m (2.6 ft) to a peak water level of El 244.7 m (El 802.9 ft) with the operation of the outlet channels. Though this water level exceeds the AECOM 1:100 year level by 0.02 m (0.1 ft), the flood routing results show that this is the only year when the LSM water level exceeds El 244.7 m (El 802.8 ft). This demonstrates that the outlet channel is successful in maintaining water levels below the 1:100 year level, in all years except during extreme flood events such as in 2011.

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14.0 REVEGETATION

The revegetation rationale described herein is a conceptual approach developed in conjunction with Scatliff Miller Murray Inc. The concepts are largely based on the existing conditions observed at the LSM Emergency Outlet Channel; some conditions are expected to be similar at the proposed locations for the LMB channel. A general description of potential pre-plant site preparation requirements, planting considerations and scheduling/sequencing has been provided. Future work for detailed design will include finalizing species composition and application rates of soil amendment, seed and weed control to refine the level of effort and the cost for revegetation.

The rationale for revegetating the channels is to mitigate the potential for surface erosion and the potential colonization of the channels by weeds. Persistent noxious weeds aggressively colonize exposed soils, threatening the stability of surrounding natural ecosystems and often do little to prevent additional erosion. Along Reaches 1 and 3 of the existing LSM Emergency Outlet Channel, which were not revegetated following their construction, there has been substantial rill and gully erosion and weeds are in the early stages of colonization.

14.1 PRE-PLANT SITE PREPARATION

To facilitate successful revegetation, the seed bed should be smooth, level (not steeper than 4:1), firm (but not compacted), free of large obstacles and with sufficient nutrient and organic materials. Pre-plant site preparation generally consists of the following planning elements:

- **Organics Quantity Requirements** – At Reach 1 and 3, the glacial till sub-soils that the channels will be expanded/constructed through have no discernible soil horizon development and are deficient in soil organic matter and most plant available nutrients. It is likely that these conditions exist along sections of the proposed alignments for the LMB Channel, though some sections on the periphery or within farmland may have more developed soil horizons. To achieve planting objectives in areas lacking appropriate soil horizons, organic material should be integrated into the existing glacial till sub-soils. The quantity (depth) of organics required varies based on the vegetation type (grass, shrub, etc.). Organics, free of coarse woody debris should be stockpiled during clearing of the site. If there is not sufficient stockpiled materials then alternative sources would need to be located, such as adjacent treeless sedge meadows/fens.

- **Sub-soil Preparation and Growth Media Placement** – If sub-soils are compacted by construction activities, then heavy equipment such as a tandem disc, or a ripping tooth in frozen conditions, would be used to break up compacted soils.

- **Seed Bed Conditioning Requirements** – Following integration of the organic material the seed bed will likely require some level of conditioning to facilitate proper and consistent seed placement. A light cultivation and/or harrowing is generally sufficient to break down large soil chunks to create a smooth and level surface. Harrowing may also help remove minor debris, which could otherwise interfere with seed placement.

- **Fertilizer/Additives** – In marginal soil conditions, such as those through which the channels will be constructed, a low rate phosphorous fertilizer can make a significant difference in rate of establishment and growth of native seedlings. Fertilizer application is recommended particularly in areas that require fast cover establishment, such as drainage swales and channel mid-slope sites.

- **Erosion Control** – Strategic placement of erosion control blankets (ECB) can be used to minimize the exposure of prepared ground to further erosion; however, it is costly and inefficient in large-scale work. In comparison, for a large-scale project such as the LMB and LSM channels, the use of a cover crop would be a more feasible option. Areas that have been prepared for seeding but have not been seeded to native cover should be seeded with a heavy rate of temporary cover crop. When applying native seed, erosion control crop should be added to the seed mix, though at a lower rate, to provide early growth and erosion control while not out-competing native seedlings. After the end of the native seeding window (approximately June 15), cover crops such as oats (Avena sativa) and/or winter wheat (Triticum aestivum) would be seeded and later mowed or desiccated using herbicide approximately six to eight weeks after planting.

- **Pre-plant Weed Control** – Weed control is less problematic if the necessary steps are taken prior to, or immediately after, construction rather than allowing sites to become heavily infested over time. Early weed control will yield better results for desirable revegetation and erosion control. Weed control planning and application must be in accordance with all appropriate Provincial permitting requirements, regulations and guidelines. A certified agronomist should be used to develop a weed control strategy, which typically would include three herbicide applications throughout the growing season.

14.2 PLANTING CONSIDERATIONS

Revegetation work typically includes three tasks: design, plant material procurement, and methods. Revegetation design will reflect the range of environmental conditions in the affected area. Revegetation zones are linked to position in the channel cross-section and divided into upland berm, mid-slope, lower slope, and wetland, with the wetland zone further divided into toe-of-slope and channel bottom.

Based on the proposed channel design, the Lake Manitoba channel (both options) and Reach 1 of the Lake St. Martin channel will permanently retain water. As such, the wetland zone will be defined by the normal water level in the channels; and the channel bottom will not need to be revegetated. If the control structure for the LMB Channel was located near Lake Manitoba, the channel could periodically dry out; the vegetation would likely not survive the extended periods of inundation during operation, and the channel bottom would be susceptible to erosion when dry.

All upland and side-slope areas shall be seeded with a composition of species to reflect the changing moisture conditions (drought to flooding). In wetland zones, excavated bulk propagules will be used though seeding can augment propagules placement in areas accessible to drill seeding equipment. Pre-plant site preparation should create the conditions, wherever possible, to facilitate drill seeding.

14.2.1 Plant Material Procurement

Most required seed can be obtained commercially although certain species can be harvested (wild seed collection) to augment species mixes. Commercially available seed should be certified and seed quality data should be reviewed by a native revegetation specialist prior to purchasing seed. Quantities of required material will depend upon method of installation (drill seeding vs. harrow-broadcast-harrow seeding) and will be divided by planting zone.

14.2.2 Methods

The Truax drill has proven to be the best method for drill seeding multi-species native grass mixes as the machinery and various internal mechanisms have been optimized to ensure even and consistent placement of native seeds at appropriate depths. Slopes are to be no steeper than 4:1 for safe operation of the tractor and drill, which may preclude drill operation on some part of the channel side slopes. Where a drill seeder cannot be safely operated, the seed must be broadcast and harrowed into the soil surface, which requires twice the amount of seed compared to drill seeding. The time window for seeding native species is either in the spring from May to mid-June or, for application of dormant seeds, in the fall from mid-October until frost or snow prohibits normal seed placement.

Excavation, hauling and placement of wetland propagule plantings are usually undertaken in frozen conditions typically between late November and early March. Propagules of emergent species cannot be planted deeper than 0.45 cm below anticipated water levels. Some propagule plantings may be placed at the toe of the slope or embedded at various positions a short distance up the side slope based on anticipated water levels. Wetland bulk propagules should be installed as soon after excavating to minimizing the amount of handling and storage time. Severe wind chill conditions should be avoided as living root tissue may die due to excessive freezing and/or desiccation. Additionally, over-handling of frozen bulk propagules should be avoided as they could break apart and become less effective for revegetation.

14.3 SCHEDULING/SEQUENCING

Due to the seasonal nature of revegetation work, start-up time for site preparation and seeding affects how revegetation activities unfold in a given year. Site preparation and planting activities are highly integrated and are sensitive to time of growing season. Subsequently, missing key dates for completion of various elements may set the project behind schedule for up to one year. Additional time contingency planning will be required. Staging of sufficient machinery and organics prior to, or during construction will be critical to the overall success of revegetation. Machinery for site preparation and seeding should be mobilized in early winter and coordinated to begin work at the earliest opportunity. Stockpile staging and preparation is to be undertaken when machinery is able to access sites and operate in stable conditions, for example, frozen conditions are required to access organics from peat bogs.

The transition from channel construction activities to revegetation preparation and planting activities needs to be addressed in further detailed planning. Ideally, the channel construction should not leave compacted conditions that are prohibitive to plant establishment and survival. From a project efficiency perspective, including scarification and organics placement and integration as part of channel construction work could be considered. Seed-bed conditioning and seeding shall be conducted by revegetation crews.

To make the most efficient use of seeding opportunities and to minimize exposure of prepared sites to further erosion, ground that is prepared should be seeded within 24 hours. Revegetation

activities occur as a tightly coordinated series of passes. Conceptually, once channel construction has been completed the sequence of passes should be as follows:

- **Scarification** – If sub-soils are left in a compacted state following construction, heavy equipment such as a tandem disc or a ripping tooth would be used to break up compacted soils.
- **Organics Placement** – Stockpile or staged organics are placed and spread onto scarified sub-soils.
- **Organics Integration** – Organics are cultivated into scarified sub-soils to the appropriate depth. Note this may be the better stage to transition from channel construction to revegetation contractors.
- **Seedbed Conditions** – Harrowing is undertaken to break up soil clumps following integration. More than one pass may be required.
- **Seeding** – The native grasses spring seeding window is from May to mid-June, whereas the cover crop seeding is from mid-June to late September. Not accounting for delays beyond the control of MIT or contractors, and provided that one set of all required equipment is provided, roughly 1.0 ha (2.5 acres) can be prepared and seeded (either with native seed or cover crop) per day.
- **Dormant Native Seeding** – Dormant seeding is usually undertaken from October 20 to early November depending on prevailing weather conditions.
- **Propagule Placement** – Propagule work and planting-bed excavation is generally undertaken in late fall to the winter period.

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15.0 POTENTIAL ENVIRONMENTAL IMPACTS

Operation of the proposed outlet channel between Lake Manitoba and Lake St. Martin and the proposed modifications to the existing outlet channel system between Lake St. Martin and Lake Winnipeg will provide a permanent, long-term and large magnitude positive effect by helping to alleviate flooding in the region. Construction and operation of these channels will, however, also result in a number of potential adverse environmental impacts. Biophysical attributes that may be affected include, but are not limited to surface water quality, groundwater, terrestrial environment, aquatic environment and fish resources. Social attributes and concerns that could affect the project include land use and ownership, access, and unresolved First Nation litigation claims. While these and other potential environmental concerns will be examined in detail during the development of future licensing and permitting for the proposed project, this report acknowledges the likelihood of particular environmental concerns from a general perspective and focuses on the localized effects along each of the individual outlet channel options to qualitatively assess the relative difference between them.

A general description of the potential biophysical and social environmental concerns is provided in the following sections. The potential adversity of these concerns was qualitatively categorized into negligible, minor, moderate or major. The categorization considered aspects such as the frequency, duration, extent and magnitude of potential effects. The categorization was based on what was known about a project of this nature and the existing information about the current proposed locations for the outlet channels, as well as our understanding of certain environmental impacts that were likely to occur. It was anticipated that substantial additional environmental information will be collected in support of the future licencing and permitting process. The relative categorization is qualitative and the biophysical and social environmental criteria have not been weighted based on the potential level of effect for this preliminary assessment. For example, criteria that may be assigned more importance could include groundwater, erosion / sedimentation, fish resources, land use / ownership and litigation claims; however, this was beyond the scope of this Stage II Study. The information herein will be used to gauge the extent of potential impacts for each of the preferred outlet channel alignments, with the categorization summarized in Table 15.1 (Section 15.7) so as to aide in selection of the final preferred option, with the expectation that an environmental assessment will follow.

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15.1 SURFACE WATER QUALITY

Based on examination of monitoring data for the Reach 1 Emergency Outlet Channel in 2011 through 2012 (KGS Group, 2013; NSC, 2013) and ongoing monitoring, there would likely be varying levels of impact to surface water quality during construction, initial operation and continued operation of the proposed outlet channels. Water quality in direct proximity to the project activities and the downstream receiving waters could be affected through several physical effects pathways associated with the proposed Lake Manitoba and Lake St. Martin channels including:

- Alteration in the rate and seasonality of flow discharged into downstream water bodies within the project study area.
- Effects of flooding along the outlet channel routes.
- Potential for erosion and/or mobilization of sediment due to the diversion.

Many of the details described in the following sub-sections were previously developed as a part of the base of examination for the 2011-2012 monitoring program for the construction and operation of the Reach 1 Emergency Outlet Channel (NSC, 2013).

15.1.1 Alterations in Rate and Seasonality of Flow Discharges

Operation of the proposed project will result in an increased rate of discharge from Lake Manitoba through Lake St. Martin and into Lake Winnipeg. These water bodies typically drain into one another in this sequence; however, operation of the outlet channel systems may alter the timing and will alter the rate of the discharge. The concern is that these alterations could lead to changes in the water quality within the downstream water bodies. Review of routine water quality variables indicated that water quality in the Fairford and Dauphin Rivers exhibited seasonal differences, which may in turn affect conditions in Lake Winnipeg (NSC, 2013).

The outlet channel would be operated when needed in response to flood conditions, regardless of which option was selected, so there would be little to no difference between any of the options in relation to changes in timing of discharge. In comparison, the change in discharge is directly related to the increased volume or capacities of the proposed outlet channels and the volume of the downstream receiving water body. As such, each reach of the Lake St. Martin

outlet channel options was categorized the same because they all have the same potential increase in discharge capacity. While this would be a long-term effect associated with operation, the extent would be localized to the outlet area, and given the larger volume of Lake Winnipeg, the change in water quality would likely not be measureable. Therefore, the adversity was assessed as negligible. Lake Manitoba channels Options C and D were also equally ranked because they both had the same potential discharge capacity increases. Again the potential effect would be long-term associated with operation and while the extent was localized to the outlet area, the Lake Manitoba channels would have a relatively greater effect compared to the Lake St. Martin outlet channel options given the smaller volume of Lake St. Martin and were, therefore, assessed as minor.

15.1.2 Effects of Flooding along the Outlet Channel Routes

Flooding of terrestrial habitat may affect water quality through leaching and decomposition of organic materials, which may in turn consume dissolved oxygen (DO), decrease pH, and increase the concentration of various nutrients and metals in the surface water. Flooding of terrestrial habitat may also mobilize mercury and increase the methylation of mercury leading to increased concentrations downstream and potential bioaccumulation within aquatic biota. This could in turn be affected by factors such as the total area flooded, differences in terrestrial habitat that is inundated (mass of organic material), and changes in water residence times and thermal regimes.

All of the proposed channels will provide a benefit to some extent as they are designed to decrease flooding and the associated adverse effects within the drainage basins. Lake Manitoba channels Options C and D are equally ranked as negligible because they will both relieve the flooding on Lake Manitoba with no flooding of land outside of the constructed channels. While each reach of the Lake St. Martin channel options has equal discharge capacity to reduce the flooding on Lake St. Martin, Reach 1 results in the potential for flooding of Buffalo Lake and the surrounding bog, whereas, Reach 2 and Reach 3 have containment dikes to prevent flooding of the surrounding land. As such, Reach 2 and both the Johnson Beach and Willow Point Reach 3 options were assessed as negligible because they all divert the flood waters away from Lake St. Martin without flooding the surrounding land. While Reach 1 has the potential to flood Buffalo Lake, the duration and frequency will depend on operation

requirements and the extent of flooding localized to the existing bog complex surrounding Buffalo Lake. As the area to be potentially flooded was an existing bog complex, there would not likely be a large magnitude of change from existing conditions. Therefore, the potential effect was assessed as minor.

15.1.3 Erosion and Sediment Mobilization

The construction, initial operation, and continued operation of the outlet channels have the potential to increase shoreline, lake bed, and creek bed erosion, which can cause increases in the concentrations of Total Suspended Solids (TSS)/turbidity and related variables in downstream receiving waters. The impact to water quality parameters such as TSS can have lethal and sub-lethal adverse effects on fish and other aquatic biota.

Construction activities such as excavation of shorelines or in proximity to shorelines, dredging within waterways or water bodies, or dewatering project sites in direct proximity to surface water bodies or watercourses can result in localized plumes of suspended sediment. To mitigate the effects of these activities, use of appropriate sediment control measures such as silt fences, turbidity curtains, and cofferdams (to allow the activities to proceed under dry conditions) would be required. In situations where dewatering is required, dissipation mats and or the use of sumps/settling ponds can reduce the extent of turbidity.

During initial operation of any channel option, it is expected that an immediate increase in TSS concentrations will be observed. This spike in the concentration of TSS could be from a combination of any of the following:

- Mobilization of loose earth material within the outlet channels.
- Eroding of the channel banks.
- Release of materials from the upstream water body being re-suspended as the inlet structure is operated.
- Movement of materials from within water bodies or wetland along the channel route.

While it is probable that the increase in concentrations during the initial operation of the outlet channels will be well above typical conditions for the downstream receiving waters, these effects are expected to be short-term in duration. The effects from prolonged operation of the channels

have the potential to continue to provide long-term increased TSS/ turbidity loading into Lake St. Martin and Lake Winnipeg; although, this would be in much lower concentrations as the channels have been designed so that average flow velocities are below the threshold to cause erosion. Periodic monitoring of the water quality throughout the project study area during construction and for a period of time following initial operation is advised to determine if concentrations of routine water quality parameters are exceeding conditions that will have detrimental impacts on fish and other aquatic biota.

All the proposed channel options will require construction of an inlet and outlet requiring work in or adjacent to water. However, based on the above discussion, the options that require additional construction activities within or immediately adjacent to water would be worse than channels through dry land. Additionally, channel options that are longer, and in particular through till sections versus rock, would have more materials exposed for potential erosion during initial operation. The Channel Option C would mostly be constructed in the dry and only approximately 6 km of the 11.6 km channel length would be constructed through till, therefore, the potential effect was assessed as minor. In comparison, Channel Option D will be constructed in close proximity to several small lakes and wetlands along Birch Creek with the approximately 24 km channel length constructed entirely within till; therefore, the potential effect was assessed as moderate.

All three reaches of the Lake St. Martin outlet channel will likely require work immediately adjacent to water or some in water work. Reach 1 will require construction of the control structure at the inlet and dredging to improve the existing inlet. Reach 2 will require bank reshaping and stabilization along Buffalo Creek. Both Reach 3 options will require shoreline excavation and construction of the outlet to Lake Winnipeg. The effects associated with initial and long-term operation are directly related to the length of each Reach, with greater magnitude effects for longer channels. An additional consideration was that Reach 1 will input sediment into Buffalo Lake and that both Reach 3 options will input sediment into Lake Winnipeg. While Reach 2, as a natural waterway, will be a source of sediment with the substrate material eroding and flushing downstream during high flow it discharges into Reach 3 and not a natural waterbody. Based on these considerations the potential effect for the Reach 2 channel was assessed as minor, whereas the potential effect for Reach 1 and both Reach 3 options were assessed as moderate.

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15.2 GROUNDWATER

The potential groundwater impacts associated primarily with operation and to a lesser extent during construction of the channel options were described in detail in previous sections of this report and include:

- Conditions for potential blowout of basal soils may occur during the construction phase unless mitigated by a depressurization system, or during operation, if the groundwater pressures exceed the overburden mass and overlying water levels.
- Excavation of the proposed channels into the till, and in particular bedrock sections, will likely result in constant seepage of groundwater into the channel that will lower the aquifer groundwater level and affect groundwater wells in the vicinity of the channel.
- Flood waters in the channel could exceed groundwater levels and lead to potential infiltration to the local aquifer, especially in areas where the channel intersects bedrock (Groundwater Under the Direct Influence of Surface Water, GUDI). When the flood waters are from developed or agricultural land, there is the potential for the infiltration to cause aquifer contamination.
- Changes to surface water quality due to discharge of groundwater and potential impacts to the aquatic environment.
- The aquifer drawdown could also result in drainage of low lying wetlands and surface water bodies close to the channel alignment.

Additional construction related impacts, not previously discussed, include the potential for soil contamination from leaks and accidental spills of fuel or other hazardous substances during construction activities leaching into and impacting the groundwater.

These potential groundwater issues are more of a concern for the Lake Manitoba options as there are groundwater wells in the bedrock aquifer that are used as a source for potable water. Mitigation of wells affected by the project along Lake Manitoba routes would include deepening or drilling new wells. Mitigation to prevent leaks, spills, and releases during construction include providing secondary containment for fuel and hazardous material storage, requiring drip trays for equipment, providing spill clean-up equipment and materials, and providing an emergency (spill) response plan.

There is certainly the potential for blowout during construction and operation of Channel Option C, in particular in areas with overburden underlying the channel invert. The aquifer drawdown in the vicinity of Option C both during construction and operation is anticipated to be

significant and would likely have an impact on the available capacity of many domestic wells. There are approximately 140 domestic wells within 3 km of the channel, many of which are directly adjacent to the channel and located within the Fairford First Nation. While it is anticipated that groundwater will discharge into the channel, the available groundwater quality data does not raise any initial concerns for discharge to Lake St. Martin. There is the potential following a period of aquifer drawdown and/or a sudden increase in channel water levels during a flood that surface water could recharge into the aquifer. The concerns associated with GUDI are related to a change in the water quality of the local well users, with impacts including potential bacterial contamination. Based on the long-term operational impacts over a large area and a large number of wells, the effect of Option C on groundwater was assessed as major. Option D would affect fewer wells with only approximately 70 wells in the vicinity, none of which are located on First Nation Land. The magnitude of the drawdown on these wells would be less than anticipated along the Option C channel. The Option D channel is anticipated to have a relatively thick overburden cover over the bedrock, with less risk of blowout. Additionally, there were lower GUDI concerns; therefore, the effect of Option D on groundwater was assessed as moderate.

There is a potential for groundwater contamination during construction along each Reach (1, 2 and 3) of the Lake St. Martin outlet channel; however, any potential spills would be an infrequent event, localized and the impacted soil immediately cleaned up minimizing the potential to leach into the groundwater. Likewise, while there is potential for blowout during construction, a limited amount of groundwater seepage was observed during construction of the Reach 1 and Reach 3 emergency channels and, with the exception of the upstream portion of Reach 3, there is an assumed thick till layer below the channel invert. Operation of the Lake St. Martin outlet channel may adversely affect the groundwater regime, as noted above; however, because the groundwater in this area is not used as a potable water supply, the magnitude of the effect is much less. Additionally, groundwater naturally discharges to Lake Winnipeg so any seepage into the channel will still discharge to Lake Winnipeg. As such, the potential effects on groundwater were assessed as minor for each Reach of the Lake St. Martin outlet channel.

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15.3 TERRESTRIAL ENVIRONMENT

The key components of the terrestrial environment that may potentially be impacted by this project include vegetation associated with clearing for the channel right-of-way (ROW) and the associated impacts to wildlife through physical disturbance and loss of habitat.

15.3.1 Vegetation

Vegetation will be permanently lost associated with the site preparation and construction activities such as clearing, excavation, and blasting. Secondary impacts of construction activities include potential introduction of weedy species and the short-term production of fugitive dust during construction, which can settle on vegetation surrounding the project site and impair growth and development. Additionally, during operation higher flows along natural waterways, such as the bog complex at the end of Reach 1 and Buffalo Creek along Reach 2 of the Lake St. Martin channel could result in losses in vegetation either from inundation, or from high velocity of the water eroding and flushing the substrate material downstream. The extent of impact to vegetation is largely a function of alignment length as the entire right-of-way will be cleared to develop the channel. A qualifier for determining the magnitude of impact is the quality of vegetation being cleared; agriculture fields or heavily disturbed areas may be viewed as lower quality compared to relatively undisturbed vegetation. Mitigation to prevent these effects may include ensuring equipment is clean to avoid transfer of weedy species as well as taking measures to control dust such as dust suppressants, covering loads when hauling materials and restricting activities during high wind events, minimizing clearings to the extent absolutely required to complete the tasks, whenever possible using previously disturbed areas, and re-vegetating disturbed and reclaimed areas after construction.

Option D is approximately twice as long as Option C, therefore, the extent of the impact is larger. Most of the vegetation that would be impacted along Option D, however, is previously disturbed agricultural land with only approximately 3.5 km of channel length through forested areas. In comparison, approximately half the length (6 km) of Option C would require clearing of forested areas; therefore, Option C has a larger magnitude of effect. Based on the smaller extent for Option C but the smaller magnitude for Option D, the impact of both options on vegetation was assessed as minor.

While the vegetation around Reach 2 is largely undisturbed, much less clearing is required compared to the other reaches, to accommodate the construction of approximately 3 to 4 km length of dikes. Based on the relatively small extent of clearing along Reach 2 and that the vegetation will re-establish on the dikes following construction, the potential impact to vegetation was assessed as negligible. In comparison, Reach 1, Reach 3 to Johnson Beach and Reach 3 to Willow Point are approximately 8 km, 9.7 km and 10.6 km, respectively, requiring a greater extent of vegetation clearing. Portions of the Lake St. Martin outlet channel Reach 1 and Reach 3 were previously cleared when the emergency channel was originally constructed in 2011; therefore, the potential additional impacts to vegetation associated with these reaches were assessed as minor.

15.3.2 Wildlife/Habitat

The vegetation cleared during site preparation and construction activities will result in a direct permanent loss of wildlife habitat used for breeding and foraging and may have an indirect effect through construction noise that may disturb wildlife during nesting and rearing. Habitat may also be disturbed or lost through modification of natural conditions through inundation or drainage associated with construction and operation of the outlet channels. Mitigation to reduce the adversity of these effects may include cataloging and avoiding, when feasible, sensitive areas or areas that contain species of interest, in particular, during critical nesting and rearing periods (typically spring and early summer).

Construction activities such as transporting materials during construction and increased vehicle traffic along highways and access roads will increase risk of vehicle-wildlife interactions and potential for disturbance, injury or mortality. Mitigation may include operating transport trucks during daylight hours, providing wildlife awareness information to drivers and adhering to set speed limits.

Project effects to wildlife and wildlife habitat, as noted, are directly related to the amount and quality of vegetation disturbed. As such, the assessment of effects associated with each of the outlet channels reflects the assessment previously assigned under vegetation, with a few slight differences. The approximately 6 km length of Option C excavated through bedrock will have steep bedrock side slopes that will act as a barrier to wildlife movement increasing the

magnitude of the impact to wildlife; therefore, the potential impact was elevated to moderate. The Lake St. Martin outlet channels are in an area with less human disturbance that provides better habitat. More wildlife is likely present, which may be affected by these channels; therefore, the assessed effects were elevated to minor for Reach 2 and moderate for the other reaches.

15.4 FISH HABITAT

The proposed project will result in the alteration of fish biota habitat and has the potential for habitat loss. Currently, none of the proposed control structures will be constructed within water bodies; however, there is the potential for infilling and habitat loss during construction. Alteration of habitat will occur from temporary cofferdams and shoreline excavation during construction and increased or altered flow patterns, flooding, and water quality changes from erosion and sedimentation during operation. The habitat alteration and potential loss on its own is not likely to result in serious harm to the fishery in Lake St. Martin and Lake Winnipeg, although efforts should be made during the Environmental Impact Assessment to assess the quality of the habitat that will be affected for the preferred option.

The placement and removal of cofferdams (in water work) to facilitate shoreline excavation (in the dry) for construction of the inlet and outlet for each of the Lake Manitoba and Lake St. Martin channels will result in alteration and potential loss of fish habitat. However, this impact to fish habitat will be offset by the creation of new fish habitat in the channels. The Lake Manitoba channel Option C and Option D and Reach 1 of the Lake St. Martin channel will permanently contain water and provide new fish habitat. Reach 2 is the existing Buffalo Creek with natural fish habitat and some altered habitat where the banks will be reshaped and stabilized with rip-rap. In comparison, Reach 3 of the Lake St. Martin channel will only provide temporary new fish habitat during operation until the flows are ended, although there will likely be some base flow from precipitation, as well as the small creeks intersecting with Reach 3. After closure of the Lake St. Martin Channel, the water in Reach 3 would recede and because of the gradient control structures the channel will be inaccessible to fish.

The Lake St. Martin outlet channel will involve increased flows or altered flow patterns in Buffalo Lake and along the upper Buffalo Creek during operation. Similar to what was observed in

2011-2012, the operation of Reach 1 will result in increased water levels in Buffalo Lake and flooding of the surrounding bog and wetland areas. This will provide additional temporary usable habitat for fish during operation and for some time after closure as the water recedes. While diversion could continue well past the spring spawning period, the reduction in flow through Buffalo Lake after closure could result in exposure of spawning habitat and a reduced littoral zone, which could result in exposure of egg incubation and early larval rearing habitat. The inclusion of flow from Reach 1 and subsequent increased flow out of Buffalo Lake have the potential to alter the habitat type towards a more riverine environment, which could reduce the residency time for fish within the lake. As water continues along the upper portion of Buffalo Creek, the increase in flow and potential for scour could alter channel geometry, and certainly impact the riparian and in-stream vegetation and fine-grained sediment.

As discussed above, both Lake Manitoba channels Option C and Option D would mostly be constructed in the dry, except the habitat alterations at the inlet and outlet, which would be compensated for by the length of channel providing new fish habitat. While the Option D channel is in close proximity to Birch Creek and may require in water work to tie the channel into the creek near the downstream end, route optimization may eliminate the need for in water work, and more new fish habitat would be created compared to Option C due to the greater channel length. As such, the impact of both options on fish habitat was assessed as minor.

All three reaches of the Lake St. Martin outlet channel will require alteration of fish habitat. Reach 2 consists of installation of erosion protection along the banks of Buffalo Creek in some areas with minimal excavation. This will be a small area and temporary disturbance during construction that will mitigate erosion concerns during operation. However, because of the potential changes in flow conditions to Buffalo Creek during operation the potential impact on fish habitat was assessed as minor. Reach 1 and Reach 3 (both options) would mostly be constructed in the dry, except the habitat alterations at the inlet and outlet. While the habitat alteration associated with Reach 1 will be compensated for by the length of channel providing new fish habitat the impacts to fish habitat were assessed as moderate because of the potential impacts to Buffalo Lake associated with flow changes during operation. As noted, Reach 3 (both options) will only provide temporary fish habitat during operation, which does not fully offset the habitat alteration associated with the outlet construction; therefore, the impacts to fish habitat were assessed as moderate.

15.5 FISH RESOURCES

Three aspects of the project that could impact fish resources in the study area include habitat change and fish species composition/distribution changes from flow pattern alterations, as well as fish passage.

15.5.1 Habitat Change from Alterations in Flow Patterns

Within Buffalo Lake and upper Buffalo Creek, increase in flows can result in flooding and erosion of aquatic and terrestrial vegetation. This could affect the availability and distribution of spawning habitat and potentially affect spawning behavior and timing. Erosion of substrate composition and sedimentation can also affect both egg distribution and incubation success rates. Similarly, increased depth, sedimentation, and turbidity from increased flow could impact the littoral zone habitat used by many species of fish for rearing and feeding and could result in a temporary redistribution of fish to other areas within the watershed or to adjacent, unaffected watersheds. Other indirect effects include transportation and redistribution of invertebrates, which serve as prey items for the fish and may result in movement of fish to locations further downstream.

Lake Manitoba channel Option C and Option D are not directly connected to any other natural water body along the route in which flow patterns or water levels would be altered. Both Lake Manitoba channel options, however, will result in an increased flow to Lake St. Martin during operation with associated effects related to sedimentation. These potential impacts will be localized and relatively low magnitude, therefore, the potential effect was assessed as minor. Reach 1 of the Lake St. Martin outlet channel would result in an increased flow to Buffalo Lake and Reach 2 will have increased flows to upper Buffalo Creek. The increase in flows to Buffalo Lake and Buffalo Creek during operation will be of a relatively large magnitude compared to the size of these water bodies affected as described above; therefore, the potential effect was assessed as moderate. While, Reach 3 (both options) will result in an increased flow to Lake Winnipeg during operation, the associated effects related to sedimentation will be relatively low magnitude given the size of Lake Winnipeg; therefore, the potential effect was assessed as minor.

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15.5.2 Change in Species Composition and Distribution

Increased flows and changes in flow pattern may result in velocity barriers to certain species of fish that are adapted to lower flow conditions (e.g. yellow perch, northern pike, etc.), which may limit the amount of available habitat for these species during operation. Conversely, fish that are more adapted to higher water velocity conditions may become more prevalent during operation of the outlet channels. Depending on the timing, higher flows may negatively impact egg and larval fish distribution. Eggs may be flushed downstream into habitat unsuitable for incubation and drifting larval fish may be transported to areas further downstream that are unsuitable or have increased numbers of potential predators. Both scenarios can lead to increased mortality rates.

Alternative flows and/or increased flows may act as attractants to certain fish species during fall and spring spawning runs affecting the timing and distribution of spawning activity. This could occur at the downstream end of the Lake Manitoba channel options and at the downstream end of either alignment option for Reach 3 of the Lake St. Martin Channel. Fish that would normally migrate up the Fairford or Dauphin Rivers may alternatively ascend the corresponding channel until they are impeded by the control structures. While water will be permanently retained in the Lake Manitoba channel (either option), closure of the Lake St. Martin channel following operation may result in stranding of fish as the water slowly recedes. Consideration should be given to the operation and closure of the Lake St. Martin channel so as to reduce the effect on spring and fall spawning runs. Further, in addition to the proposed gradient control structures, consideration should be given to installing a drop structure at the downstream end of Reach 3, to prevent fish from ascending the channels during migration. Reach 1, is proposed to be extended to connect with Buffalo Lake so that it permanently retains water to prevent fish stranding.

Lake Manitoba channel Option C and Option D are not directly connected to any other natural water body along the route in which flow patterns or water levels would be altered. As such they only have the potential concern of impeding upstream migration of any fish attracted to the channel. There is the potential that fish may be able to migrate upstream of the control structure during operation and downstream migration will not be impeded. As noted, because the channel

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will permanently retain water, fish stranding is not a concern; therefore, the potential effect was assessed as minor.

Reach 1 of the Lake St. Martin outlet channel has a large potential to change flow patterns and water levels on Buffalo Lake, and Reach 2 will have increased flows to upper Buffalo Creek. Therefore, the potential effect to species composition was assessed as moderate. The concern for fish stranding observed in Reach 1 during operation of the emergency channel will be alleviated by extending Reach 1 to connect with Buffalo Lake, whereas there is no concern for fish stranding in Buffalo Creek (Reach 2). Reach 3 to both Willow Point and Johnson Beach will act as an attractant to certain species with the increased flows at the outlet during operation and may be a concern for fish stranding when the channel is closed; therefore, the potential effect to species composition was assessed as moderate.

15.5.3 Fish Passage

The Lake Manitoba and Lake St. Martin Regulation Review Committee recommended that *"if the Province builds a new outlet to Lake Manitoba it should take that opportunity to design the new outlet in such a way as to provide unrestricted fish passage between Lake Manitoba and Lake St. Martin"*. As the proposed Lake Manitoba Channel will not be operated year round, neither option is appropriate for providing unrestricted fish passage between the two lakes. As indicated in the previous section, fish access to the channels during operation could hinder rather than help the fish populations by altering migration patterns during spawning. An option that may be more valuable in accomplishing the goal of unrestricted fish passage would be including the improvement for fish passage at the current FRWCS as part of the proposed project, regardless of the Lake Manitoba outlet channel that is selected.

Because neither of the Lake Manitoba outlet channel options are appropriate for providing unrestricted fish passage between the two lakes, as noted above, and because the review committee did not require fish passage for the Lake St. Martin outlet channels, the options were not ranked based on this criteria.

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15.6 SOCIAL ENVIRONMENT

Certain options may be viewed as more or less favorable by the First Nation communities and other stakeholders. While the project as a whole provides a direct benefit to the communities on the drainage basin by mitigating future flooding issues and subsequent environmental and social impacts, the individual components may not be viewed as such. The most likely First Nation and public concerns associated with this project include land use and ownership, access, and unresolved litigation claims. This is based on our knowledge of the area and experiences associated with this project to date. The following sections contain a brief overview of these issues.

15.6.1 Land Use/Ownership

The Lake St. Martin outlet channel is located entirely within crown land while the Lake Manitoba outlet channel options are routed through a mix of private and crown land with Option C adjacent to the Pinaymootang First Nation. The land consists of a mix of undeveloped natural forest and wetland vegetation, agricultural fields and residential development. Acquiring the required land for the channels will take these areas away from the current land use while some of the channels may also affect the adjacent land use.

There are long-term unresolved issues over the operation of the FRWCS and how changes in flow conditions on the Fairford River have caused flooding along the river and in Lake Pineimuta and Lake St. Martin. This flooding has impacted land use and activities including fishing, muskrat trapping, waterfowl hunting, agriculture hay fields, and a multitude of infrastructure (roads, houses, supply wells, etc.).

Option C is located within private and crown land running through a mix of undeveloped natural forest and agricultural fields, which will be permanently changed. While the area directly affected by the land use change is relatively small, the potential drawdown in the groundwater table, as discussed in Section 15.2, has the potential to impact a large number of supply wells associated with residential and agricultural land use over a larger area. Based on the large magnitude and extent of the impact from both construction and operation and because the majority of these wells are within the Pinaymootang First Nation, the effect of Option C on land

use was assessed as moderate. Option D is located within predominately private agricultural land that requires a greater amount of land acquisition compared to Option C, although there are substantially fewer supply wells in the area and a smaller magnitude of impact on these wells. During field drilling investigations completed in 2015, the land owners indicated several potential concerns related to the Option D route alignment. Specifically, they noted the presence of a home and graveyard along the route, as such the route was adjusted to not impact these two land uses. Their two main concerns were removing good agricultural land from production, in particular along Bayton Road, and that the channel would separate agricultural lots, impeding access to and lowering the value of the land. While not opposed to the proposed channel, the land owners believe that locating the channel further east away from the high and dry land towards the low lying wetlands and lakes along Birch Creek would preserve the good agricultural land. The location of Option D will need to be optimized to preserve good agricultural land while avoiding altering the natural lakes and wetlands in the area. While there will be substantially less impact to supply wells, based on the potential public concern related to the loss of good agricultural land, the effect of Option D on land use was assessed as moderate.

As noted, the Lake St. Martin outlet channel is located entirely within crown land that is predominately undeveloped so there will be little to no change to land use. Reach 1 of the Lake St. Martin outlet channel will result in increased water levels in Buffalo Lake and flooding of the surrounding bog, as previously noted. Also, Reach 2 may result in localized flooding along the upper portion of Buffalo Creek. However, these changes will not affect the land use in the area; therefore, the effect was assessed as negligible. Both the Johnson Beach and Willow Point Reach 3 options will affect the shoreline of Lake Winnipeg. However, the Dauphin River First Nation community noted a preference to have the Reach 3 outlet located on the east side of Willow Point due to concern that the Johnson Beach outlet would have an adverse effect on the Lake Winnipeg fishery and the beach itself. Based on the permanent change to the shoreline, the Willow Point option was assessed as minor, whereas with the additional potential impact to the fishery and beach, associated with the Johnson Beach option, the effect was assessed as moderate.

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15.6.2 Access

The Lake Manitoba outlet channel options will disturb access along PTH 6 and potentially several municipal roads during construction and create permanent barriers to access during operation. Bridge crossings have been proposed to minimize interruption to existing public access along municipal roads. Option D, however, will result in a localized blockage of one existing municipal road, requiring rerouting of the current access. Both Lake Manitoba channel options will create a permanent barrier during operation. As Option D is located in predominately agricultural land, the barrier will be access to agricultural fields as discussed in the previous section, whereas, Option C is located in a less developed area with more recreational (off-road) use. As such, the approximately 6 km of channel with steep bedrock side slopes pose a substantial threat to public safety. Option C will cause temporary disturbance to two municipal crossings and to the PTH 6 Bridge during construction; however, because of the permanent disturbance to recreational access and in particular the risk to public safety, the effect of Option C was assessed as major. Option D will cause temporary disturbance to four municipal crossings and to the PTH 6 Bridge during construction and will result in permanent localized changes to the current municipal road access pattern. In addition, Option D will create permanent barriers to agricultural land access, which as discussed, will be faced by public opposition; therefore, the effect of Option D was assessed as moderate.

The Lake St. Martin channel options require construction of an all-season road that will provide access to an area previously inaccessible. The Peguis First Nation may have a concern with the project as the proposed all-season road would be constructed within and along the periphery of the Area of Interest for the Peguis First Nation. A likely concern is that the road could provide access to hunters that would otherwise not attempt to hunt in this area. While the all-season road covers a large area and will provide permanent access, the frequency of use and magnitude of impact are likely very low. Regardless, based on the potential First Nation concern related to increased hunter access, the effect of each reach was assessed as minor.

15.6.3 Litigation Claims

While litigation claims are not a social environment component that will be affected by the project and, therefore, are not ranked, they have the potential to affect the project approval

process. Overall, the project and the public engagement process may be hindered by an overtone of distrust that was apparent during previous engagement and consultation events within the communities in 2011-2012 associated with the Reach 1 Emergency Outlet Channel. As well, the Pinaymootang, Little Saskatchewan, Lake St. Martin and Dauphin River First Nation communities are currently involved in a class action lawsuit pertaining to the flooding that occurred in the region in 2011. The suit against the Province includes, but is not limited to the following: general non-pecuniary damages for negligence, nuisance, breach of fiduciary duty and breach of or interference with treaty rights, damages for expenses and loss of income, and diminution and loss of property value (Manitoba Justice, 2012). Further to the issues over the 2011 flooding, the Pinaymootang First Nation has an on-going lawsuit with Canada (1961 to the present day) over the fiduciary duties, which the Band suggested is owed to them relating to flooding from operation of the FRWCS. The allegations associated with the lawsuit included the loss of hay lands negatively impacting farming, destruction of the natural habitat negatively impacting the opportunity to engage in hunting, fishing and trapping both on and off reserve, disease such as dysentery and contamination of the water. The Band further alleged that a byproduct of the breach of fiduciary responsibility has led to a loss of self-sufficiency by Band members including an increase in alcoholism, drug addiction, mental illness or distress, community strife and increase in unemployment and dependency on government welfare (Office of the Commissioner for Federal Judicial Affairs Canada, 1998).

Based on the unresolved litigation, any potential project effects to First Nation Land will be faced with strong resistance and potentially delay the project. As such, Options C is more likely to face opposition compared to Option D because of the potential impacts to groundwater supply wells and public safety as previously discussed. The Lake St. Martin outlet channel will alleviate flooding on Lake St. Martin without contributing to additional flooding along the Dauphin River and affecting the Dauphin River First Nation. The Dauphin River First Nation, however, have indicated a preference to have the Reach 3 outlet located on the east side of Willow Point rather than the Johnson Beach outlet option because of the potential adverse effect on the Lake Winnipeg fishery and on Johnson Beach.

15.7 SUMMARY OF ENVIRONMENTAL CONCERNS

The biophysical and social environmental concerns for each of the Lake Manitoba and Lake St. Martin channel options, as described in the preceding sections, has been summarized in Table 15.1. This summary of environmental concerns indicates the overall adversity of effect for each alternative from a biophysical and social environmental perspective and will be used along with other criteria in the selection of a preferred option.

Table 15.1
Summary of Environmental Concerns

Criteria	Lake Manitoba Outlet Channels		Lake St. Martin Outlet Channels			
	C	D	R1	R2	R3JB	R3WP
Biophysical Environment						
Surface Water Quality						
- Flow Rate	neg	neg	min	min	min	min
- Flooding	neg	neg	min	neg	neg	neg
- Erosion/Sedimentation	min	mod	mod	min	mod	mod
Groundwater	**maj**	mod	min	min	min	min
Terrestrial Environment						
- Vegetation	min	min	min	neg	min	min
- Wildlife/Habitat	mod	min	mod	min	mod	mod
Fish Habitat	min	min	mod	min	mod	mod
Fish Resources						
- Habitat Change	min	min	mod	mod	min	min
- Species Composition	min	min	mod	mod	mod	mod
Social Environment						
Land Use/Ownership	mod	mod	neg	neg	mod	min
Access	**maj**	mod	min	min	min	min

Notes: Level of effect is shown as; neg = negligible; min = minor; mod = moderate; and **maj** = major

Based on the above summary of environmental concerns for the Lake Manitoba channels, Option D is better considering both the biophysical and social environment perspectives. None

of the potential environmental concerns associated with Option D were assessed as major, whereas the potential effect of Option C on groundwater and access were assessed as major.

Based on the above summary of environmental concerns for the Lake St. Martin channels, while there does not appear to be a preferred option for the location of the Reach 3 outlet considering the biophysical environment, the Willow Point option is better from a social environment perspective because of the concerns related to land use.

15.8 APPROVAL PROCESS

15.8.1 Federal Approvals

The proposed Lake Manitoba and Lake St. Martin Outlet Channels will each require approval by the Canadian Environmental Assessment Agency (CEA Agency), as they each are a designated project under C*EAA 2012 Annexed Regulation SOR/2012-147A "Regulations Designating Physical Activities"*. The proposed construction access road, however, is not a designated project as it will require less than 50 km of new road right-of-way and, therefore, will not require approval under CEAA 2012. The environmental assessment process, as managed by the CEA Agency is shown in Figure 15.1 and summarized along with the additional steps completed by the proponent as follows:

- Develop Project Description (Proponent; see schedule line 15): The proponent will prepare a project description conforming with the requirements outlined in the Guide to Preparing a Description of a Designated Project, which specifies the information that is required to inform the CEA Agency of the possibility that the project may cause adverse environmental effects and determine whether an EA is required under CEAA 2012.
- Project Description Review (CEA Agency; see schedule line 17): Upon receipt of the Project Description, the CEA Agency has 10 calendar days to review and assess whether the project is a designated project, if all the required information is provided, and if there is sufficient detail to determine whether an EA is required.
- Determination of EA (CEA Agency; see schedule line 17): Upon acceptance of the Project Description the CEA Agency posts a notice on the Canadian Environmental Assessment Registry (Registry) announcing that it is determining whether an EA is required and initiating a 20-day period for the public to provide comments. Based on a review of the Project Description, the potential for adverse effects and public comments received, the CEA Agency will determine if an EA is required within 45 days of acceptance of the Project Description.

- EA Commencement (CEA Agency; see schedule line 18): Upon determining that an EA is required, the CEA Agency will post a Notice of Commencement on the Registry to mark the beginning of the 365-day period to reach the EA Decision. The CEA Agency posts a draft of the Environmental Impact Statement (EIS) guidelines to the Registry for a 30-day public review period. The final EIS guidelines specifying the nature, scope and extent of information required by the proponent are then issued incorporating the public comments. If warranted within 60-days of the EA Commencement, the Minister of the Environment may refer the EA to a review panel.

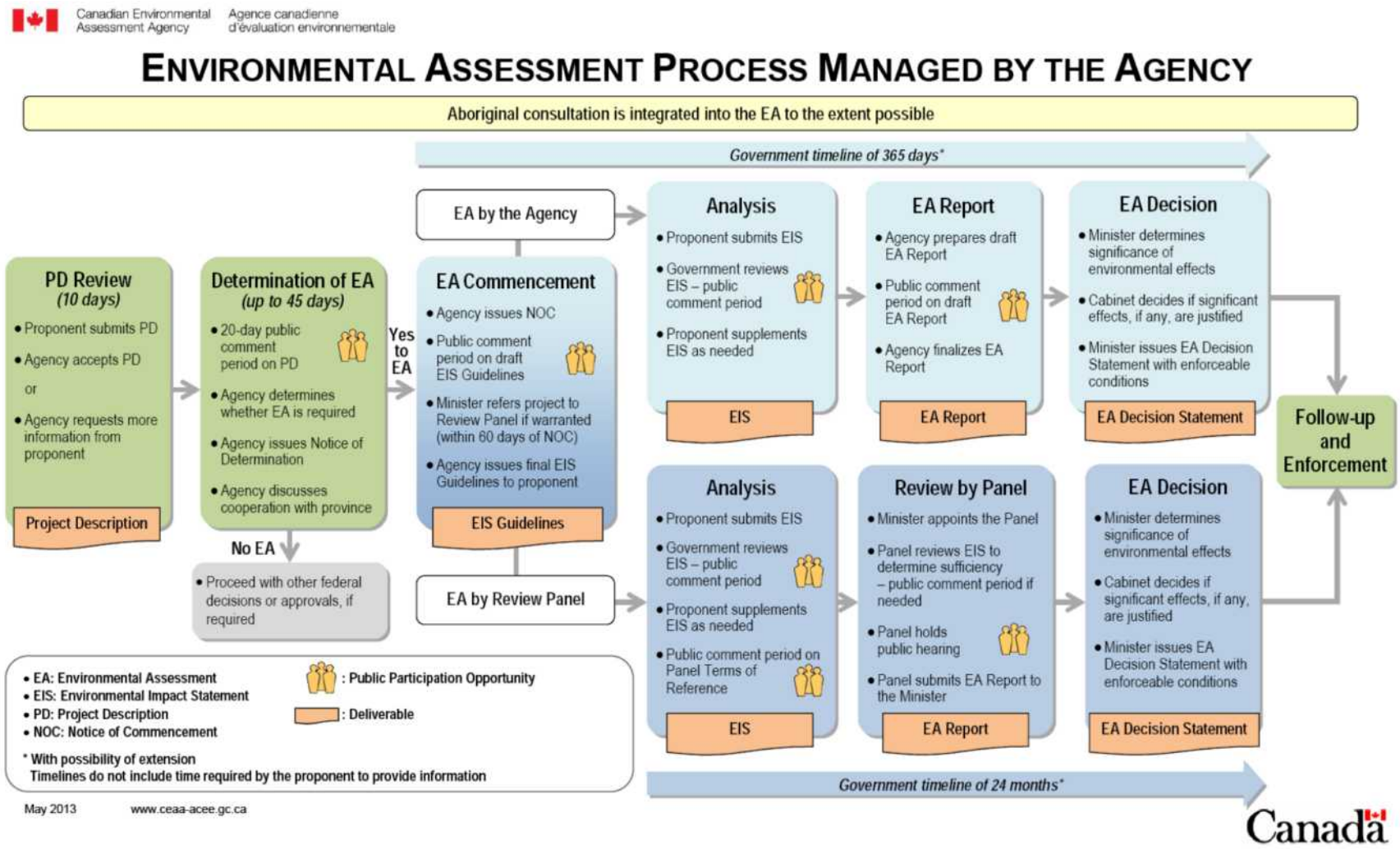
- Develop Environmental Impact Statement (Proponent, see schedule line 19): The proponent will prepare the EIS providing sufficient data and analysis of any potential changes to the environment to permit a thorough evaluation of the environment effects of the project by the CEA Agency. The EIS will meet the minimum information requirement outlined in the final EIS Guidelines, and it will identify potential adverse environmental effects, identify technically and economically feasible mitigation measures, evaluate the significance of residual adverse effects and describe any follow-up program. Approximately 140 days has been assumed in the project schedule (line 19) to allow sufficient time to conduct further field programs to ensure sufficient baseline data. The 365-day period for the CEA Agency is paused following the EA Commencement while the proponent prepares the EIS.

- Analysis (CEA Agency; see schedule line 21): Upon receipt of the final EIS the CEA Agency will review its conformity with the EIS guidelines and will conduct a detailed review of the EIS to ensure it adequately assesses potential adverse effects, identifies appropriate mitigation measures and follow-up and identifies the significance of residual effects. Additional information or clarifications may be required from the proponent. A summary of the EIS and the EIS are posted to the Registry for public review.

- EA Report (CEA Agency; see schedule line 21): Following the CEA Agency analysis, an EA report will be drafted including the rationale, conclusions and recommendations regarding the potential environmental effects of the designated project, the mitigation measures that were taken into account and the significance of residual effects and follow-up program requirements. A copy of the draft EA Report will be posted to the Registry for public review and comment. The EA report will be finalized incorporating any public comments received and submitted to the Minister of the Environment.

- EA Decision (CEA Agency; see schedule line 22): Based on the EA Report the Minister of the Environment determines whether the project is likely to cause significant effects and issues an EA Decision with enforceable conditions.

Figure 15.1
Canadian Environmental Assessment Agency, Environmental Assessment Process



Under the *Navigation Protection Act* (NPA), work in a waterway on the list of scheduled waters requires Ministerial review with works determined likely to substantially interfere with navigation requiring approval whereas works determined not likely to substantially interfere with navigation are Permitted. Both Lake Manitoba and Lake Winnipeg are scheduled waters, and the proposed cofferdams for construction of the channel inlet and outlet are considered works. As the cofferdams would simply be isolating a portion of the shoreline, the work will not cause a substantial interference with navigation. Regardless, a Notice to the Minister would need to be prepared for the NPA to review the likely interference with navigation and determine if further authorization work is required. The Notice to the Minister would need to include a completed "Notice of Works" form and provide a location map, plan and profile view drawings, a legal site description and work position, as well as a project description outlining construction methodology and anticipated start and end dates.

The proposed channels have the potential to impact fish and fish habitat as previously described in Section 15.0. The Environmental Impact Assessment for the project will need to assess the potential project effects in greater detail to determine the likelihood of causing serious harm to the fishery in Lake St. Martin and Lake Winnipeg. As the emergency channel construction was authorized under the Fisheries Act, it is assumed that, at a minimum, a request for review will need to be prepared and submitted to the Fisheries Protection Program to determine whether authorization is required under the *Fisheries Act*.

15.8.2 Provincial Approvals

The Lake Manitoba and Lake St. Martin Outlet Channels and the proposed construction access road are each considered a development under the *Classes of Development Regulation* (Reg. 164/88). As such the project will need to apply for a Provincial license under the *Environment Act*. This will require preparation of an Environment Act Proposal (EAP) to be submitted for review and approval by Manitoba Conservation and Water Stewardship (MCWS) Environmental Approvals Branch (EAB). The EIS being prepared to satisfy the CEA Agency process would also meet the requirements of an EAP, and the provincial licencing process has a shorter schedule.

15.8.3 Duty to Consult

Given the proximity of the proposed project to First Nations, the Crown will have a Duty to Consult (DTC) responsibility that should be conducted concurrently with the environmental assessment so that Aboriginal concerns can be identified and addressed within the EAP and EIS.

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16.0 COST ESTIMATES

16.1 GENERAL

The cost estimate is considered to be an Association for the Advancement of Cost Engineering (AACE) Estimate Class 3 based on semi-detailed unit costs sufficient for budget authorization. The cost estimate has been prepared assuming that the work will be divided into a number of contracts managed by MIT or their designate. This contracting philosophy is consistent with MIT's methodology for executing large projects. Although the level of effort to manage the work will be increased compared to a single large contract, the total overall cost should be significantly less. It is likely that the final contract execution strategy will involve First Nation's "set aside" requirements as part of the construction process. The estimate has not provided a specific allowance for this process, as this would best be addressed when these requirements are clearer, with adjustments made to the estimate as appropriate.

A description of the major construction components and how they have been tentatively divided is outlined below:

- **Earthworks** – It is likely separate excavation contracts would be tendered for each of the Lake St Martin and Lake Manitoba Outlet Channels, respectively. Depending on contractor capability and the government's desire to distribute work, these separate work areas could be further divided into two or more contracts. This would be similar to the contracting strategy used for the Floodway Expansion Project, which had a goal of distributing the work to a number of contractors. For the purpose of this estimate, we have assumed four separate earthwork contracts, one for each channel or reach (i.e. LMB outlet channel, Reach 1, Reach 2 and Reach 3).

  It has been assumed that, given the remoteness of the work, each channel excavation contract will be supported by a camp. It may, however, be practical for the Lake Manitoba Project to be executed with local labour and supervision utilizing local accommodations and commuting to the work areas without the need for a formal camp. This would be a reasonable assumption for the Lake Manitoba Channel due to the proximity of local communities, cottages and labour. For example, Manitoba Hydro executed the Pointe du Bois Spillway Replacement Project without a formal camp using local accommodations for their labour force. It is, however, likely that a formal camp would be required for the Lake St. Martin Channel depending on the contractor's assessment of the comparative costs. These issues and the potential impact on the cost estimate will be addressed in greater detail at the tender preparation stage.

  In addition to the excavation, there will be requirements for dike construction and cofferdams, as well as the development of riprap borrow areas and the placement of

riprap for the rock drop structures along Reach 3. For the purpose of this estimate, we have assumed that these will be included in the excavation contracts.

- **Access Road to the Lake St Martin Channel** – It has been assumed that this access road will be executed as a separate Contract, with its own approval process, designed and administered internally by MIT.
- **Control Structures** – It has been assumed that each of the two control structures for Lake St Martin and Lake Manitoba, respectively, would be tendered as separate contracts. The gates and hoists could also be tendered separately as supply and install projects similar to Manitoba Hydro's practice for their generating station construction projects. For the purpose of this estimate, we have assumed that the control structures and all of their ancillary components will be tendered as a single contract. At subsequent stages of design, the merits of tendering the components such as the gates, hoists, backup power, control building, etc. separately should be considered.
- **Bridges** – With the exception of the control structure bridges, it has been assumed that the channel municipal and provincial bridges and any required roadway re-alignments would be tendered separately. These could be bundled with other bridges in the vicinity or separately depending on the project scale and MIT's procurement philosophy at the time.
- **Power Supply** – it has been assumed that permanent power with a backup generator will be required for the long term. At this level of estimate, we have assumed that this work would be tendered separately and will require a contractor familiar in working with Manitoba Hydro Interconnections.
- **Land Acquisition** – It has been assumed that the land acquisition process will be administered internally by MIT.
- **Fish Passage** – the fish passage structure estimate has been prepared separately assuming that this would be tendered as a separate contract. It could, however, be included with one of the major earthworks or structures contracts.

16.2 BASIS OF THE ESTIMATE

The cost estimates proposed in the following section update the previous estimates included in the report, "Assiniboine River & Lake Manitoba Basins Flood Mitigation Study", (KGS Group, 2015). The dimensions of the channels and corresponding excavation volumes and structure lengths have been substantially updated in this report based on a more advanced hydraulic assessment of each option. Additional project components identified in the current cost estimate table include construction dewatering, control structure gates and hoists, cofferdams, inlet sediment control groins, construction and permanent power supply, municipal bridge approach roadway re-alignments, extension of Reach 1 to Big Buffalo Lake, and Buffalo Creek erosion protection (for Reach 2). As such, the 5% miscellaneous allowance included in the previous

estimate has now been removed; and the overall contingency has been reduced from 30% to 20%.

The basis for the estimate for each of the project components is outlined below.

16.2.1 Earthworks

The following section describes how the costs for each component of the outlet channels earthworks were developed for the various options and includes unit measures and pricing for updated project components that were not discussed in previous studies. Earthworks unit prices were assumed to include all of the contractors' direct and indirect costs, as well as allowances for overhead and profit.

Excavation

The excavation quantities and unit prices are based on the following:

- Quantities based on LIDAR and channel cross sections and calculated using civil 3D. Quantities for peat, till and rock excavation were calculated separately.
- Unit prices – assuming inclusive of contractor indirects based on previous experience and discussions with local contractors.
- Unclassified earth excavation - $\$10/m^3$.
- Rock excavation (limestone) – $\$25/m^3$.
- Construction dewatering – lump sum.

Dikes

Diking is required within Reach 2 to contain flows within Buffalo Creek. Fill quantities for the dikes were calculated using civil 3D based on LIDAR and an assumed dike geometry with an 8 m (26 ft) top width and 4:1 side slopes. The base of the dike was assumed to be 2 m (6.6 ft) below the top of the existing peat. The dikes also incorporated a 1.0 m (3.3 ft) additional height allowance for freeboard. The assumed unit price for peat excavation, dike fill and clearing and grubbing was $\$10/m^3$, $\$20/m^3$, and \$16,500/ha, respectively.

Cofferdams and Sediment Control Groins

The placement and removal of cofferdams is required to facilitate shoreline excavation (in the dry) for construction of the inlet and outlet for each of the Lake Manitoba and Lake St. Martin channels. It is anticipated that segments of the LMB channel inlet cofferdams may remain as permanent groin structures to prevent infilling of the entrance to the channel with sediment due to natural shoreline processes in Lake Manitoba.

The assumed unit price for cofferdam / groin placement was $\$20/m^3$ for earth fill and $\$90/m^3$ for rock riprap. It was assumed that only 80% of the temporary cofferdam material would be recoverable at a removal unit rate of $\$20/m^3$ for both earth fill and rock riprap. For the LMB and LSM channels, excavation of the inlet and outlet areas was assumed at a unit rate of $\$20/m^3$, which includes an allowance for dewatering the work area. For the LSM channel Reach 1 extension to Buffalo Creek, a cofferdam will also be required; but due to the unique conditions in this area, an additional lump sum for construction dewatering was included.

Buffalo Creek Diversion Structure

Both Reach 3 options will require a diversion structure complete with culverts in Buffalo Creek, downstream of the inlet location to divert flows into Reach 3, while maintaining riparian flows in Buffalo Creek. As part of this design, a weir structure would also be constructed at the inlet to Reach 3. The estimate for this structure is based on calculated earth fill and riprap quantities and a lump sum allowance for culverts, geotextile, construction staging, etc.

Riprap for Drop Structures

The assumed unit rate for the rock riprap cost estimate of $\$90/m^3$ was based on average unit prices where rock riprap must be hauled from existing off-site quarries.

This assumption was based on analysis of bedrock samples collected in 2015 from the rock quarry near the previous construction campsite at the end of the forestry road, which suggested that the bedrock may be suitable for use as riprap. The rock from this quarry has been used to date for the LSM channel Reach 1 inlet cofferdam.

MIT Spec 1297 for stone riprap states that: “Quarried limestone shall have a maximum Los Angeles Abrasion Loss of 32% (ASTM C535) and a maximum Magnesium Sulphate Soundness Loss of 13% (ASTM C88)”.

The 2015 results indicated that the shot rock limestone had a L.A. Abrasion Loss of 31.2%, just less than the maximum allowable of 32%. Results of the sulphate soundness test were not yet available. Testing of additional limestone samples has, therefore, been recommended.

Previously in 2012, bedrock samples from the rock ridge near Reach 3 were submitted to MIT testing laboratories for LA abrasion, sulphate soundness, and specific gravity and absorption testing. This bedrock was found to be highly susceptible to mechanical breakdown (56% losses in the LA abrasion test) and freeze-thaw action (45% to 46% losses in the sulphate soundness test). The Reach 3 limestone had a specific gravity that ranged from 2.55 to 2.59 and was also found to be highly absorptive (3.0% to 3.4%). The results of the testing indicated that the Reach 3 bedrock did not meet MIT Riprap Standard Specification 1297, would only be considered for temporary erosion protection (5 years or less) and emergency usage.

It is possible that other sources of bedrock in proximity to the Lake St. Martin and Lake Manitoba channel options may be discovered and developed into quarries. However, a conservative value for the unit price of riprap was used to account for the uncertainty in terms of bedrock quality.

Construction Camp

The construction camp estimates for the earthworks contracts are based on the size of the construction camp used for the development of Reach 3 in 2012. A daily cost was estimated at $102/person to cover food and lodging for onsite staff. A mobilization and demobilization fee was included, which covers the costs of provincial permits (permit for storage and handling of petroleum products, explosive magazine permits, and an onsite wastewater management systems permit), and the installation and removal of trailers for lodging, washhouses, dining area and office space ($2,800/unit). These prices assume that the camp equipment / infrastructure was owned by the contractor administering the camp rather than renting this required infrastructure from an outside source.

The estimated construction camp costs vary based on the maximum number of staff proposed to be in the camp at one time, which is a function of the project magnitude and construction schedule. A construction camp cost for the Lake St. Martin outlet channel was estimated and assumed a base requirement of 50 staff and 14 units. This option was deemed to be the most comparable to the construction camp operated during the development of Reach 3 in 2012, which was used as a basis for the cost estimate.

Based on the above, it was determined that the LSM channel construction camp was approximately 5% of the subtotal of all direct earthworks costs (excluding the construction camp). The 5% value was, therefore, used for all options and is intended to reflect the appropriate construction schedules and size of the construction camp relative to the size of each option and the complexity due to additional structures, rock excavation, etc.

Revegetation

The estimated cost to provide appropriate weed control and vegetation cover for any of the outlet channel options at Lake Manitoba or Lake St. Martin is based on costs for conducting similar work along the East Side Road, which was developed and administered by Scatliff Miller Murray Inc. For the East Side Road, revegetation costs ranged from approximately $8,000/ha to $15,000/ha. For this estimate, the average value of $11,500/ha was assumed for the LSM Outlet Channels and the low value of $8,000/ha was assumed for the LMB Outlet Channels. This price assumed:

- Specifications will be developed prior to construction activities to allow for appropriate stockpiling of overburden and site / seed bed preparation (slopes, organic cover, mechanically preparing soils, etc.).
- All shaping of embankments and site / seed bed preparation is included in the construction costs.
- Appropriate site access is available for all options.
- Appropriate site conditions for seeding requirements.
- No significant delays or hindrances to revegetation work.

Total revegetation costs were calculated based on 75% of the total hectares estimated for the land acquisition (ha) multiplied by the unit price/ha. The estimate used 75% of the footprint area

since revegetation will not be required on the channel bottom or lower side slopes or over the length of the rock sections that are included in the total area. This will require further review prior to developing the specifications for weed control and vegetation cover.

Mitigation Costs

Costs associated with proposed best practices to mitigate effects during construction, such as control of surface water and groundwater (dewatering, ditching, silt fences and settling ponds) have been included in the construction cost estimate as part of the unit price for excavation. Design measures such as riprap to mitigate the effects of erosion and the use of control structures to reduce velocities during operation have been incorporated into the channel design and the costs included as part of the cost estimate for structures. Likewise, the costs associated with land acquisition to compensate people for land required as part of the channels has been included, as previously described.

Mitigation and compensation costs that have not been accounted for in the cost estimate include costs for long-term monitoring, groundwater mitigation costs for wells affected by the project (Lake Manitoba routes), compensation for damage to fish habitat, compensation to fishermen or any additional mitigation and compensation measures that may come from Regulator requirements determined during the advancement of the licensing and permitting process for the channel. These costs have been estimated as 5% of the direct project costs for all options.

16.2.2 Control Structures

A detailed estimate for the Spillway structure and the associated gates and guides was prepared using unit prices developed from similar recent KGS Group projects. Quantity ”take offs” for the estimate were based on the sketches shown on Plates 15, 16 and 17. As discussed in Section 10.0, concrete thicknesses and reinforcing steel requirements were based on KGS Group’s experience and will be confirmed at the final design stage. Similarly, the requirements for gates, guides, and hoists are largely based on experience and will be confirmed at the detailed design stage.

The estimate has been separated into contractor direct and indirect costs, with direct costs reflecting all works on site. Indirect costs consider camp costs, offsite contract support and supervisory staff requirements. At this level of estimate, a detailed breakdown of the indirect costs was not considered practical, and a percentage of direct costs of 20% was used to represent this cost. General contractor overhead and profit equal to 10% of the total construction cost was calculated separately in addition to the unit rates. Again, this was based on experience with similar remote or "semi-remote" projects. The detailed estimates and assumed unit rates for the Lake St. Martin and Lake Manitoba control structures are shown on the tables in Appendix I. At this level of design, we have assumed that the arrangement and costs for the Lake Manitoba channel Route C and D structures are the same.

16.2.3 Access Road

The Lake Manitoba outlet channel options will not require significant development of permanent roads for construction purposes, and access to the control structures for operation will be via PTH 6. The Lake St. Martin outlet channel options could be accessed along winter road systems for construction purposes; however, this would restrict all construction activities to winter months (late December to mid-March). The cost estimate assumes that an all-season road will be required to permit year round access to the project site for construction and also in the future for the purpose of operating the control structure, maintaining the revegetation components of the project, and general maintenance to the structure and channel. All-season access to Reach 2 and Reach 3 would be required only if access to Reach 1 was already established, therefore, the cost estimates for Reach 2 and 3 include only the incremental cost to extend access from Reach 1.

There is an existing forestry road approximately 61 km in length extending from Spearhill, Manitoba that was used for access during the construction of Reach 3 in 2012. At the end of the forestry road, a winter road was developed extending the remaining distance to the Reach 1 inlet and the Reach 3 project site. The Reach 1 road access is approximately 19 km. The access to Reach 2 and 3 from the Reach 1 access road would require an additional 16 km road. It has been assumed that the channels themselves will be accessed along their right-of-ways and that this will be developed as part of the earthworks cost. It was estimated that upgrading the current 61 km forestry road to a single-lane gravel road would cost approximately

$100,000/km, and upgrading the current winter road access to a single-lane gravel road would cost approximately $500,000/km.

16.2.4 Bridges

The estimated bridge costs for each option were calculated based on the footprint area of each bridge and the number of bridges required. The footprint area was estimated using the calculated lengths of the PTH bridges and the municipal bridges and a standard width of 12 m (39 ft), and 10.8 m (35 ft), respectively. Because the PTH bridges will be built over the proposed control structures, the bridge lengths were based on the length of the control structures, whereas, the lengths for the municipal bridges were based on the average top width of the channel (in till sections).

While Option D crosses PR 239, for the purposes of the cost estimate, it was treated as a municipal road. As previously noted, it may be possible to reduce the number of new bridge crossings required for some options by localized realignment of roads. An all-inclusive unit rate of $25 per metre of footprint area was used for the municipal bridges. The PTH bridges were included as part of the control structure cost estimate. A lump sum of $3 million was added to each PTH bridge and $0.5 million to each municipal bridge to account for approach re-alignments and traffic control.

16.2.5 Electrical Power Supply Estimates

Permanent Power

A. Lake St. Martin Control Structure

Manitoba Hydro has been contacted and has indicated they can accommodate a 550 kW load from its existing 24 kV line along PR 513. This will require approximately 11 km of overhead line cut through the existing undeveloped terrain from PR 513 to the control structure site. The estimated cost would be approximately $150,000/km and assumes there will be no issues with First Nations or land acquisition.

Estimated cost of 11 km at $150,000/km	$1,650,000.
Estimated cost of 750 kVA pad mount	$ 70,000
Total	$1,720,000*

*Note: KGS is awaiting a cost estimate from Manitoba Hydro for this component.

B. Lake Manitoba Control Structure

Manitoba Hydro has been contacted and has indicated they can accommodate a 300 kW load from its existing 24 kV line along Hwy 6. This will require approximately 1 km of overhead line cut through the existing undeveloped terrain from PTH 6 to the control structure site. The estimated cost would be approximately $150,000/km and assumes there will be no issues with First Nations or land acquisition.

Estimated cost of 1 km at $150,000	$150,000.
Estimated cost of 750 kVA pad mount	$ 40,000
Total	$190,000*

*Note KGS is awaiting a cost estimate from Manitoba Hydro for this component.

Construction Power

A. Lake St Martin Control Structure

Manitoba Hydro has been contacted and has indicated they cannot accommodate a 3,000 kVA construction power load at this location.

Since construction power is a short term (two-year) requirement, the most practical and economical approach is to provide 3,000 kVA of prime power diesel generation. A detailed description and cost estimate can be found in the April 10, 2015 memorandum titled, “Diesel Generated Electricity for Construction – 6-Bay Spillway” in Appendix H.

The estimated cost for prime power diesel generation at the Lake St Martin Site is $ 3,636,000, plus taxes. This equates to $0.42/kW-hr. The costs include

Generator Rental	$1,098,000
Mob/Demob Costs	$ 119,000

Maintenance Cost	$ 138,000
Operating Cost	$2,281,000
Total	$3,636,000

B. Lake Manitoba Control Structure

Although a smaller structure, the construction power requirements are considered to be similar. Manitoba Hydro has been contacted and has indicated they cannot accommodate a 3,000 kW load from its existing power line along Hwy 6. Accordingly, on-site prime diesel power generation is appropriate. The construction site is closer to fuel sources and travel time for maintenance is shorter. At this stage of study, a lump sum amount of $2,000,000 is judged appropriate.

Annual operating Costs for Electricity

At this stage of design, it appears that all gates at both structures will require their heating systems to be operational throughout the winter. Failure to do so could cause damage to the gates or make them inoperable. The annual cost to heat all gates is significant, and the annual costs for electricity are estimated at $ 41,000 at Lake St Martin and $21,000 at Lake Manitoba. In the detailed design phase, this requirement needs to undergo additional study. Options such as bubbler systems at the upstream and downstream face of the gates should be considered.

In addition, the reliability of power becomes important to maintain the heating systems and ensure they are operational in the event of an electrical grid power failure. Diesel generators sized at 600 kVA for Lake St Martin and 300 kVA for Lake Manitoba should be considered in the final design.

16.2.6 Land Acquisition

The area of land acquisition required for each channel option was estimated by multiplying the channel length by the width of the appropriate right-of-way. The ROW for each channel option was estimated based on the typical cross sections that were developed. The ROW represents the area of the channel top width, berms, spoil piles, drainage ditching and a buffer zone.

16.2.7 Fish Passage

As indicated in Section 2.0 (Background), the Lake Manitoba and Lake St. Martin Regulation Review Committee recommended that: “If the Province builds a new outlet to Lake Manitoba as recommended, it should take that opportunity to design the new outlet in such a way as to provide unrestricted fish passage between Lake Manitoba and Lake St. Martin”. However, unrestricted fish passage would likely be ineffective, if included as part of a newly developed Lake Manitoba outlet channel. Instead, improvement for fish passage at the current FRWCS should be included as part of the proposed project, regardless of the Lake Manitoba outlet channel selected. As such, a fish passage concept design and cost estimate was prepared for a pool and riffle style fishway at the FRWCS and was included for each of the Lake Manitoba outlet channel options.

16.2.8 Cost Summary

The total costs for each of the Lake Manitoba and Lake St. Martin outlet channel options are summarized in tables 16.1, 16.2, 16.3 and 16.4. This cost summary is based on the project components for each option as described in the previous sections with the detailed estimates shown on the tables provided in Appendix I. The total costs include a 20% allowance for engineering, administration and approvals as well as a 20% contingency.

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Table 16.1
Total Cost Summary – LMB Outlet Channel Route C

Construction Component	Estimated Cost
Earth Works	$ 107,925,000
Control Structure	
Spillway	$ 14,678,000
Gates, Guides and Hoists	$ 9,500,000
Bridges	$ 5,556,000
Electrical Power Supply	
Permanent Power	$ 190,000
Construction Power	$ 2,000,000
Land Acquisition	$ 2,455,000
Fish Passage	$ 1,081,000
Sub-total	**$ 142,755,000**
Mitigation Cost (5%)	$ 7,138,000
Engineering, Contract Admin., Approvals (20%)	$ 28,551,000
Sub-total	**$ 178,444,000**
Contingency Cost (20%)	$ 35,689,000
TOTAL	**$ 214,133,000**

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Table 16.2
Total Cost Summary – LMB Outlet Channel Route D

Construction Component	Estimated Cost
Earth Works	$ 129,865,000
Control Structure	
Site Work & Structure	$ 14,678,000
Gates, Guides and Hoists	$ 9,500,000
Bridges	$ 12,167,000
Electrical Power Supply	
Permanent Power	$ 190,000
Construction Power	$ 2,000,000
Land Acquisition	$ 4,290,000
Fish Passage	$ 1,081,000
Sub-total	**$ 173,771,000**
Mitigation Cost (5%)	$ 8,688,550
Engineering, Contract Admin., Approvals (20%)	$ 34,754,200
Sub-total	**$ 217,214,000**
Contingency Cost (20%)	$ 43,442,800
TOTAL	**$ 260,657,000**

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Table 16.3
Total Cost Summary – LSM Outlet Channel with Outlet at Johnson Beach

Construction Component	Estimated Cost	
Earth Works		
Reach 1	$	42,501,000
Reach 2	$	12,858,000
Reach 3	$	32,990,000
Control Structure		
Spillway	$	23,139,000
Gates, Guides and Hoists	$	15,351,000
Access Road		
Reach 1	$	15,600,000
Reach 3	$	8,000,000
Electrical Power Supply		
Permanent Power	$	1,720,000
Construction Power	$	3,636,000
Sub-total	**$**	**155,790,000**
Mitigation Cost (5%)	$	8,175,500
Engineering, Contract Admin., Approvals (20%)	$	31,158,000
Sub-total	**$**	**194,740,000**
Contingency Cost (20%)	$	38,948,000
TOTAL	**$**	**233,690,000**

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Table 16.4
Total Cost Summary – LSM Outlet Channel with Outlet East of Willow Point

Construction Component	Estimated Cost	
Earth Works		
Reach 1	$	42,501,000
Reach 2	$	12,858,300
Reach 3	$	42,162,400
Control Structure		
Spillway	$	23,139,000
Gates, Guides and Hoists	$	15,351,000
Access Road		
Reach 1	$	15,600,000
Reach 3	$	8,000,000
Electrical Power Supply		
Permanent Power	$	1,720,000
Construction Power	$	3,636,000
Sub-total	**$**	**164,970,000**
Mitigation Cost (5%)	$	8,248,500
Engineering, Contract Admin., Approvals (20%)	$	32,994,000
Sub-total	**$**	**206,210,000**
Contingency Cost (20%)	$	41,242,000
TOTAL	**$**	**247,450,000**

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17.0 PROJECT SCHEDULE

The project schedule, as shown in Plate 19, has been developed to meet a May 2020 operation date for the Lake Manitoba and Lake St. Martin Channels. The schedule includes on-going engineering/design and environmental studies, environmental data collection, assessment of preferred alternatives, environmental permitting, Aboriginal consultation, and design, tender, and construction of the LSM access road and the LSM and LMB Channels.

Several critical paths exist that are dependent on the completion of specific tasks which, if not completed in the allotted time, could result in delays. First, the completion and acceptance of the Stage 2 Conceptual Design is the critical path leading to the selection of the preferred alternative. With the exception of the development of the LSM Access Road, commencement of all future project tasks are contingent on the selection of the preferred alternative, which is proposed to be established by the end of October 2015.

The development of the LSM Access Road will include environmental permitting that is separate from the channel development, design, tender, and construction. No critical path has been specified for this group of tasks, as it is assumed that the LSM Access Road can be completed prior to the commencement of the LSM Channel construction.

Once the preferred alternative is established for the project, two concurrent tasks will begin: the Environmental Assessment (EA) process for the LMB and LSM Channels, and the design of the LMB and LSM Channels. Leading to the proposed commencement of construction for the LMB and LSM Channels, there will be a critical path beginning with a design phase (approximately one year and eight months) followed by development and issuing of tender documents and obtaining appropriate construction permits.

The EA process for the channels, including federally required Aboriginal consultation, has been estimated at a total of one year and seven months as described in Section 15.8. Completion of the EA process, which will be dependent on a decision by the Canadian Environmental Assessment Agency, is itself a critical path that could potentially delay the project as a licence is required before construction can begin.

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Legal surveys and planning can occur but land acquisition, which is estimated at six months, cannot officially commence until after completion of the EA process. It has been assumed that portions of the LMB channel that are on crown land or within existing roadway right-of-ways could begin prior to acquisition of private land, whereas the LSM channel is on crown land so acquisition is not required.

The control structures will require the longest duration to complete and will be a critical path item for the two years and three months allotted for the construction task. It has been assumed that construction of the control structures and bridges would not occur in the winter months to avoid the additional cost of heating and hoarding. However, it may be advantageous to complete portions of the channel excavation during the winter months to allow wet areas to freeze. A detailed schedule of the construction activities should be developed at the next stage of design for both the LMB and LSM Channels.

Revegetation is multi-year process and cannot commence until the channel excavation is substantially complete. The rationale for revegetating the channels is to mitigate the potential for surface erosion and colonization by weeds, but it is not critical for the operation of the channels. Therefore, it is assumed that revegetation would continue beyond the May 2020 date when the channels would be operated if needed based on hydraulic conditions at that time.

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18.0 CONCLUSIONS

Specific basis of designs have been developed for the following preferred outlet channel options identified in the Stage 1 Study:

- Lake Manitoba Outlet Channel – Route C.
- Lake Manitoba Outlet Channel – Route D.
- Lake St. Martin Outlet Channel with outlet at Johnson Beach.
- Lake St. Martin Outlet Channel with outlet east of Willow Point.

The design capacity of the Lake Manitoba Outlet Channel is 212 m^3/s (7,500 cfs) with LMB at El 248.1 m (El 814.0 ft) and is 326 m^3/s (11,500 cfs) with LSM at elevation El 244.1 m (El 801.0 ft) for the Lake St. Martin Outlet Channel, as committed by the Province of Manitoba in the Fall of 2014.

Conclusions for each of the key study components are presented below.

18.1 CHANNEL DESIGN

- Having the Lake Manitoba Outlet Channel control structure located at PTH 6 allows for a narrower structure than if located at LMB and also helps reduce potential groundwater impacts along the channel upstream of the structure when it is closed. It also allows the control structure and the PTH 6 bridge to be combined into a single structure to save on construction costs.
- An ice cover is unlikely to occur during operation of the channels. However, if the channels are used for flow regulation (to supplement the FRWCS for example), it is possible that the gates could be opened and flow would be initiated after a stable ice cover had already formed in the channel. The capacity of the channels are reduced to approximately 142 m^3/s to 156 m^3/s (5,000 cfs to 5,500 cfs) from 212 m^3/s 7,500 cfs for Route C and D and from 326 m^3/s 11,500 cfs for Reach 1.
- The potential for basal heave or blowout is high along the entire proposed channel alignment during the construction and operational phases, due to the high piezometric pressures and limited overburden cover below the proposed channel invert for Route D. For Route C, the potential is high in channel areas with overburden underlying the channel invert during the construction phase, particularly downstream of the proposed Control Structure location. An aquifer depressurization program would be required to mitigate basal heave or blowout.

- Basal heave or blowout may be anticipated at various locations of the Reach 3 channel during the construction phase, particularly where relatively high bedrock elevations have been identified. As a result of the potential for blowout conditions, a depressurization program, or other construction-based method of accommodating the high aquifer piezometric pressures and associated basal heave/blowout conditions, would be required during the construction and operational phases of the project.
- An estimated >140 third party supply wells are located within a 3 km offset of the proposed Route C channel alignment and about 70 for Route D. Aquifer piezometric pressure drawdown may affect available water supplies near the channel during both construction and operational phases, including within the First Nation lands located north of Route C. Additionally, potential for Groundwater Under the Direct Influence of Surface Water (GUDI) exists during channel operations.
- A number of ponds, sloughs, and lakes are located within the vicinity of the proposed Route D channel alignment. It is assumed that some connection exists between the bedrock aquifer and these surface water bodies, based on the upward groundwater gradients observed in the area. As such, drawdown of the groundwater aquifer may impact the water levels within these water bodies. Lacustrine fine grained sediments that have formed within these basins would likely limit the drainage of the surface water system through the basin bottom, even with a drop in groundwater piezometric pressures.

18.2 FLOOD ROUTING

Based on the assumed rules of operation discussed in Section 13.1 of the report, the results of the flood routing show that:

- The operation of the LMB outlet channel will have a significant benefit for lowering the water level on Lake Manitoba. The peak water level of El 249.1 m (El 817.1 ft) that occurred in 2011 would have been reduced by 0.5 m (1.6 ft) to El 248.6 (El 815.5 ft). This level is also 0.4 m (1.3 ft) below the unregulated (conditions without FRWCS, Portage Diversion or outlet channels) peak of El 249.0 m (El 816.8 ft).
- The operation of the LMB outlet channel would have maintained the LMB water level 0.3 m (1 ft) below the flood stage of El 248.1 m (El 814.0 ft) in all but one year (2011) of the 54 years of simulation (1961 and 2014), compared to 12 of 54 years for historic conditions and 28 of 54 years with unregulated conditions.
- The minimum water level on LMB would also have been reduced by 0.5 m (1.6 ft) with the outlet channel, which may not be desirable. Refinement of the operating rules to minimize the impacts during dry periods should be considered at the next stage of design when the operating rules are being finalized.
- The operation of the LSM outlet channel will have a significant benefit for lowering the water level on Lake St. Martin. The historical peak water level of 245.6 m (805.5 ft) in 2011 would have been reduced by 0.8 m (2.6 ft) to El 244.7 m (El 802.9 ft). This level is also 0.1 m (0.3 ft) below the calculated unregulated (conditions without FRWCS, Portage

Diversion or outlet channels) peak of El 244.8 m (El 803.2 ft). This demonstrates that the 326 m^3/s (11,500 cfs) capacity of the LSM outlet channel, which is 113 m^3/s (4,000 cfs) more than the capacity of the LMB outlet channel, can successfully reduce water levels on LSM below the calculated unregulated conditions during extreme flood events such as in 2011.

- The operation of the LSM outlet channel would have maintained the water level in LSM below the 1:100 year water level of El 244.7 m (El 802.9 ft), computed by AECOM, (2012) in all years except in 2011 when it was exceeded by0.02 m (0.1 ft). Simulated water levels would have been maintained below the flood stage of El 244.4 m (El 801.7 ft) approximately 99% of the time.

- The computed peak flows in the LMB and LSM outlet channels are 250 m^3/s (8,835 cfs) and 420 m^3/s (14,820 cfs), respectively, at peak lake levels of El 248.6 (El 815.5 ft) and El 244.7 m (El 802.9 ft), respectively, which exceeds the design flows of 212 m^3/s (7,500 cfs) and 326 m^3/s (11,500 cfs). Limiting the flows to the design capacity could be achieved by operating the outlet control structures, if necessary.

- The LSM outlet channel increases the duration of time that the LSM water levels fall within the range of El 242.9 to El 243.8 m (797.0 to 800.0 ft) to 73% from 56% of the time for historic conditions and 61% of the time for unregulated conditions (without FRWCS, Portage Diversion or outlet channels). This falls short of the 90% recommendation from the Regulation Review due to low inflows into LSM from LMB at low lake levels. Should this recommendation be identified as a strict guideline for future operation on LSM, modifications to the operating rules would have to be considered during the next phase of design when the operating rules for the outlet channels will be finalized.

- The LMB and LSM outlet channels would have been operated for 24 of the 54-year simulation period. The operation would be primarily confined to the open water period from April 1 to November 30. Winter operation would have been required only for very large flood events such as in 2011, 2012 and 2014.

18.3 ENVIRONMENTAL

Based on the summary of environmental concerns for the outlet channels:

- Option D is preferred considering both the biophysical and social environment perspectives. None of the potential environmental concerns associated with Option D were assessed as major, whereas the potential effect of Option C on groundwater and access were assessed as major.

- While there does not appear to be a preferred option for the location of the Reach 3 outlet, considering the biophysical environment the Willow Point option is preferred from a social environment perspective because of the First Nation concerns related to land use.

Based on the unresolved litigation:

- Any potential project effects to First Nation land will likely be faced with strong resistance and potentially delay the project. As such, Option C is more likely to face opposition compared to Option D because of the potential impacts to groundwater supply wells and public safety as previously discussed.
- The Dauphin River First Nation have indicated a preference to have the Reach 3 outlet located on the east side of Willow Point rather than the Johnson Beach outlet option because of the potential adverse effect on the Lake Winnipeg fishery and on Johnson Beach.

18.4 PROJECT COSTS AND SCHEDULE

Based on the cost estimates and the proposed project schedule described in the report:

- The LMB Outlet Channel Option C has an estimated cost of $214 million.
- The LMB Outlet Channel Option D has an estimated cost of $261 million.
- The LSM Outlet Channel with outlet at Johnson Beach has an estimated cost of $234 million.
- The LSM Outlet Channel with outlet east of Willow Point has an estimated cost of $247million.
- The total estimated project cost ranges between $449 and $508 million and is considered an AACE (The Association for the Advancement of Cost Engineering) Estimate Class 3 based on semi-detailed unit costs sufficient for budget authorization. The costs include a 20% allowance for engineering, contract administration and approvals, as well as a 20% contingency allowance.
- The completion and acceptance of the Stage 2 Conceptual Design is the critical path leading to the selection of the preferred alternative. With the exception of the development of the LSM Access Road, commencement of all future project tasks are contingent on the selection of the preferred alternative, which is proposed to be established by the end of October 2015.
- Future tasks including the Environmental Assessment (EA) process for the LMB and LSM Channels are also part of the critical path to meet the target year of 2020 operation date.

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19.0 RECOMMENDATIONS

Based on the study results described in this report, as well as the ongoing Aboriginal Consultation process conducted by MIT, the Province should select the final LMB and LSM Outlet Channel alternatives as soon as reasonably possible. This will allow the Environmental Impact Statement (EIS) process and Detailed Design to proceed and the operational target year of 2020 to be maintained.

The following items are recommended for consideration at the next stage of design:

- Conduct a water well survey in the vicinity of areas along the selected Lake Manitoba Outlet Channel route and conduct a field investigation program to assess necessary aquifer protection and mitigation measures
- Develop a groundwater monitoring program to measure the existing piezometers along the outlet channels. This will provide historical groundwater records prior to the construction of the channels and provide a better understanding on the artesian groundwater conditions.
- Conduct laboratory soils/rock testing such as direct shear tests and flexible wall permeability tests from remolded proctor samples to verify the soil strength parameters.
- Conduct an investigation program for the detailed design of the inlet and outlet of the different channels and of the Reach 2 containment dikes including the collection of geotechnical information and bathymetric data. At this stage, there is limited information in those areas.
- Further investigation for the Reach 3 quarry and granular sources as borrow areas for construction. As well, the suitability of rock for the Reach 3 drop structures need to be confirmed.
- Conduct a study of the shoreline process along Lake Manitoba at the location of the inlet of the selected outlet channel route to identify the requirements, if any, for mitigation measures such as the construction of permanent groins that will prevent the migration of sand and silt into the channel and minimize the risk of infill.
- Refinement of the operating rules for the outlet channels, considering:
    - The Environmental Approval process.
    - Results from the ongoing Provincial Flood Control Infrastructure Review of Operating Guidelines initiative.
    - The recommendation from the LMB and LSM Regulation Review Committee to maintain the Lake St. Martin water level between 242.9 to 243.8 m (797.0 to 800.0 ft) 90% of the time.

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  - The need for dikes on Reach 2.
  - Minimum allowable water levels on Lake Manitoba and Lake St. Martin.
  - The convenience of operating the automated gates at the outlet channel control structure to supplement the FRWCS.
  - Potential effects of ice on channel capacity depending on timing of operation and the need for winter operation.

- Conduct more detailed surveys of Buffalo Creek and the Big Buffalo Lake bog area to refine water surface profiles along Reach 2 and the impacts on the proposed Reach 1 design.
- Refinement of the channel geometries and excavations using a channel optimization routine similar to those applied to the floodway expansion design.
- Optimization of the capacity of Reach 1 considering higher lake level targets due to the potential flood easements on Lake St. Martin.
- Conduct as-built surveys of the Reach 1 and Reach 3 Emergency Channels to optimize the channel design and excavation volumes.
- Assessment of the need for access across Reach 3 to the diversion structure and the Reach 2 dikes when the outlet channels are in operation or at times of high local runoff.
- The design and operation requirements of the Reach 3 diversion structure to maintain riparian flow in Buffalo Creek based on the results of the Environmental Approval process.
- The design and construction requirements of the inlet and outlet cofferdams considering risk and timing associated with water levels and wind.
- The power supply requirements for construction and operation of the control structure, in coordination with Manitoba Hydro.
- The optimization of the design and alignment of the channels and spoil piles to accommodate various details such as road re-alignments, privately owned structures, bipole transmission line towers, etc.
- Further assessment and contingency plans at the outlet of Reach 1 and within Reach 2 to address the capacity risks associated with water flowing over the bog area surrounding Big Buffalo Lake.
- The added benefits of additional discharge capacity at the Fairford River Water Control Structure from decommissioning the existing Denil Fishway and construction of a new fishway north of the structure. This should consider the overall discharge capacity of the system and of the proposed outlet channels, as well as the need for a new fishway based on the results of the environmental approval process.

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20.0 STATEMENT OF LIMITATIONS AND CONDITIONS

20.1 THIRD PARTY USE OF REPORT

This report has been prepared for Manitoba Infrastructure and Transportation (MIT) and any use a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. KGS Group accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions undertaken based on this report.

20.2 GEO-ENVIRONMENTAL STATEMENT OF LIMITATIONS

KGS Group prepared the geo-environmental conclusions and recommendations for this report in a professional manner using the degree of skill and care exercised for similar projects under similar conditions by reputable and competent environmental consultants. The information contained in this report is based on the information that was made available to KGS Group during the investigation and upon the services described, which were performed within the time and budgetary requirements of MIT. As the report is based on the available information, some of its conclusions could be different if the information upon which it is based is determined to be false, inaccurate or contradicted by additional information. KGS Group makes no representation concerning the legal significance of its findings or the value of the property investigated.

20.3 CAPITAL COST ESTIMATE STATEMENT OF LIMITATIONS

The cost estimates included with this report have been prepared by KGS Group using its professional judgment and exercising due care consistent with the level of detail required for the stage of the project for which the estimate has been developed. These estimates represent KGS Group's opinion of the probable costs and are based on factors over which KGS has no control. These factors include, without limitation, site conditions, availability of qualified labour and materials, present workload of the Bidders at the time of tendering and overall market conditions. KGS does not assume any responsibility to MIT, in contract, tort or otherwise in connection with such estimates and shall not be liable to MIT, if such estimates prove to be inaccurate or incorrect.

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TABLES

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TABLE 3.4: GROUNDWATER MONITORING RESULTS
LMB OUTLET CHANNELS ROUTE C AND D
KGS: 12-0300-011
ASSINIBOINE RIVER LAKE MANITOBA BASINS FLOOD MITIGATION STUDY
LMB AND LSM OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

KGS GROUP CONSULTING ENGINEERS

Location	Station	Test Hole	Soil Type	Piezometer	Ground Elevation (m)	Tip Depth (m)	Tip Elevation (m)	Pressure Gauge Reading (psi)	Groundwater Depth (m)	Groundwater Elevation - After drilling (m)	Groundwater Elevation July 16, 2015 (m)	Comments
Route C	8+100	15-RC-01	Silt	Standpipe	252.62	4.6	248.02			-	251.64	
			Limestone	Standpipe	252.61	11.9	240.71			-	251.41	
	5+168	15-RC-02	Topsoil, Cobbles, Limestone	Standpipe	255.46	1.5	253.96			-	254.15	
	0+464	15-RC-04	Clay till	Standpipe	249.69	5.5	244.19			248.69	248.7	Water level 0.9 m below grade upon completion of drilling
			clay till	Standpipe	249.69	10.7	238.99			248.69	248.68	Water level 0.9 m below grade upon completion of drilling
	4+200	15-RC-06	Limestone	Vibrating wire	254.97	5.2	249.77			-		Water level at bottom of hole upon completion of drilling
			Limestone	Standpipe	254.97	13.5	241.47			-	253.86	
Route D	2+672	15-RD-01	silty clay	standpipe	248.3	10.4	237.9	1	-0.703635	249.003635	249.27	
			Clay till	Standpipe	248.3	20.4	227.9	4	-2.81454	251.11454	251.73	
	12+776	15-RD-02	Silty clay till	Standpipe	248.65	14.9	233.75	4	-2.81454	251.46454	254.45	
	12+776	15-RD-02A	Silty clay	Standpipe	248.63	7.6	241.03			-	248.39	
	17+032	15-RD-03	Silty clay till	Standpipe	251.84	7.6	244.24			250.94	250.99	Water level 0.9 m below grade upon completion of drilling
			Clay till	Standpipe	251.84	14.9	236.94			250.94	252.39	Water level 0.9 m below grade upon completion of drilling
	17+032	15-RD-03A	sand	Vibrating wire	251.86	10.4	241.46			-		Water level at bottom upon completion of drilling
	19+256	15-RD-04	Silty clay	Standpipe	251.76	7.6	244.16			-	251.73	
			silty clay till	Standpipe	251.76	14.5	237.26	2	-1.40727	253.16727	253.89	
	21+464	15-RD-05	silty clay	Standpipe	247.09	7.6	239.49			246.19	246.12	Water level 0.9 m below grade upon completion of drilling
			silty clay	Standpipe	247.09	11.9	235.19			246.19	248.02	Water level 0.9 m below grade upon completion of drilling
	17+800	15-RD-10A	silty clay	Vibrating wire	248.87	7.6	241.27			-	-	
			silt till	Standpipe	248.87	18.3	230.57			-	-	Water level at bottom of hole upon completion of drilling

TABLE 3.4: GROUNDWATER MONITORING RESULTS
LMB OUTLET CHANNELS ROUTE C AND D
KGS: 12-0300-011
ASSINIBOINE RIVER LAKE MANITOBA BASINS FLOOD MITIGATION STUDY
LMB AND LSM OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2
AUGUST 2015

Location	Area	Standpipe	Soil Type	Ground Elevation (m)	Tip Depth (m)	Tip Elevation (m)	Groundwater Depth (m)	Groundwater Elevation (m)	Stabilized (YES/NO)	Gradient	Falling Head Test Complete (YES/NO)	Estimated K (Hvorslev 1951)	Well Diameter (mm)	Effective Slotted Length (m)	Sandpack Diameter (mm)	Sandpack Length (m)	Notes
Reach 1 Inlet	South Dike	TH15-01A	Bedrock	247.74	-27.68	220.06	-0.57	247.17	YES		NO		25.4	1.52	70 - 89	3.45	11.43 m of slough above sandpack.
		TH15-01B	Silt Till	247.74	-9.07	238.67	-2.79	244.95	YES	0.12	NO		25.4	1.52	150	2.13	Was frosted at grade, dethawed with water
		TH15-01C	Clay Till / Silt Till	247.74	-4.52	243.22	-3.08	244.67	YES	0.06	YES		25.4	0.91	150	1.30	
	North Dike																
Reach 3 Inlet	East of Buffalo Creek	TH15-02	Bedrock	234.16	-15.24	218.92	1.95	236.11	YES		N/A		No Install - Artesian head measured 1.96 m above grade.				
		TH15-02A	Silt Till	235.34	-6.68	228.66	-1.25	234.09	YES	0.21	YES		25.4	1.52	125	2.13	
	West of Buffalo Creek																
Reach 3 Channel	Sta. 17+311	TH15-03	Bedrock	237.01	-6.83	230.18	-1.87	235.14	YES		YES		25.4	1.52	70 - 89	3.96	2.29 m of slough above sandpack
		TH15-03A	Silt Till	237.01	-4.76	232.25	-2.09	234.92	YES	0.10	YES		25.4	1.52	125	1.98	
	Sta. 18+459	TH15-04	Bedrock	236.67	-12.11	224.56	0.55	237.22	YES		NO		25.4	1.52	89	5.41	
		TH15-04A	Silt Till	236.67	-6.02	230.65	-1.36	235.31	YES	0.31	YES		25.4	1.52	125	1.88	
	Sta. 19+424	TH15-05	Bedrock	234.7	-9.05	225.65	-1.37	233.33	YES		YES		25.4	1.52	70	3.02	
		TH15-05A	Silt Till	234.7	-5.51	229.19	-1.50	233.20	YES	0.04	YES		25.4	1.52	125	2.13	
Willow Point	Sta. 23+144	TH15-06	Silt Till	228.5	-9.27	219.23	-3.08	225.42	YES				25.4	1.52	89	2.29	
		TH15-06A	Silt Till	228.5	-4.67	223.83	-1.42	227.08	YES	-0.36			25.4	1.52	125	1.68	
	Sta. 23+540	TH15-07	Clay Till	228.03	-8.87	219.16	-0.81	227.22	YES		NO		25.4	1.52	89	2.29	
		TH15-07A	Silt Till	228.03	-4.57	223.46	-0.18	227.85	YES	-0.15			25.4	1.52	125	1.75	
	Sta. 23+738	TH15-08A	Clay Till	227.41	-9.32	218.09	-2.40	225.01	YES		NO		25.4	1.52	150	1.83	
		TH15-08B	Silt Till	227.41	-4.43	222.98	-0.19	227.22	YES	-0.45	NO		25.4	1.52	150	1.98	Frozen
	Sta. 24+041	TH15-09A	Clay Till	226.68	-5.88	220.81	-0.36	226.32	YES		NO		25.4	0.76	150	1.68	
		TH15-09B	Silt Till	226.68	-3.07	223.61	-0.21	226.47	YES	-0.05			25.4	0.76	150	0.91	
	Sta. 25+036	TH15-10A	Clay Till	224.32	-9.30	215.03	-2.76	221.56	YES		NO		25.4	1.52	150	1.83	
		TH15-10B	Silt Till	224.32	-4.80	219.53	-0.11	224.22	YES	-0.59	NO		25.4	1.52	150	1.83	
	Sta. 25+550	TH15-11A	Clay Till	221.85	-7.68	214.18	-0.74	221.12	YES		NO		25.4	1.52	150	1.98	
		TH15-11B	Silt Till	221.85	-4.30	217.56	-0.17	221.68	YES	-0.17	NO		25.4	1.52	150	1.83	Frozen
	Sta. 26+544	TH15-12A	Silt Till	221.13	-7.27	213.87	-0.45	220.69	YES		NO		25.4	1.52	150	1.68	
		TH15-12B	Silt Till	221.13	-4.58	216.55	-0.18	220.96	YES	-0.10	NO		25.4	1.52	150	1.83	

Standpipe	r	Le	R	t37	K (m/min)	K (m/s)	t37 adjusted	Kadjusted (m/Min)	K Adjust (m/Sec)
TH15-01C	0.0127	0.915	0.075	1900	1.20184E-07	2.00307E-09			
TH15-02A	0.0127	2.14	0.075	78	2.04313E-06	3.40522E-08			
TH15-03A	0.0127	1.98	0.075	1260	1.26479E-07	2.10799E-09	1330	1.00243E-07	1.67072E-09
TH15-04A	0.0127	2.134	0.0625	70	2.41446E-06	4.02409E-08	42	3.17673E-06	5.29455E-08
TH15-05A	0.0127	2.13	0.0625	600	2.2267E-07	3.71117E-09	700	4.06533E-07	6.77554E-09
TH15-06A	0.0127	1.98	0.075	18.5	8.61428E-06	1.43571E-07			

TABLE 5.2: ROUTE C LMB OUTLET CHANNEL SLOPE STABILITY SUMMARY
KGS: 12-0300-011
ASSINIBOINE RIVER LAKE MANITOBA BASINS FLOOD MITIGATION STUDY
LMB AND LSM OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

KGS GROUP CONSULTING ENGINEERS

Assumptions of Design - Route C

- Soil Profile — Till
- Groundwater Conditions — Till - El. 247.6 m for excavations up to 8 m, 1.5 m below ground surface in excavations greater than 8 m.
- Slope — 4H:1V for excavations up to 8 m, 4H:1V with a 4 m bench at 8 m for excavations deeper than 8 m

		Factor of Safety											
Depth of Excavation		6 m			8 m			10 m			12 m		
Friction Angle (ϕ)	Soil Parameter c'= 4 kPa	27	32	35	27	32	35	27	32	35	27	32	35
Groundwater Conditions													
Construction	Dry Conditions	1.466	1.747	1.909	1.419	1.667	1.828	1.481	1.755	1.933	1.444	1.713	1.889
Long Term Conditions	Closed Gate, Downstream of Drop Structure	1.596	1.862	2.04	1.49	1.749	1.918	1.532	1.817	2.003	1.478	1.756	1.938
Rapid Drawdown Conditions	Opening of Gate	3.097	3.612	3.952	2.438	2.877	3.166	2.348	2.799	3.092	2.226	2.667	2.954
	Closing of Gate	1.858	2.179	3.388	1.834	2.179	2.402	1.996	2.392	2.701	2.067	2.445	2.703

Phase:

Construction — Dry conditions - Till water level at ground surface in excavation transitioning to 247.6m for excavations between 6 to 8 m. Water level at ground surface in excavation transitioning to 1.5 m below grade in excavations from 10 to 12 m.

Long term Conditions — Channel water level 1.5 m above base of channel, downstream of the drop structure. Water level in till at channel water level transitioning to 247.6 m for excavations between 6 to 8 m, and 1.5 m below grade in excavations from 10 to 12 m.

Rapid Drawdown Conditions — Opening of Gate -Water level lowered from 247.66 m to 247.05.

Closing of Gate - Water level lowered from 244.1 to 242.78 m.

TABLE 5.2: ROUTE C LMB OUTLET CHANNEL SLOPE STABILITY SUMMARY
KGS: 12-0300-011
ASSINIBOINE RIVER LAKE MANITOBA BASINS FLOOD MITIGATION STUDY
LMB AND LSM OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2
AUGUST 2015

TABLE 6.2: ROUTE D LMB OUTLET CHANNEL SLOPE STABILITY SUMMARY
KGS: 12-0300-011
ASSINIBOINE RIVER LAKE MANITOBA BASINS FLOOD MITIGATION STUDY
LMB AND LSM OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

KGS GROUP CONSULTING ENGINEERS

Assumptions of Design

- Soil Profile	Upper till - 242.1 m to 251.8 m (ground surface)
	Sand - 238.1 m to 242.1 m
	Lower till - below 238.1 m
- Groundwater Conditions	Upper till - 3 m below ground surface
	Sand - 3 m below ground surface
	Lower till -artesian conditions, 2 m above ground surface
- Slope	2-4H:1V of 1/2 height slope with a bench for an effective slope of 5H:1V

		Factor of Safety											
Depth of Excavation		6 m			8 m			10 m			12 m		
Friction Angle (ϕ)	Soil Parameter c'= 4 kPa	27	32	35	27	32	35	27	32	35	27	32	35
Groundwater Conditions													
Construction	Dry Conditions with Artesian in Lower Till	1.754	1.97	2.07	0.965	1	1.023	0.489	0.494	0.511	0.401	0.545	0.617
	Dry Conditions with De-watering of Lower Till	1.754	2.061	2.241	1.61	1.741	1.806	1.388	1.472	1.53	1.389	1.41	1.514
Long term Conditions	Closed Gate, Downstream of Drop Structure	2.363	2.786	3.062	1.945	2.148	2.242	1.593	1.701	1.757	1.468	1.537	1.593
Rapid Drawdown Conditions	Opening of Gate	2.112	2.503	2.698	2.058	2.275	2.379	2.001	2.166	2.248	2.024	2.155	2.244
	Closing of Gate				2.103	2.275	2.357	1.805	1.929	2	1.749	1.897	1.981

Assumptions of Design

- Soil Profile	Upper till - 242.1 m to 251.8 m (ground surface)
	Sand - 238.1 m to 242.1 m
	Lower till - below 238.1 m
- Groundwater Conditions	Upper till - 3 m below ground surface
	Sand - 3 m below ground surface
	Lower till -artesian conditions, 2 m above ground surface
-Slope	2-5H:1V of 1/2 height slope with a bench for an effective slope of 6H:1V

		Factor of Safety											
Depth of Excavation		6 m			8 m			10 m			12 m		
Friction Angle (ϕ)	Soil Parameter c'= 4 kPa	27	32	35	27	32	35	27	32	35	27	32	35
Groundwater Conditions													
Construction	Dry Conditions with Artesian in Lower Till	2.203	2.441	2.58	1.396	1.491	1.577	0.587	0.605	0.724	0.431	0.567	0.671
	Dry Conditions with De-watering of Lower Till	2.476	2.724	2.842	2.214	2.332	2.394	2.038	2.197	2.288	1.998	2.087	2.157
Long term Conditions	Closed Gate, Downstream of Drop Structure	3.326	3.717	3.895	2.674	2.854	2.945	2.509	2.643	2.727	2.145	2.254	2.324
Rapid Drawdown Conditions	Opening of Gate	3.003	3.335	3.467	3.05	3.178	3.296	2.879	3.213	3.33	2.987	3.204	3.331
	Closing of Gate				2.57	3.063	3.259	2.792	2.825	2.949	2.429	2.878	3.016

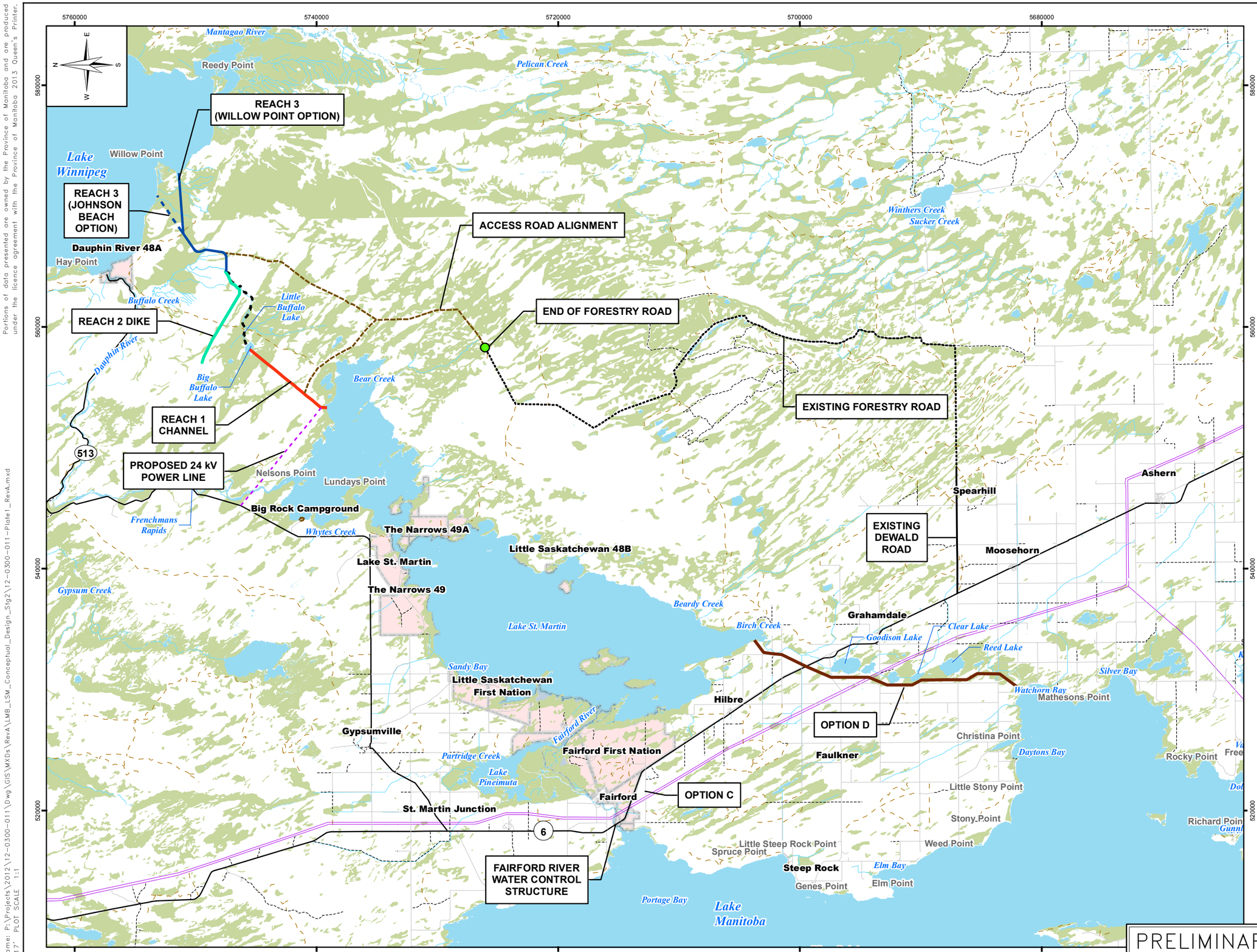
Phase:

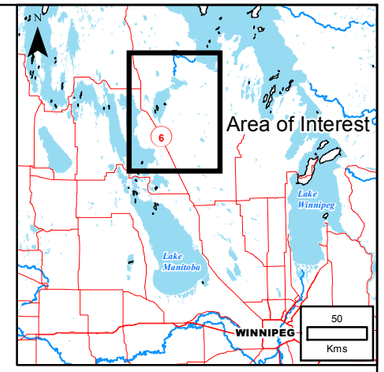
Construction	Dry conditions with artesian conditions in lower till - Artesian water level in lower till 2 m above grade. Sand and upper till water level at ground surface in excavation transitioning to 3 m below grade.
	Dry conditions with de-watering of lower till - Water level in lower till 1 m below grade at channel base, increasing to 2 m above grade at an offset of 10 m from top of bank. Water level in upper till and sand layer at ground surface in excavation transitioning to 3 m below grade.
Long term Conditions	Channel water level 3 m above base of channel, downstream of the drop structure. Water level in lower till at channel elevation increasing to 2 m above grade at an offset of 10 m from top of bank. Water level in upper till and sand at channel water level transitioning to 3 m below grade.
Rapid Drawdown Conditions	Opening of Gate -Water level lowered from 247.66 m to 247.05. Water level in lower till at channel water level increasing to 2 m above grade at an offset of 10 m from top of bank.
	Closing of Gate - Water level lowered from 244.61 to 242.78 m. Water level in lower till at channel water level increasing to 2 m above grade at an offset of 10 m from top of bank.

PLATES

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LEGEND:

- LSM Reach 1 Channel
- LSM Reach 2 Containment Dike
- Reach 3 – Willow Point Option
- Reach 3 – Johnson Beach Option
- Buffalo Creek Channel
- LMB Channel Option C
- LMB Channel Option D
- Proposed 24 kV Transmission Line
- Existing Transmission Line
- Forestry Road
- Access Road
- Municipal Road
- Highway
- Limited Use Road
- Trail
- Watercourse
- Wetlands
- Waterbody
- First Nation
- Campsite

DRAFT

0 2 4 6 8 10
Kms

SCALE: 1:300,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/12	ISSUED WITH DRAFT REPORT	PAL

REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

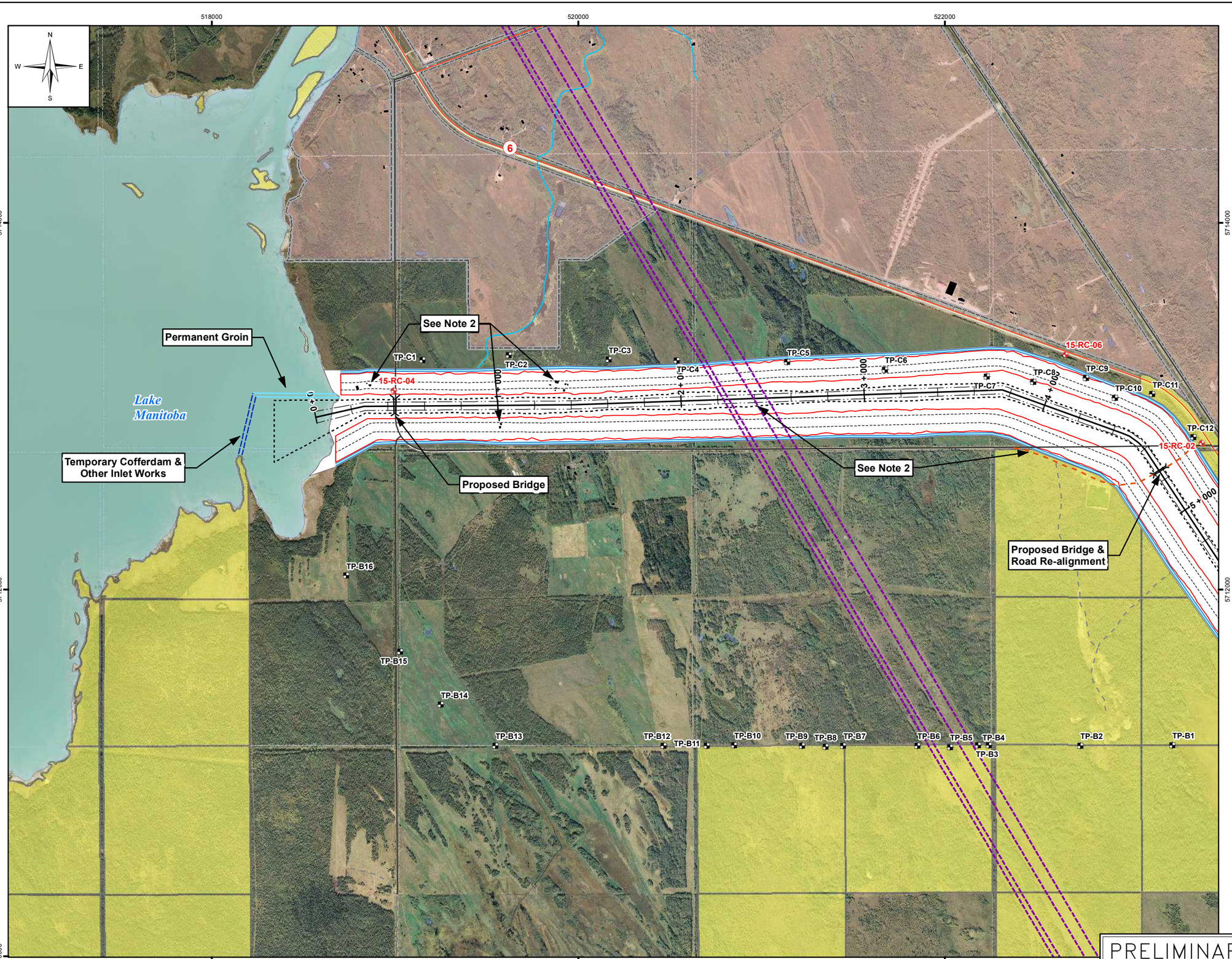
GENERAL SITE PLAN

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

AUGUST 2015 | PLATE 1 | REV: A

FileName: P:\Projects\2012\12-0300-011\Dwg\GIS\MXDs\RevA\LMB_LSM_Conceptual_Design_Stg2\12-0300-011-Plate1_RevA.mxd
11"x17" PLOT SCALE 1:1

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LEGEND:

- Test Hole (June 2015)
- Borehole (2011)
- Test Pit (2011)
- Building

Channel Linework
- Channel Alignment
- Toe of Ditch
- Top of Ditch
- Top of Spoil
- Toe of Channel
- Temporary Cofferdam
- Permanent Rock Groin
- Top of Channel Footprint
- Spoil Footprint
- Right of Way Footprint
- Control Structure & Bridge

Utility Lines
- Transmission Line

Roads
- Paved Road/Street (1 or more lanes)
- Gravel Road
- Dry Season Road
- Trail
- Proposed Road Re-alignment

Water Features
- River/Stream/Ditch
- Lake
- Section
- Crown Land
- First Nation
- Proposed Bridge

NOTES:

1. Imagery is dated 2007 – 2011 and supplied by the Province of Manitoba, Manitoba Land Initiative.
2. Final channel and spoil pile alignment to accommodate bipole transmission line towers, road realignments, privately owned structures, etc...

DRAFT

0 200 400 600 800 1,000

Meters

SCALE: 1:20,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

REVISIONS / ISSUE

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

CONCEPTUAL LAYOUT PLAN OF LMB OUTLET CHANNEL ROUTE C (SHEET 1 OF 2)

PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

AUGUST 2015 | PLATE 2.1 | REV: A

FileName: P:\Projects\2012\12-0300-011\Dwg\GIS\MXDs\RevA\LMB_LSM_Conceptual_Design_Stg2\12-0300-011-Plate2_RevA.mxd
11"x17" PLOT SCALE 1:1

Portions of data presented are owned by the Province of Manitoba and are produced under the licence agreement with the Province of Manitoba 2011 Queen's Printer.

524000 526000 528000 530000

5712000

5710000

N W E S

TP-C13

TP-C14

TP-C15

6+000

7+000

8+000

9+000

10+000

11+000

BH-BC3 BH-BC1 BH-BC2

BH-BC4 BH-BC6 BH-BC5

15-RC-01

Control Structure & Bridge

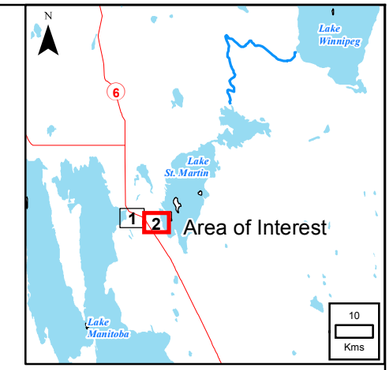
See Note 2

Proposed Road Re-alignment

Temporary Cofferdam & Other Outlet Works

Lake St. Martin

6



LEGEND:

- Test Hole (June 2015)
- Borehole (2011)
- Test Pit (2011)
- Building

Channel Linework
- Channel Alignment
- Toe of Ditch
- Top of Ditch
- Top of Spoil
- Toe of Channel
- Temporary Cofferdam
- Permanent Rock Groin
- Top of Channel Footprint
- Spoil Footprint
- Right of Way Footprint
- Control Structure & Bridge

Utility Lines
- Transmission Line

Roads
- Paved Road/Street (1 or more lanes)
- Gravel Road
- Dry Season Road
- Trail
- Proposed Road Re-alignment

Water Features
- River/Stream/Ditch
- Lake

- Section
- Crown Land
- First Nation
- Proposed Bridge

NOTES:

1. Imagery is dated 2007 – 2011 and supplied by the Province of Manitoba, Manitoba Land Initiative.
2. Final channel and spoil pile alignment to accommodate bipole transmission line towers, road realignments, privately owned structures, etc...

DRAFT

0 200 400 600 800 1,000

Meters

SCALE: 1:20,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

REVISIONS / ISSUE

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

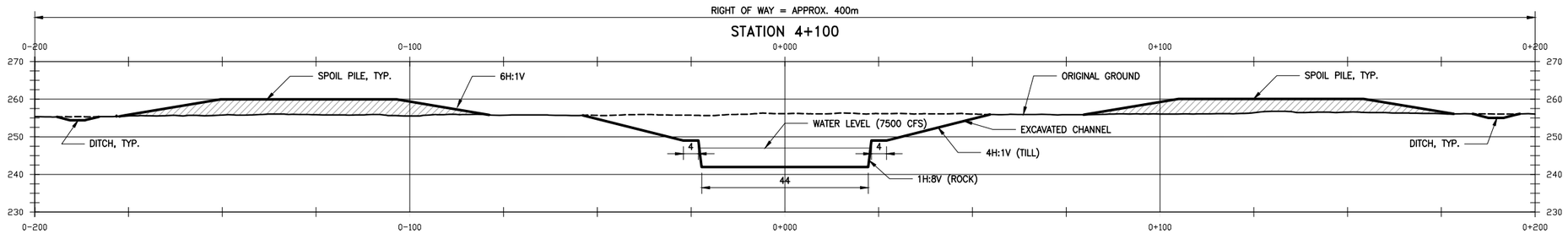
LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS
CONCEPTUAL DESIGN – STAGE 2

CONCEPTUAL LAYOUT PLAN OF LMB OUTLET CHANNEL ROUTE C (SHEET 2 OF 2)

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

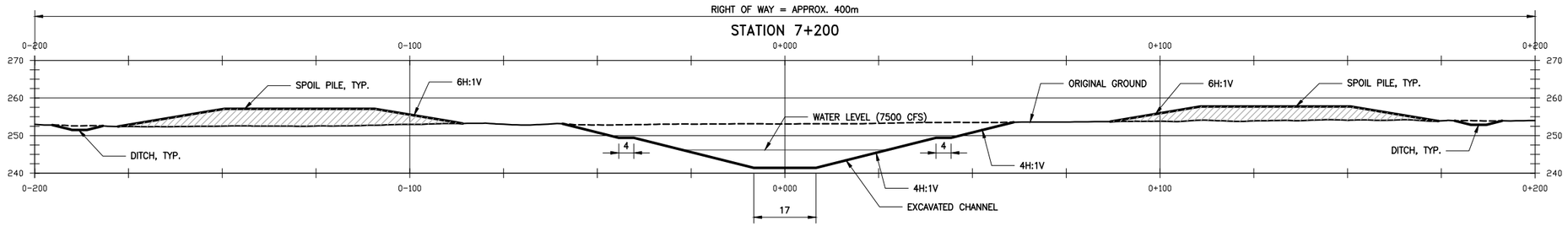
AUGUST 2015 | PLATE 2.2 | REV: A

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11"x17" PLOT SCALE 1:1



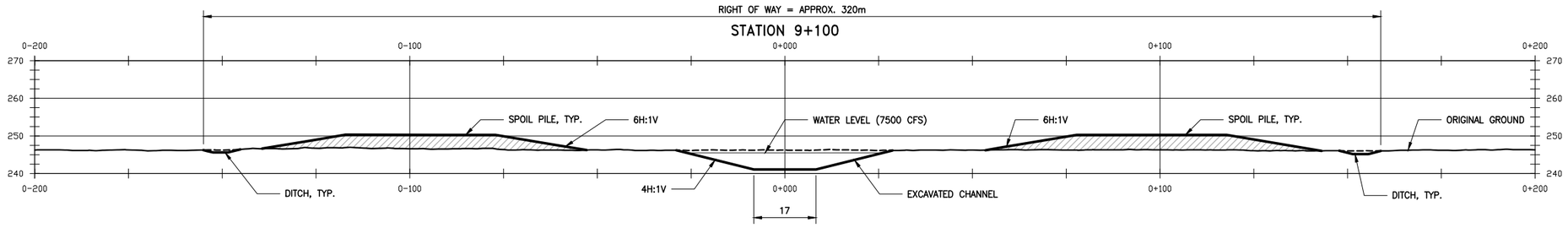
ROUTE C – CROSS SECTION IN ROCK

SCALE: 1:750



ROUTE C – CROSS SECTION > 8m CUT

SCALE: 1:750



ROUTE C – CROSS SECTION 8m CUT OR LESS

SCALE: 1:750

NOTES

1. CROSS SECTIONS ARE TYPICAL AND BASED ON PROPOSED CHANNEL DESIGN. CROSS SECTIONS MAY DIFFER SLIGHTLY FROM CIVIL 3D LAYOUT PLANS.

NO.	YY/MM/DD	DESCRIPTION	
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

REVISIONS / ISSUE

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

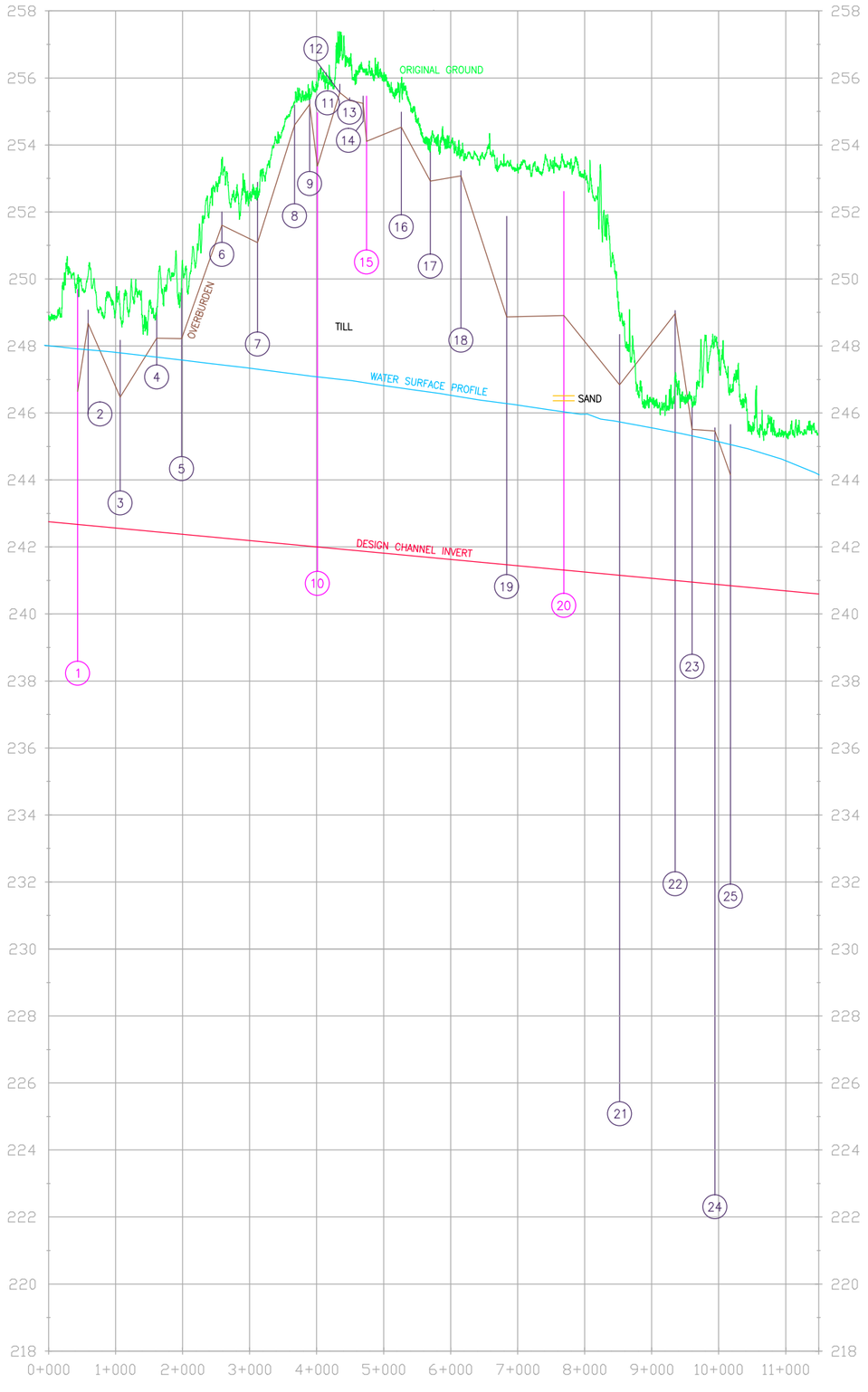
LAKE MANITOBA & LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

TYPICAL CROSS SECTIONS OF LAKE MANITOBA OUTLET CHANNEL ROUTE C

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

AUGUST 2015 | PLATE 3 | REV: A

FileName: P:\Projects\2012\12-0300-011\Dwg\Struct\LMB_LSM Stage 2\12-0300-011_Plate 3.dwg – Tab: Layout1 Plotted By: pzyla 15/08/11 [Tue 3:56pm]
11"x17" PLOT SCALE: 1"=2'



TEST PITS 2011		
SYMBOL	NUMBER	OFFSET
2	TP-C1	-252.11
3	TP-C2	-273.74
4	TP-C3	-240.06
5	TP-C4	-223.02
6	TP-C5	-193.83
7	TP-C6	-133.12
8	TP-C7	-74.63
9	TP-C8	-100.31
11	TP-C9	-216.85
12	TP-C10	-168.86
13	TP-C11	-261.62
14	TP-C12	-257.63
16	TP-C13	-263.80
17	TP-C14	-258.40
18	TP-C15	-132.99
BORE HOLES 2011		
SYMBOL	NUMBER	OFFSET
19	BH-D109	-457.12
21	BH-D100	-269.47
22	BH-D101	-1086.87
23	BH-D102	-286.21
24	BH-D105	-1027.68
25	BH-D104	-294.23
BORE HOLES 2015		
SYMBOL	NUMBER	OFFSET
1	15-RC-04	-86.23
10	15-RC-06	-297.37
15	15-RC-02	-278.89
20	15-RC-01	-269.87

LEGEND

- ORIGINAL GROUND
- WATER LEVEL
- DESIGN INVERT
- 2011 BOREHOLES
- 2015 BOREHOLES
- SAND
- BEDROCK
- OVERBURDEN

NOTES

1. ALL UNITS ARE IN METERS.
2. VERTICAL EXAGGERATION 1:500
3. HORIZONTAL EXAGGERATION 1:2

NO.	YY/MM/DD	DESCRIPTION	
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

PROFILE AND STATIGRAPHY ALONG ROUTE C

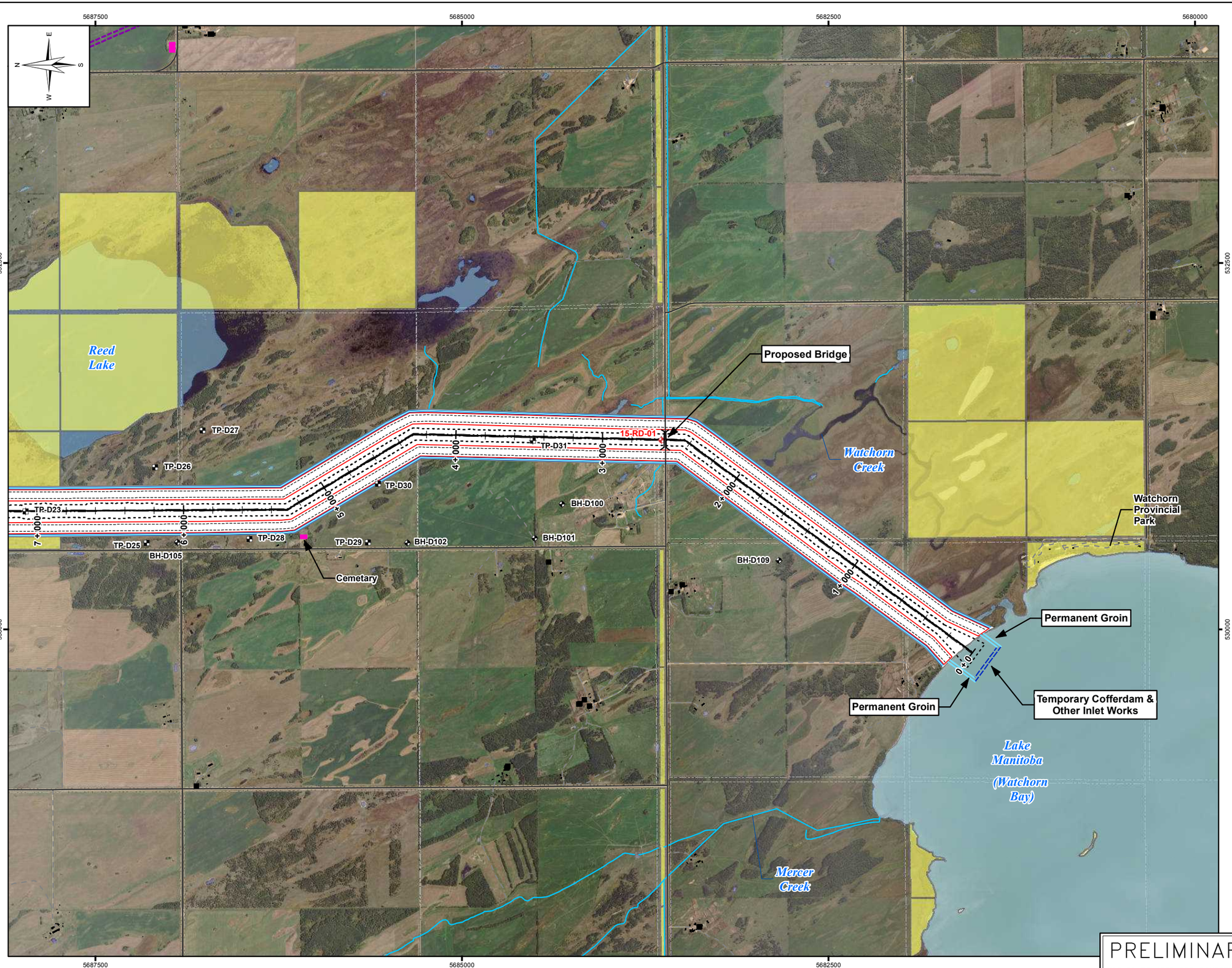
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

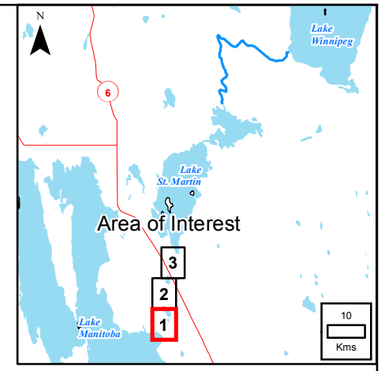
AUGUST 2015 | PLATE 4 | REV: A

11x17

FileName: P:\Projects\2012\12-0300-011\Dwg\Struct\LMB_LSM Stage 2\12-0300-011_Plate 4.dwg – Tab: Layout1 Plotted By: pzylo 15/08/12 [Wed 1:27pm]
11"x17" PLOT SCALE: 1"=2"

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LEGEND:

- Test Hole (June 2015)
- Borehole (2011)
- Test Pit (2011)
- Building

Channel Linework
- Channel Alignment
- Toe of Ditch
- Top of Ditch
- Top of Spoil
- Toe of Channel
- Permanent Rock Groin
- Temporary Cofferdam
- Top of Channel Footprint
- Spoil Footprint
- Right of Way Footprint
- Control Structure & Bridge

Utility Lines
- Transmission Line

Roads
- Paved Road/Street (1 or more lanes)
- Gravel Road
- Dry Season Road
- Trail
- Proposed Road Re-alignment

Water Features
- River/Stream/Ditch
- Lake
- Section
- Crown Land
- Proposed Bridge

NOTES:

1. Imagery is dated 2007 – 2011 and supplied by the Province of Manitoba, Manitoba Land Initiative.
2. Final channel and spoil pile alignment to accommodate bipole transmission line towers, road realignments, privately owned structures, etc...

DRAFT

0 200 400 600 800 1,000

Meters

SCALE: 1:25,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS
CONCEPTUAL DESIGN – STAGE 2

CONCEPTUAL LAYOUT PLAN OF LMB OUTLET CHANNEL ROUTE D (SHEET 1 OF 3)

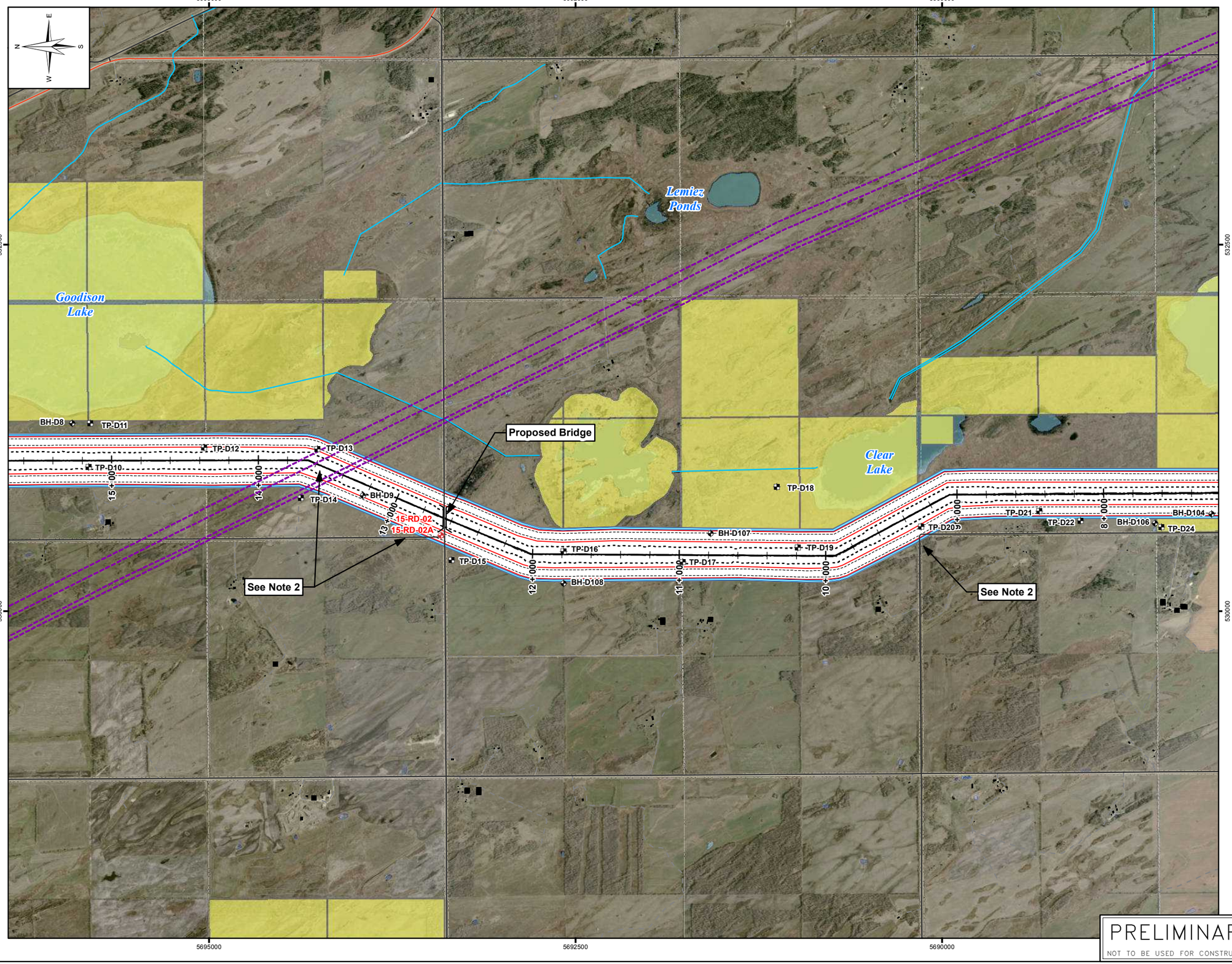
PRELIMINARY

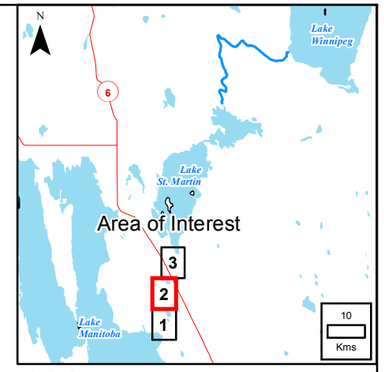
NOT TO BE USED FOR CONSTRUCTION

AUGUST 2015 | PLATE 5.1 | REV: A

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11"x17" PLOT SCALE 1:1

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LEGEND:

- Test Hole (June 2015)
- Borehole (2011)
- Test Pit (2011)
- Building

Channel Linework
- Channel Alignment
- Toe of Ditch
- Top of Ditch
- Top of Spoil
- Toe of Channel
- Permanent Rock Groin
- Temporary Cofferdam
- Top of Channel Footprint
- Spoil Footprint
- Right of Way Footprint
- Control Structure & Bridge

Utility Lines
- Transmission Line

Roads
- Paved Road/Street (1 or more lanes)
- Gravel Road
- Dry Season Road
- Trail
- Proposed Road Re-alignment

Water Features
- River/Stream/Ditch
- Lake
- Section
- Crown Land
- Proposed Bridge

NOTES:

1. Imagery is dated 2007 – 2011 and supplied by the Province of Manitoba, Manitoba Land Initiative.
2. Final channel and spoil pile alignment to accommodate bipole transmission line towers, road realignments, privately owned structures, etc...

DRAFT

0 200 400 600 800 1,000

Meters

SCALE: 1:25,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS
CONCEPTUAL DESIGN – STAGE 2

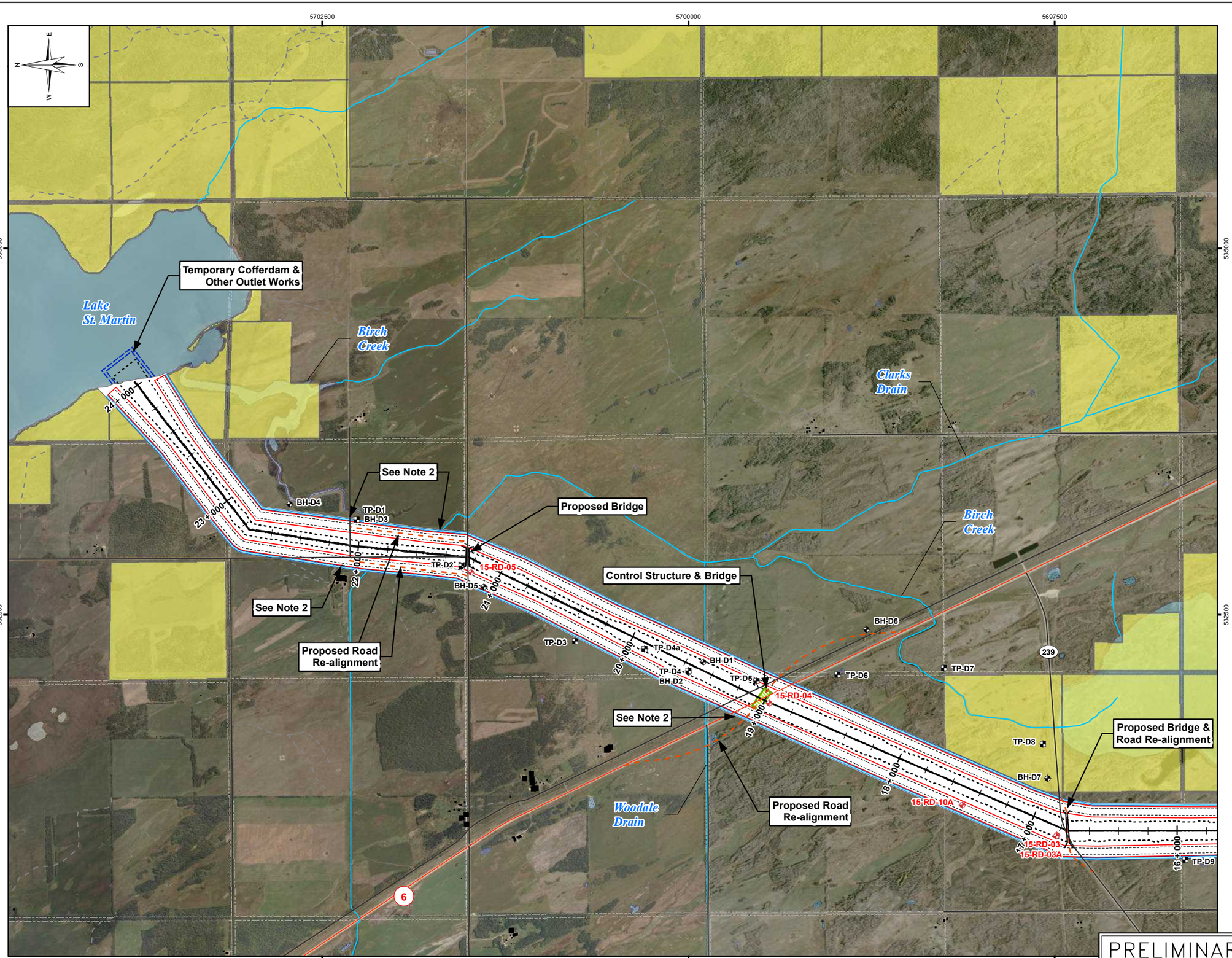
CONCEPTUAL LAYOUT PLAN OF LMB OUTLET CHANNEL ROUTE D (SHEET 2 OF 3)

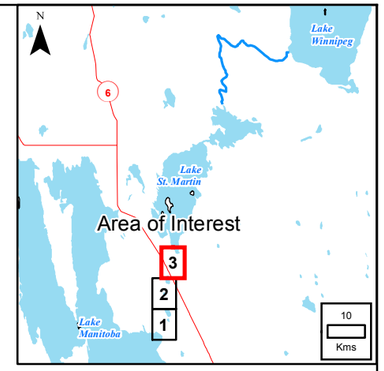
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

AUGUST 2015 | PLATE 5.2 | REV: A

FileName: P:\Projects\2012\12-0300-011\Dwg\GIS\MXDs\RevA\LMB_LSM_Conceptual_Design_Sig2\12-0300-011-Plate5_RevA.mxd
11"x17" PLOT SCALE 1:1

Portions of data presented are owned by the Province of Manitoba and are produced under the licence agreement with the Province of Manitoba 2011 Queen's Printer.





LEGEND:

- Test Hole (June 2015)
- Borehole (2011)
- Test Pit (2011)
- Building

Channel Linework
- Channel Alignment
- Toe of Ditch
- Top of Ditch
- Top of Spoil
- Toe of Channel
- Permanent Rock Groin
- Temporary Cofferdam
- Top of Channel Footprint
- Spoil Footprint
- Right of Way Footprint
- Control Structure & Bridge

Utility Lines
- Transmission Line

Roads
- Paved Road/Street (1 or more lanes)
- Gravel Road
- Dry Season Road
- Trail
- Proposed Road Re-alignment

Water Features
- River/Stream/Ditch
- Lake
- Section
- Crown Land
- Proposed Bridge

NOTES:

1. Imagery is dated 2007 – 2011 and supplied by the Province of Manitoba, Manitoba Land Initiative.
2. Final channel and spoil pile alignment to accommodate bipole transmission line towers, road realignments, privately owned structures, etc...

DRAFT

0 200 400 600 800 1,000

Meters

SCALE: 1:25,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

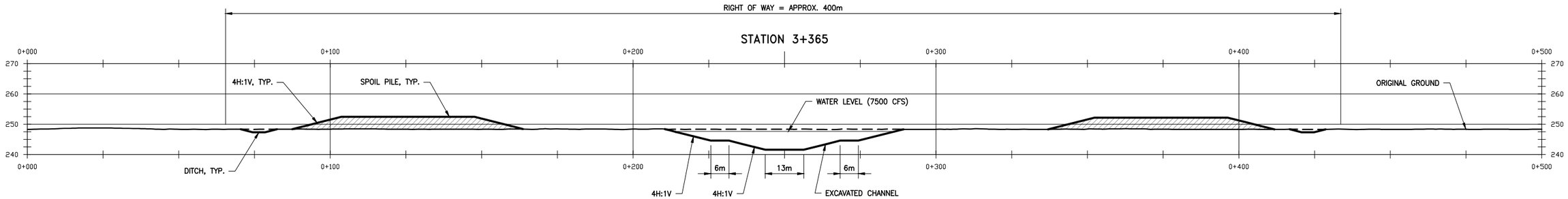
LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS
CONCEPTUAL DESIGN – STAGE 2

CONCEPTUAL LAYOUT PLAN OF LMB OUTLET CHANNEL ROUTE D (SHEET 3 OF 3)

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

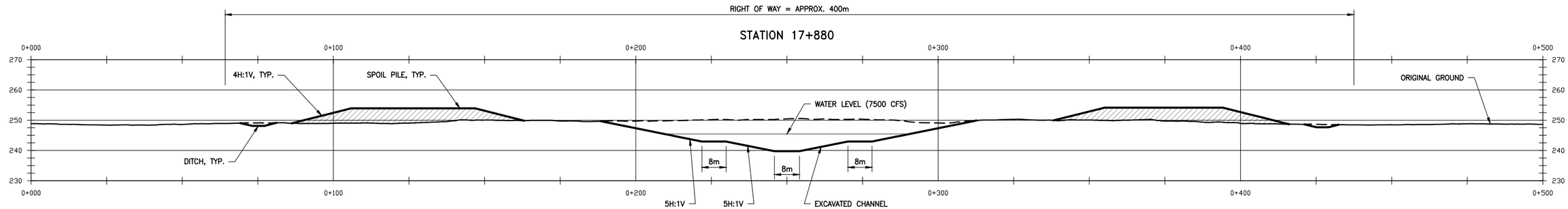
AUGUST 2015 | PLATE 5.3 | REV: A

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11"x17" PLOT SCALE 1:1



ROUTE D – CROSS SECTION 8m CUT OR LESS

SCALE: 1:750



ROUTE D – CROSS SECTION >8m CUT

SCALE: 1:750

NOTES

1. CROSS SECTIONS ARE TYPICAL AND BASED ON PROPOSED CHANNEL DESIGN. CROSS SECTIONS MAY DIFFER SLIGHTLY FROM CIVIL 3D LAYOUT PLANS.

NO.	YY/MM/DD	DESCRIPTION	
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

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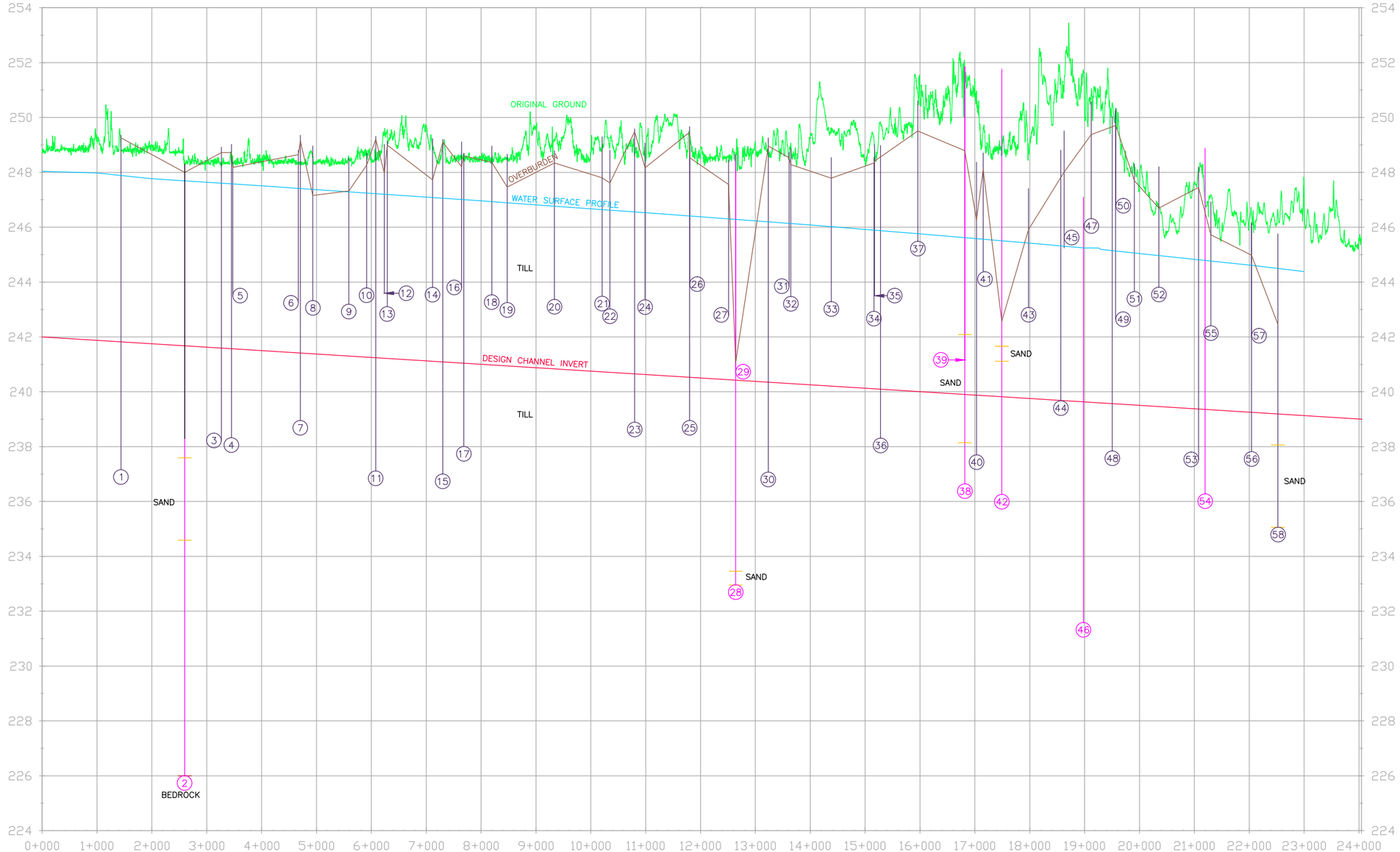
LAKE MANITOBA & LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

TYPICAL CROSS SECTIONS OF LAKE MANITOBA OUTLET CHANNEL ROUTE D

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

AUGUST 2015 | PLATE 6 | REV: A

FileName: P:\Projects\2012\12-0300-011\Dwg\Struct\LMB_LSM Stage 2\12-0300-011_Plate 6.dwg – Tab: Layout1 Plotted By: pzyla 15/08/11 [Tue 3:58pm]
11"x17" PLOT SCALE: 1"=2'
11"x17"



TEST PITS 2011		
SYMBOL	NUMBER	OFFSET
5	TP-D31	-24.95
6	TP-D30	-164.00
8	TP-D29	-473.36
9	TP-D28	-63.88
10	TP-D27	675.51
12	TP-D26	419.89
13	TP-D25	-96.56
14	TP-D23	114.74
16	TP-D24	-123.56
16	TP-D104	-31.77
18	TP-D22	-85.01
19	TP-D21	-18.31
20	TP-D20	-98.72
21	TP-D19	56.77
22	TP-D18	468.92
24	TP-D17	-46.86
26	TP-D16	21.34
27	TP-D15	-244.01
31	TP-D14	-258.31
32	TP-D13	94.69
33	TP-D12	86.80
34	TP-D11	253.16
35	TP-D10	-41.82
37	TP-D9	-200.43
41	TP-D8	479.71
43	TP-D7	686.92
45	TP-D6	358.17
47	TP-D5	93.57
50	TP-D4	-45.25
51	TP-D4A	-42.03
52	TP-D3	-199.17
55	TP-D2	-65.41
57	TP-D1	182.88
BORE HOLES 2011		
SYMBOL	NUMBER	OFFSET
1	BH-D109	-276.90
3	BH-D100	-455.41
4	BH-D101	-689.52
7	BH-D102	-617.34
11	BH-D105	-90.86
15	BH-D104	-31.77
17	BH-D106	-94.89
23	BH-D107	149.26
25	BH-D108	-196.66
30	BH-D9	-74.83
36	BH-D8	254.38
40	BH-D7	275.51
44	BH-D6	720.11
48	BH-D1	54.51
49	BH-D2	-53.35
53	BH-D5	-136.13
56	BH-D3	179.99
58	BH-D4	213.83
BORE HOLES 2015		
SYMBOL	NUMBER	OFFSET
2	15-RD-01	-2.48
28	15-RD-02	-114.61
29	15-RD-02A	-115.38
38	15-RD-03	-56.10
39	15-RD-03A	-62.27
42	15-RD-04	-6.80
46	15-RD-05	-86.20
54	15-RD-10A	-123.31

LEGEND

- ORIGINAL GROUND
- WATER SURFACE PROFILE
- DESIGN CHANNEL INVERT
- 2011 BOREHOLES
- 2015 BOREHOLES
- BEDROCK
- OVERBURDEN
- SAND

NOTES:

1. ALL UNITS ARE IN METERS.
2. VERTICAL EXAGGERATION 1:500
3. HORIZONTAL EXAGGERATION 1:2

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

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LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

PROFILE AND STATIGRAPHY ALONG ROUTE D

PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

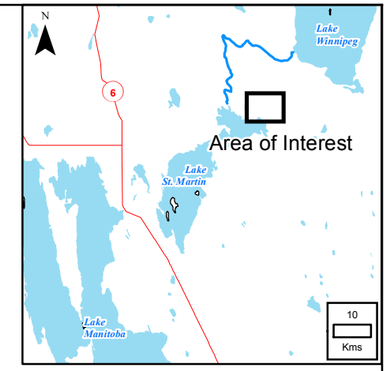
AUGUST 2015 | PLATE 7 | REV: A

11x17

FileName: P:\Projects\2012\12-0300-011\Dwg\Struct\LMB_LSM Stage 2\12-0300-011_Plate 7.dwg - Tab: Layout2 Plotted By: pzylo 15/08/11 [Tue 3:59pm]
11"x17" PLOT SCALE: 1"=2"

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LEGEND:

- Test Pit (2015)
- Test Hole (2015)
- Borehole/Hand Auger/Test Hole (2011)
- Test Pit (2011)
- Peat Probe (2011)

Channel Linework

- Channel Alignment
- Toe of Ditch
- Top of Ditch
- Top of Spoil
- Toe of Channel
- Temporary Cofferdam
- Top of Channel Footprint
- Spoil Footprint
- Right of Way Footprint
- Control Structure
- Access Road

Water Features

- River/Stream
- Lake

NOTES:

1. Imagery is dated 2011 and supplied by the Province of Manitoba.

DRAFT

0 200 400 600 800 1,000

Meters

SCALE: 1:30,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

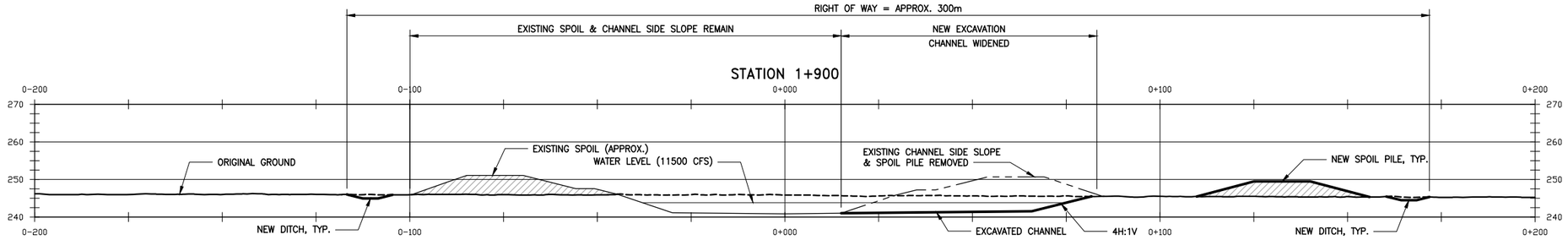
LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS
CONCEPTUAL DESIGN – STAGE 2

CONCEPTUAL LAYOUT PLAN OF LSM REACH 1 OUTLET CHANNEL

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

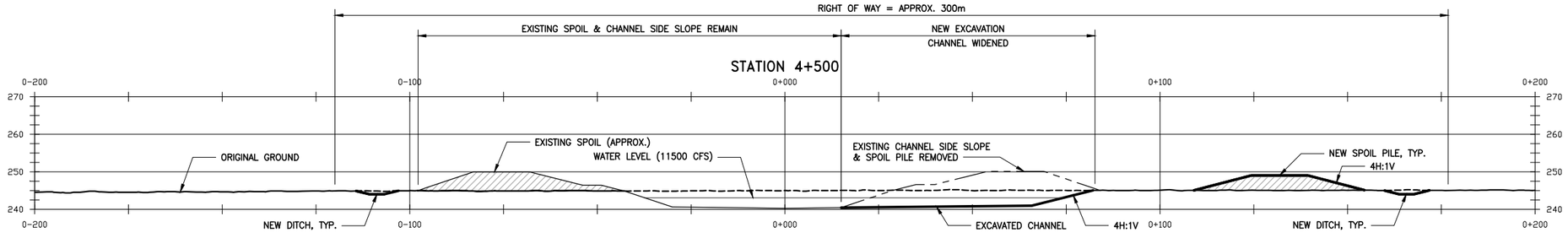
AUGUST 2015 | PLATE 8 | REV: A

FileName: P:\Projects\2012\12-0300-011\Dwg\GIS\MXDs\RevA\LMB_LSM_Conceptual_Design_Stg2\12-0300-011-Plate8_RevA.mxd
11"x17" PLOT SCALE 1:1



REACH 1 – CROSS SECTION (STA 1+900)

SCALE: 1:750



REACH 1 – CROSS SECTION (STA 4+500)

SCALE: 1:750

NOTES

1. CROSS SECTIONS ARE TYPICAL AND BASED ON PROPOSED CHANNEL DESIGN. CROSS SECTIONS MAY DIFFER SLIGHTLY FROM CIVIL 3D LAYOUT PLANS.

NO.	YY/MM/DD	DESCRIPTION	
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

REVISIONS / ISSUE

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

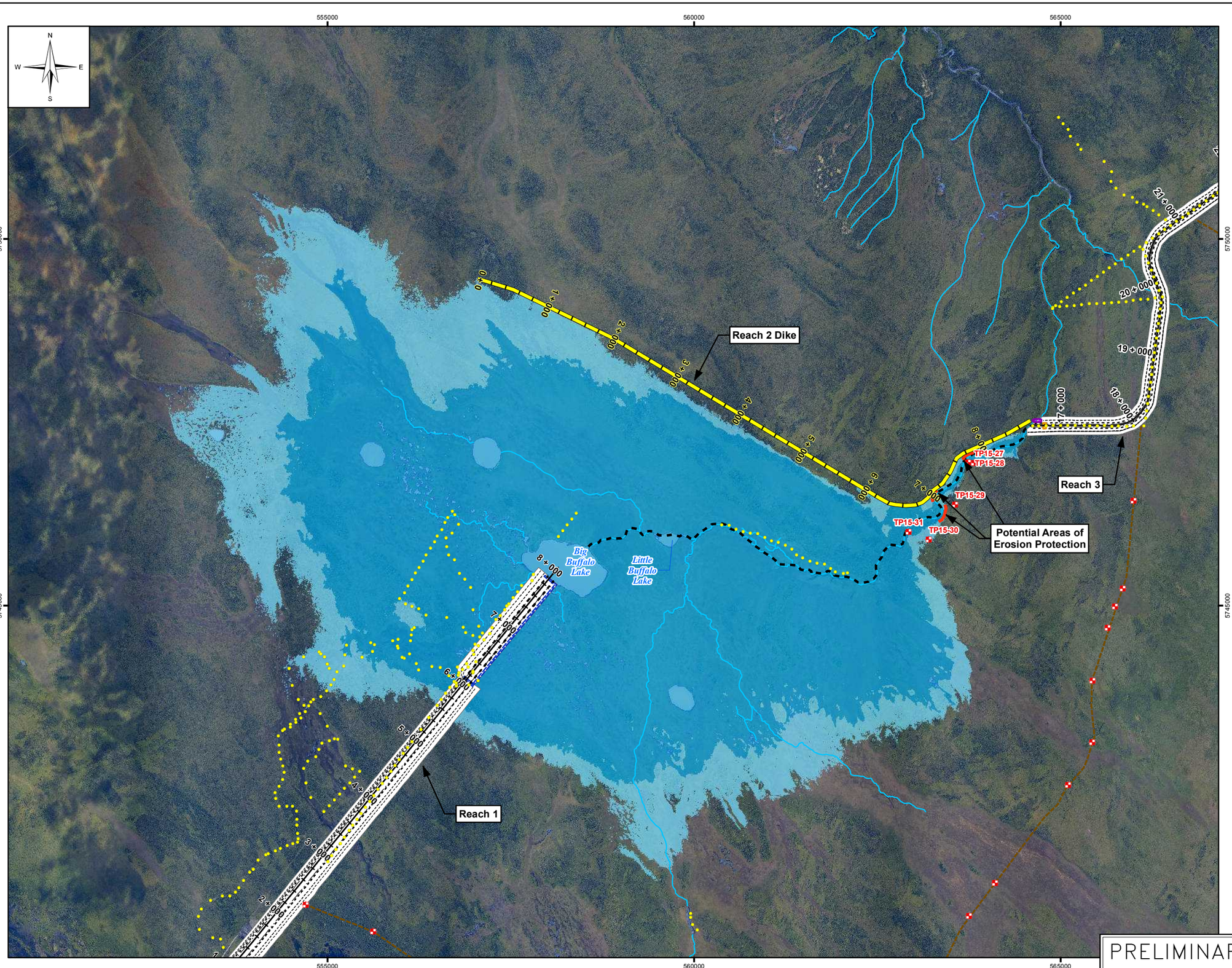
LAKE MANITOBA & LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

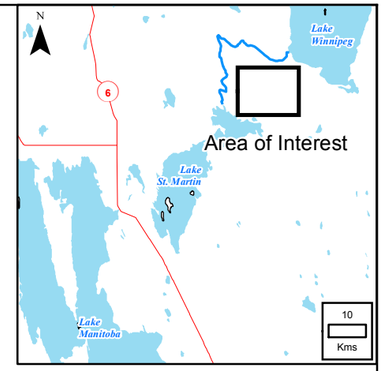
TYPICAL CROSS SECTIONS OF LAKE ST. MARTIN REACH 1 OUTLET CHANNEL

AUGUST 2015 | PLATE 9 | REV: A

11"x17"
FileName: P:\Projects\2012\12-0300-011\Dwg\Struct\LMB_LSM Stage 2\12-0300-011_Plate 9.dwg – Tab: Layout1 Plotted By: pzyla 15/08/11 [Tue 4:00pm]
PLOT SCALE: 1"=2'

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LEGEND:

- Test Pit (2015)
- Peat Probe (2011)
- Reach 2 Containment Dike
- Potential Areas of Erosion Protection

Channel Linework

- Channel Alignment
- Temporary Cofferdam
- Toe of Channel
- Top of Spoil
- Top of Expanded Channel Footprint
- Right of Way Footprint
- Inlet Weir & Low Flow Crossing
- Reach 3 Diversion Structure
- Buffalo Creek Channel
- Access Road

Water Features

- River/Stream
- Lake

Depth of Flooding

- 0 – 0.5m
- > 0.5m

NOTES:

1. Imagery is dated 2011 and supplied by the Province of Manitoba.

DRAFT

0 500 1,000 1,500 2,000 2,500

Meters

SCALE: 1:50,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

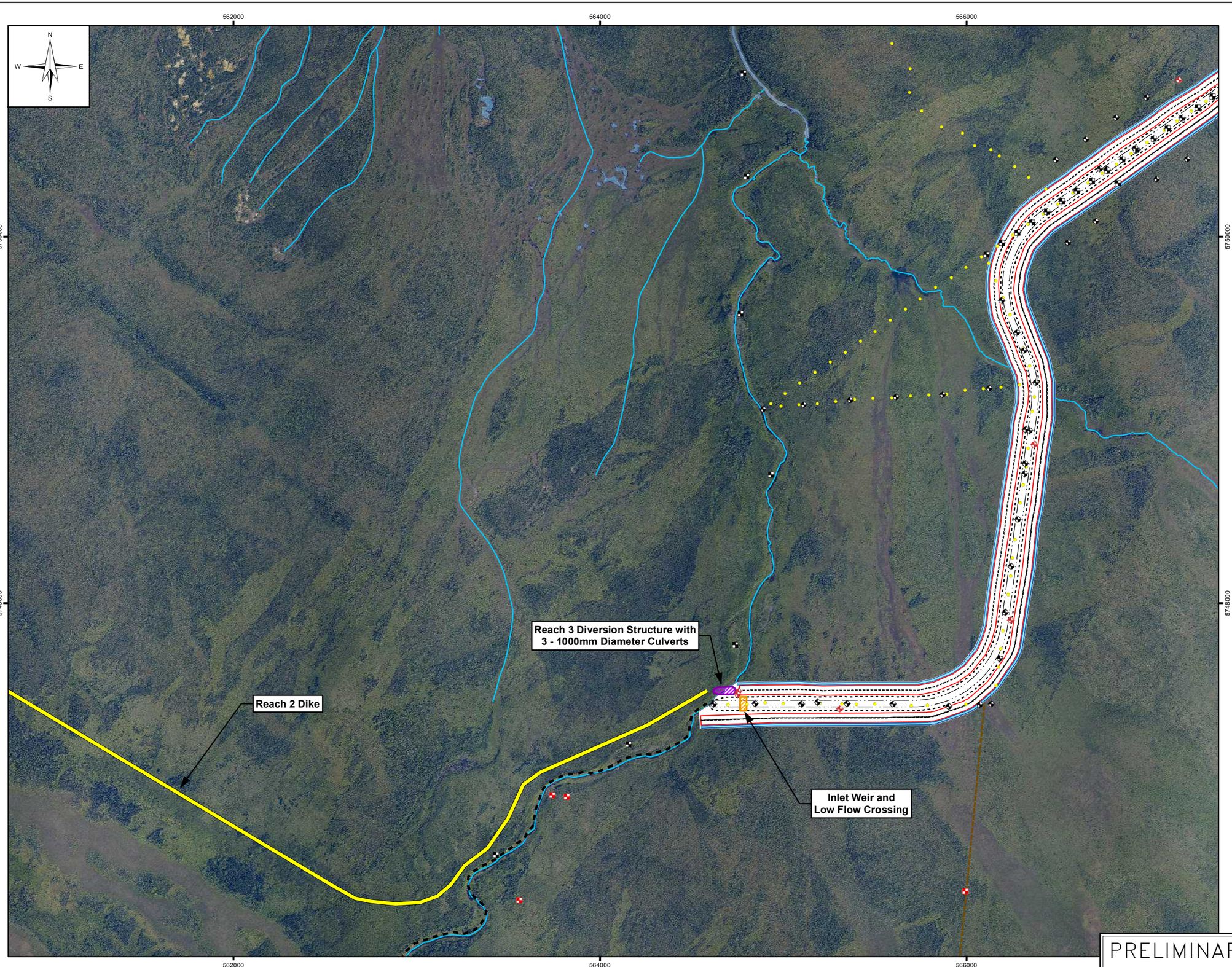
INUNDATION PLAN AND CONCEPTUAL ALIGNMENT OF LSM REACH 2 DIKE

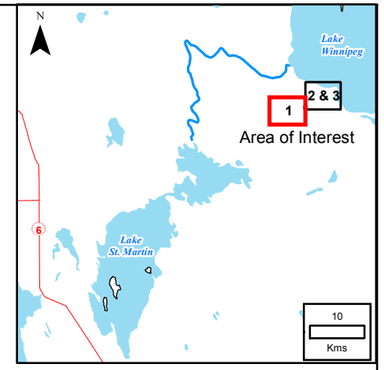
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

AUGUST 2015 | PLATE 10 | REV: A

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11"x17" PLOT SCALE 1:1

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LEGEND:

- Test Pit (2015)
- Test Hole (2015)
- Borehole/Hand Auger/Test Hole (2011)
- Test Pit (2011)
- Peat Probe (2011)

Channel Linework

- Channel Alignment
- Top of Ditch
- Toe of Ditch
- Top of Spoil
- Toe of Channel
- Temporary Cofferdam
- Spoil Footprint
- Top of Channel Footprint
- Right of Way Footprint
- Inlet Weir & Low Flow Crossing
- Reach 3 Diversion Structure
- Reach 2 Containment Dike
- Access Road
- Buffalo Creek Channel
- River/Stream

NOTES:

1. Imagery is dated 2011 and supplied by the Province of Manitoba.

DRAFT

0 200 400 600 800 1,000

Meters

SCALE: 1:20,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS
CONCEPTUAL DESIGN – STAGE 2

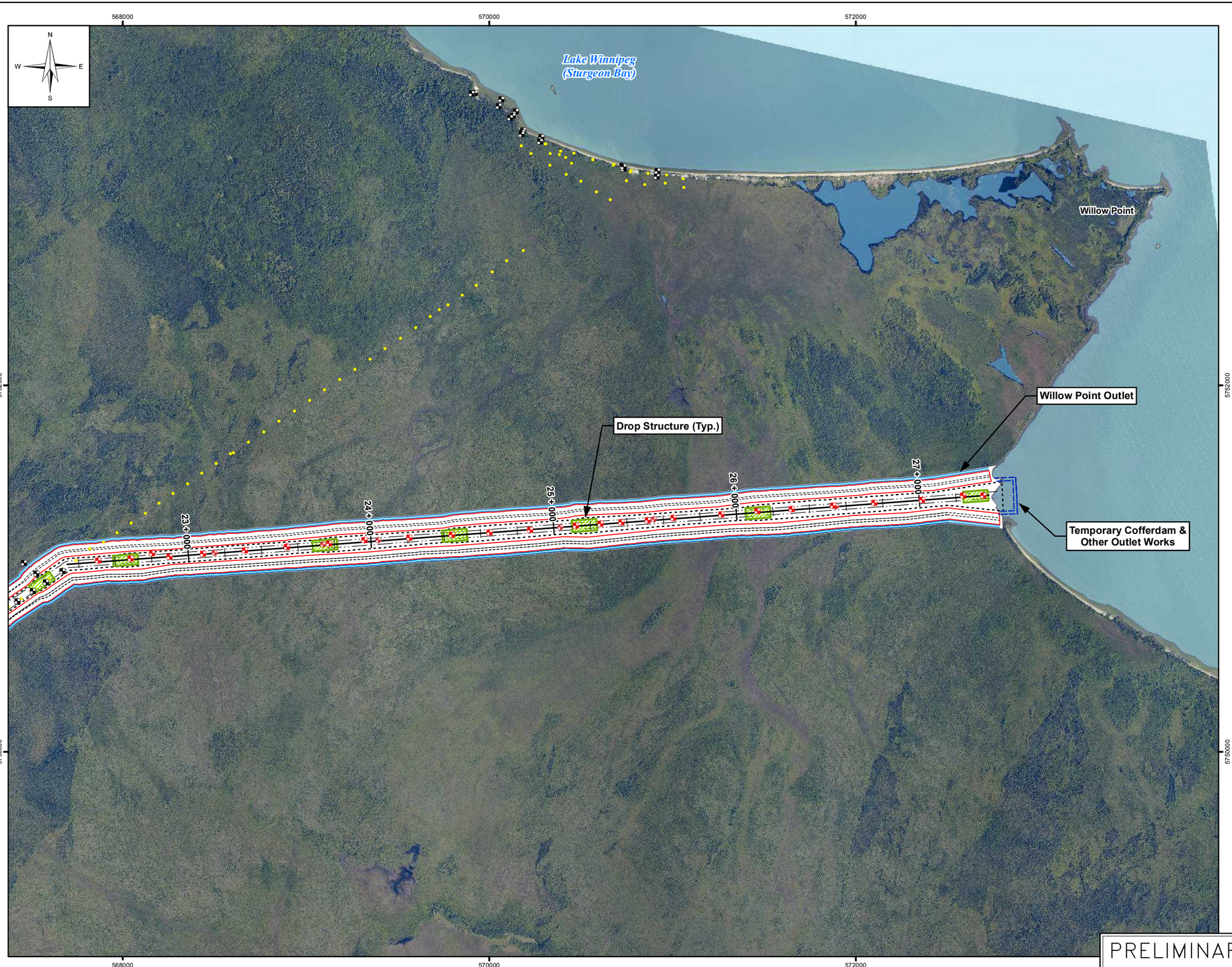
CONCEPTUAL LAYOUT PLAN OF LSM REACH 3 CHANNEL (SHEET 1 OF 3)

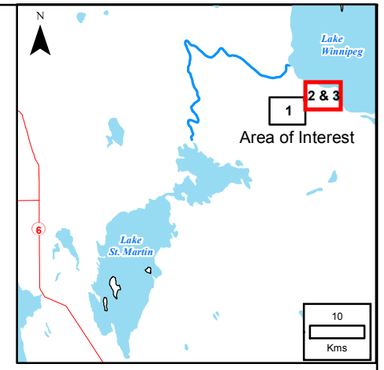
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

AUGUST 2015 | PLATE 11.1 | REV: A

FileName: P:\Projects\2012\12-0300-011\Dwg\GIS\MXDs\RevA\LMB_LSM_Conceptual_Design_Stg2\12-0300-011-Plate11_RevA.mxd
11"x17" PLOT SCALE 1:1

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LEGEND:

- Test Pit (2015)
- Test Hole (2015)
- Borehole/Hand Auger/Test Hole (2011)
- Test Pit (2011)
- Peat Probe (2011)

Channel Linework

- Channel Alignment
- Top of Ditch
- Toe of Ditch
- Top of Spoil
- Toe of Channel
- Temporary Cofferdam
- Spoil Footprint
- Top of Channel Footprint
- Right of Way Footprint
- Drop Structure
- Lake

NOTES:

1. Imagery is dated 2011 and supplied by the Province of Manitoba.

DRAFT

0 200 400 600 800 1,000

Meters

SCALE: 1:20,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

CONCEPTUAL LAYOUT PLAN OF LSM REACH 3 CHANNEL WILLOW POINT (SHEET 2 OF 3)

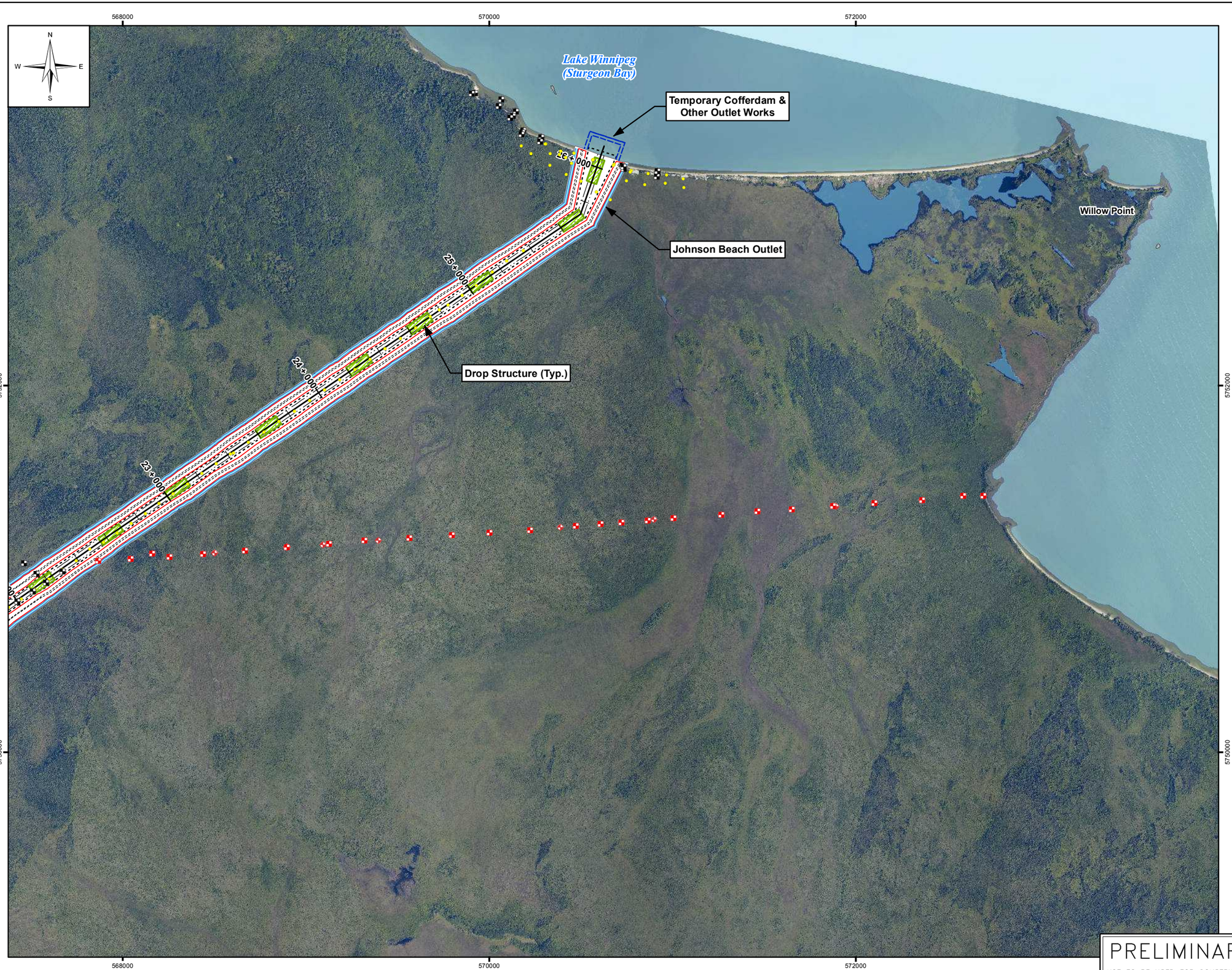
PRELIMINARY

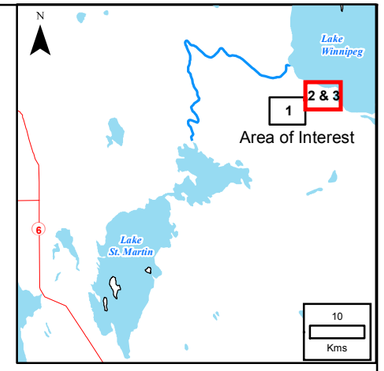
NOT TO BE USED FOR CONSTRUCTION

AUGUST 2015 | PLATE 11.2 | REV: A

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11"x17" PLOT SCALE 1:1

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LEGEND:

- Test Pit (2015)
- Test Hole (2015)
- Borehole/Hand Auger/Test Hole (2011)
- Test Pit (2011)
- Peat Probe (2011)

Channel Linework

- Channel Alignment
- Toe of Ditch
- Top of Ditch
- Top of Spoil
- Toe of Channel
- Temporary Cofferdam
- Spoil Footprint
- Top of Channel Footprint
- Right of Way Footprint
- Drop Structure
- Lake

NOTES:

1. Imagery is dated 2011 and supplied by the Province of Manitoba.

DRAFT

0 200 400 600 800 1,000
Meters

SCALE: 1:20,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

CONCEPTUAL LAYOUT PLAN OF LSM REACH 3 CHANNEL JOHNSON BEACH (SHEET 3 OF 3)

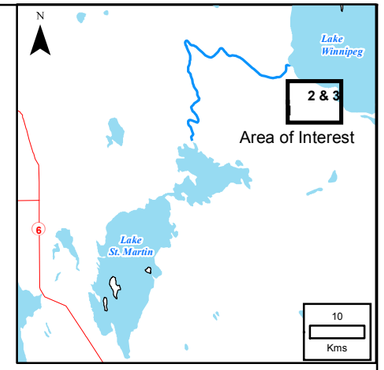
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

AUGUST 2015 | PLATE 11.3 | REV: A

FileName: P:\Projects\2012\12-0300-011\Dwg\GIS\MXDs\RevA\LMB_LSM_Conceptual_Design_Sig2\12-0300-011-Plate11_RevA.mxd
11"x17" PLOT SCALE 1:1

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LEGEND:

- Test Pit (2015)
- Test Hole (2015)
- Test Hole/Borehole/Hand Auger (2011)
- Test Pit (2011)
- Peat Probe (2011)

Channel Linework

- Channel Alignment
- Reach 2 Containment Dike
- Access Road
- Buffalo Creek Channel
- River/Stream
- Lake

NOTES:

1. Imagery is dated 2011 and supplied by the Province of Manitoba.

DRAFT

0 200 400 600 800 1,000

Meters

SCALE: 1:30,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

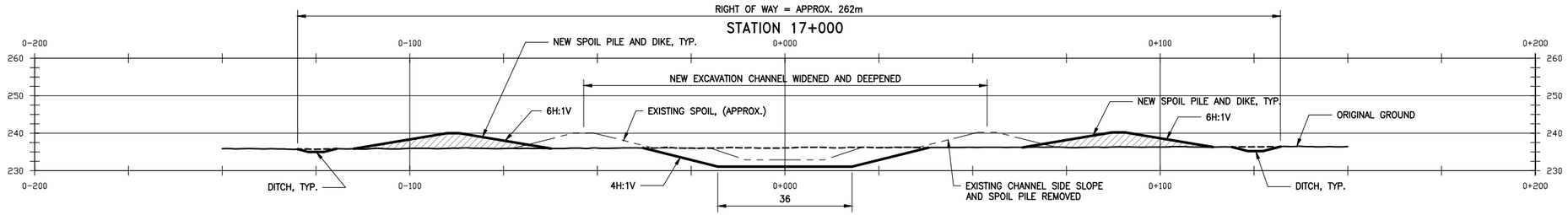
FIELD INVESTIGATION SUMMARY FOR LSM REACH 3 CHANNEL

PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

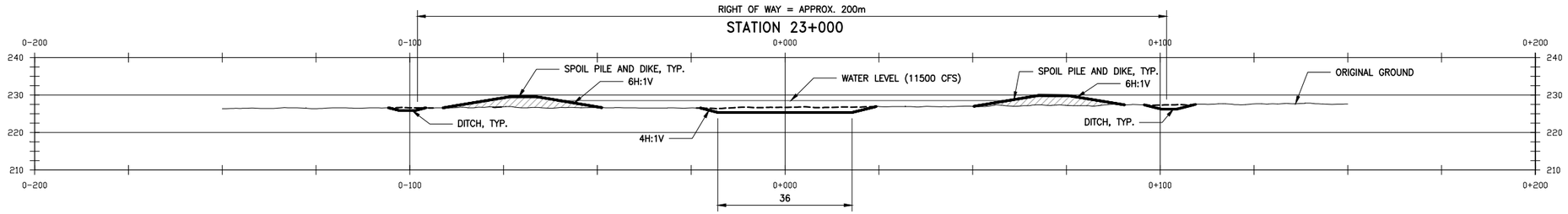
AUGUST 2015	PLATE 12	REV: A

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11"x17" PLOT SCALE 1:1



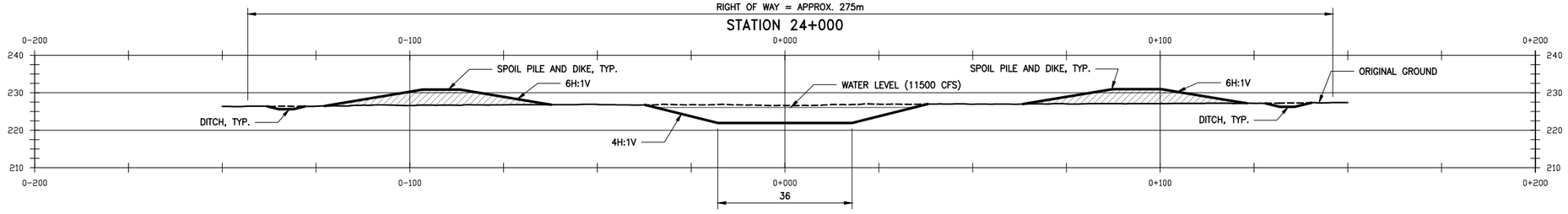
REACH 3 – CROSS SECTION (STA 17+000)

SCALE: 1:750



REACH 3 JOHNSON BEACH OUTLET – CROSS SECTION

SCALE: 1:750



REACH 3 WILLOW POINT OUTLET – CROSS SECTION

SCALE: 1:750

NOTES

1. CROSS SECTIONS ARE TYPICAL AND BASED ON PROPOSED CHANNEL DESIGN. CROSS SECTIONS MAY DIFFER SLIGHTLY FROM CIVIL 3D LAYOUT PLANS.

NO.	YY/MM/DD	DESCRIPTION	
A	15/08/12	ISSUED WITH DRAFT REPORT	TNN

REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA & LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

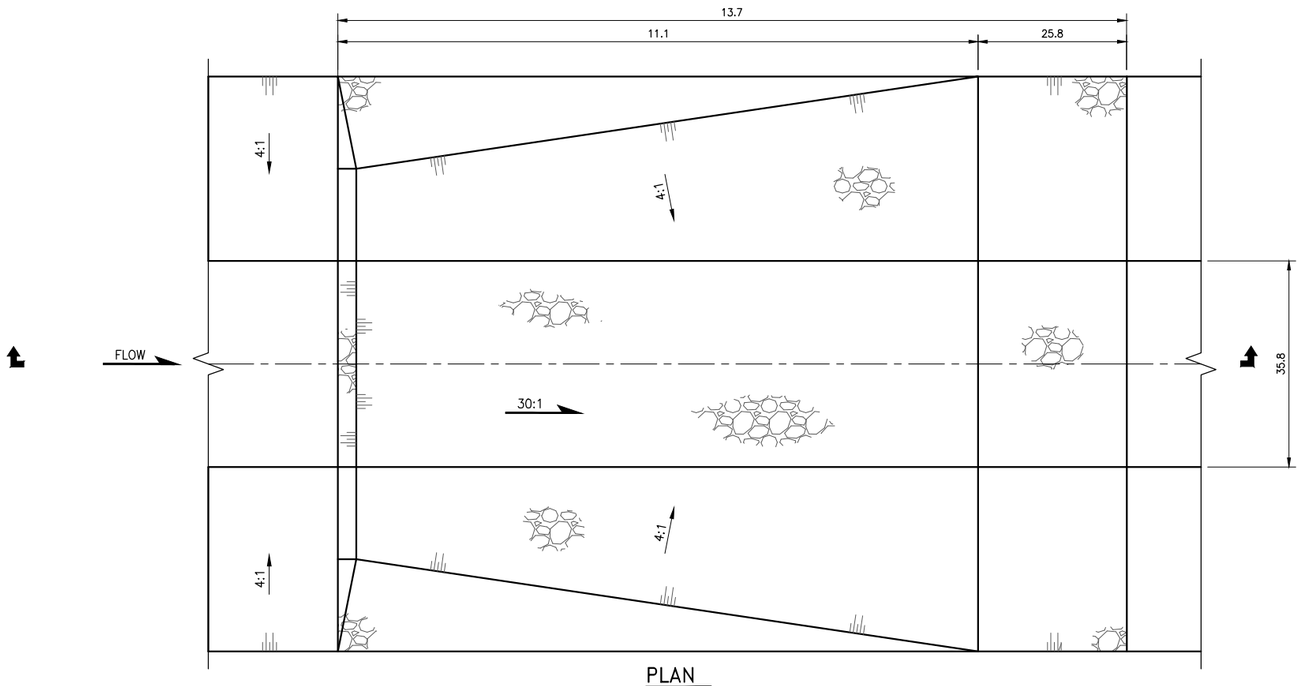
TYPICAL CROSS SECTIONS OF LAKE ST. MARTIN REACH 3 OUTLET CHANNEL

PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

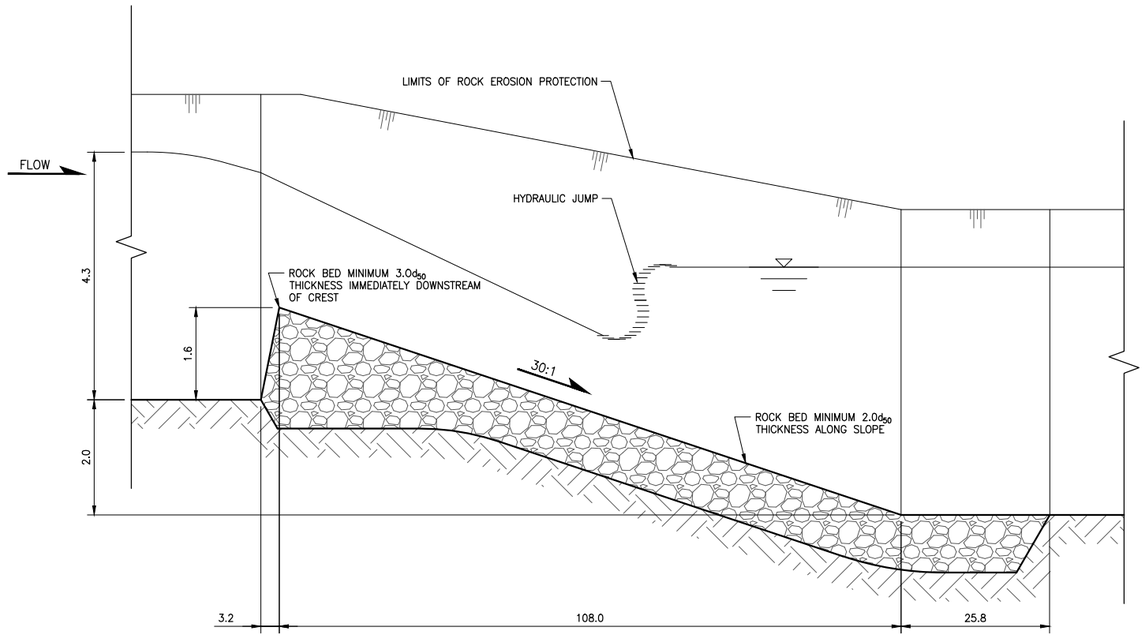
AUGUST 2015 | PLATE 13 | REV: A

11"x17"
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11"x17" PLOT SCALE: 1"=2'



PLAN

SCALE: 1:500



SECTION (10X EXAGGERATED VERTICAL SCALE)

SCALE: 1:500

PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

NO.	YY/MM/DD	DESCRIPTION	
A	15/08/12	ISSUED WITH DRAFT REPORT	PAL

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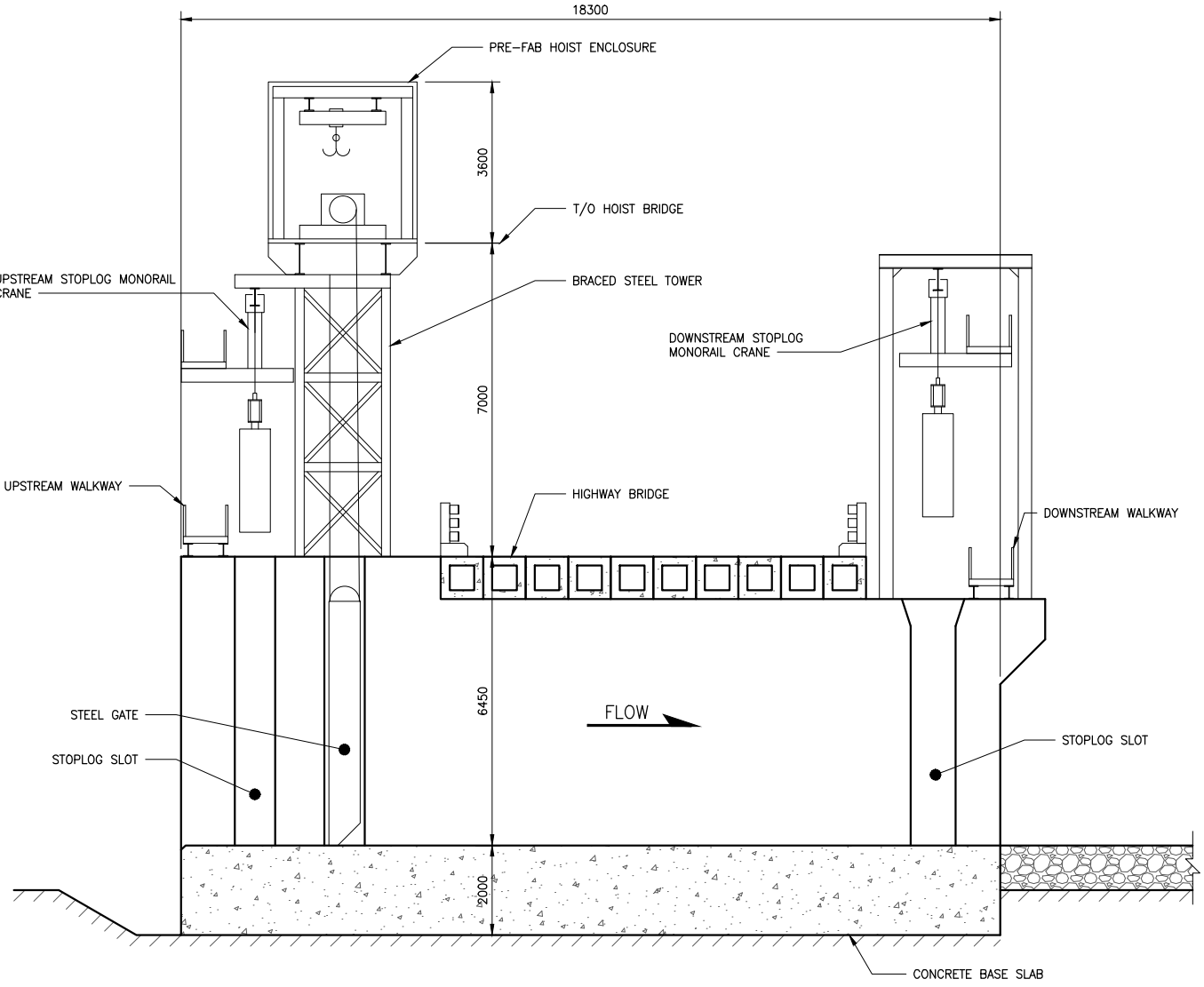
LAKE MANITOBA & LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

PLAN & PROFILE OF TYPICAL DROP STRUCTURE ON LAKE ST. MARTIN REACH 3 CHANNELS

AUGUST 2015 | PLATE 14 | REV: A

11x17

FileName: P:\Projects\2012\12-0300-011\Dwg\Struct\LMB_LSM Stage 2\12-0300-011_Plate 14.dwg – Tab: LAYOUT Plotted By: pzylo 15/08/11 [Tue 4:38pm]
11"x17" PLOT SCALE: 1"=2'



CONTROL STRUCTURE – SECTION

SCALE: 1:150

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/12	ISSUED WITH DRAFT REPORT	DBM

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA & LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

PROPOSED CONTROL STRUCTURE SECTION

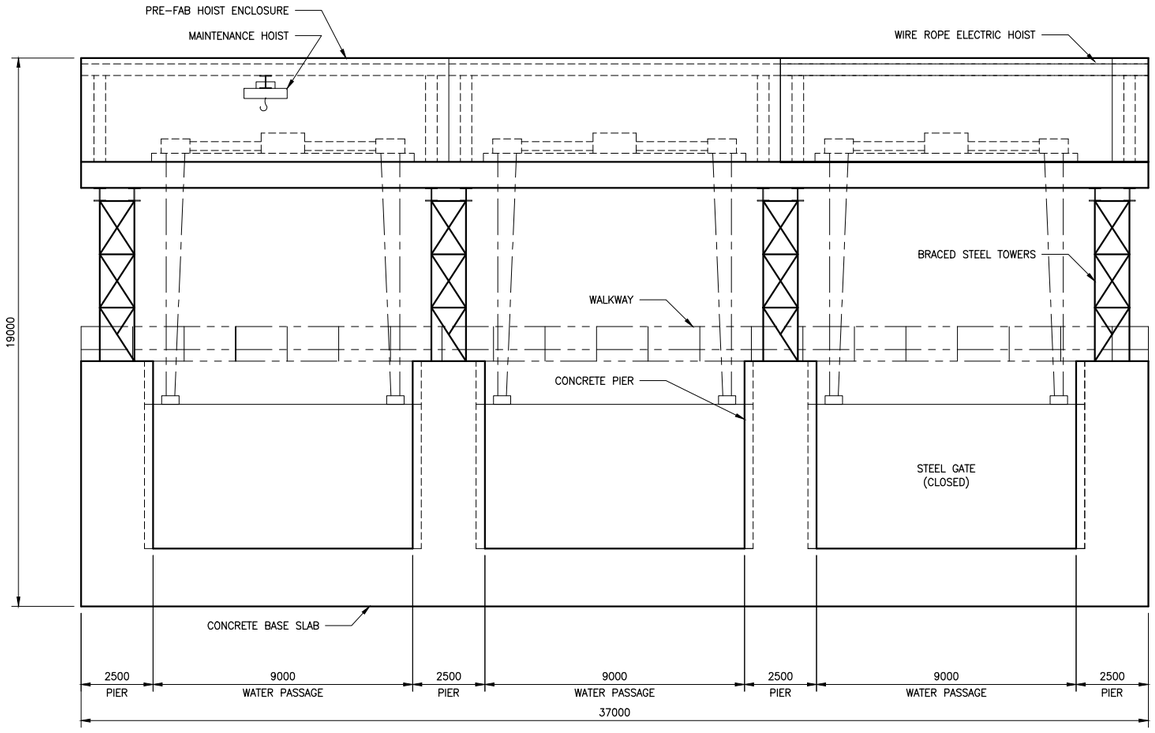
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

AUGUST 2015 | PLATE 15 | REV: A

8.5x11
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8.5"x11" PLOT SCALE: 1"=2"

11x17

FileName: P:\Projects\2012\12-0300-011\Dwg\Struct\LMB_LSM Stage 2\12-0300-011_Plate 16.dwg - Tab: LAYOUT Plotted By: pzyla 15/08/11 [Tue 4:05pm]
11"x17" PLOT SCALE: 1"=2'



3 BAY CONTROL STRUCTURE – UPSTREAM ELEVATION

SCALE: 1:200

NO.	YY/MM/DD	DESCRIPTION	
A	15/08/12	ISSUED WITH DRAFT REPORT	DBM

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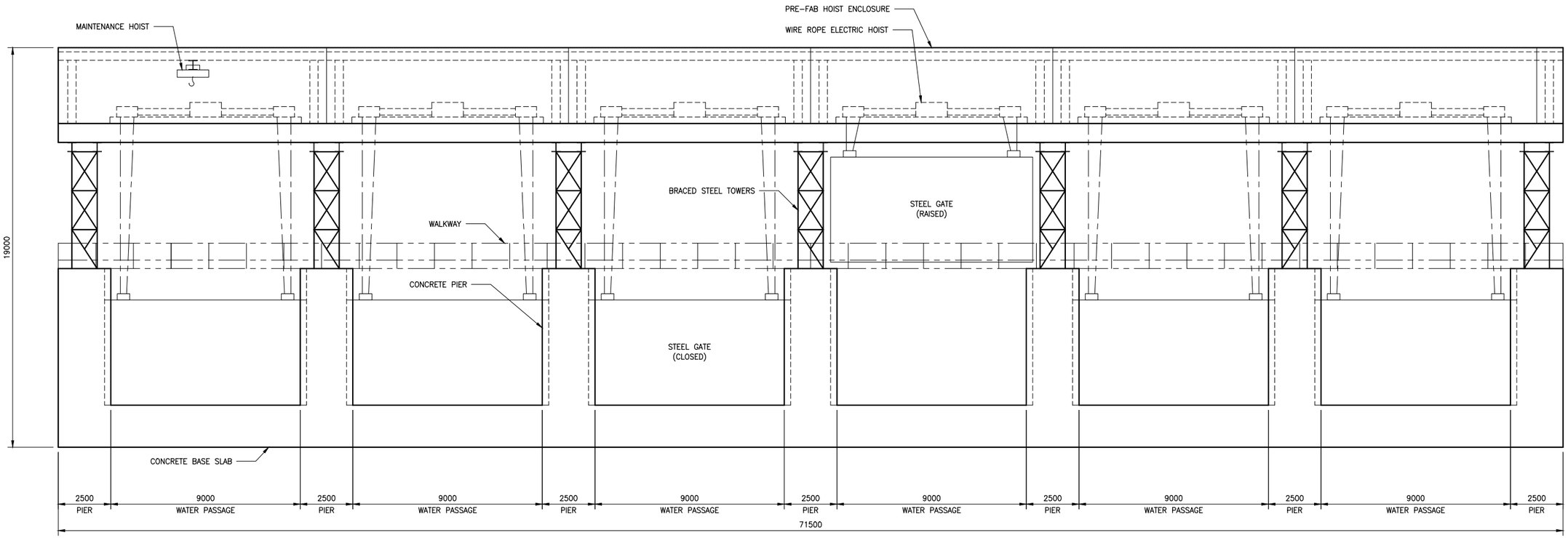
LAKE MANITOBA & LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

PROPOSED 3 BAY CONTROL STRUCTURE PLAN & ELEVATION

PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

AUGUST 2015	PLATE 16	REV: A



6 BAY CONTROL STRUCTURE – UPSTREAM ELEVATION

SCALE: 1:200

NO.	YY/MM/DD	DESCRIPTION	
A	15/08/12	ISSUED WITH DRAFT REPORT	DBM

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA & LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

PROPOSED 6–BAY CONTROL STRUCTURE ELEVATION

AUGUST 2015 | PLATE 17 | REV: A

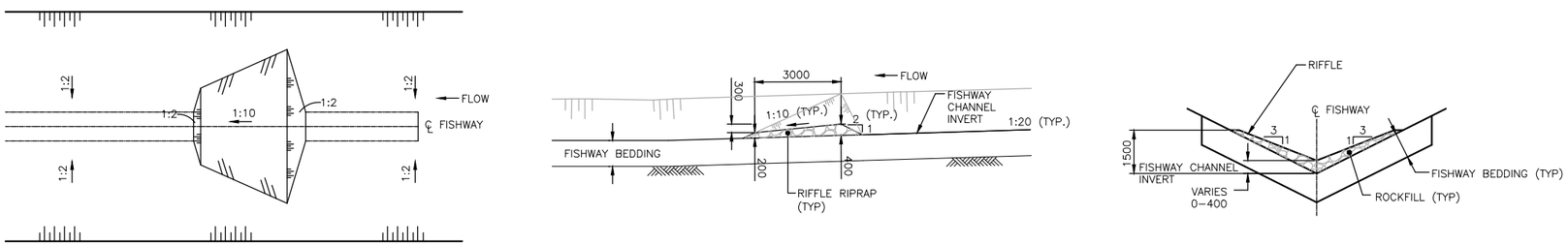
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11"x17" PLOT SCALE: 1"=2'



FISHWAY PLAN

SCALE: 1:250



FISHWAY RIFFLES (DETAILS)

SCALE: NTS

PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

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A	15/08/12	ISSUED WITH DRAFT REPORT	DBM

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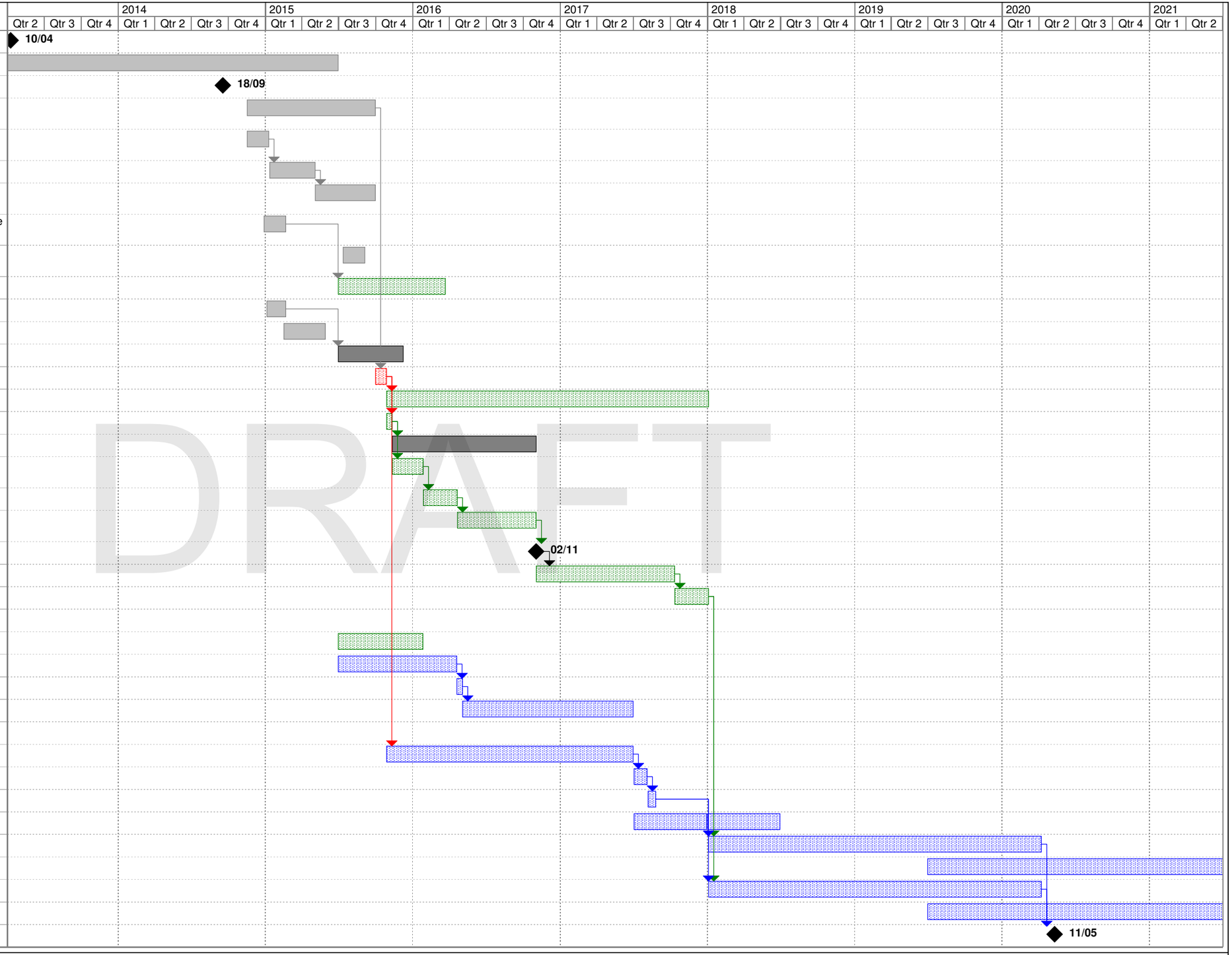
LAKE MANITOBA & LAKE ST. MARTIN OUTLET CHANNELS CONCEPTUAL DESIGN – STAGE 2

CONCEPTUAL LAYOUT PLAN OF PROPOSED FRWCS FISHWAY

AUGUST 2015 | PLATE 18 | REV: A

FileName: P:\Projects\2012\12-0300-011\Dwg\Struct\LMB_LSM Stage 2\12-0300-011_Plate 18.dwg - Tab: Layout1 Plotted By: pzyla 15/08/11 [Tue 4:14pm]
11"x17" PLOT SCALE: 1"=2"
11x17

ID	Task Name
1	**Provincial Press Release**
2	Assiniboine River and LMB Basins Study
3	**Ashern Open House**
4	Conceptual Design Stage 2 - Review of Preferred Alternatives
5	Optimize Hydraulic Design of Preferred Alternatives
6	Geotech/survey Field Investigations
7	Refine Costs and Quantities of Preferred Alternatives and Prepare Report
8	Identify Environmental Assessment (EA) Requirements for Future Licensing
9	Fish Passage Assessment - Fairford R. Water Control Structure
10	Environmental Field Programs (baseline data)
11	Analysis of Social Impacts of Preferred Alternatives
12	LSM Access Rd - Geotech Investigations
13	Aboriginal Consultation (Provincial)
14	Selection of Preferred Alternative
15	Environmental Impact Statement (EIS) Process
16	Develop Project Description & EAPF (Consultant)
17	Aboriginal Consultation (Federal)
18	Review of Project Description (Canadian Environmental Assessment Agency - CEAA) & EAPF
19	EA Commencement (CEAA / MCWS)
20	Develop EIS (Consultant); Including Any Additional Field Work
21	**Submit EIS to CEAA**
22	EA Analysis and Report (CEAA)
23	EA Decision (CEAA) / Env. Act Licence Decision (MCWS)
24	LSM Access Road
25	Environmental Permitting
26	Design
27	Tender
28	Construction
29	LMB & LSM Channels
30	Design
31	Tender
32	Work Permits/Construction Camp Permitting
33	Legal Survey and Land Acquisition
36	LMB Channel - Construction
37	LMB Channel - Revegetate
38	LSM Channel - Construction
39	LSM Channel - Revegetate
40	**LMB and LSM Channels Operational**



DRAFT

APPENDICES

DRAFT

APPENDIX A

RECORD DRAWINGS OF THE LAKE ST. MARTIN

REACH 1 EMERGENCY OUTLET CHANNEL

DRAFT

D SIZE 22" x 34" (558.8mm x 863.6mm)

Lake Manitoba and Lake St. Martin Emergency Channel Outlet Channel - Lake St. Martin to Big Buffalo Lake (24-33-6-W1)

HYDRAULIC DESIGN

Design Flow = 106m³/s
Design WL = ** Lake St. Martin WL = 244.14m

** See profile for Design Water Level

Gauges

Point	Chainage	Northing	Easting	Elevation	Quadrant	Sec	Twp	Rge	Meridian
Gauge 1	1+318	5740239.646	553879.845	243.515	NE	3	33	6	W1
Gauge 2	3+260	5741749.141	555100.960	240.292	SE	11	33	6	W1
Gauge 3	5+200	5743251.540	556329.327	242.802	NW	13	33	6	W1

Benchmarks

TBM 1	2+200	5740890.610	554485.255	248.701	SW	11	33	6	W1
TBM2 (Construction camp)	2+430	5741003.778	554718.650	245.656	SW	11	33	6	W1
TBM 3	3+860	5742193.802	555516.505	247.487	NW	12	33	6	W1

Manitoba
Infrastructure and Transportation

LIST OF PROJECT DRAWINGS

05-G-000	COVER SHEET
05-G-001	SITE PLAN
05-C-107	CHANNEL AND ASSOCIATED WORKS - PROFILE STA 0+000 TO STA 6+150
05-C-109	TYPICAL DESIGN SPOIL PILE SECTION
05-C-110	CHANNEL AND SPOIL PILE SECTIONS
05-C-401	INLET CONTROL SECTIONS AND DETAILS (3/4 CHANNEL)

KEY MAP

ISSUED FOR RECORD

Issue Date: 12/05/08

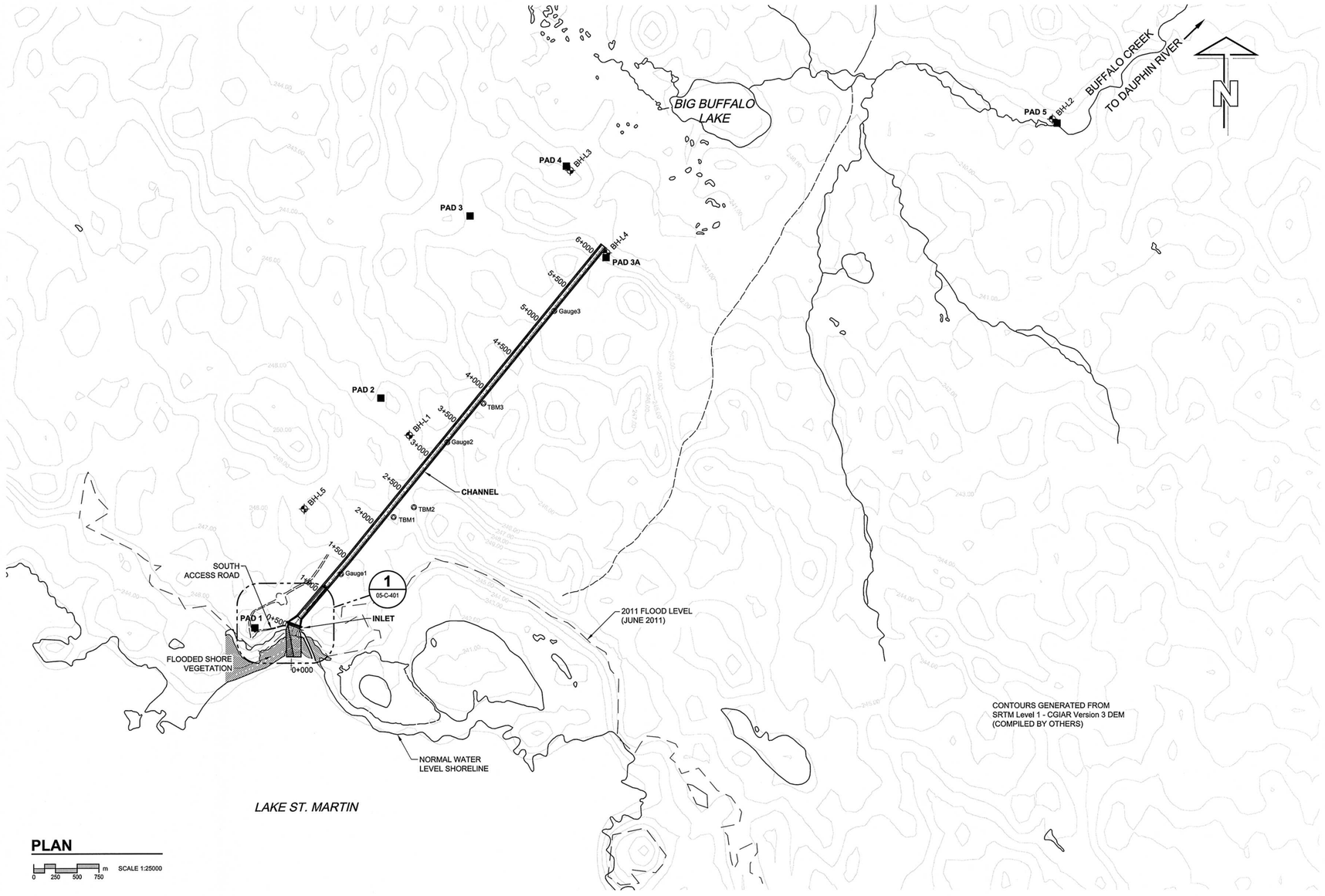
AECOM

Set No.: _____

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
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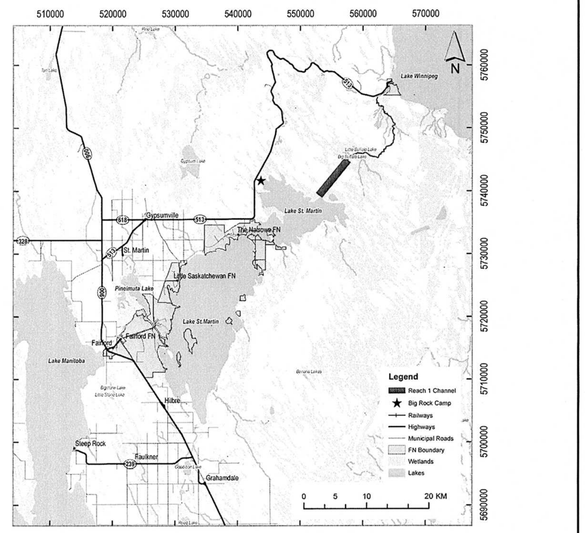
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AECOM FILE NAME: 60212781-05-G-000-R0X.DWG

SHEET SIZE 914.4x618 (36"x24.33")



PLAN

0 250 500 750 m SCALE 1:25000



LOCATION PLAN
SCALE: NTS

Gauges

Point	Chainage	Northing	Easting	Elevation	Quadrant	Sec	Twp	Rge	Meridian
Gauge 1	1+318	5740239.646	553879.845	243.515	NE	3	33	6	W1
Gauge 2	3+260	5741749.141	555100.960	240.292	SE	11	33	6	W1
Gauge 3	5+200	5743251.540	556329.327	242.802	NW	13	33	6	W1

Benchmarks

TBM 1	2+200	5740890.610	554485.255	248.701	SW	11	33	6	W1
TBM2 (Construction camp)	2+430	5741003.778	554718.650	245.656	SW	11	33	6	W1
TBM 3	3+860	5742193.802	555516.505	247.487	NW	12	33	6	W1

Chainage points

Point	Chainage	Northing	Easting	Quadrant	Sec	Twp	Rge	Meridian
	0+000	5739140.087	553309.061	SE	3	33	6	W1
	0+500	5739636.573	553336.372	SE	3	33	6	W1
5	0+520	5739654.634	553344.956	SE	3	33	6	W1
	0+550	5739680.577	553359.997	SE	3	33	6	W1
12	0+582	5739706.111	553378.457	SE	3	33	6	W1
	0+600	5739720.184	553390.432	SE	3	33	6	W1
	1+000	5740024.817	553649.659	NE	3	33	6	W1
	1+300	5740253.291	553844.079	NE	3	33	6	W1
	1+500	5740405.614	553973.686	NW	2	33	6	W1
	2+000	5740793.025	554289.775	SW	11	33	6	W1
	2+500	5741180.437	554605.864	SW	11	33	6	W1
	3+000	5741567.848	554921.953	NE	11	33	6	W1
	3+500	5741955.260	555238.042	NE	11	33	6	W1
	4+000	5742342.671	555554.132	SW	13	33	6	W1
	4+500	5742730.083	555870.221	SW	13	33	6	W1
	5+000	5743117.494	556186.310	NW	13	33	6	W1
	5+500	5743543.647	556534.008	NE	13	33	6	W1
	6+000	5743892.317	556818.488	SE	24	33	6	W1
	6+100	5743969.799	556881.706	SE	24	33	6	W1

Helipads

Location	Point ID SURVEY	Northing	Easting	Elevation	Quadrant	Sec	Twp	Rge	Meridian
PAD 1	Hpad 1S	5739534.702	552926.419	245.568	SW	3	33	6	W1
PAD 1	Hpad 1N	5739544.875	552928.946	245.618	SW	3	33	6	W1
PAD 3A	Hpad 3aSW	5743805.260	556901.380	241.961	NE	13	33	6	W1
PAD 3A	Hpad 3aNE	5743816.511	556908.042	241.940	NE	13	33	6	W1

RECORD DRAWING

LEGEND

- BENCHMARK
- BOREHOLE (JULY 2011)
- HELICOPTER LANDING PAD
- 2011 FLOOD LEVEL - JUNE 2011
- LAKE ST. MARTIN CHANNEL
- UNCLASSIFIED ROAD / OLD WINTER ROAD
- RIVER / STREAM
- LAKE

APEGM
Certificate of Authorization
AECOM Canada Ltd.
No. 4671 Date: May 8, 2012

REVISIONS		
2012/05/08	KLC	ISSUED FOR RECORD
DATE	BY	DESCRIPTION

Lake Manitoba and Lake St. Martin Emergency Outlet Channel - Lake St. Martin to Big Buffalo Lake

SITE PLAN

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A. J. FRIESEN
Member 21406
May 8, 2012
REGISTERED PROFESSIONAL ENGINEER

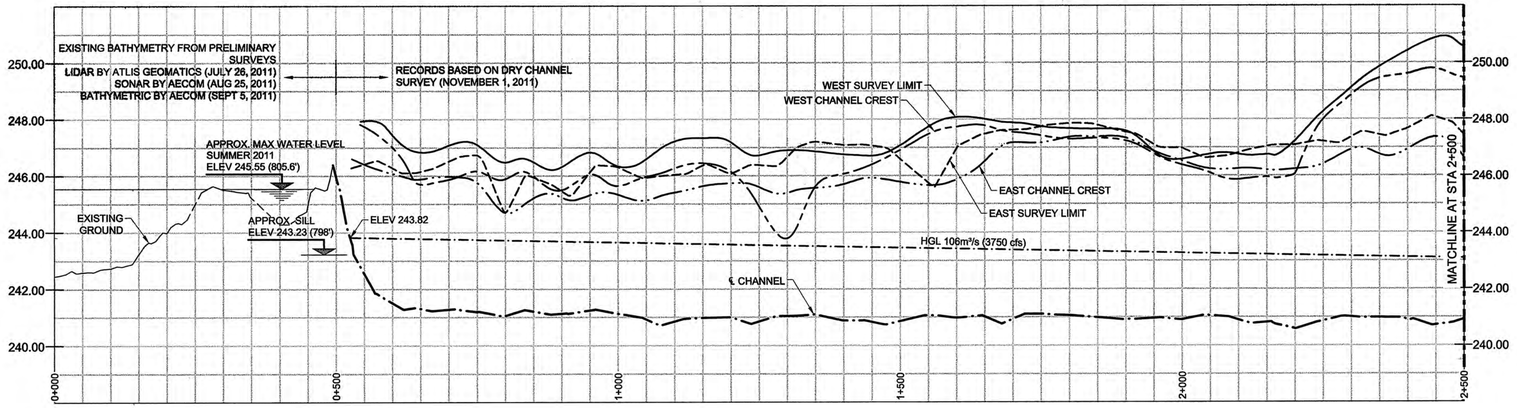
Manitoba
Infrastructure and Transportation
Water Control & Structures

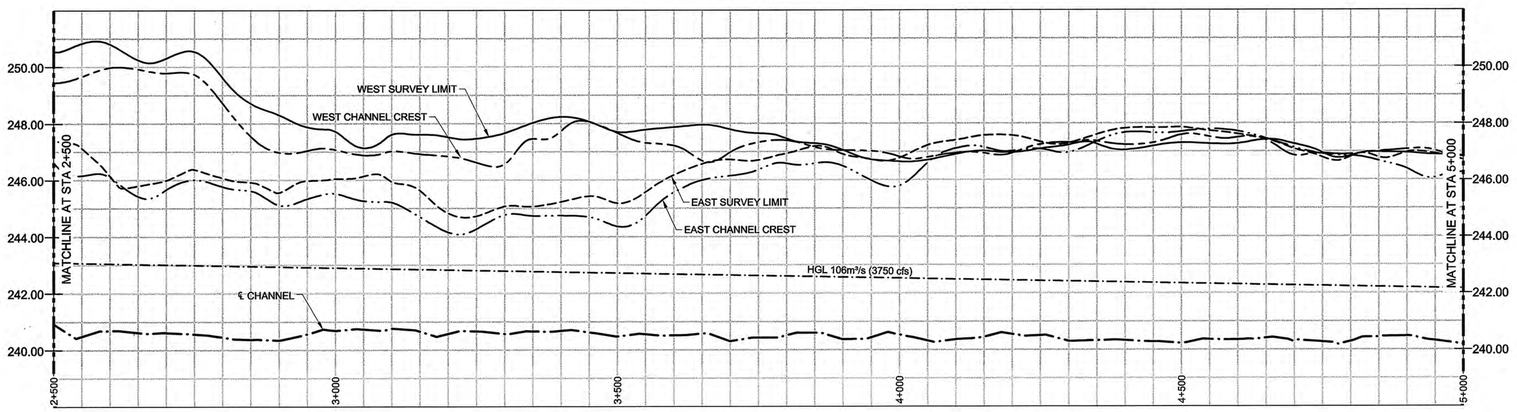
RELEASED FOR CONSTRUCTION
BY:
DIRECTOR
WATER CONTROL OPERATIONS BRANCH
DATE

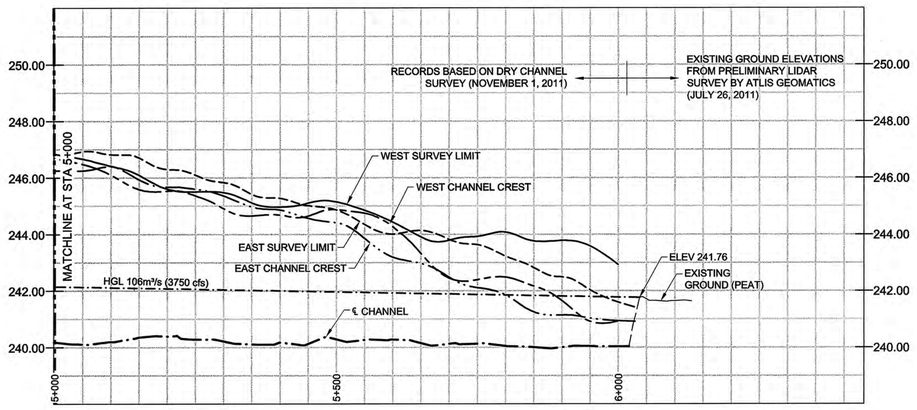
DESIGN BY: AJF
CHECKED: EB
DETAILS BY: DW
CHECKED:

SCALE: AS SHOWN
SHEET No. 05-G-001
SITE Nos.

SHEET SIZE 914.4x619 (36"x24.33")

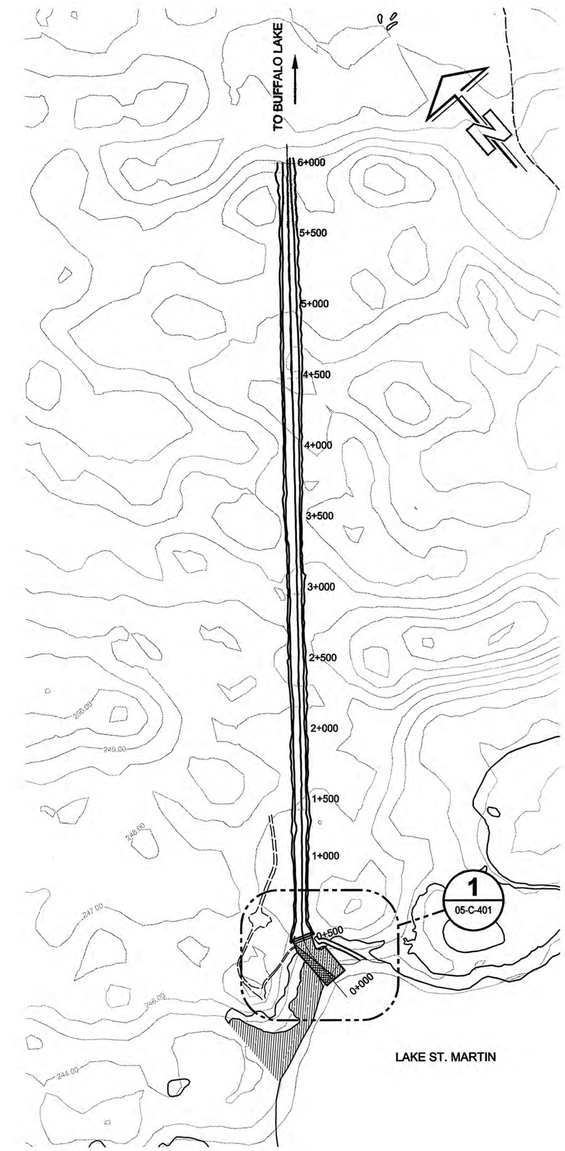






PROFILE

0 50 100 150 m H=1:5000
0 1 2 3 V=1:100



CHANNEL PLAN

0 200 400 600 m SCALE 1:20000

LEGEND
- WEST SURVEY LIMIT
- WEST CHANNEL CREST
- EAST SURVEY LIMIT
- EAST CHANNEL CREST
- CHANNEL BOTTOM
- HYDRAULIC GRADE LINE (HGL)

NOTE:
'WEST AND EAST CHANNEL CREST' IS THE TOP OF CHANNEL SLOPE WITH ROUGHLY 3:1 (H:V) OR FLATTER SLOPES BELOW. 'WEST AND EAST SURVEY LIMITS' IS THE OUTERMOST POINT COLLECTED BY AECOM SURVEYORS. SPOIL PILES EXTEND OUTWARD FOR AN UNDEFINED DISTANCE FROM THIS POINT ON ROUGH IRREGULAR TILL/PEAT SPOIL MATERIAL. OUTER SPOIL PILE SLOPE IS UNFINISHED, AT ANGLE OF REPOSE FOR THE MIXED WET TILL/PEAT MATERIAL, WITH OUTER SPOIL PILE TOE NOT MEASURED DUE TO ROUGH UNCONSOLIDATED CONDITIONS. OUTER DRAINS CONSTRUCTED FOR EARLY PHASE DEWATERING WERE OBLITERATED BY SPOIL PILE PLACEMENT.

RECORD DRAWING

APEGM
Certificate of Authorization
AECOM Canada Ltd.
No. 4671 Date: May 30, 2012

REVISIONS		
2012/05/25	KLC	ISSUED FOR RECORD.Rev 2
2012/05/08	KLC	ISSUED FOR RECORD
DATE	BY	DESCRIPTION

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PROVINCE OF MANITOBA
A. J. FRIESEN
Member 21406
May 30, 2012
REGISTERED PROFESSIONAL ENGINEER

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Lake Manitoba and Lake St. Martin Emergency Outlet Channel - Lake St. Martin to Big Buffalo Lake

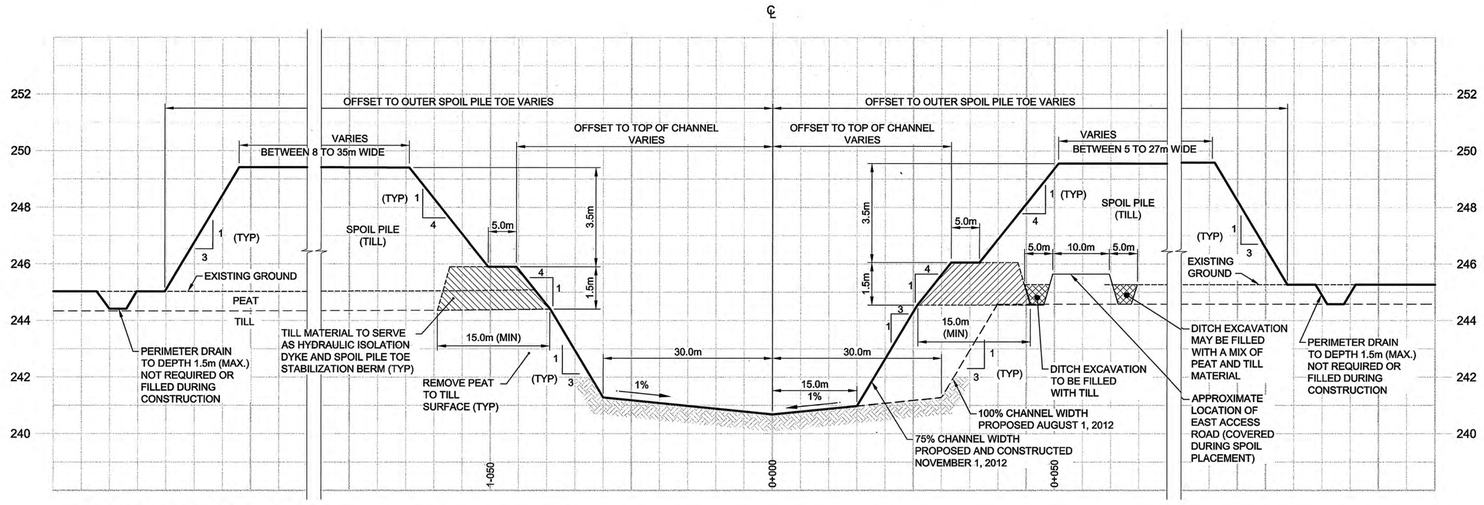
CHANNEL AND ASSOCIATED WORKS PROFILE STA 0+000 TO STA 6+150

Manitoba Infrastructure and Transportation
Water Control & Structures

RELEASED FOR CONSTRUCTION
BY: _____ DATE
DIRECTOR
WATER CONTROL OPERATIONS BRANCH

DESIGN	BY:	SCALE: AS SHOWN	SHEET No. 05-C-107
	CHECKED:		
DETAILS	BY:		SITE Nos.
	CHECKED:		

SHEET SIZE 914.4x618 (36"x24.33")



TYPICAL CROSS SECTION

0 5 10 15 m H=1:500
0 1 2 3 V=1:100

NOTE: THE FULL CHANNEL SECTION IS SYMETRIC ABOUT THE CENTER LINE. THE ¾ CHANNEL SECTION SHIFTS ALL EAST LINE ELEMENTS 15m WEST TOWARDS THE CENTER LINE.

NOTE:
OUTER LIMITS OF SPOIL PILE TOP AND TOE WERE NOT SURVEYED DUE TO ROUGH UNFINISHED CONDITIONS. TOTAL WIDTH CHANNEL AND SPOIL PILE FIT INSIDE 300m WIDE FOOTPRINT.
SPOIL PILE TOP WIDTH ESTIMATED FROM SURVEYED CROSS-SECTIONS.

ISSUED FOR INFORMATION ONLY.
FINAL CONSTRUCTION SHOWN ON PLAN, PROFILE AND SECTIONS.

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APEGM
Certificate of Authorization
AECOM Canada Ltd.
No. 4671 Date: May 30, 2012

REVISIONS		
2012/05/25	klc	REVISED DIMENSIONS
2012/05/08	KLC	ISSUED FOR INFORMATION
DATE	BY	DESCRIPTION

Lake Manitoba and Lake St. Martin
Emergency Outlet Channel -
Lake St. Martin to Big Buffalo Lake

TYPICAL DESIGN SPOIL PILE SECTION

Manitoba
Infrastructure and Transportation
Water Control & Structures

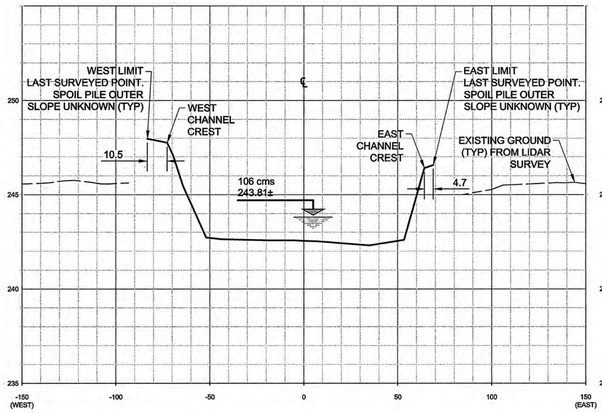
RELEASED FOR CONSTRUCTION
BY:
DIRECTOR DATE
WATER CONTROL OPERATIONS BRANCH

DESIGN BY: KT
CHECKED: FK
DETAILS BY:
CHECKED:

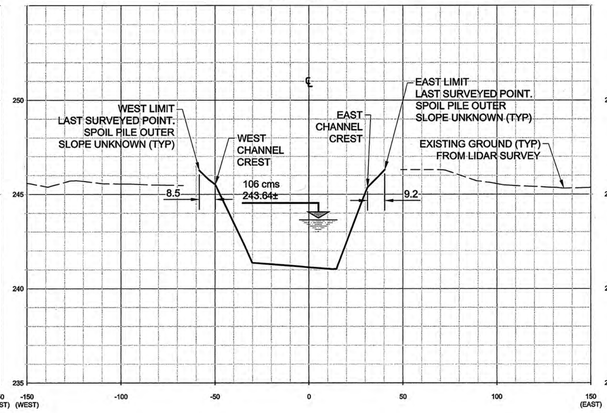
SCALE: AS SHOWN
SHEET No. 05-C-109
SITE Nos.

SHEET SIZE 914.4x618 (36"x24.33")

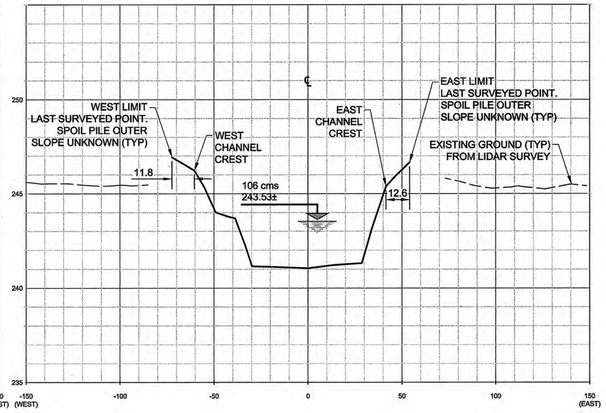
STA 0+550.00



STA 1+000.00

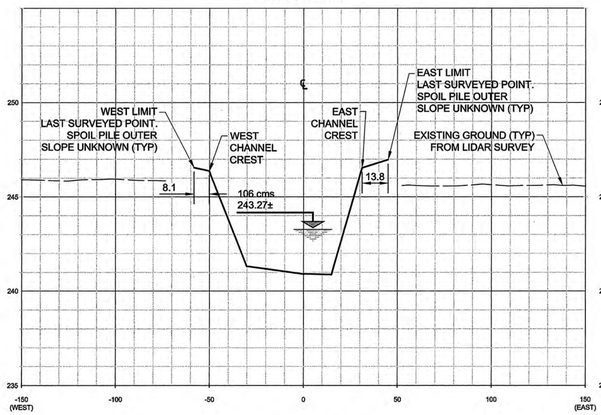


STA 1+300.00

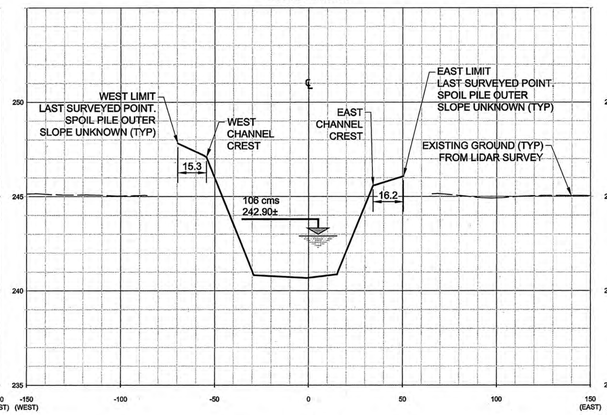


NOTE:
SURVEY WAS NOT COLLECTED ON OUTER SPOIL PILE SLOPE AND TOE DUE TO UNSAFE ACCESS CONDITIONS ON ROUGH UNCONSOLIDATED UNDRAINED PEAT AND TILL SPOIL DURING THE CONSTRUCTION PERIOD

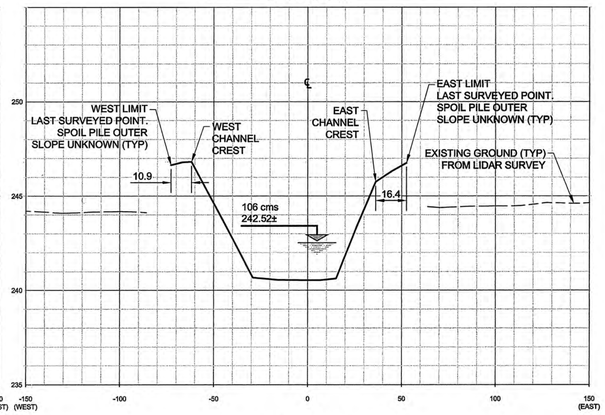
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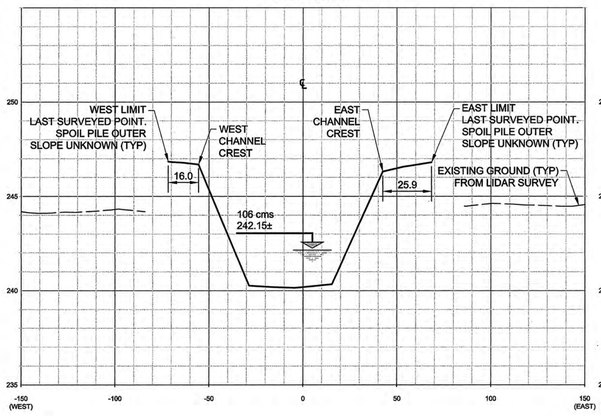
STA 3+000.00



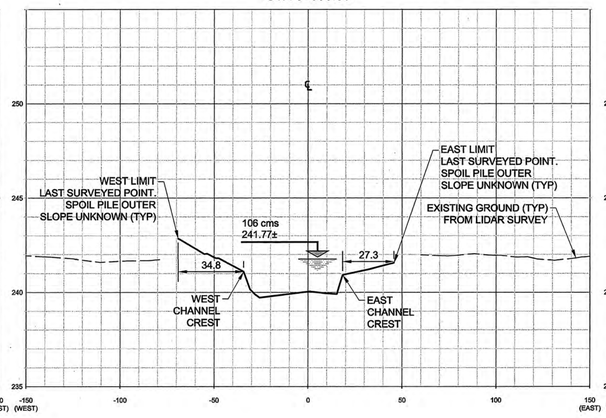
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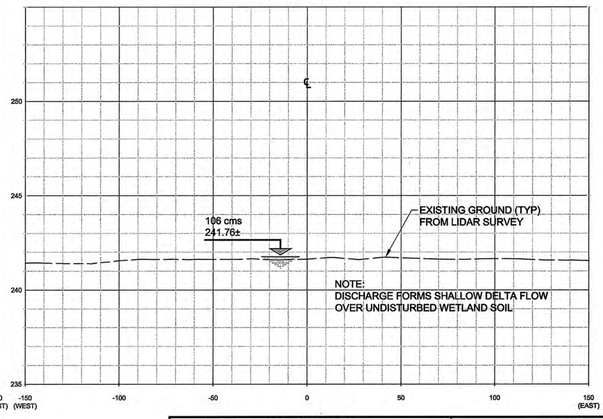
STA 5+000.00



STA 6+000.00



STA 6+100.00



RECORD DRAWING

SECTIONS

0 15 30 45 m H=1:1500
0 1.5 3 4.5 V=1:150

LEGEND
EXISTING GROUND
FINISHED GRADE

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AECOM Canada Ltd.
No. 4671 Date: May 30, 2012

REVISIONS		
2012/05/25	KLC	ISSUED FOR RECORD.Rev 2
2012/05/08	KLC	ISSUED FOR RECORD
DATE	BY	DESCRIPTION

Lake Manitoba and Lake St. Martin Emergency Outlet Channel - Lake St. Martin to Big Buffalo Lake

CHANNEL AND SPOIL PILE SECTIONS

Manitoba Infrastructure and Transportation
Water Control & Structures

RELEASED FOR CONSTRUCTION
BY:
DIRECTOR DATE
WATER CONTROL OPERATIONS BRANCH

DESIGN BY:
CHECKED: K-LD
DETAILS BY:
CHECKED:

SCALE: AS SHOWN
SHEET No. 05-C-110
SITE Nos.

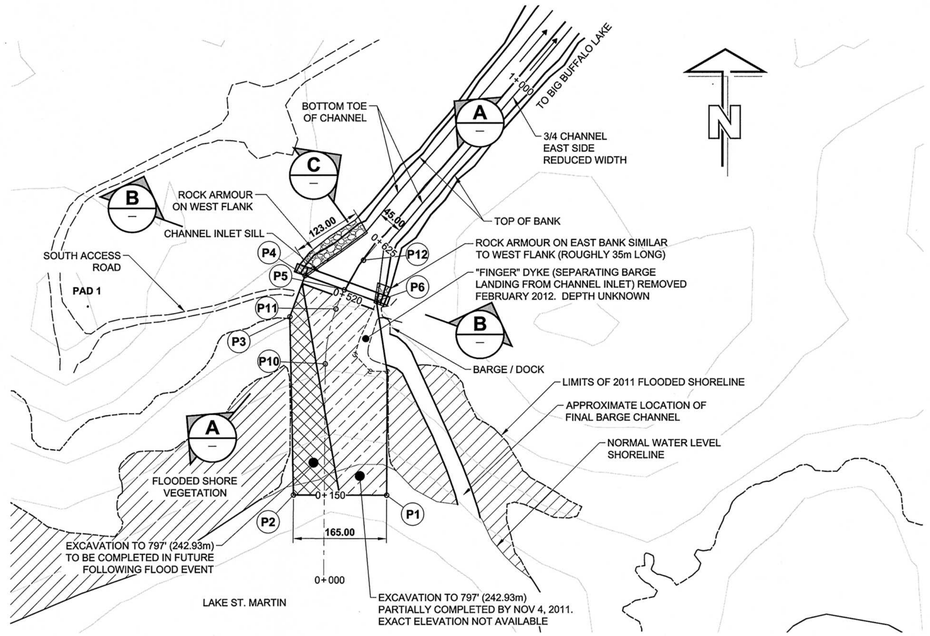
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PROVINCE OF MANITOBA
A. J. FRIESEN
Member 21408
May 30, 2012
REGISTERED PROFESSIONAL ENGINEER

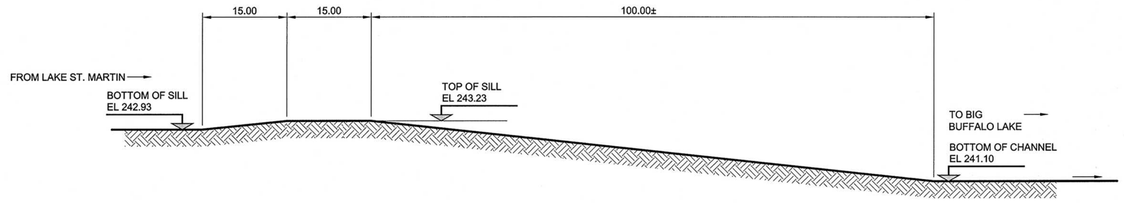
SHEET SIZE 914.4x618 (36"x24.33")



DETAIL 1 (05-G-001)

0 50 100 150 m SCALE 1:5000

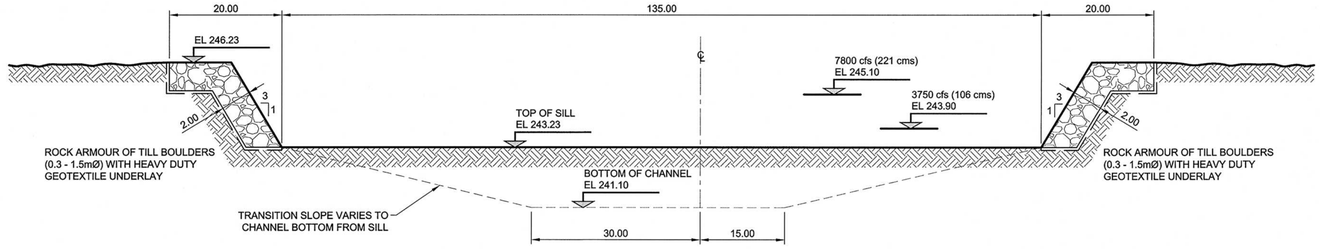
INLET AT LAKE ST. MARTIN



PROFILE A

0 5 10 15 m H=1:500
0 1 2 3 V=1:100

CHANNEL INLET SILL



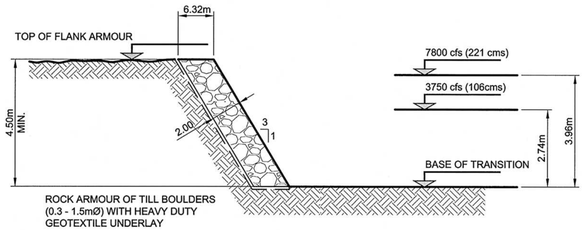
SECTION B

0 5 10 15 m H=1:500
0 1 2 3 V=1:100

CHANNEL INLET SILL

COORDINATE LAYOUT TABLE (UTM 14) as of Sept.29, 2011			
POINT	NORTHING	EASTING	CHAINAGE
1	5739289.605	553420.767	
2	5739290.322	553255.024	
3	5739606.163	553247.800	
4	5739679.180	553274.618	
5	5739653.880	553344.569	0 + 520
6	5739633.271	553401.572	
~~7~~	~~5739539.122~~	~~553363.554~~	
~~8~~	~~5739509.338~~	~~553390.904~~	
~~9~~	~~5739509.338~~	~~553420.904~~	
10	5739522.698	553311.011	0 + 383
11	5739619.935	553329.694	0 + 482
12	5739706.111	553378.457	0 + 582

BENCHMARK TABLE SHOWN ON SHEET 05-G-001



SECTION C

0 5 10 15 m H=1:500
0 1 2 3 V=1:100

CHANNEL INLET SILL WEST FLANK ARMOUR

NOTE:
DRAWINGS BASED ON DESIGN. RECORD DETAILS NOT AVAILABLE AT INLET SECTION DUE TO HIGH FLOWS.

RECORD DRAWING

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AECOM Canada Ltd.
No. 4671 Date: May 8, 2012

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REVISIONS		
2012/05/08	KLC	ISSUED FOR RECORD
DATE	BY	DESCRIPTION

PROVINCE OF MANITOBA — A. J. FRIESEN — Member 21406 — REGISTERED PROFESSIONAL ENGINEER — May 8, 2012

Lake Manitoba and Lake St. Martin Emergency Outlet Channel - Lake St. Martin to Big Buffalo Lake

INLET CONTROL SECTIONS AND DETAILS (3/4 CHANNEL)

Manitoba Infrastructure and Transportation
Water Control & Structures

RELEASED FOR CONSTRUCTION
BY:
DIRECTOR, WATER CONTROL OPERATIONS BRANCH — DATE

DESIGN	BY: AJF	SCALE: AS SHOWN
	CHECKED: EB	SHEET No. 05-C-401
DETAILS	BY:	SITE Nos.
	CHECKED:	

APPENDIX B

TENDER DRAWINGS OF THE LAKE ST. MARTIN

REACH 3 EMERGENCY CHANNEL

DRAFT

EMERGENCY CHANNEL REACH 3

TENDER CONTRACT No 6178

LIST OF DRAWINGS:

DRAWING NO.	DRAWING TITLE
11-0300-18-CSrev3.DWG	COVER SHEET AND LIST OF DRAWINGS
11-0300-18-G01rev2.DWG	SITE PLAN WITH PROPOSED CONSTRUCTION ACCESS ROUTE
11-0300-18-G02rev3.DWG	GENERAL ARRANGEMENT OF STRUCTURES
11-0300-18-G03rev3.DWG	CHANNEL AND DIKE PROFILES
11-0300-18-G04rev3.DWG	DETAILED PLANS AND SECTIONS
11-0300-18-G05rev3.DWG	TYPICAL CHANNEL AND DIKE SECTIONS
11-0300-18-G06rev1.DWG	DROP AND WEIR STRUCTURES, PLAN, PROFILE AND SECTIONS

DRAWINGS IN THIS CONTRACT SHALL BE READ IN CONJUNCTION WITH THE SPECIFICATIONS IN THE TENDER WHICH PROVIDES TECHNICAL SPECIFICATIONS FOR MATERIALS AND PROCEDURES SHOWN ON THE DRAWINGS. CLARIFICATION SHALL BE PROVIDED BY THE CONTRACT ADMINISTRATOR AS REQUIRED.

MANITOBA INFRASTRUCTURE AND TRANSPORTATION

COVER SHEET AND LIST OF DRAWINGS

MARCH 1, 2012

Manitoba INFRASTRUCTURE AND TRANSPORTATION

KGS GROUP | CONSULTING ENGINEERS

FileName: P:\Projects\2011\11-0300-18\Doc.Control\ToBeIssued\DWG\11-0300-18_CS-Rev 3.dwg -- Tab: FIG 01 Plotted By: DDaroche 03/01/2012 [Thu 2:10pm]

DAUPHIN RIVER FLOW

N

LAKE WINNIPEG

CHANNEL CENTRELINE LAYOUT TABLE			
CP	STATION	EASTING	NORTHING
CP-1		NA	NA
CP-2	16+585.38	564583.162	5747452.429
CP-3		566146.849	5747452.429
CP-4		566387.283	5749200.822
CP-5		566096.674	5749900.713
CP-6	22+611	567968.417	5751211.287
DEFLECTOR DIKE LAYOUT TABLE			
CP	STATION	EASTING	NORTHING
CP-7	22+611	567948.301	5751239.933
CP-8	22+858	568199.089	5751314.048

HOLD

PROPOSED DEFLECTOR DIKE EXTENSION (SEE NOTE 6)

PROTECT POTENTIAL PIPING PLOVER HABITAT

200m SHORELINE BREACH (SEE NOTE 4)

DETAIL 4 (SEE DWG G04)

HOLD

EXISTING PILOT DITCH

DEFLECTOR DIKE (SEE NOTE 5)

LIMITS OF RIPRAP

CHANNEL BASE WIDTH 28m

DETAIL 3 (SEE DWG G04)

BUFFALO CREEK FLOW

WEST CHANNEL DIKE

REACH 3 CHANNEL

EAST CHANNEL DIKE

WEIR STRUCTURE 1 STA. 20+946 (SEE DWG. G06)

HC-3 L=676.587 R=500.000 Δ= 77.531°

HC-2 L=265.109 R=500.000 Δ=30.379°

CREEK 2

DETAIL 2 (SEE DWG G04)

CREEK 1

CHANNEL BASE WIDTH 21m

DROP STRUCTURE 2 STA. 19+400 (SEE DWG. G06)

CREEK 3

DROP STRUCTURE 1 STA. 18+800 (SEE DWG. G06)

EAST CHANNEL DIKE

HC-1 L=717.930 R=500.000 Δ=82.269°

DETAIL 1 (SEE DWG G04)

PLAN
SCALE: 1:15000 24x36
SCALE: 1:30000 11x17

NOTES:

1. FOR PROFILES SEE DWG 11-0300-18-G03
2. FOR DETAIL PLANS SEE DWG 11-0300-18-G04
3. WATER LEVEL WAS APPROXIMATELY AT 150mm BELOW GROUND SURFACE DURING INVESTIGATION (NOVEMBER 2011).
4. BEACH HEAD SHALL BE EXCAVATED FOR 200 METRES ALONG SHORELINE, AS DIRECTED BY THE ENGINEER.
5. DEFLECTOR DIKE ALIGNMENT SHALL BE CENTRED OVER THE PILOT DITCH (CONSTRUCTED DECEMBER 2011) AS DIRECTED BY THE ENGINEER.
6. DEFLECTOR DIKE EXTENSION TO BEACH HEAD AS DIRECTED BY THE ENGINEER WITH 30m BUFFER TO POTENTIAL PIPING PLOVER HABITAT.

500 0 500 1000m

SCALE: 1:15000 METRIC 24"x36"
1:30000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
3	12/03/01	RE-ISSUED FOR CONSTRUCTION	
2	12/02/03	ISSUED FOR CONSTRUCTION	TNN
1	11/11/25	ISSUED WITH AMENDMENT No. 1	TNN
0	11/11/17	ISSUED FOR TENDER	TNN

REVISIONS / ISSUE

CLIENT: Manitoba INFRASTRUCTURE AND TRANSPORTATION

PROJECT: LAKE MANITOBA AND LAKE ST. MARTIN EMERGENCY CHANNELS REACH 3

DWG. DESCRIPTION: GENERAL ARRANGEMENT OF STRUCTURES

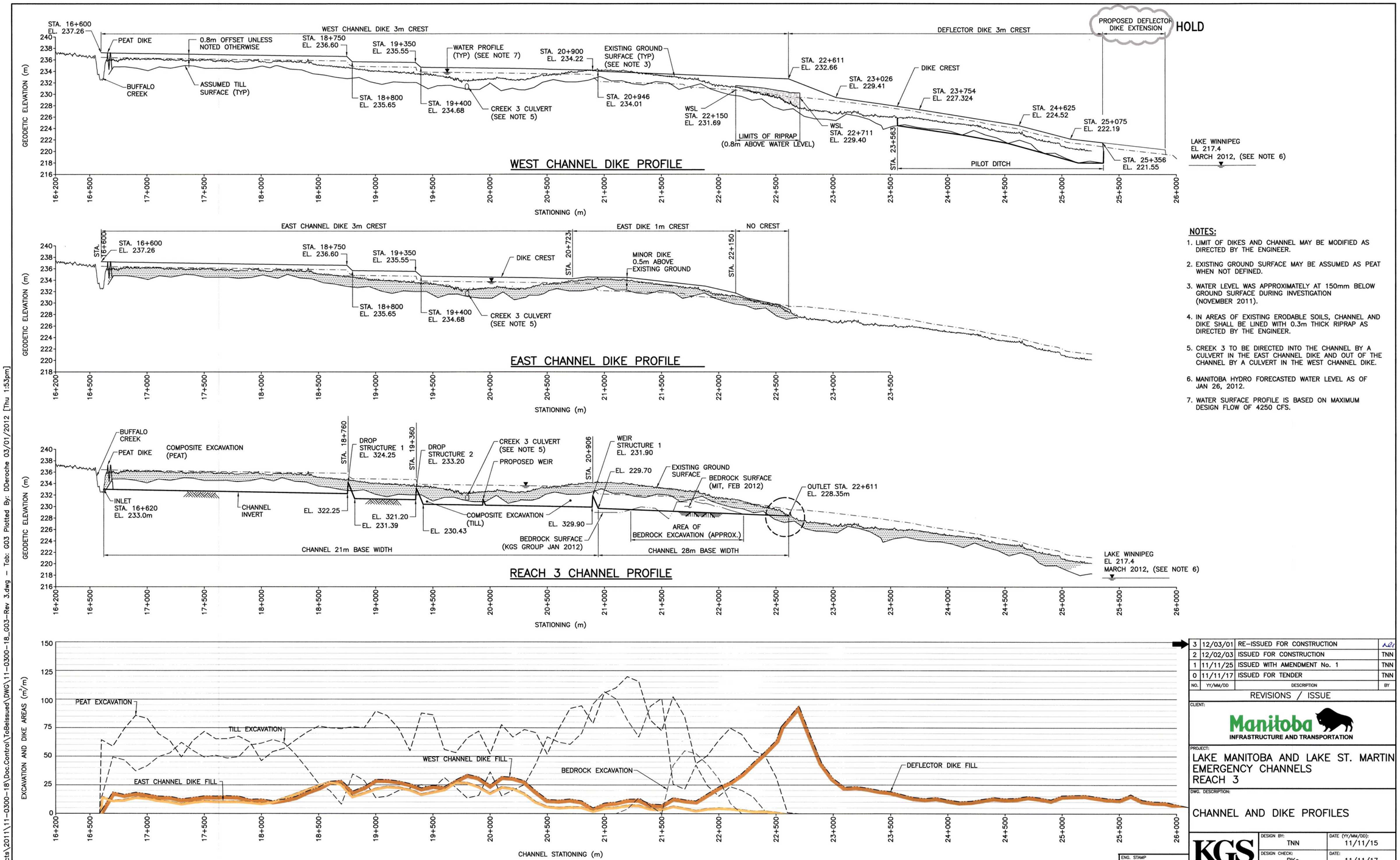
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ENG. STAMP
THE ORIGINAL ISSUE REV. 0 WAS STAMPED, DATED AND SIGNED
BY T.N. NG
ON 17 NOV 2011 D/M/Y

KGS GROUP CONSULTING ENGINEERS

DESIGN BY: TNN	DATE (YY/MM/DD): 11/11/15		
DESIGN CHECK: RKe	DATE: 11/11/17		
DRAWN BY: PwD	DATE: 11/11/15		
DWG CHECK: jS	DATE: 11/11/17		
DWG. NO. 11-0300-18	G02	REV: 3	

FileName: P:\Projects\2011\11-0300-18\Doc.Control\ToBeIssued\DWG\11-0300-18_G02-Rev 3.dwg -- Tab: G02 Plotted By: DDeroche 03/01/2012 [Thu 1:53pm]



NOTES:

1. LIMIT OF DIKES AND CHANNEL MAY BE MODIFIED AS DIRECTED BY THE ENGINEER.
2. EXISTING GROUND SURFACE MAY BE ASSUMED AS PEAT WHEN NOT DEFINED.
3. WATER LEVEL WAS APPROXIMATELY AT 150mm BELOW GROUND SURFACE DURING INVESTIGATION (NOVEMBER 2011).
4. IN AREAS OF EXISTING ERODABLE SOILS, CHANNEL AND DIKE SHALL BE LINED WITH 0.3m THICK RIPRAP AS DIRECTED BY THE ENGINEER.
5. CREEK 3 TO BE DIRECTED INTO THE CHANNEL BY A CULVERT IN THE EAST CHANNEL DIKE AND OUT OF THE CHANNEL BY A CULVERT IN THE WEST CHANNEL DIKE.
6. MANITOBA HYDRO FORECASTED WATER LEVEL AS OF JAN 26, 2012.
7. WATER SURFACE PROFILE IS BASED ON MAXIMUM DESIGN FLOW OF 4250 CFS.

NO.	YY/MM/DD	DESCRIPTION	BY
3	12/03/01	RE-ISSUED FOR CONSTRUCTION	[illegible]
2	12/02/03	ISSUED FOR CONSTRUCTION	TNN
1	11/11/25	ISSUED WITH AMENDMENT No. 1	TNN
0	11/11/17	ISSUED FOR TENDER	TNN

REVISIONS / ISSUE

CLIENT: Manitoba INFRASTRUCTURE AND TRANSPORTATION

PROJECT: LAKE MANITOBA AND LAKE ST. MARTIN EMERGENCY CHANNELS REACH 3

DWG. DESCRIPTION: CHANNEL AND DIKE PROFILES

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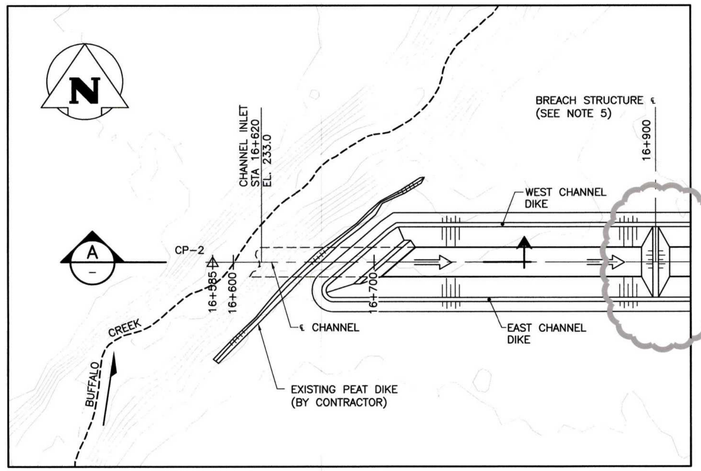
ENG. STAMP: THE ORIGINAL ISSUE REV. 0 WAS STAMPED, DATED AND SIGNED BY T.N. NG ON 17 NOV 2011 D/M/Y

KGS GROUP CONSULTING ENGINEERS

		DATE (YY/MM/DD):
DESIGN BY:	TNN	11/11/15
DESIGN CHECK:	RKe	11/11/17
DRAWN BY:	PEC	11/11/15
DWG CHECK:	JS	11/11/17

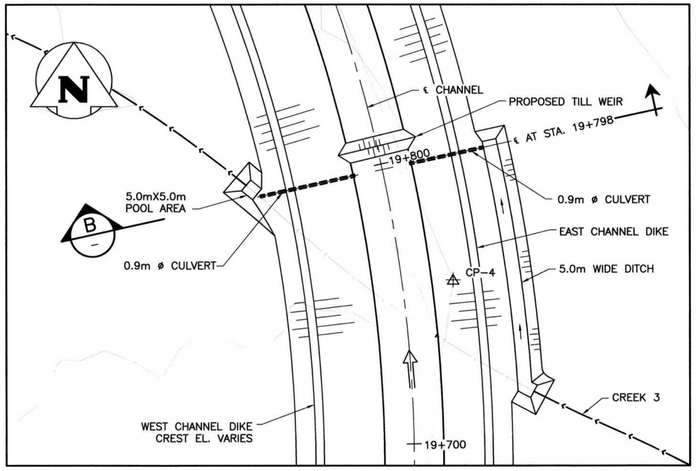
DWG. NO. 11-0300-18 G03 REV: 3

FileName: P:\Projects\2011\11-0300-18\Doc.Control\ToBeIssued\DWG\11-0300-18_G03-Rev 3.dwg - Tab: G03 Plotted By: DDeroche 03/01/2012 [Thu 1:53pm]

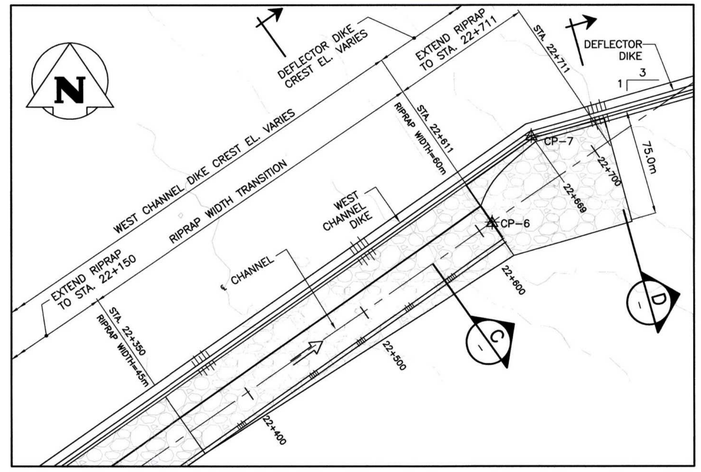


HOLD

PLAN DETAIL 1 – INLET
SCALE: 1:2000



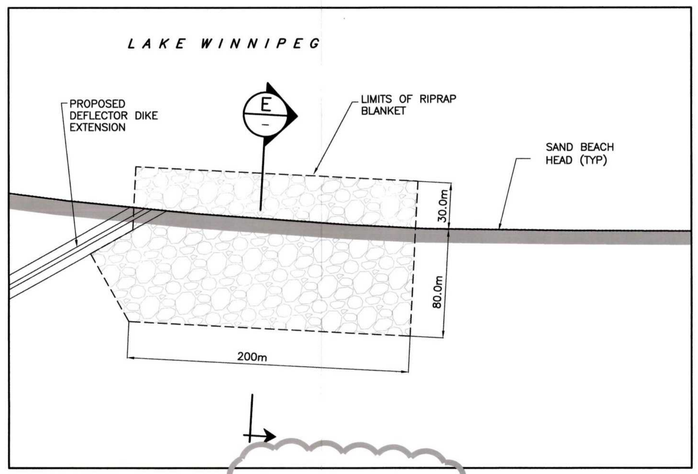
PLAN DETAIL 2
SCALE: 1:1000



PLAN DETAIL 3 – OUTLET
SCALE: 1:2000

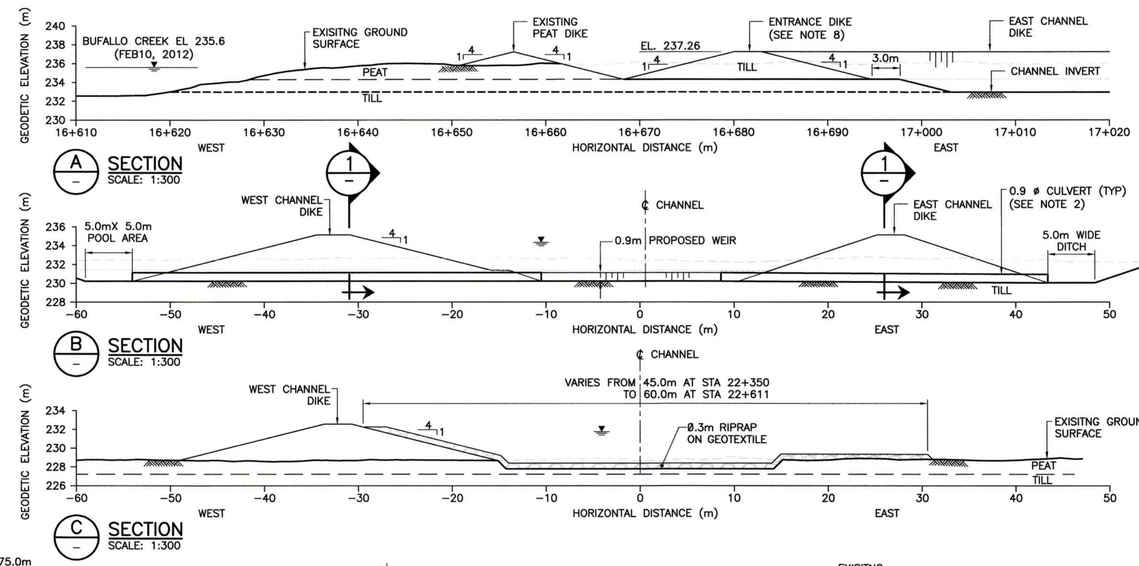
NOTES:

1. ALL PEAT SHALL BE REMOVED IN AREA OF CHANNEL ENTRANCE AND BUFFALO CREEK FOUNDATION AND LINED WITH RIPRAP AS DIRECTED BY THE ENGINEER.
2. CREEK No. 3 SHALL BE ALLOWED TO CROSS CHANNEL BY USING 0.9m ø CULVERTS THROUGH WEST AND EAST CHANNEL DIKES SET AT CHANNEL INVERT WITH 5X5m POOL AREAS AT EITHER SIDE AS DIRECTED BY THE ENGINEER.
3. RIPRAP SHALL BE PLACED ON THE EAST SIDE OF THE DEFLECTOR DIKE IMMEDIATELY DOWNSTREAM OF CHANNEL, AS DIRECTED BY THE ENGINEER.
4. WATER LEVEL WAS APPROXIMATELY AT 150mm BELOW GROUND SURFACE DURING INVESTIGATION (NOVEMBER 2011).
5. CONTRACTOR SHALL SUBMIT FINAL DESIGN OF BREACH STRUCTURE FOR REVIEW AND APPROVAL BY THE ENGINEER.
6. CHANNEL OUTLET AREA SHALL BE TREATED WITH 0.3m THICK RIPRAP ON GEOTEXTILE TO GEOMETRY SHOWN AND AS DIRECTED BY THE ENGINEER.
7. IN AREAS OF EXISTING ERODABLE SOILS, CHANNEL AND DIKE SHALL BE LINED WITH 0.3m THICK RIPRAP AS DIRECTED BY THE ENGINEER.
8. ENTRANCE DIKE ALIGNMENT SHALL BE SITE DETERMINED BY THE ENGINEER.



HOLD

PLAN DETAIL 4
SCALE: 1:2000



50 0 50 100 150m
SCALE: (PLAN DETAILS) 1:2000 METRIC 24"x36"
1:4000 METRIC 11"x17"

10 0 10 20m
SCALE: (SECTIONS) 1:300 METRIC 24"x36"
1:600 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
3	12/03/01	RE-ISSUED FOR CONSTRUCTION	
2	12/02/03	ISSUED FOR CONSTRUCTION	TNN
1	11/11/25	ISSUED WITH AMENDMENT No. 1	TNN
0	11/11/17	ISSUED FOR TENDER	TNN

REVISIONS / ISSUE

CLIENT: Manitoba INFRASTRUCTURE AND TRANSPORTATION

PROJECT: LAKE MANITOBA AND LAKE ST. MARTIN EMERGENCY CHANNELS
REACH 3

DWG. DESCRIPTION: DETAILED PLANS AND SECTIONS

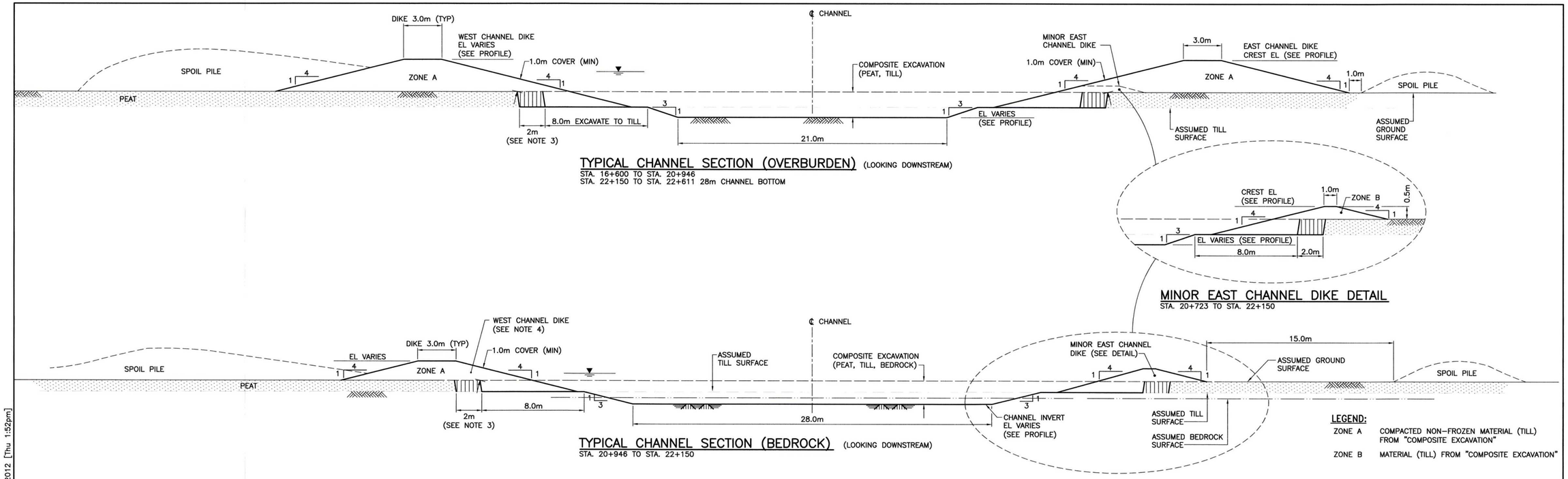
APEGM Certificate of Authorization KGS Group No. 245

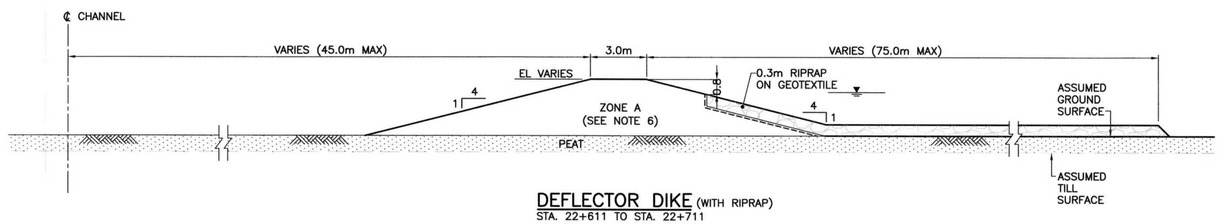
ENG. STAMP
THE ORIGINAL ISSUE REV. 0 WAS STAMPED, DATED AND SIGNED
BY T.N. NG
ON 17 NOV 2011 D/M/Y

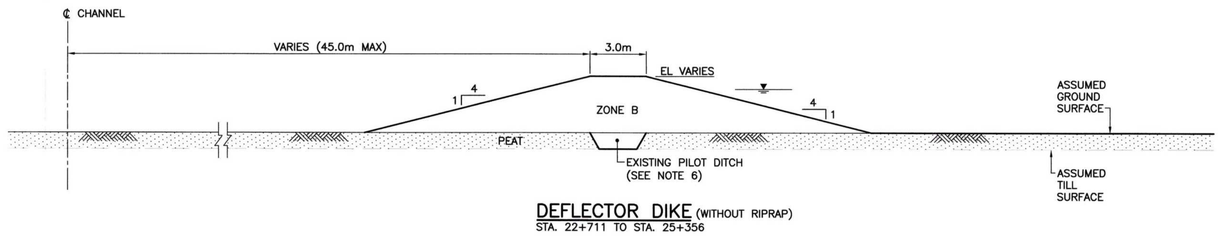
KGS GROUP CONSULTING ENGINEERS

DESIGN BY: TNN	DATE (YY/MM/DD): 11/11/15		
DESIGN CHECK: RKe	DATE: 11/11/17		
DRAWN BY: PwD	DATE: 11/11/15		
DWG CHECK: jS	DATE: 11/11/17		
DWG. NO. 11-0300-18	G04	REV: 3	

FileName: P:\Projects\2011\11-0300-18\Doc.Control\ToBeIssued\DWG\11-0300-18_G04-Rev 3.dwg – Tab: G04 Plotted By: DDeroche 03/01/2012 [Thu 1:52pm]







LEGEND:

ZONE A	COMPACTED NON-FROZEN MATERIAL (TILL) FROM "COMPOSITE EXCAVATION"
ZONE B	MATERIAL (TILL) FROM "COMPOSITE EXCAVATION"

NOTES:

1. WATER LEVEL WAS APPROXIMATELY AT 150mm BELOW GROUND SURFACE DURING INVESTIGATION (NOVEMBER 2011).
2. SPOIL MAY CONSIST OF UNDESIRABLE OR UNUSED MATERIAL AND DISPOSED OF AS SHOWN AND DIRECTED BY THE ENGINEER.
3. ADDITIONAL 2m PEAT EXCAVATION MAY BE REQUIRED DEPENDING ON FIELD CONDITIONS AND AS DIRECTED BY THE ENGINEER.
4. DEFLECTOR DIKE MATERIAL (TILL) SHALL BE SELECTED FROM THE MAIN CHANNEL "COMPOSITE EXCAVATION".
5. IN AREAS OF EXITING ERODABLE SOILS, CHANNEL AND DIKE SHALL BE LINED WITH 0.3m THICK RIPRAP AS DIRECTED BY THE ENGINEER.
6. ALIGNMENT OF DEFLECTOR DIKE SHALL BE GOVERNED FOR THE LENGTH OF THE PILOT DITCH BY CENTERING DIKE DIRECTLY OVER THE DITCH OR AS DIRECTED BY THE ENGINEER.

5 0 5 10m

SCALE: 1:150 METRIC 24"x36"
1:300 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
3	12/03/01	RE-ISSUED FOR CONSTRUCTION	
2	12/02/03	ISSUED FOR CONSTRUCTION	TNN
1	11/11/25	ISSUED WITH AMENDMENT No. 1	TNN
0	11/11/17	ISSUED FOR TENDER	TNN

REVISIONS / ISSUE

CLIENT: Manitoba INFRASTRUCTURE AND TRANSPORTATION

PROJECT: LAKE MANITOBA AND LAKE ST. MARTIN EMERGENCY CHANNELS REACH 3

DWG. DESCRIPTION: TYPICAL CHANNEL AND DIKE SECTIONS

APEGM Certificate of Authorization KGS Group No. 245

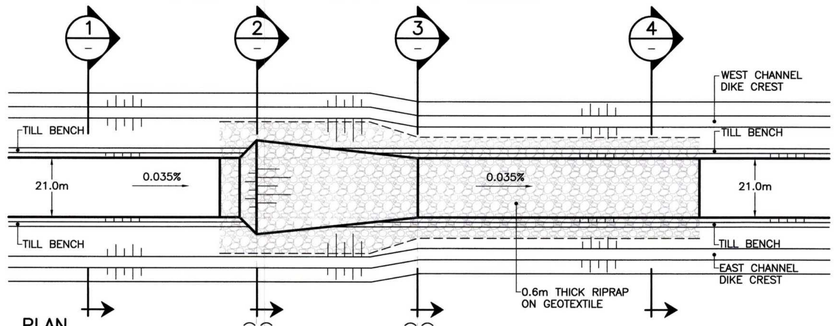
ENG. STAMP: THE ORIGINAL ISSUE REV. 0 WAS STAMPED, DATED AND SIGNED BY T.N. NG ON 17 NOV 2011 D/M/Y

KGS GROUP CONSULTING ENGINEERS

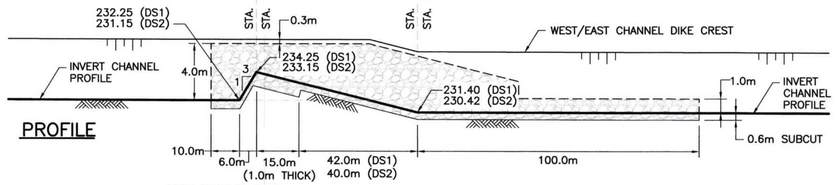
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DESIGN CHECK: RKe	DATE: 12/01/31		
DRAWN BY: PEC	DATE: 11/11/15		
DWG CHECK: jS	DATE: 12/01/31		
DWG. NO. 11-0300-18	G05	REV: 3	

FileName: P:\Projects\2011\11-0300-18\Doc.Control\ToBeIssued\DWG\11-0300-18_G05-Rev 3.dwg - Tab: G05 Plotted By: DDeroche 03/01/2012 [Thu 1:52pm]

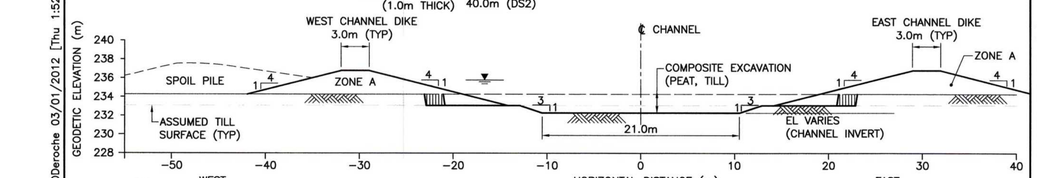
DROP STRUCTURES 1 AND 2 (DS1 AND DS2)



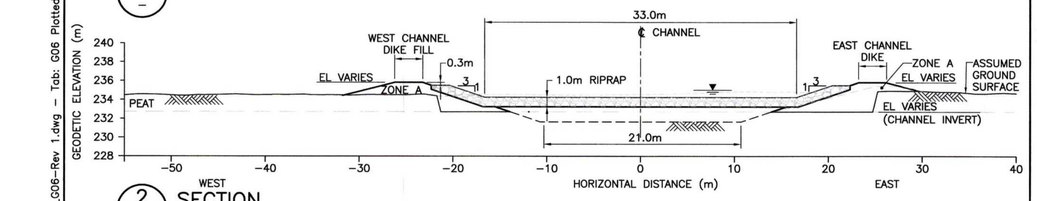
PLAN



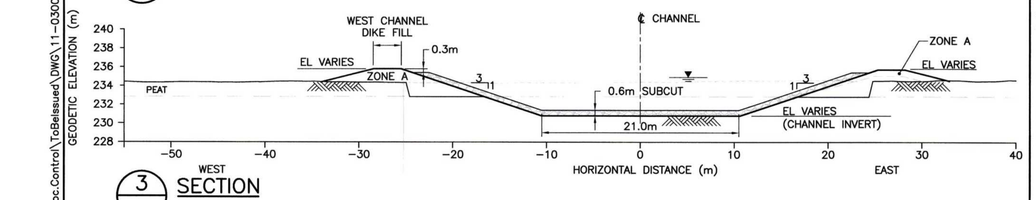
PROFILE



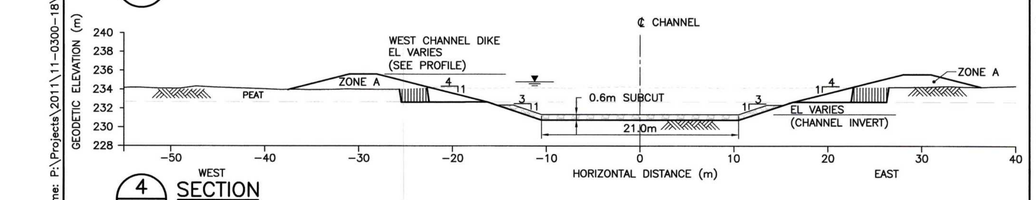
1 SECTION



2 SECTION

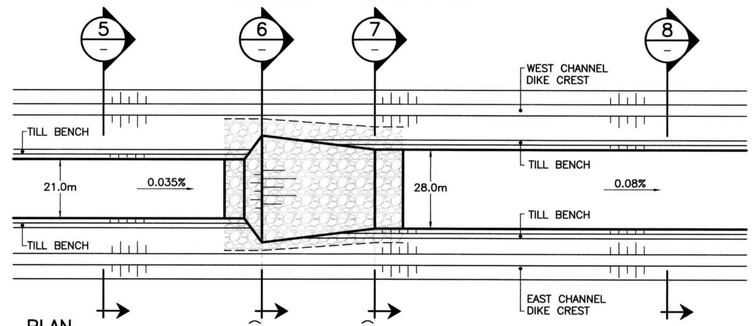


3 SECTION

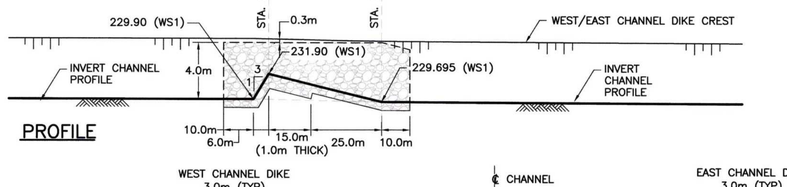


4 SECTION

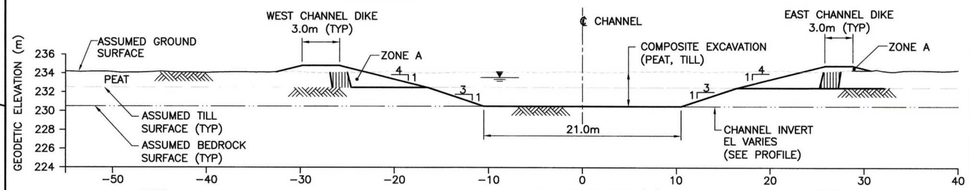
WEIR STRUCTURE 1 (WS1)



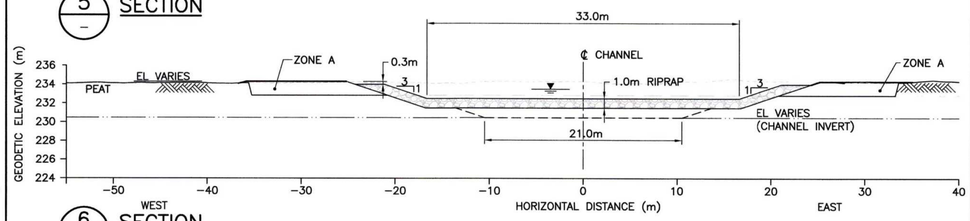
PLAN



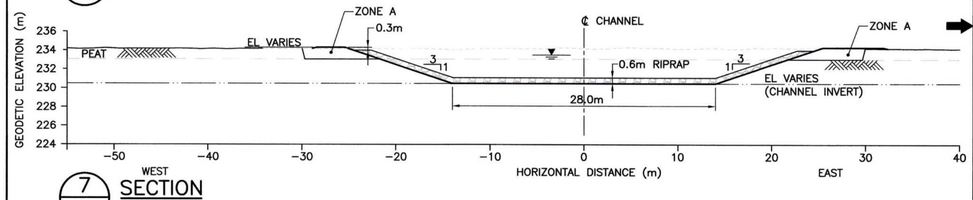
PROFILE



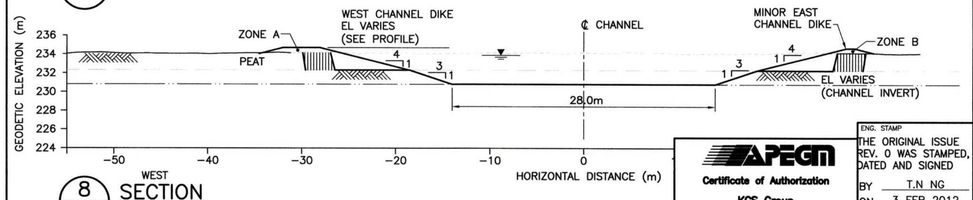
5 SECTION



6 SECTION



7 SECTION



8 SECTION

LEGEND:

ZONE A	COMPACTED NON-FROZEN MATERIAL (TILL) FROM "COMPOSITE EXCAVATION"
ZONE B	MATERIAL (TILL) FROM "COMPOSITE EXCAVATION"

PLAN AND PROFILE
20 0 20 40 60 80m
SCALE: 1:1000 METRIC 24"x36"
1:2000 METRIC 11"x17"

SECTIONS
10 0 10 20m
SCALE: 1:300 METRIC 17"x22"
1:600 METRIC 8.5"x11"

DETAILS
5 0 5 10m
SCALE: 1:150 METRIC 24"x36"
1:300 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
1	12/03/01	RE-ISSUED FOR CONSTRUCTION	RG
0	12/02/03	ISSUED FOR CONSTRUCTION	TNN

REVISIONS / ISSUE

CLIENT: Manitoba INFRASTRUCTURE AND TRANSPORTATION

PROJECT:
LAKE MANITOBA AND LAKE ST. MARTIN EMERGENCY CHANNELS
REACH 3

DWG. DESCRIPTION:
DROP AND WEIR STRUCTURES
PLAN, PROFILE AND SECTIONS

APEGM Certificate of Authorization KGS Group No. 245

ENG. STAMP
THE ORIGINAL ISSUE REV. 0 WAS STAMPED, DATED AND SIGNED
BY T.N NG
ON 3 FEB 2012
D/M/Y

KGS GROUP CONSULTING ENGINEERS

DESIGN BY:	BMB	DATE (YY/MM/DD):	11/12/09
DESIGN CHECK:	RKe	DATE:	12/01/31
DRAWN BY:	PwD	DATE:	12/01/24
DWG CHECK:	jS	DATE:	12/01/31

DWG. NO. 11-0300-18 G06 REV: 1

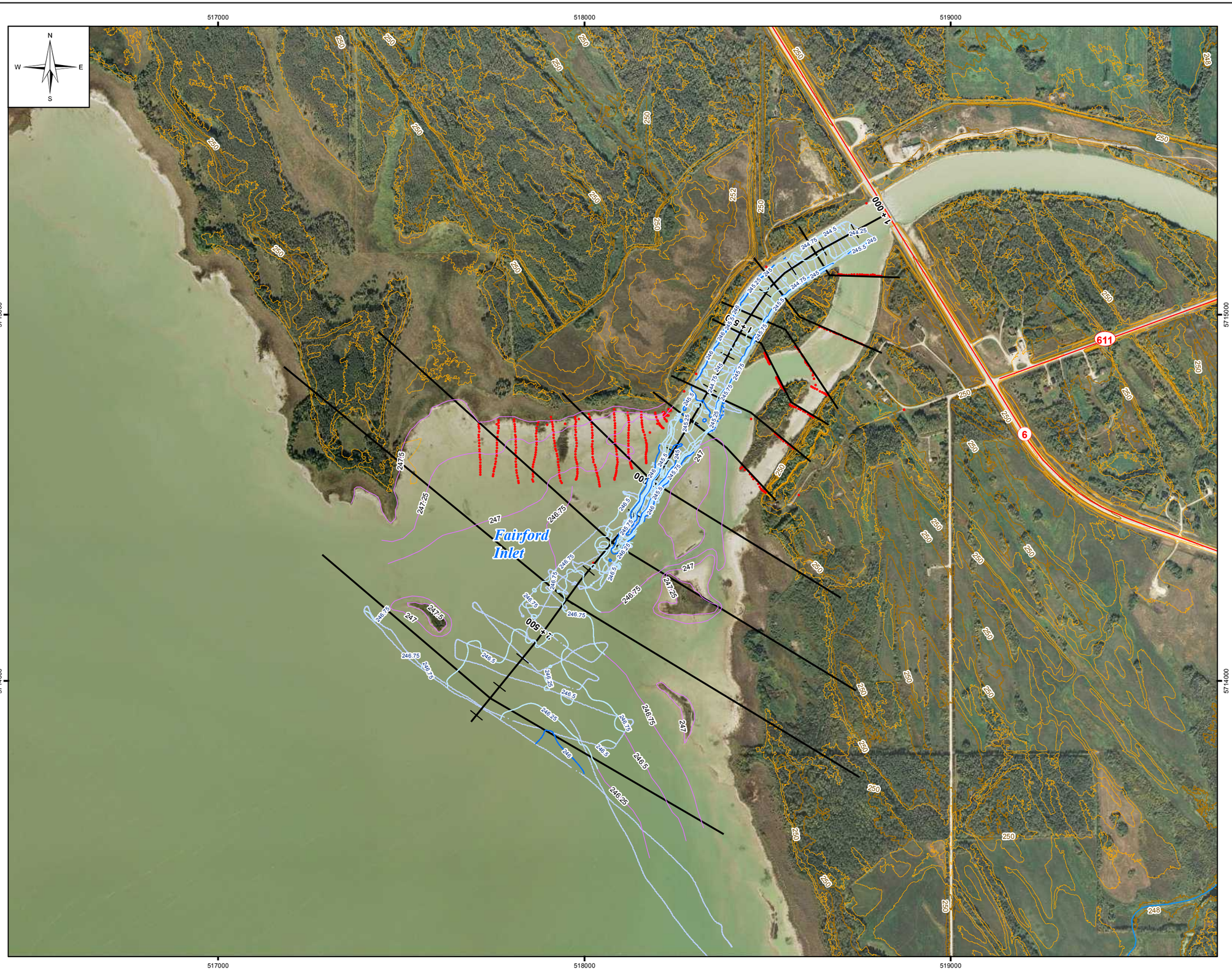
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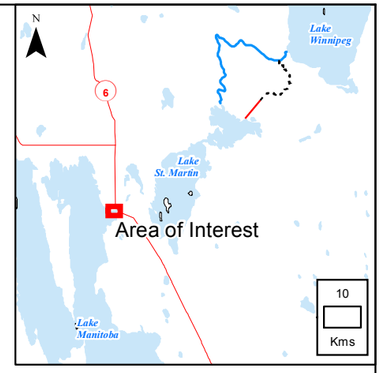
APPENDIX C

LAKE MANITOBA BATHYMETRY

DRAFT

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LEGEND:

- Survey Point
- Sonar Point
- Cross Section
- Highway
- Watercourse
- 2m Index Contour
- 0.5m Contour
- 1m Index Sonar Contour
- 0.25m Sonar Contour
- Interpolated Contours

NOTES:

1. Aerial Imagery: July 2011.
2. Original ground surface based on LiDAR provided by Atlis Geomatics (June/July 2011).

100 0 100 200 300 400
Metres

SCALE: 1:10,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
X	15/08/12	ISSUED WITH DRAFT REPORT	PAL

REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS STAGE 2

BATHYMETRY OF FAIRFORD RIVER INLET LOCATION

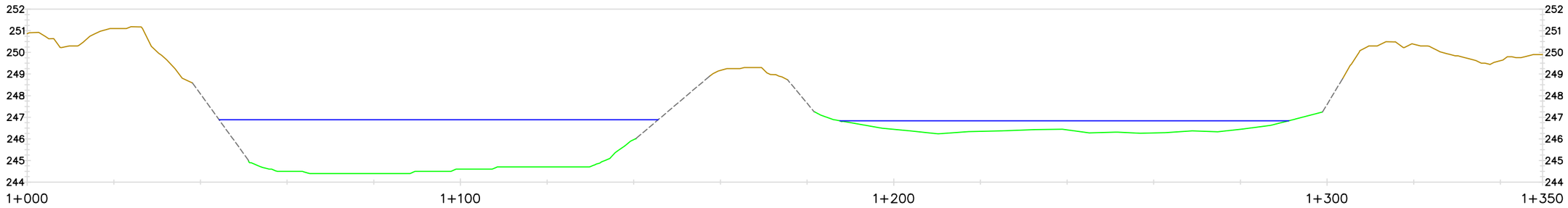
AUGUST 2015 | FIGURE C-1 | REV: X

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11"x17" PLOT SCALE 1:1

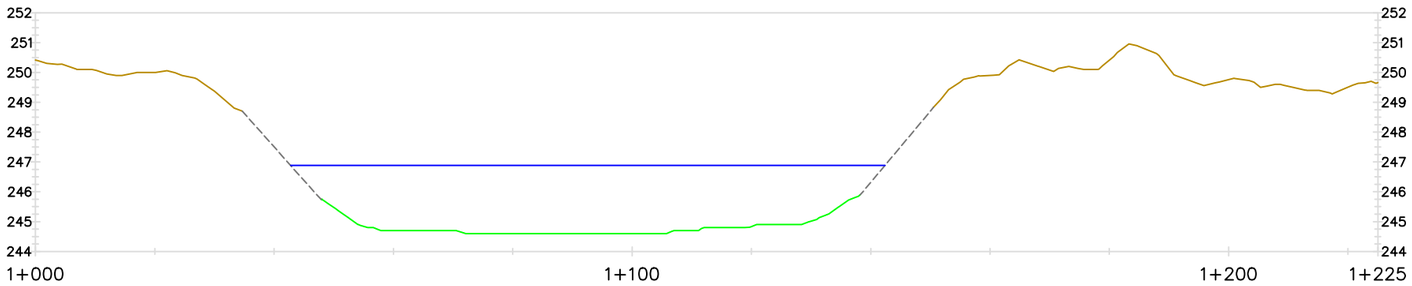
AUGUST 12/15
1 : 1000 5X VERT.

FAIRFORD INLET PROFILES

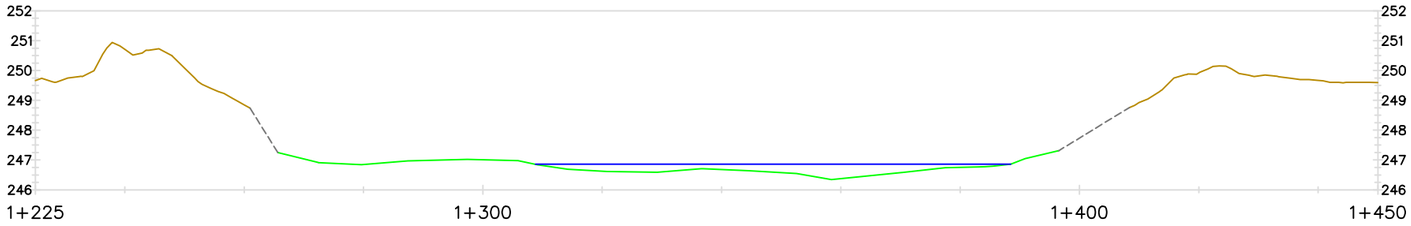
Profile View of 1+223



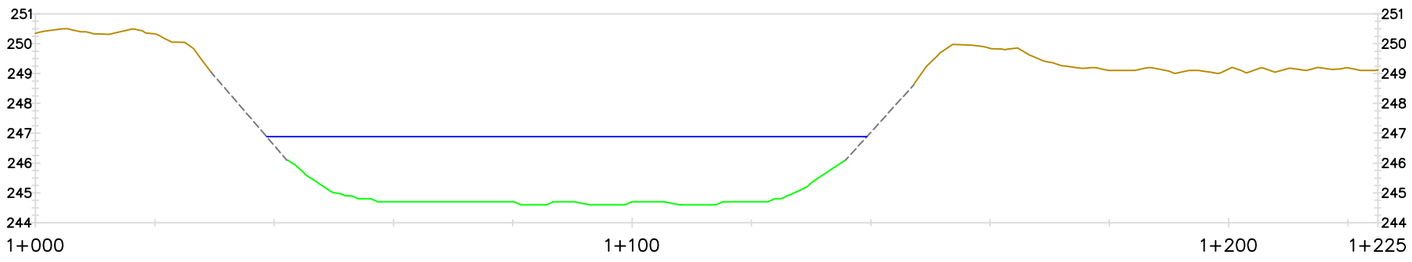
Profile View of 1+365



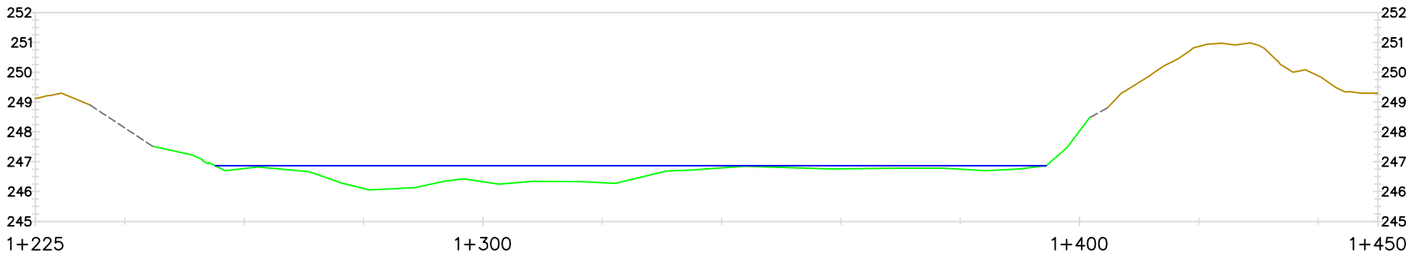
Profile View of 1+365



Profile View of 1+470



Profile View of 1+470



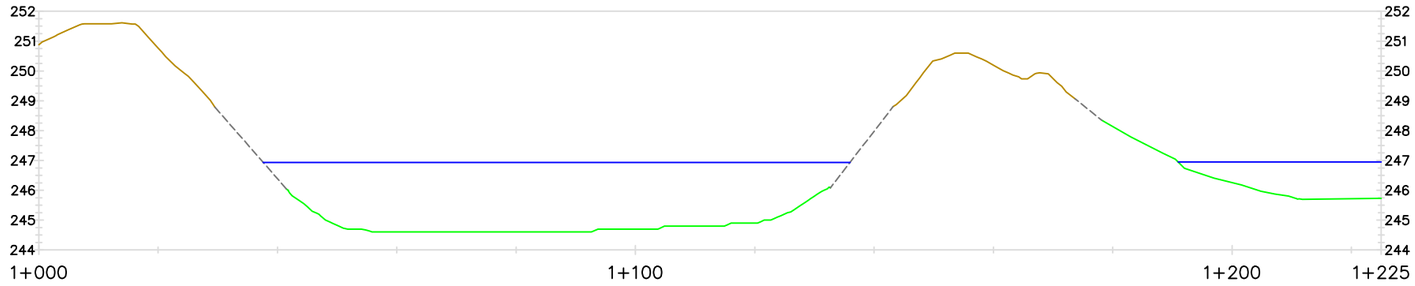
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AUGUST 12/15
1 : 1000 5X VERT.

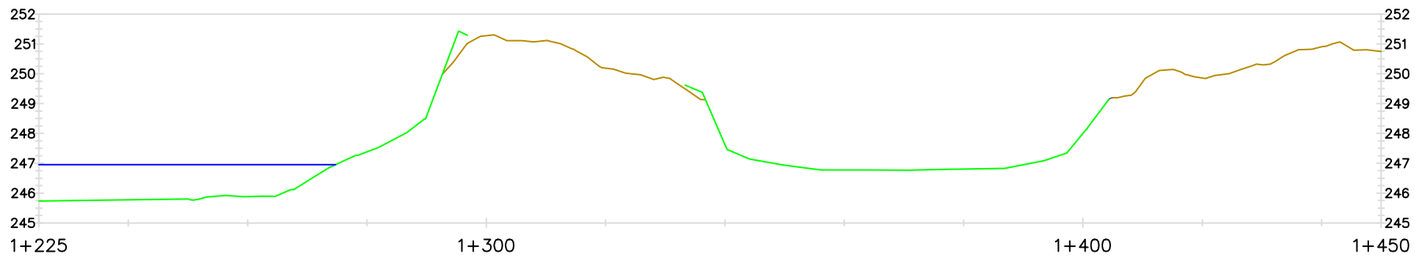
LiDAR
SONAR/TOPO
INTERPOLATED
WATER LEVEL

FAIRFORD INLET PROFILES

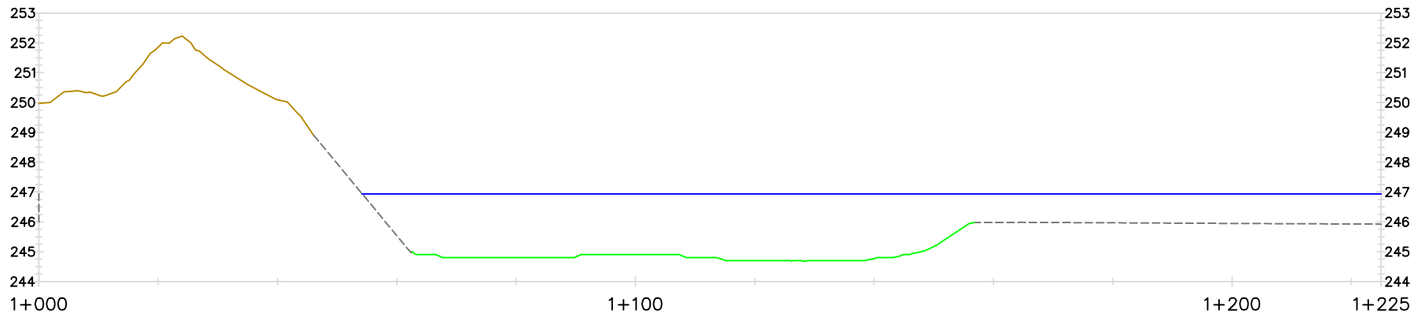
Profile View of 1+528



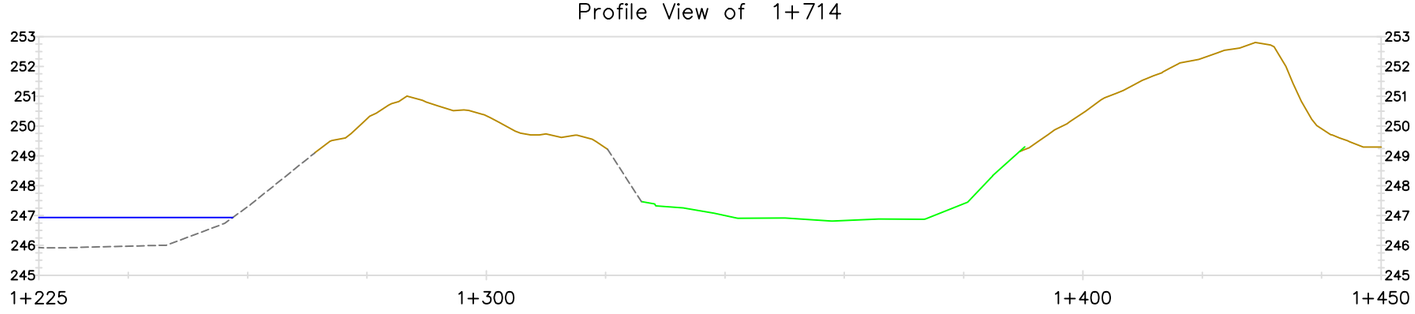
Profile View of 1+528



Profile View of 1+714



Profile View of 1+714



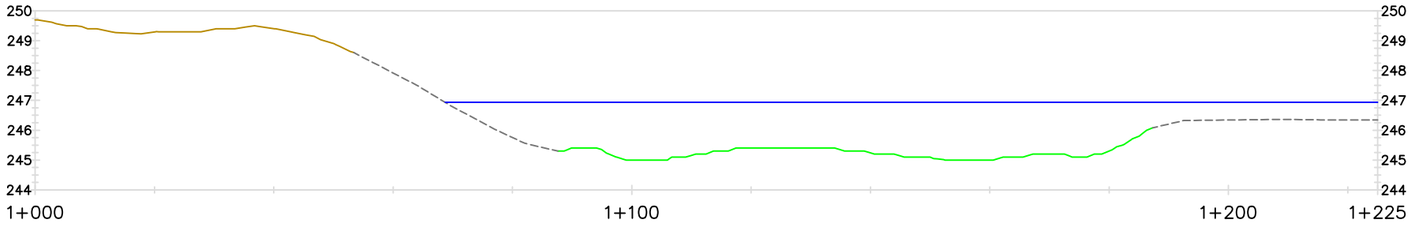
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AUGUST 12/15
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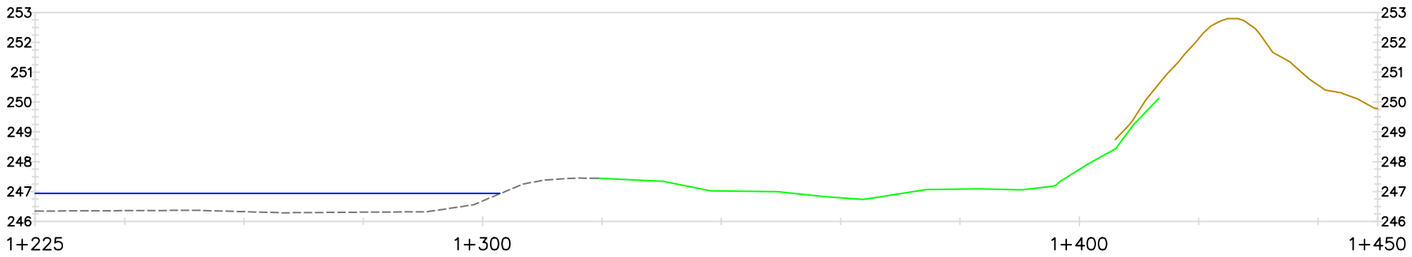
LiDAR
SONAR/TOPO
INTERPOLATED
WATER LEVEL

FAIRFORD INLET PROFILES

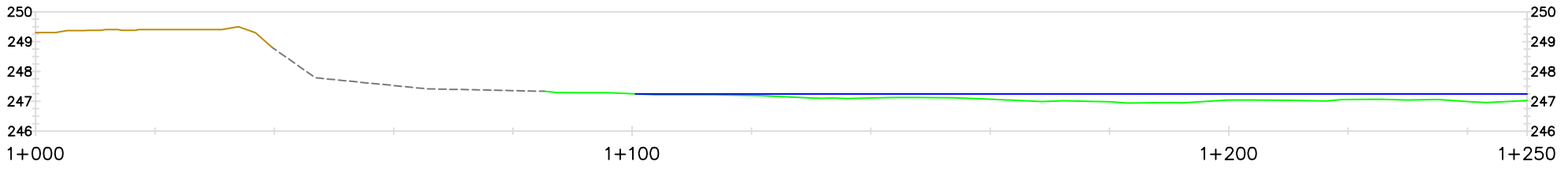
Profile View of 1+803



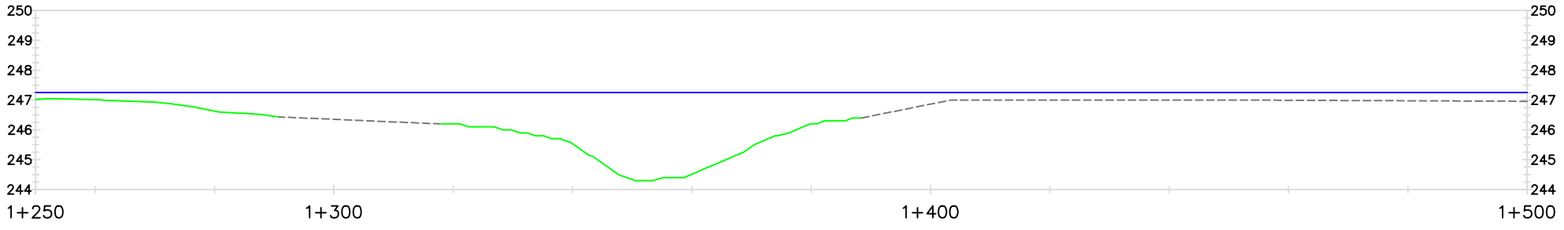
Profile View of 1+803



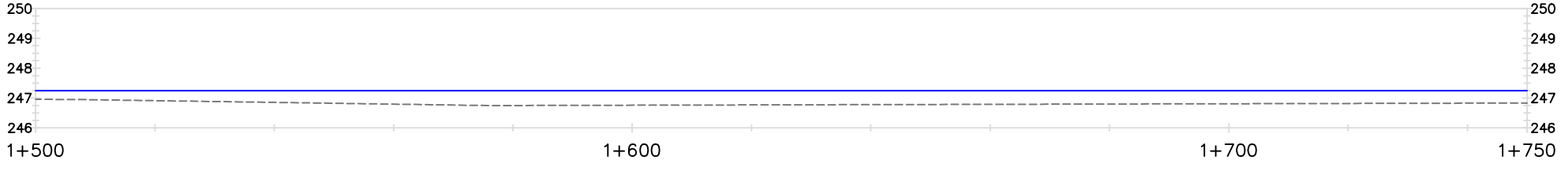
Profile View of 2+000



Profile View of 2+000



Profile View of 2+000



Profile View of 2+000



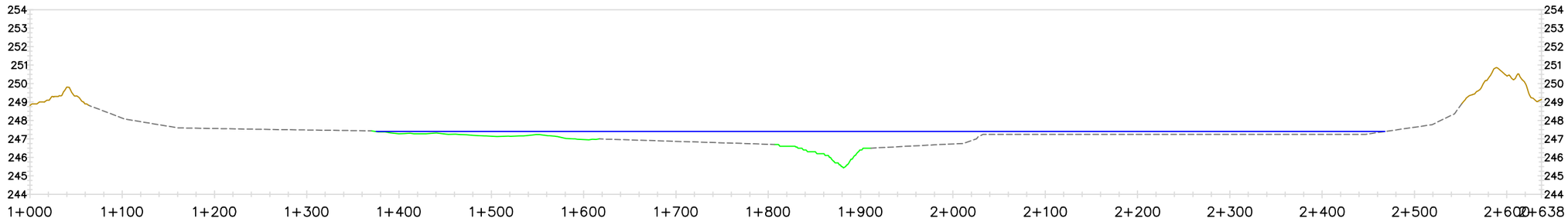
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AUGUST 12/15
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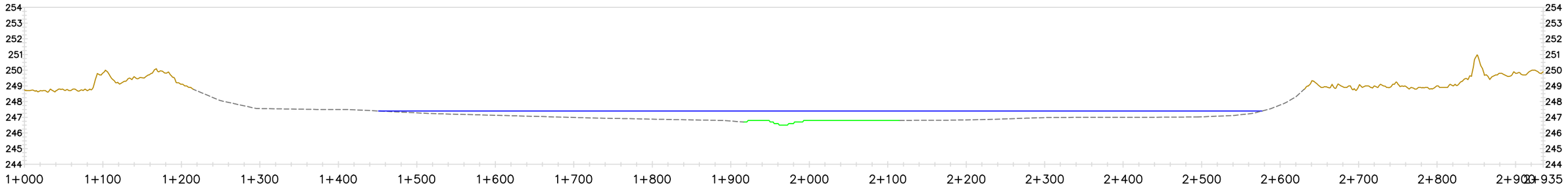
FAIRFORD INLET PROFILES

LiDAR
SONAR/TOPO
INTERPOLATED
WATER LEVEL

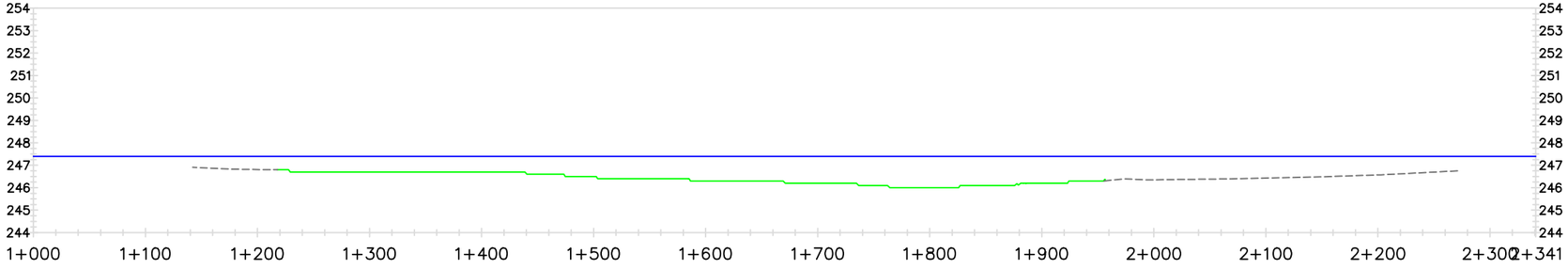
Profile View of 2+200



Profile View of 2+400



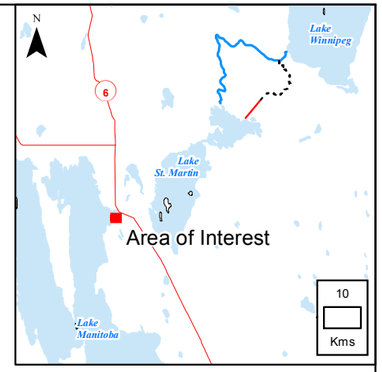
Profile View of 2+740



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LEGEND:

- Alignment
- 1m Index Sonar Contour
- 0.25m Sonar Contour

NOTES:

1. Aerial Imagery: July 2011.
2. Original ground surface based on LiDAR provided by Atlis Geomatics (June/July 2011).

50 0 50 100 150 200

Metres

SCALE: 1:5,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
X	15/08/12	ISSUED WITH DRAFT REPORT	PAL

REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS
STAGE 2

BATHYMETRY OF ROUTE B AND C INLET LOCATIONS

AUGUST 2015 | FIGURE C-2 | REV: X

FileName: P:\Projects\2012\12-0300-011\Dwg\GIS\MXDs\RevA\LMB_LSM_Conceptual_Design_Stg2\Appendix C\12-0300-011_FigC2_RevX.mxd
11"x17" PLOT SCALE 1:1

AUGUST 12/15
1 : 1000 5X VERT.

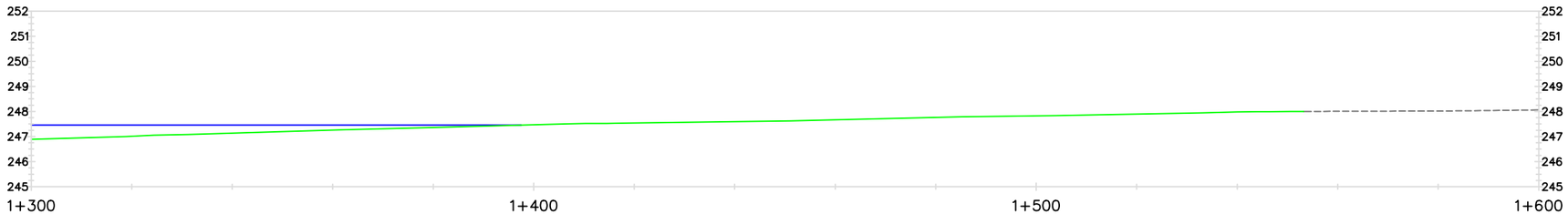
LiDAR
SONAR/TOPO
INTERPOLATED
WATER LEVEL

ROUTE B & C INLET PROFILES

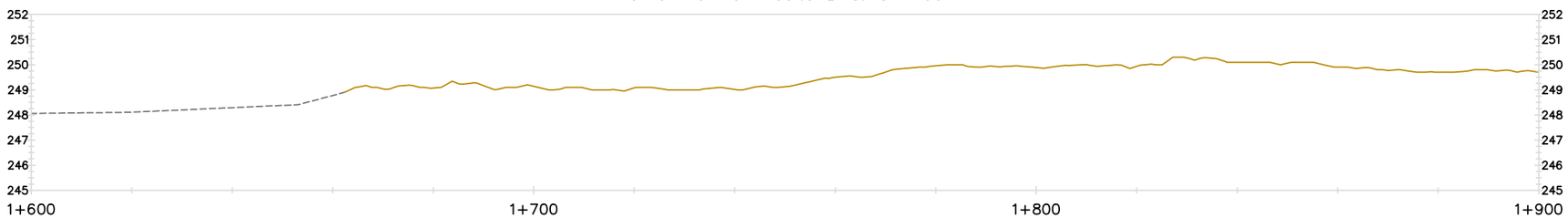
Profile View of Route B & C Area 1



Profile View of Route B & C Area 1



Profile View of Route B & C Area 1



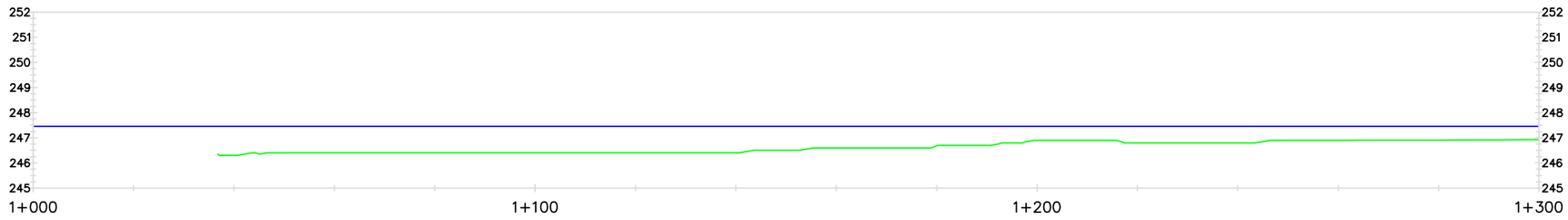
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AUGUST 12/15
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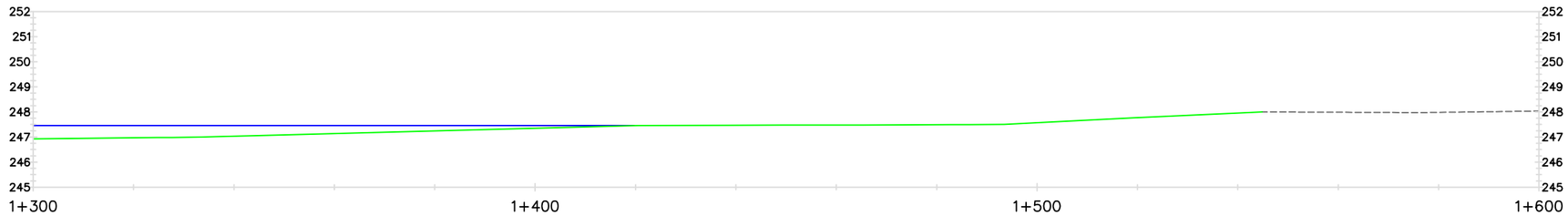
LiDAR
SONAR/TOPO
INTERPOLATED
WATER LEVEL

ROUTE B & C INLET PROFILES

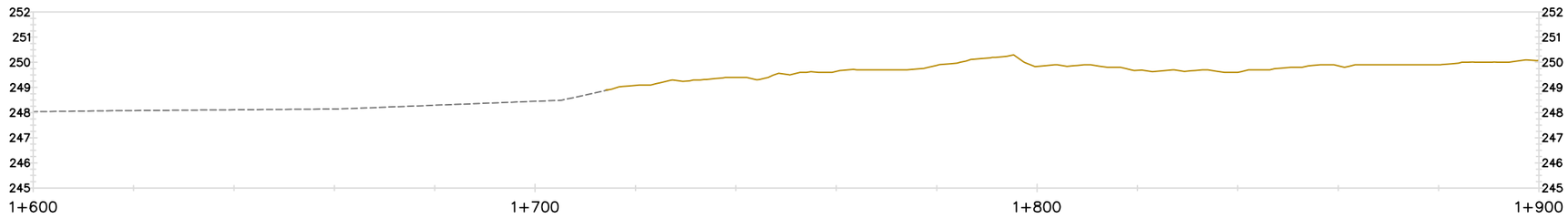
Profile View of Route B & C Area 2



Profile View of Route B & C Area 2



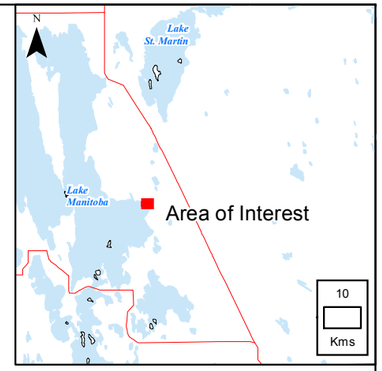
Profile View of Route B & C Area 2



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LEGEND:

- Alignment
- 1m Index Sonar Contour
- 0.25m Sonar Contour

NOTES:

1. Aerial Imagery: July 2011.
2. Original ground surface based on LiDAR provided by Atlis Geomatics (June/July 2011).

50 0 50 100 150 200
Metres

SCALE: 1:6,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
X	15/08/12	ISSUED WITH DRAFT REPORT	PAL

REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

Manitoba INFRASTRUCTURE AND TRANSPORTATION

LAKE MANITOBA AND LAKE ST. MARTIN OUTLET CHANNELS
STAGE 2

BATHYMETRY OF ROUTE D
INLET LOCATIONS

AUGUST 2015 | FIGURE C-3 | REV: X

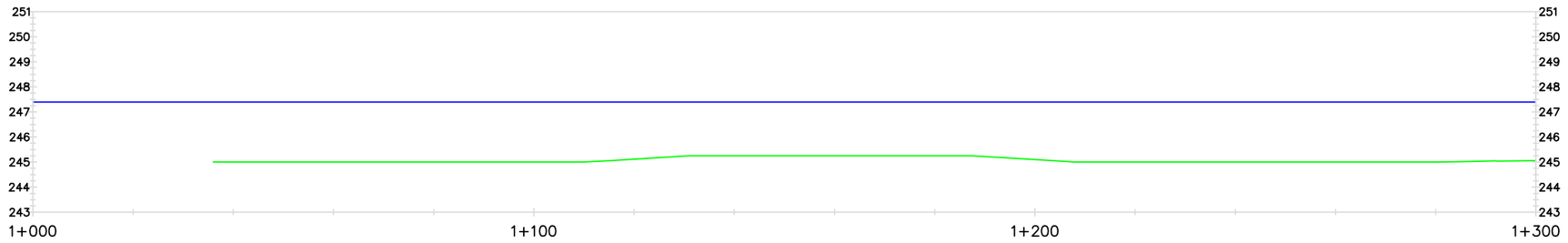
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11"x17" PLOT SCALE 1:1

AUGUST 12/15
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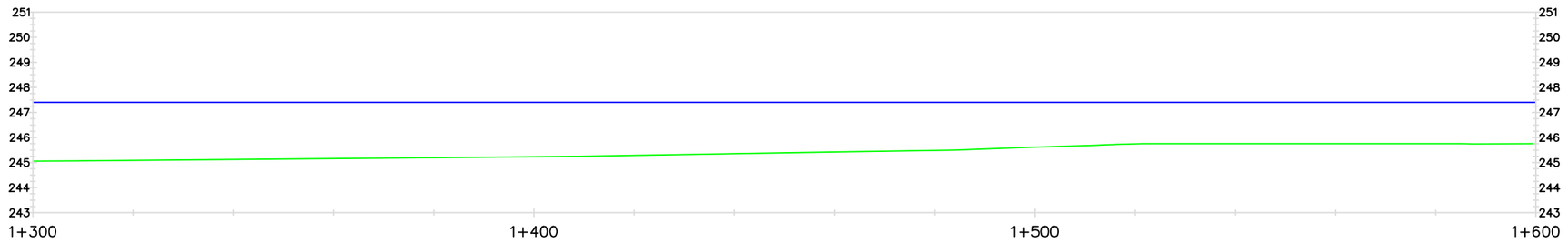
LiDAR
SONAR/TOPO
INTERPOLATED
WATER LEVEL

ROUTE D INLET PROFILES

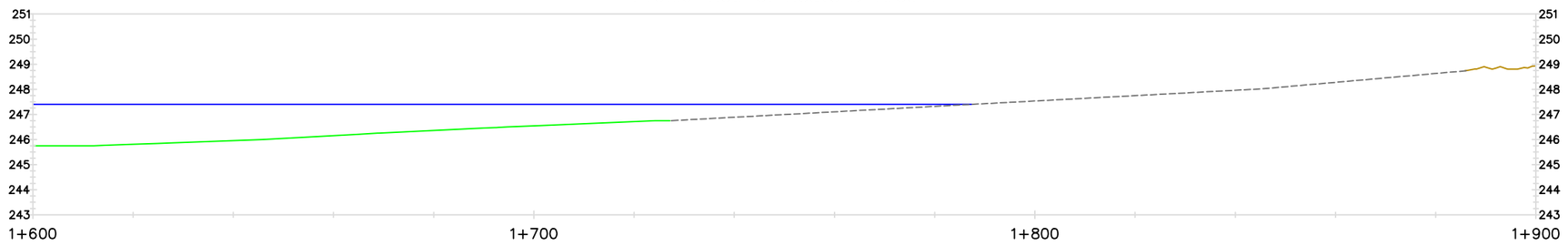
Profile View of Route D Area 1



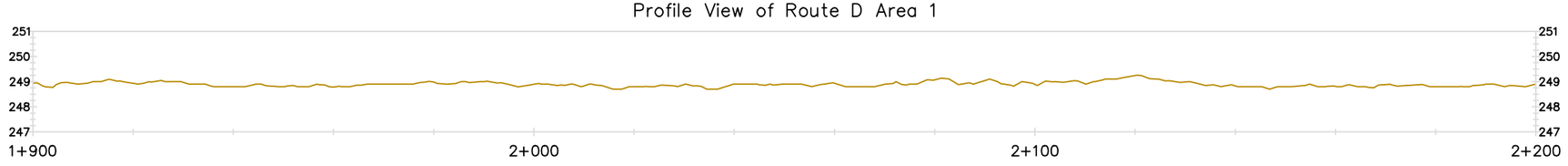
Profile View of Route D Area 1



Profile View of Route D Area 1



Profile View of Route D Area 1

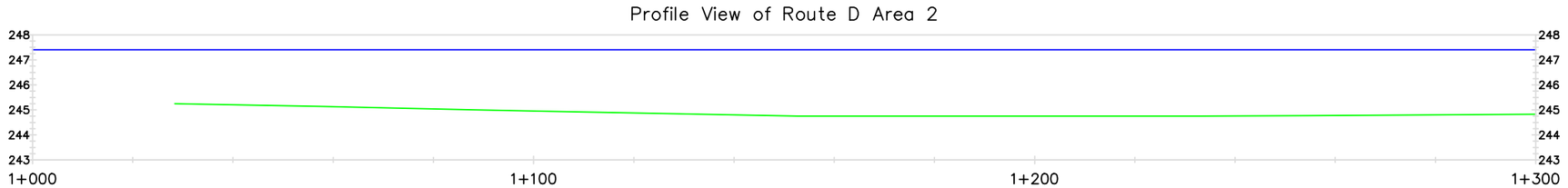


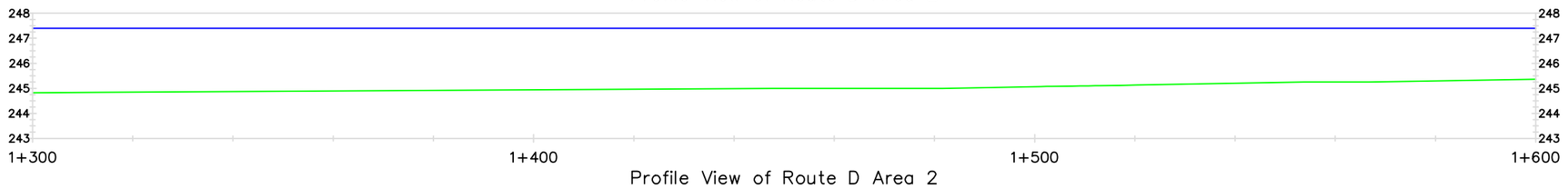
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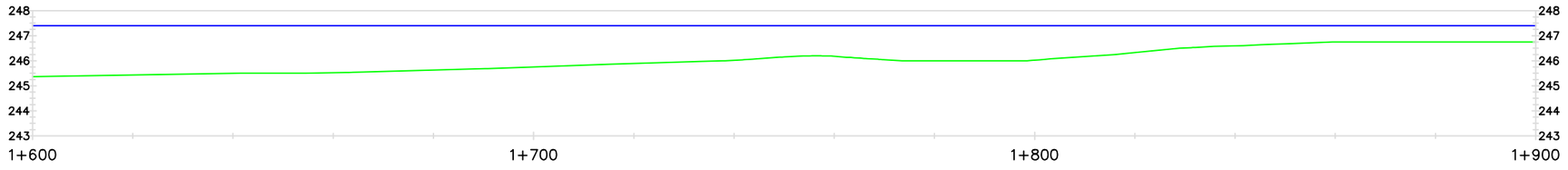
AUGUST 12/15
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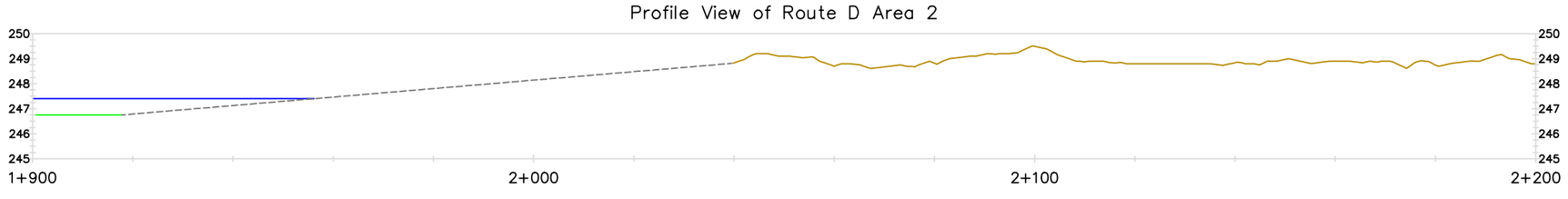
LiDAR
SONAR/TOPO
INTERPOLATED
WATER LEVEL

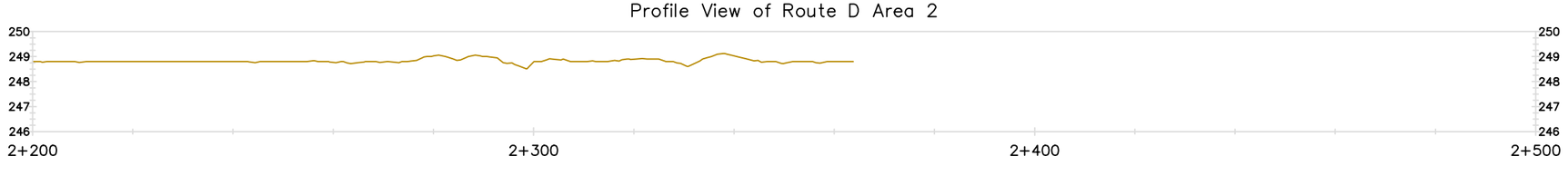
ROUTE D INLET PROFILES











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APPENDIX D

DETAILED FIELD INVESTIGATION RESULTS

FOR LMB OUTLET CHANNEL – ROUTE C

DRAFT

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RC-01**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 8+100, ROUTE C
DRILLING METHOD 125 mm ø Solid Stem Auger, HQ Core Barrel, Acker Renegade

JOB NO. **12-0300-011**
GROUND ELEV. **252.61 m**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **6/15/2015**
UTM (m) N **5,710,341** E **525,018**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆
252.3	0	0		**TOPSOIL** - Black, moist.							
				SILTY CLAY - Light grey, moist, hard, trace sand, trace angular fine grained to coarse grained gravel (up to 25 mm).							
252	1	5									
251	2						S1		100	▲7 ▲21 ▲32	
250	3	10		- Grain size distribution at 3.3 m: Gravel (14%), Sand (37%), Silt (38%), Clay (11%).			S2		78	▲69 spoon refusal	
249				**SILT** - Light grey, dry, trace sand.		3.7	S2A				
	4	15		- Grey, moist, hard, some clay, trace fine grained gravel (up to 10 mm) below 4.6 m.		4.6	S3		67	▲39 ▲47 spoon refusal	
248				- Grain size distribution at 4.8 m: Gravel (8%), Sand (40%), Silt (45%), Clay (7%).							
247	5										
246.5	6	20		**SAND** - Brown, moist, fine grained.			S4A		22	▲35 ▲50 spoon refusal	
246.4				**LIMESTONE** - Yellowish brown, moderately weathered. - Run 1 from 6.2 m to 7.8 m. 26% RQD.			S4B		67		
246											

SAMPLE TYPE ☒ Split Spoon ⊠ Auger Grab ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RC-01**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE / NUMBER / RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
245	8	25		- Run 2 from 7.8 m to 9.0 m. 22% RQD.			R1	20 40 60	20 40 60 80
				- Clay inclusion at 8.0 m.			R2		
244	9	30		- Run 3 from 9.0 m to 10.5 m. 53% RQD.					
243							R2		
	10	35		- Run 4 from 10.5 m to 12.0 m. 32% RQ.					
242	11			- Silt inclusion and clay seam at 11.0 m.		11.0	R4		
241						11.9			
240.6	12	40		**END OF TEST HOLE at 12.0 m**					
240				Notes: 1. Installed 2 standpipe (1" ø) piezometers, one slotted from 11.0 m to 11.9 m and one slotted from 3.7 m to 4.6 m. 2. Water level in test hole not encountered upon completion of drilling on June 15, 2015.					
239	13	45							
	14								
238									
	15	50							

SAMPLE TYPE ☒ Split Spoon ⚿ Auger Grab ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2012\12-0300-011\DESIGN\GEO\LOGS\ROUTE C\ROUTE C_LOGS.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RC-02**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION

PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY

SITE LAKE ST. MARTIN EMERGENCY CHANNELS

LOCATION STA. 5+168, ROUTE C

DRILLING METHOD 125 mm ø Solid Stem Auger, HQ Core Barrel, Acker Renegade

JOB NO. **12-0300-011**
GROUND ELEV. **255.46 m**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **6/16/2015**
UTM (m) N **5,712,800**
E **523,402**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
255				**TOPSOIL** - Grey.		0.6				20 40 60	20 40 60 80	20 40 60 80
254.5	1			**COBBLES** - Some fine grained to coarse grained sand, trace fine grained to coarse grained sand. - Switched from solid stem to coring below 0.9 m.								
254.1				**LIMESTONE** - Yellowish brown, moderately weathered.		1.5						
254		5		- Run 1 from 1.5 m to 3.0 m. 26% RQD.				R1	100			
253	2											
252	3	10		- Run 2 from 3.0 m to 4.6 m. 52% RQD.				R2	90			
251	4											
250.9		15		**END OF TEST HOLE at 4.6 m**								
250	5			Notes: 1. Installed standpipe (1" ø) piezometer, slotted from 0.6 m to 1.5 m.								
249	6	20										

SAMPLE TYPE ■ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RC-04**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 0+464, ROUTE C
DRILLING METHOD 125 mm ø Solid Stem Auger, HQ Core Barrel, Acker Renegade

JOB NO. **12-0300-011**
GROUND ELEV. **249.69 m**
TOP OF PVC ELEV.
WATER ELEV. **248.79 m**
DATE DRILLED **6/16/2015**
UTM (m) N **5,713,086** E **518,993**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
249												
248.9 ▼	0			**TOPSOIL** - Black, moist to wet, with organics.								
	1	5		**SILTY CLAY** - Grey, moist, hard, trace fine grained gravel (up to 25 mm).								
248							S1		56	▲11 ▲23 ▲33	●	
	2			- Trace cobbles (>100 mm) at 2.1 m.								
247												
246.6	3	10		**CLAY TILL** - Greenish grey, wet, hard, some sand, trace fine grained to coarse grained gravel (up to 75 mm). - Grain size distribution at 3.3 m: Gravel (11%), Sand (37%), Silt (42%), Clay (10%).			S2		94	▲34 ▲44 spoon refusal	●	
246												
	4	15				4.6	S3		72	▲13 ▲14 ▲23	●	
245				- Grain size distribution at 4.8 m: Gravel (13%), Sand (41%), Silt (38%), Clay (8%).								
	5					5.5						
244												
	6	20					S4		94	▲16 ▲22 spoon refusal	●	
243												

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RC-04**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
242	8	25		- Very stiff below 7.6 m. - Grain size distribution at 7.8 m: Gravel (35%), Sand (32%), Silt (26%), Clay (7%).			S5		67	▲16 ▲16 ▲13	
241	9	30					S6		39	▲10 ▲11 ▲13	
240	10					9.8					
239		35		- Stiff below 10.7 m. - Grain size distribution at 10.9 m: Gravel (25%), Sand (31%), Silt (35%), Clay (9%).		10.7	S7		44	▲4 ▲5 ▲7	
238.6	11			**END OF TEST HOLE at 11.1 m**							
238	12	40									
237	13										
236		45									
235	14										
	15	50									

Notes:
1. Installed 2 standpipe (1" ø) piezometers, one slotted from 10.7 m to 9.8 m and one slotted from 5.5 m to 4.6 m.
2. Water level in test hole at 0.9 m below grade upon completion of drilling on June 16, 2015.

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RC-06**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 4+200, ROUTE C
DRILLING METHOD 125 mm ø Solid Stem Auger, HQ Core Barrel, Acker Renegade

JOB NO. **12-0300-011**
GROUND ELEV. **254.97 m**
TOP OF PVC ELEV.
WATER ELEV. **241.25 m**
DATE DRILLED **6/17/2015**
UTM (m) N **5,713,281** E **522,658**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
254.4				**TOPSOIL** - Black, moist, with organics.								
254	1			**SILTY CLAY** - Grey, dry to moist, trace fine grained to coarse grained gravel (up to 25 mm).								
253.3		5		- Switched from solid stem to coring below 1.5 m.			S	S1	22	▲50 spoon refusal		
253	2			**LIMESTONE** - Grey, faintly weathered (machine breaks). - Run 1 from 1.6 m to 3.0 m. 10% RQD.				R1	100			
252	3	10		- Run 2 from 3.0 m to 4.6 m. 27% RQD. - Fractures at 3.4 m and 4.0 m.				R2	63			
251	4											
250	5	15		- Run 3 from 4.6 m to 6.1 m. 37% RQD.	VW	5.1 5.2		R3	88			
249	6	20		- Run 4 from 6.1 m to 7.6 m. 50% RQD.				R4	100			
248												

SAMPLE TYPE ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RC-06**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80) / PL MC LL % (20 40 60 80)
247	8	25		- Run 5 from 7.6 m to 9.1 m. 50% RQD.			R5		100		
246	9	30		- Run 6 from 9.1 m to 10.7 m. 68% RQD.			R6		100		
245	10	35		- Run 7 from 10.7 m to 12.2 m. No recovery, 76 mm clay inclusion.			R7		0		
244	11										
243	12	40		- Run 8 from 12.2 m to 13.7 m. 62% RQD, faintly weathered.		12.6	R8		100		
242	13					13.5					
243		45		**END OF TEST HOLE at 13.7 m**	▼						
241	14										
240	15	50									

Notes:
1. Installed standpipe (1" ø) piezometer slotted from 12.6 m to 13.5 m.
2. Installed water saturated vibrating wire piezometer to a depth of 5.2 m below grade.
3. Water level in test hole at bottom of hole upon completion of drilling on June 17, 2015.

SAMPLE TYPE ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2012\12-0300-011\DESIGN\GEO\LOGS\ROUTE C\ROUTE C_LOGS.GPJ

H. MANALO CONSULTING LTD.
1402 Notre Dame Avenue, Winnipeg, MB R3E 3G5
PHONE: 204 697-3854 CELL: 204 997-1355
hmanalo@mts.net

Project: **Assiniboine River & Lake Manitoba Basins Flood Route C**			**Client: KGS Group**	**Laboratory Tests Results**							
TH Number	**Sample No.**	**Depth (ft)**	**Sample Description** (provided by Client)	**Moisture Content (%)**	**Atterberg Limits**			**Soil Composition**			
					LL	**PL**	**PI**	**% Gravel**	**% Sand**	**% Silt**	**% Clay**
15-RC-01	S-1	5'	Silty Clay	10.0							
	S-2	10'	Silty Clay	7.0	17	10	7	14	37	38	11
	S-2A	11'	Silt	6.0							
	S-3	15'	Silt	8.0	14	11	3	8	40	45	7
	S-4A	20'	Sand	12.0							
	S-4B	20'	Silty Clay	7.0							
15-RC-04	S-1	5'	Silty Clay	8.0							
	S-2	10'	Clay	8.0	15	11	4	11	37	42	10
	S-3	15'	Clay	8.0	15	11	4	13	41	38	8
	S-4	20'	Clay	10.0							
	S-5	25'	Clay	8.0	16	10	6	35	32	26	7
	S-6	30'	Clay	9.0							
	S-7	35'	Clay	8.0	16	9	7	25	31	35	9
15-RC-06	S-1	5'	Silty Clay	7.0							
15-RD-01	S-1	5'	Silty Clay	22.0							
	S-2	10'	Silty Clay	11.0							
	S-3	15'	Silty Clay	11.0	18	10	8	1	45	41	13
	S-4	20'	Silty Clay	10.0							
	S-5	25'	Silty Clay	8.0	16	11	5	7	34	50	9
	S-6	30'	Silty Clay	9.0							
	S-7	35'	Sand	13.0							
	S-8	40'	Sand Till	10.0	16	10	6	7	50	33	10

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1402 Notre Dame Avenue, Winnipeg, MB R3E 3G5
PHONE: 204 697-3854 CELL: 204 997-1355
hmanalo@mts.net

Project: **Assiniboine River & Lake Manitoba Basins Flood Route C**			**Client: KGS Group**	**Laboratory Tests Results**							
TH Number	**Sample No.**	**Depth (ft)**	**Sample Description** (provided by Client)	**Moisture Content (%)**	**Atterberg Limits**			**Soil Composition**			
					LL	**PL**	**PI**	**% Gravel**	**% Sand**	**% Silt**	**% Clay**
15-RD-01	S-9	50'	Clay Till	8.0	17	10	7	2	43	42	13
	S-9A	52'	Clay Till	6.0							
	S-10	55'	Clay Till	4.0							
	S-11	60'	Clay Till	9.0	14	11	3	14	50	30	6
	S-11A	62'	Clay Till	7.0							
	S-12	66'	Clay Till	7.0	16	10	6	4	29	56	11
15-RD-02	S-1	5'	Silty Clay	18.0							
	S-2	10'	Silty Clay	12.0	19	11	8	7	32	48	13
	S-3	15'	Silty Clay	11.0							
	S-4	20'	Silty Clay	11.0	15	10	5	9	41	40	10
	S-5	25'	Silty Clay Till	9.0	16	10	6	26	29	35	10
	S-6	30'	Silty Clay Till	10.0							
	S-7	35' '	Silty Clay Till	10.0	16	9	7	9	35	44	12
	S-8	40'	Silty Clay Till	12.0							
	S-9	45'	Silty Clay Till	9.0	14	10	4	5	37	49	9
	S-10	50'	Sand	14.0							
15-RD-03	S-1	5'	Silty Clay	10.0							
	S-2	10'	Silty Clay Till	7.0	17	10	7	32	28	30	10
	S-3	15'	Silty Clay Till	9.0							
	S-4	20'	Silty Clay Till	8.0	15	10	5	29	28	34	9

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Project: **Assiniboine River & Lake Manitoba Basins Flood Route C**			**Client: KGS Group**	**Laboratory Tests Results**							
TH Number	**Sample No.**	**Depth (ft)**	**Sample Description** (provided by Client)	**Moisture Content (%)**	**Atterberg Limits**			**Soil Composition**			
					LL	**PL**	**PI**	**% Gravel**	**% Sand**	**% Silt**	**% Clay**
15-RD-03	S-5	25'	Silty Clay Till	3.0							
	S-5A	26'	Silty Clay Till	9.0							
	S-6	30'	Silty Clay Till	8.0	17	10	7	30	30	31	9
	S-7	45'	Clay Till	8.0	16	9	7	31	22	38	9
	S-8	49'	Clay Till	8.0							
15-RD-04	S-1	5'	Silty Clay	16.0							
	S-2	10'	Silty Clay	10.0							
	S-3	15'	Silty Clay	9.0	18	10	8	10	28	49	13
	S-4	20'	Silty Clay	9.0							
	S-5	25'	Silty Clay	9.0	15	10	5	12	25	56	7
	S-6	30'	Silty Sand	14.0	Non-plastic						
	S-7	35'	Silty Clay	13.0	Non-plastic			9	31	55	5
	S-8	40'	Silty Clay Till	8.0							
	S-9	50'	Silty Clay Till	In the list but not found in the bags of samples							
15-RD-05	S-1	5'	Silty Clay	11.0							
	S-2	10'	Silty Clay	9.0	17	11	6	12	30	45	13
	S-3	15'	Silty Clay	9.0							
	S-4	20'	Silty Clay	7.0	15	9	6	15	31	43	11
	S-5	25'	Silty Clay	7.0							

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Project: **Assiniboine River & Lake Manitoba Basins Flood Route C**			**Client: KGS Group**	**Laboratory Tests Results**							
TH Number	**Sample No.**	**Depth (ft)**	**Sample Description** (provided by Client)	**Moisture Content (%)**	**Atterberg Limits**			**Soil Composition**			
					LL	**PL**	**PI**	**% Gravel**	**% Sand**	**% Silt**	**% Clay**
15-RD-05	S-6	30'	Silty Clay	8.0	18	10	8	12	29	46	13
	S-7	35'	Silty Clay	8.0							
	S-8	40'	Sandy Clay Till	7.0	14	10	4	31	46	18	5
15-RD-10A	S-1	5'	Silty Clay	17.0							
	S-2	10'	Silty Clay	9.0							
	S-3	15'	Silty Clay	10.0	16	10	6	16	29	44	11
	S-4	20'	Silty Clay	12.0							
	S-5	25'	Silty Clay	11.0	17	10	7	18	41	32	9
	S-6	30'	Silt Till	5.0	17	10	7	8	38	42	12
	S-7	35'	Silt Till	7.0							
	S-8	40'	Silt Till	6.0	16	9	7	1	31	54	14
	S-9	45'	Silt Till	7.0							
	S-10	50'	Silt Till	6.0	17	10	7	4	34	50	12
	S-11	55'	Silt Till	7.0							
	S-12	60'	Silt Till	7.0	15	10	5	11	30	48	11
Additional Tests		Note: Samples were received from Client placed inside packing bags and labeled, but not found in the list provided									
15-RD-02	DS-7A	39'	———	6.0							
15-RD-03	FS-06A	33'	———	18.0							
15-RD-03	DS-6B	36'	———	2.0							
15-RD-04	FS-06A	33'	———	12.0							
15-RD-04	AS-09A & 09B	50' to 50'-6"	———	14.0							
		Number of Tests		**80**	**35**			**34**			

KGS GROUP
CONSULTING ENGINEERS

MEMORANDUM

TO: **Tony Ng**

FROM: **T. Packulak / J. Mann**

DATE: **July 20, 2015**

FILE NO: **12-0300-011**

RE: **Assiniboine River and Lake Manitoba Flood Study: Geological Setting and Rock Core Inspection – Route C - Draft**

1.0 INTRODUCTION

Between July 15, 2015 – July 17, 2015 detailed discontinuity logging was completed on cored limestone and dolomite bedrock from three (3) test holes; 15-RC-01, 15-RC-02, and 15-RC-06. The rock core is from the Lake Manitoba Outlet Channel Option C located approximately 220 km north west of the City of Winnipeg, Manitoba, Canada, between Lake Manitoba and Lake St. Martin.

2.0 ROCK CORE INSPECTION

2.1 GEOLOGICAL DETAIL LOGGING

Based upon local geological maps and inspection of the cored bedrock, the local bedrock is dominated by Middle Silurian Dolomitic Limestone and Argillaceous Limestone associated with the Cedar Lake Formation of the Interlake Group.

Jointing observed in the bedrock core is composed predominately of sub-horizontal fractures which vary in weathering degree, iron staining, or have had calcite and iron minerals precipitate out along groundwater flow pathways formed by the bedrock fracture network., The majority of the cored limestone and dolomite shows signs of weathering outside of the joint faces. The limestone and dolomite exhibit a vuggy porosity where voids vary between 2 to 10 mm and up to 60 mm in diameter.

A summary of the test hole conditions are shown in Table 1, with individual detailed fracture logs included in Appendix A. Photographs of each core box are included in Appendix B. Structurally, the limestone appears to be highly fractured, shows karstic characteristics, and recoveries of the individual core runs are between approximately 0% and 100 %. The bedrock overall, based on core recoveries and Rock Quality Designation (RQD), appears to be in poor

condition. RQD rankings vary between approximately 0% and 61%, ranging from very poor, to fair classification. Broken core zones and broken lost core zones were identified in all cored test holes, with estimated core losses ranging from approximately 0.02 m to 1.52 m.

TABLE 1
SUMMARY OF MEASURED RQD'S AND RECOVERIES
FOR INDIVIDUAL RUNS OF CORED LIMESTONE

Hole	Run	Depth (m)	Recovery	RQD	Classification
15-RC-01	1	6.20 - 7.77	93%	46%	Poor
	2	7.77 - 8.99	64%	11%	V. Poor
	3	8.99 - 10.52	94%	56%	Fair
	4	10.52 - 12.04	95%	35%	Poor
15-RC-02	1	1.36 - 1.52	Not Applicable (Not Enough Core)		
	2	1.52 - 3.05	100%	31%	Poor
	3	3.05 - 4.57	87%	41%	Poor
15-RC-06	1	1.60 - 3.05	87%	10%	V. Poor
	2	3.05 - 4.57	92%	36%	Poor
	3	4.57 - 6.10	63%	16%	V. Poor
	4	6.10 - 7.62	95%	48%	Poor
	5	7.62 - 9.14	98%	33%	Poor
	6	9.14 - 10.67	78%	61%	Fair
	7	10.67 - 12.19	0%	0%	V. Poor
	8	12.19 - 13.72	78%	52%	Fair

Prepared By:

Timothy Packulak, B.Sc., E.I.T.
Geotechnical Engineer-in-Training

Approved By:

Jason Mann, M.Sc., P.Geo.
Senior Geologist

Attachment

DRAFT

APPENDIX A

GEOLOGICAL DETAIL FRACTURE LOGS

DRAFT

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	15-RC-01
		Sheet	1 of 3
Site / Location	STA. 8+100, Route C	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Lake MB Flood Study
Core Diameter	HQ	Project No.	12-0300-011
Method	HQ Coring, Acker Renegade	Logged By	T. Packulak
		Date	July 15-16, 2015
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90	Date	
Depth to Rock Surface	6.2 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING									
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT	
6.20	TOR	83				X																
6.41	Joint	80		X		X																
6.45	Joint	53					X			X			X								X	
6.65	Joint	41			X	X																
6.65 – 6.87	BLCZ	Loss of 0.05 m																				
6.87	Joint	80			X		X			X												
6.96	Joint	52		X		X																
7.00	Joint	78			X	X				X												
7.10	Joint	87		X			X			X												
7.18	Joint	84			X		X															
7.24	Joint	77			X	X																
7.24 – 7.43	BLCZ	Loss of 0.06 m																				
7.43	Joint	87			X		X			X												
7.58	Joint	80			X	X																
7.62	Joint	49		X		X																
7.65	Joint	49			X	X																
7.77	MB / EOR	89					X															
7.89	Joint	90			X	X				X	X		X								X	

APPROVED:	SHIFT:	DATE:

LEGEND:	BZ – Broken Zone	H – Horizontal	V – Vertical
	MB – Machine Break	SH- Sub-Horizontal	SV - Sub-Vertical

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	15-RC-01
		Sheet	2 of 3
Site / Location	STA. 8+100, Route C	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Lake MB Flood Study
Core Diameter	HQ	Project No.	12-0300-011
Method	HQ Coring, Acker Renegade	Logged By	T. Packulak
		Date	July 15-16, 2015
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90	Date	
Depth to Rock Surface	6.2 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING									
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT	
7.89 – 7.94	Injected Till	-																				
7.94 – 8.53	BLCZ	Loss of 0.44								X			X								X	
8.53	Joint	85					X															
8.66	Joint	86			X	X																
8.75	Joint	82			X		X						X								X	
8.85	Joint	84			X		X			X												
8.90	Joint	89			X		X			X												
8.99	MB / EOR	89		X			X			X												
9.19	Joint	89			X		X			X												
9.26	MB	85		X			X															
9.33	Joint	89		X		X																
9.50	Joint	87			X	X																
9.55	Joint	90		X		X																
9.64	Joint / GBD	84			X		X															
9.88	Joint / GBD	85			X		X															
9.99	Joint / GBD	84			X		X															
10.16	Joint / GBD	87			X		X															
10.25	Joint	87		X			X															

APPROVED:	SHIFT:	DATE:

LEGEND:	BZ – Broken Zone	H – Horizontal	V – Vertical
	MB – Machine Break	SH- Sub-Horizontal	SV - Sub-Vertical

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	15-RC-01
		Sheet	3 of 3
Site / Location	STA. 8+100, Route C	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Lake MB Flood Study
Core Diameter	HQ	Project No.	12-0300-011
Method	HQ Coring, Acker Renegade	Logged By	T. Packulak
		Date	July 15-16, 2015
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90	Date	
Depth to Rock Surface	6.2 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION																				
													JOINT FILLING										
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT	
10.33	Joint	78		X			X			X													
10.43	Joint	86		X			X			X													
10.43 – 10.52	BLCZ	Loss of 0.09 m																					
10.52	EOR	-																					
10.52 – 11.18	BLCZ	Loss of 0.08 m								X	X		X								X		
11.18	Joint	90			X	X				X			X								X		
11.24	Joint	87			X		X			X													
11.28	Joint	26		X			X			X			X								X		
11.43	Joint	87		X			X																
11.47	Joint	77		X			X																
11.73	Joint	75			X		X						X								X		
11.86	Joint	87		X			X																
11.93	Joint	78			X		X																
11.93 – 12.04	BCZ	-																					
12.04	EOH	-																					

APPROVED:	SHIFT:	DATE:

LEGEND:	BZ – Broken Zone	H – Horizontal	V – Vertical
	MB – Machine Break	SH- Sub-Horizontal	SV - Sub-Vertical

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	15-RC-02
		Sheet	1 of 2
Site / Location	STA. 5+168, Route C	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Lake MB Flood Study
Core Diameter	HQ	Project No.	12-0300-011
Method	HQ Coring, Acker Renegade	Logged By	T. Packulak
		Date	July 16, 2015
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90	Date	
Depth to Rock Surface	1.36 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING									
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT	
1.40	TOR	86					X															
1.49	Joint	85		X			X						X							X		
1.52	MB / EOR	88		X			X															
1.65	Joint	86			X	X				X	X				X							
1.74	MB/Joint	80		X			X													X		
1.88	Joint	69		X			X														X	
1.98	Joint	81		X			X			X										X		
2.01	Joint	88		X			X			X										X		
2.07	Joint	83		X			X			X												
2.15	Joint	73		X			X													X		
2.25	Joint/GBD	81			X		X															
2.31	Joint	74		X			X			X										X		
2.39	Joint	65			X		X			X												
2.41	Joint	72			X		X			X												
2.44	Joint	88		X			X			X										X		
2.51	Joint	77		X			X			X										X		
2.57	Joint	65		X			X													X		
2.64	Joint	45		X		X																

APPROVED: SHIFT: DATE:

LEGEND:	BZ – Broken Zone	H – Horizontal	V – Vertical
	MB – Machine Break	SH- Sub-Horizontal	SV - Sub-Vertical

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	15-RC-02
		Sheet	2 of 2
Site / Location	STA. 5+168, Route C	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Lake MB Flood Study
Core Diameter	HQ	Project No.	12-0300-011
Method	HQ Coring, Acker Renegade	Logged By	T. Packulak
		Date	July 16, 2015
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90	Date	
Depth to Rock Surface	1.40 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION																			
													JOINT FILLING									
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT	
2.79	Joint	71			X	X																
2.82	Joint	80			X	X							X									
2.84	MB	79		X		X																
2.90	MB	84		X			X															
2.93	MB	81		X		X																
2.97	Joint/MB	86			X	X																
2.97 – 3.05	BCZ	-																				
3.05	MB	75					X															
3.15	MB/ Joint	78		X			X															
3.23	Joint	86		X			X															
3.33	Joint	80		X			X															
3.54	Joint	75			X		X			X	X				X							
3.70	Joint	69		X			X															
3.77	Joint	61		X		X																
4.01 – 4.31	BLCZ	Loss of 0.2 m								X	X											
4.57	EOH	77								X	X		X								X	

APPROVED:	SHIFT:	DATE:

LEGEND:	BZ – Broken Zone	H – Horizontal	V – Vertical
	MB – Machine Break	SH- Sub-Horizontal	SV - Sub-Vertical

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	15-RC-06
		Sheet	1 of 4
Site / Location	STA. 4+200, Route C	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Lake MB Flood Study
Core Diameter	HQ	Project No.	12-0300-011
Method	HQ Coring, Acker Renegade	Logged By	T. Packulak
		Date	July 17, 2015
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90	Date	
Depth to Rock Surface	1.60 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION																				
													JOINT FILLING										
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT	
1.60	TOR/GBD	83				X																	
1.63	Joint	87		X		X																	
1.66	Joint	86			X	X																	
1.73	Joint/GBD	85			X	X																	
1.80	Joint/GBD	87			X	X																	
1.80 – 1.88	BZ	-																					
1.88	Joint	88			X	X																	
2.04	Joint	83			X	X																	
2.04 – 3.05	BLCZ	Loss of 0.2 m																					
3.05	MB/Joint/ GBD	87																					
3.14	Joint	84																					
3.14 – 3.51	BLCZ	Loss of 0.1 m																					
3.51	Joint	21			X		X			X	X												
3.66	Joint	12			X		X			X	X												
3.72	Joint	89			X		X			X	X												
3.95	Joint	68		X			X																
4.11	Joint	56			X		X			X													
4.39	Joint	62			X		X			X													
APPROVED:				SHIFT:									DATE:										

LEGEND:	BZ – Broken Zone	H – Horizontal	V – Vertical
	MB – Machine Break	SH- Sub-Horizontal	SV - Sub-Vertical

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	15-RC-06
		Sheet	2 of 4
Site / Location	STA. 4+200, Route C	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Lake MB Flood Study
Core Diameter	HQ	Project No.	12-0300-011
Method	HQ Coring, Acker Renegade	Logged By	T. Packulak
		Date	July 17, 2015
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90	Date	
Depth to Rock Surface	1.60 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT	
4.39 – 4.57	BLCZ	Loss of 0.02 m					X			X	X				X						X	
4.57 – 5.72	BLCZ	Loss of 0.56 m																				
5.72	Joint	57			X		X				X				X					X		
5.82	Joint	82		X		X																
6.10	EOR/MB	88			X		X															
6.10 – 6.60	BLCZ	Loss of 0.08 m																				
6.65	Joint	77			X		X			X	X		X		X						X	
6.69	Joint	83			X		X															
6.83	Joint	36			X	X				X	X				X							
6.95	Joint	35			X	X				X										X		
7.02	Joint	90			X		X			X										X		
7.04	Joint	66			X		X			X										X		
7.09	Joint	83			X	X														X		
7.29	Joint	78			X	X														X		
7.62	MB	81					X															
7.65	Joint	83		X		X				X												
7.77	Joint	41			X		X			X	X		X								X	
7.92	Joint	72			X		X			X	X		X								X	

APPROVED:	SHIFT:	DATE:

LEGEND:	BZ – Broken Zone	H – Horizontal	V – Vertical
	MB – Machine Break	SH- Sub-Horizontal	SV - Sub-Vertical

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	15-RC-06
		Sheet	3 of 4
Site / Location	STA. 4+200, Route C	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Lake MB Flood Study
Core Diameter	HQ	Project No.	12-0300-011
Method	HQ Coring, Acker Renegade	Logged By	T. Packulak
		Date	July 17, 2015
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90	Date	
Depth to Rock Surface	1.60 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING									
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT	
8.05	Joint	76		X			X			X	X				X							
8.10	Joint	40			X																	
8.23 – 8.38	BLCZ	Loss of 0.02 m					X			X	X											
8.38	Joint	41			X	X																
8.41	Joint	79		X			X			X	X				X							
8.46	Joint	03		X			X			X	X				X							
8.53	Joint	80		X			X			X	X				X							
8.81	Joint	61			X		X			X										X		
8.89	Joint/GBD	88			X		X			X												
8.97	Joint	77			X		X			X												
9.14	Joint/MB	42			X		X															
9.32	Joint	37			X		X															
9.32 – 9.36	LCZ	Loss of 0.03 m																				
9.36	Joint	50			X		X			X												
9.50	Joint	85		X			X													X		
9.88	Joint	24			X	X				X	X				X							
10.06	Joint	88		X		X																
10.11 – 10.13	BLCZ	Loss of 0.02								X	X		X								X	
APPROVED:			SHIFT:										DATE:									

LEGEND:	BZ – Broken Zone	H – Horizontal	V – Vertical
	MB – Machine Break	SH- Sub-Horizontal	SV - Sub-Vertical

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	15-RC-06
		Sheet	4 of 4
Site / Location	STA. 4+200, Route C	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Lake MB Flood Study
Core Diameter	HQ	Project No.	12-0300-011
Method	HQ Coring, Acker Renegade	Logged By	T. Packulak
		Date	July 17, 2015
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90	Date	
Depth to Rock Surface	1.60 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING									
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT	
10.29	Joint	84		X			X			X												
10.31	Joint	86		X			X			X												
10.39 – 10.67	BLCZ	Loss of 0.28 m																				
10.67 – 12.19	No Recovery	0.07 m Clay recovery											X									
12.19 – 12.50	No Recovery																					
12.50	Joint/GBD	85					X													X		
12.64	Joint	76			X		X			X	X											
12.76	Joint	88			X		X			X	X				X							
13.11 – 13.16	BCZ									X	X				X							
13.23	Joint	63			X	X							X								X	
13.30	Joint	81			X		X			X			X								X	
13.31	Joint	87			X																	
13.31 – 13.34	BLCZ	Loss of 0.02 m																				
13.72	EOH/ Joint	63					X			X			X								X	

APPROVED: SHIFT: DATE:

LEGEND:	BZ – Broken Zone	H – Horizontal	V – Vertical
	MB – Machine Break	SH- Sub-Horizontal	SV - Sub-Vertical

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APPENDIX B

ROCK CORE BOX & SAMPLE PHOTOS



Photo 1 – Limestone Core: RC-15-01 (6.20 m – 12.04 m)



Photo 2 – Limestone Core: RC-15-02 (1.40 m – 4.57 m)



Photo 3 – Limestone Core: RC-15-06 (1.60 m – 13.72 m)

APPENDIX E

DETAILED FIELD INVESTIGATION RESULTS

FOR LMB OUTLET CHANNEL – ROUTE D

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-01**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 2+672, ROUTE D
DRILLING METHOD 125 mm ø Solid Stem Auger, HQ Core Barrel, Acker Renegade

JOB NO. **12-0300-011**
GROUND ELEV. **248.30 m**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **6/8/2015**
UTM (m) N **5,683,639** E **531,292**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
248.0	0	0		**TOPSOIL** - Black, moist, firm, trace organics.							
248				**SILTY CLAY** - Grey, frozen, stiff, some fine grained gravel (up to 5 mm), trace sand, trace silt pockets.							
	1										
247		5		- Wet, trace organics below 1.5 m.			S	1	100	▲2 ▲5 ▲7	
	2										
246											
	3	10		- Moist, firm, very stiff, trace angular fine grained gravel (up to 10 mm) below 3.0 m.			S	2	100	▲5 ▲8 ▲17	
245											
	4										
244		15		- Firm from 4.0 m to 5.5 m.			S	3	72	▲2 ▲3 ▲3	
	5			- Grain size distribution at 4.8 m: Gravel (1%), Sand (45%), Silt (41%), Clay (13%).							
243											
	6	20		- Wet, hard, some angular fine grained gravel (up to 10 mm), some silt below 6.1 m.			S	4	100	▲3 ▲7 ▲28	
242				- Cobbles encountered at 6.7 m.							

SAMPLE TYPE ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-01**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
241	8	25		- Light grey, moist, some sub-rounded fine grained gravel (up to 10 mm) below 7.6 m. - Grain size distribution at 7.8 m: Gravel (7%), Sand (34%), Silt (50%), Clay (9%).			S5		100	▲ 28 ▲ 35 ▲ 35	
240				- Cobbles encountered at 8.5 m.							
239	9	30		- Grey, wet, some fine grained to coarse grained sand below 9.1 m.		9.4	S6		100	▲ 28 ▲ 24 ▲ 18	
238	10					10.4					
237.6		35		**SAND** - Brown, wet, compact, medium grained.			S7		72	▲ 15 ▲ 13 ▲ 13	
237	11										
236.1	12	40		**SAND TILL** - Grey, wet.			S8		67	▲ 50 spoon refusal	
236				- Grain size distribution at 12.4 m: Gravel (7%), Sand (50%), Silt (33%), Clay (10%). - Solid stem refusal at 12.5 m. Switched to coring below 12.5 m.							
235	13	45									
234	14										
233.1	15	50									

SAMPLE TYPE ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-01**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
232	16	55		**CLAY TILL** - Light grey, moist, with boulders. - Grain size distribution at 15.5 m: Gravel (2%), Sand (43%), Silt (42%), Clay (13%).			S9		22	▲50 spoon refusal	
							S9A		100		
231	17			- With fine grained to coarse grained gravel (up to 20 mm) below 16.8 m. - Boulders (up to 300 mm) encountered at 16.8 m.			S10		100		
230	18	60					S11		56	▲50 spoon refusal	
				- Grain size distribution at 18.5 m: Gravel (14%), Sand (50%), Silt (30%), Clay (6%).			S11A		100		
229	19					19.5					
228	20	65		- Grain size distribution at 19.9 m: Gravel (4%), Sand (29%), Silt (56%), Clay (11%).		20.4	S12		100		
227.6	21			**LIMESTONE** - Faintly weathered.			S13		100		
227		70									
	22										
226.0				**END OF TEST HOLE at 22.3 m**							
226				Notes: 1. Installed 2 standpipe (1" ø) piezometers, one slotted from 19.5 m to 20.4 m and one slotted from 9.4 m to 10.4 m. Installed pressure gauges in both standpipes. 2. Water level in test hole at 3.2 m below grade following drilling on June 8, 2015. 3. Water level in standpipe installed in silty clay at 0.7 m above grade (artesian) upon completion of drilling on June 10, 2015.							
	23	75									
225											

SAMPLE TYPE ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO.
15-RD-01

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE / NUMBER / RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80) / PL MC LL % (20 40 60 80)
224	24	80		4. Water level in standpipe installed in clay till at 2.8 m above grade (artesian) upon completion of drilling on June 10, 2015.					
223	25								
222	26	85							
221	27	90							
220	28								
219	29	95							
218	30	100							
217	31								

SAMPLE TYPE ☒ Split Spoon ◧ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-02**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 12+776, ROUTE D
DRILLING METHOD 125 mm ø Solid Stem Auger, HQ Core Barrel, Acker Renegade

JOB NO. **12-0300-011**
GROUND ELEV. **248.65 m**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **6/11/2015**
UTM (m) N **5,693,417** E **530,519**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
248				**TOPSOIL** - Black, moist, with organics.							
	1										
247.4				**SILTY CLAY** - Grey, frozen, stiff, trace silt pockets, trace fine grained to coarse grained gravel.							
247		5					S	1	100	▲3 ▲4 ▲6	
	2										
246											
	3	10		- Wet, trace fine grained to coarse grained sand below 3.0 m. - Grain size distribution at 3.3 m: Gravel (7%), Sand (32%), Silt (48%), Clay (13%).			S	2	100	▲4 ▲4 ▲5
245											
	4										
		15		- Very stiff, some sub-angular coarse grained gravel (up to 40 mm) below 4.6 m.			S	3	100	▲4 ▲8 ▲8	
244	5										
243											
	6	20		- Grain size distribution at 6.3 m: Gravel (9%), Sand (41%), Silt (40%), Clay (10%).			S	4	100	▲4 ▲7 ▲11	
242											

SAMPLE TYPE ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-02**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
241.0	8	25		**SILTY CLAY TILL** - Grey, moist, hard, with fine grained to coarse grained gravel (up to 50 mm). - Grain size distribution at 7.8 m: Gravel (26%), Sand (29%), Silt (35%), Clay (10%).			S5		67	▲11 ▲53 ▲82	
240	9	30		- Solid stem refusal at 9.1 m. Switched to coring below 9.1 m.			S6		78	▲50 ▲65 spoon refusal	
239	10										
238	11	35		- With cobbles (up to 300 mm) at 10.7 m. - Grain size distribution at 10.9 m: Gravel (9%), Sand (35%), Silt (44%), Clay (12%).			S7		100	▲36 ▲50 ▲46	
237	12										
236	13	40					S8		100		
235	14	45		- Grain size distribution at 13.8 m: Gravel (5%), Sand (37%), Silt (49%), Clay (9%).		14.0	S9		100		
234	15					14.9					
233.4		50								▲6	

SAMPLE TYPE ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-02**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
233	16	55		**SAND** - Grey, wet, fine grained, dense.				S10		▲14 ▲22	
				END OF TEST HOLE at 15.7 m							
232	17			Notes: 1. Installed standpipe (1" ø) piezometer slotted from 14.0 m to 14.9 m. Installed pressure gauge in standpipe. 2. Water level in standpipe installed in silty clay till at 2.8 m above grade (artesian) upon completion of drilling on June 11, 2015.							
231	18	60									
230	19										
229	20	65									
228	21										
227	22	70									
226	23	75									

SAMPLE TYPE ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-02A**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 12+776, ROUTE D
DRILLING METHOD 125 mm ø Solid Stem Auger, Acker Renegade

JOB NO. **12-0300-011**
GROUND ELEV. **248.63 m**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **6/12/2015**
UTM (m) N **5,693,419** E **530,519**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
248										20 40 60	20 40 60 80	20 40 60 80
	1			**TOPSOIL** - Black, moist, with organics.								
247.4				**SILTY CLAY** - Grey, frozen, stiff, trace silt pockets, trace fine grained to coarse grained gravel.								
247		5										
	2											
246												
	3	10										
245												
	4											
244		15										
	5											
243												
	6	20										
242						6.7						

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-02A**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
241		25				7.6				20 40 60	20 40 60 80
240.7	8			**END OF TEST HOLE at 7.9 m**							
240				Notes: 1. Installed standpipe (1" ø) piezometer slotted from 6.7 m to 7.6 m.							
	9	30									
239											
	10										
238		35									
	11										
237											
	12	40									
236											
	13										
235		45									
	14										
234											
	15	50									

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-03**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 17+032, ROUTE D
DRILLING METHOD 125 mm ø Solid Stem Auger, HQ Core Barrel, Acker Renegade

JOB NO. **12-0300-011**
GROUND ELEV. **251.84 m**
TOP OF PVC ELEV.
WATER ELEV. **250.94 m**
DATE DRILLED **6/12/2015**
UTM (m) N **5,697,485** E **530,996**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
251.5				**TOPSOIL** - Black, moist, trace organics.								
	1	5		**SILTY CLAY** - Grey, moist, very stiff, trace fine grained to coarse grained gravel (up to 25 mm), trace sand, trace organics.			S1	S1	78	▲5 ▲6 ▲10	●	
250	2											
249												
248.8	3	10		**SILTY CLAY TILL** - Grey, moist, hard, trace fine grained to coarse grained gravel (up to 40 mm), trace sand. - Grain size distribution at 3.3 m: Gravel (32%), Sand (28%), Silt (30%), Clay (10%).			S2	S2	100	▲12 ▲13 ▲21	●H	
248	4											
		15		- Very dense, coarse grained gravel ends below 4.6 m.			S3	S3	100	▲8 ▲10 ▲13	●	
247	5			- Boulder (450 mm) encountered at 5.5 m.								
246	6	20		- Stiff, trace coarse grained gravel (up to 40 mm) below 6.1 m. - Solid stem refusal at 6.1 m. Switch to coring below 6.1 m. - Grain size distribution at 6.3 m: Gravel (29%), Sand (28%), Silt (34%), Clay (9%).		6.7	S4	S4	72	▲13 ▲12 ▲11	●H	
245												

SAMPLE TYPE ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-03**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
244	8	25				7.6	S5		6	▲11 ▲10 ▲10	
							S5A		100		
243	9	30		- Grain size distribution at 9.4 m: Gravel (30%), Sand (30%), Silt (31%), Clay (9%).			S6		44	▲9 ▲17 ▲11	
242.1				**SAND** - Grey, wet, fine grained, compact, trace silt.			S6A		100		
242	10	35		- No core recovery between 10.7 m and 11.1 m.					0	▲8 ▲12 ▲7	
241	11						S6B		100		
240	12	40		- No core recovery between 12.2 m and 12.6 m.					0	▲13 ▲14 ▲12	
239	13										
238.1		45		**CLAY TILL** - Dark grey, moist, hard, trace angular fine grained to coarse grained gravel (up to 25 mm). - Grain size distribution at 13.9 m: Gravel (31%), Sand (22%), Silt (38%), Clay (9%).		14.0	S7		67	▲21 ▲77 ▲68
238	14										
237	15					14.9	S8		100		
236.6		50									

SAMPLE TYPE ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-03**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE / NUMBER / RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
236	16	55		**END OF TEST HOLE at 15.2 m** Notes: 1. Installed 2 standpipe piezometers, one slotted from 14.0 m to 14.9 m and one slotted from 6.7 m to 7.6 m. 2. Water level in test hole at 0.9 m below grade upon completion of drilling on June 13, 2015.				20 40 60	20 40 60 80
235	17								
234	18	60							
233	19								
232	20	65							
231	21	70							
230	22								
229	23	75							

SAMPLE TYPE ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2012\12-0300-011\DESIGN\GEO\LOGS\ROUTE D\ROUTE D_LOGS.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-03A**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 17+032, ROUTE D
DRILLING METHOD 125 mm ø Solid Stem Auger, Acker Renegade

JOB NO. **12-0300-011**
GROUND ELEV. **251.86 m**
TOP OF PVC ELEV.
WATER ELEV. **241.19 m**
DATE DRILLED **6/19/2015**
UTM (m) N **5,697,489**
E **530,991**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE / NUMBER / RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
251.6				**TOPSOIL** - Black, moist, trace organics.				20 40 60	20 40 60 80
				SILTY CLAY - Grey, moist, very stiff, trace fine grained to coarse grained gravel (up to 25 mm), trace sand, trace organics.					
251	1	5							
250	2								
249									
248.8	3	10		**SILTY CLAY TILL** - Grey, moist, hard, trace fine grained to coarse grained gravel (up to 40 mm), trace sand.					
248	4	15							
247	5								
246	6	20							
245									

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-03A**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
244	8	25								20 40 60	20 40 60 80
243	9	30									
242.1				**SAND** - Grey, wet, fine grained, compact, trace silt.							
242	10				VW	10.3 10.4					
241.2		35		**END OF TEST HOLE at 10.7 m**							
241	11										
240	12	40									
239	13										
238	14	45									
237	15	50									

Notes:
1. Installed water saturated vibrating wire piezometer to a depth of 10.4 m below grade.
2. Water level in test hole at bottom of hole upon completion of drilling on June 19, 2015.

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-04**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 19+256, ROUTE D
DRILLING METHOD 125 mm ø Solid Stem Auger, HQ Core Barrel, Acker Renegade

JOB NO. **12-0300-011**
GROUND ELEV. **251.76 m**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **6/13/2015**
UTM (m) N **5,699,450** E **531,894**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
251											
250.8	0			**TOPSOIL** - Black, moist, trace organics.							
	1	5		**SILTY CLAY** - Grey, very stiff, trace silt, trace sand, trace fine grained to coarse grained gravel (up to 25 mm).			S1		83	▲ 5, 7, 12	
250	2										
249	3	10		- Trace coarse grained gravel (up to 40 mm) between 3.0 m and 4.6 m.			S2		100	▲ 3, 9, 14	
248	4										
247	5	15		- Hard below 4.6 m. - Grain size distribution at 4.8 m: Gravel (10%), Sand (28%), Silt (49%), Clay (13%).			S3		100	▲ 6, 14, 17	
246	6	20		- Greenish grey, Dry to moist, fine grained gravel ends below 6.1 m.		6.7	S4		78	▲ 10, 16, 19	
245											

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-04**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
244	8	25		- With silt, trace fine grained to coarse grained gravel (up to 40 mm) below 7.6 m. - Grain size distribution at 7.8 m: Gravel (12%), Sand (25%), Silt (56%), Clay (7%).		7.6	S5		100	▲ 28 ▲ 35 ▲ 35	
243											
242.6	9	30		**SILTY SAND** - Grey, wet, very dense, and silt, some clay. - Solid stem refusal at 9.1 m. Switch to coring below 9.1 m.			S6		100	▲ 22 ▲ 28 ▲ 43	
242											
241.7	10			**SAND** - Grey, wet, medium grained, trace clay, trace fine grained to coarse grained gravel.			S6A		44		
241.1		35		**SILTY CLAY** - Grey, wet, trace fine grained to coarse grained gravel, trace sand. - Grain size distribution at 10.9 m: Gravel (9%), Sand (31%), Silt (55%), Clay (5%).			S7		100		
241	11										
240											
239.6	12	40		**SILTY CLAY TILL** - Grey, wet, hard, trace fine grained gravel (up to 10 mm).			S8		33	▲ 50 spoon refusal	
239	13					13.6					
238		45									
237	14					14.5					
	15	50									

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-04**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
236.2				- Moist below 15.4 m.				S9	33	▲ 50 spoon refusal	
				END OF TEST HOLE at 15.5 m							
236	16			Notes: 1. Installed 2 standpipe (1" ø) piezometers, one slotted from 13.6 m to 14.5 m and one slotted from 6.7 m to 7.6 m. Installed pressure gauge in standpipe at 14.5 m below grade. 2. Water level in standpipe installed in silty clay till at 1.4 m above grade (artesian) upon completion of drilling on June 14, 2015.							
235	17	55									
234	18	60									
233	19										
232	20	65									
231	21	70									
230	22										
229	23	75									

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-05**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 21+464, ROUTE D
DRILLING METHOD 125 mm ø Solid Stem Auger, HQ Core Barrel, Acker Renegade

JOB NO. **12-0300-011**
GROUND ELEV. **247.09 m**
TOP OF PVC ELEV.
WATER ELEV. **246.19 m**
DATE DRILLED **6/14/2015**
UTM (m) N **5,701,483** E **532,787**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
247				**TOPSOIL** - Black, moist, with organics.							
246.8				**SILTY CLAY** - Light grey, moist, stiff, trace angular fine grained to coarse grained gravel (up to 30 mm).							
246	1	5					S1		100	▲ 4, ▲ 7, ▲ 8	●
245	2										
244	3	10		- Grey, very stiff, some angular fine grained to coarse grained gravel (up to 40 mm) below 3.0 m. - Grain size distribution at 3.3 m: Gravel (12%), Sand (30%), Silt (45%), Clay (13%).			S2		100	▲ 5, ▲ 10, ▲ 13	⊣●
243	4	15		- Some sand, coarse grained gravel ends below 4.6 m.			S3		94	▲ 13, ▲ 11, ▲ 68 spoon refusal	●
242	5										
241	6	20		- Hard, trace coarse grained gravel (up to 30 mm) below 6.1 m. - Grain size distribution at 6.3 m: Gravel (15%), Sand (31%), Silt (43%), Clay (11%).		6.7	S4		94	▲ 25, ▲ 22, ▲ 27	⊣●

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR **Maple Leaf Enterprises**
INSPECTOR **G. Mediwake**
APPROVED DFT
DATE 7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-05**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
240										20 40 60	20 40 60 80
	8	25		- Dry to moist below 7.6 m.		7.6	S5		100	▲18 ▲25 ▲28	●
239											
238	9	30		- Trace sand below 9.1 m. - Grain size distribution at 9.4 m: Gravel (12%), Sand (29%), Silt (46%), Clay (13%).			S6		100	▲44 ▲28 ▲26	●—■
237	10										
		35		- Light grey below 10.7 m.		11.0	S7		100	▲19 ▲26 ▲26	●
236	11										
235	12					11.9					
234.9		40		**SANDY CLAY TILL** - Grey, wet, hard, some sand, trace fine grained to coarse grained gravel (up to 50 mm). - Grain size distribution at 12.4 m: Gravel (31%), Sand (46%), Silt (18%), Clay (5%).			S8		67	▲34 ▲44 spoon refusal	●—■
234.4				**END OF TEST HOLE at 12.6 m**							
234	13			Notes: 1. Installed 2 standpipe (1" ø) piezometers, one slotted from 11.0 m to 11.9 m and one slotted from 6.7 m to 7.6 m. 2. Water level in test hole at 0.9 m below grade upon completion of drilling on June 14, 2015.							
		45									
233	14										
232	15	50									

SAMPLE TYPE ☒ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-10A**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 17+800, ROUTE D
DRILLING METHOD 125 mm ø Solid Stem Auger, Acker Renegade

JOB NO. **12-0300-011**
GROUND ELEV. **248.87 m**
TOP OF PVC ELEV.
WATER ELEV. **230.13 m**
DATE DRILLED **6/18/2015**
UTM (m) N **5,698,130** E **531,200**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
248.6	0	0		**TOPSOIL** - Black, moist, with organics.								
				SILTY CLAY - Grey, moist, very stiff, trace silt pockets, trace oxidation, trace organics, trace fine grained gravel (up to 15 mm).								
248	1	5										
247	2						S1		100	▲4 ▲13 ▲12		
246	3	10		- Moist to wet, stiff below 3.0 m.			S2		67	▲9 ▲7 ▲6		
245	4	15		- Greenish grey, moist, firm, some angular fine grained and coarse grained gravel (up to 40 mm) below 4.6 m. - Grain size distribution at 4.8 m: Gravel (16%), Sand (29%), Silt (44%), Clay (11%).			S3		94	▲2 ▲3 ▲5		
244	5											
243	6	20		- Soft below 6.1 m.			S4		89	▲1 ▲1 ▲1		
242												

SAMPLE TYPE ☒ Split Spoon ⚿ Auger Grab

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-10A**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
241	8	25		- Grain size distribution at 7.8 m: Gravel (18%), Sand (41%), Silt (32%), Clay (9%).	VW	7.5 7.6	S5		39	▲1 ▲1 ▲1	
240	9										
239.7		30		**SILT TILL** - Grey, dry, very dense, trace fine grained gravel (up to 10 mm). - Grain size distribution at 9.4 m: Gravel (8%), Sand (38%), Silt (42%), Clay (12%).			S6		83	▲74 spoon refusal	
239	10										
		35		- Trace coarse grained gravel (up to 50 mm) below 10.7 m.			S7		67	▲78 spoon refusal	
238	11										
237	12	40		- Decreasing coarse grained gravel below 12.2 m. - Grain size distribution at 12.4 m: Gravel (1%), Sand (31%), Silt (54%), Clay (14%).			S8		67	▲70 spoon refusal	
236	13										
		45					S9		67	▲50 spoon refusal	
235	14										
234	15	50								▲50 spoon refusal	

SAMPLE TYPE ☒ Split Spoon ⚿ Auger Grab

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-10A**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
233	16	55		- Grain size distribution at 15.5 m: Gravel (4%), Sand (34%), Silt (50%), Clay (12%).				S10	50		
232	17							S11			
231	18	60		- Greenish grey, dry to moist, hard, some clay below 18.3 m.		17.4					
230.1				- Grain size distribution at 18.5 m: Gravel (11%), Sand (30%), Silt (48%), Clay (11%).		18.3		S12		▲26 ▲46 ▲42	
230	19			**END OF TEST HOLE at 18.7 m**							
229	20	65									
228	21	70									
227	22										
226	23	75									

Notes:
1. Installed standpipe (1" ø) piezometer slotted from 17.4 m to 18.3 m.
2. Installed water saturated vibrating wire piezometer to a depth of 10.4 m below grade.
3. Water level in test hole at bottom of hole upon completion of drilling on June 18, 2015.

SAMPLE TYPE ☒ Split Spoon ⊠ Auger Grab

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	G. Mediwake	DFT	7/22/15

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H. MANALO CONSULTING LTD.
1402 Notre Dame Avenue, Winnipeg, MB R3E 3G5
PHONE: 204 697-3854 CELL: 204 997-1355
hmanalo@mts.net

Project: **Assiniboine River & Lake Manitoba Basins Flood Route C**			**Client: KGS Group**	**Laboratory Tests Results**							
TH Number	**Sample No.**	**Depth (ft)**	**Sample Description** (provided by Client)	**Moisture Content (%)**	**Atterberg Limits**			**Soil Composition**			
					LL	**PL**	**PI**	**% Gravel**	**% Sand**	**% Silt**	**% Clay**
15-RC-01	S-1	5'	Silty Clay	10.0							
	S-2	10'	Silty Clay	7.0	17	10	7	14	37	38	11
	S-2A	11'	Silt	6.0							
	S-3	15'	Silt	8.0	14	11	3	8	40	45	7
	S-4A	20'	Sand	12.0							
	S-4B	20'	Silty Clay	7.0							
15-RC-04	S-1	5'	Silty Clay	8.0							
	S-2	10'	Clay	8.0	15	11	4	11	37	42	10
	S-3	15'	Clay	8.0	15	11	4	13	41	38	8
	S-4	20'	Clay	10.0							
	S-5	25'	Clay	8.0	16	10	6	35	32	26	7
	S-6	30'	Clay	9.0							
	S-7	35'	Clay	8.0	16	9	7	25	31	35	9
15-RC-06	S-1	5'	Silty Clay	7.0							
15-RD-01	S-1	5'	Silty Clay	22.0							
	S-2	10'	Silty Clay	11.0							
	S-3	15'	Silty Clay	11.0	18	10	8	1	45	41	13
	S-4	20'	Silty Clay	10.0							
	S-5	25'	Silty Clay	8.0	16	11	5	7	34	50	9
	S-6	30'	Silty Clay	9.0							
	S-7	35'	Sand	13.0							
	S-8	40'	Sand Till	10.0	16	10	6	7	50	33	10

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Project: **Assiniboine River & Lake Manitoba Basins Flood Route C**			**Client: KGS Group**	**Laboratory Tests Results**							
TH Number	**Sample No.**	**Depth (ft)**	**Sample Description** (provided by Client)	**Moisture Content (%)**	**Atterberg Limits**			**Soil Composition**			
					LL	**PL**	**PI**	**% Gravel**	**% Sand**	**% Silt**	**% Clay**
15-RD-01	S-9	50'	Clay Till	8.0	17	10	7	2	43	42	13
	S-9A	52'	Clay Till	6.0							
	S-10	55'	Clay Till	4.0							
	S-11	60'	Clay Till	9.0	14	11	3	14	50	30	6
	S-11A	62'	Clay Till	7.0							
	S-12	66'	Clay Till	7.0	16	10	6	4	29	56	11
15-RD-02	S-1	5'	Silty Clay	18.0							
	S-2	10'	Silty Clay	12.0	19	11	8	7	32	48	13
	S-3	15'	Silty Clay	11.0							
	S-4	20'	Silty Clay	11.0	15	10	5	9	41	40	10
	S-5	25'	Silty Clay Till	9.0	16	10	6	26	29	35	10
	S-6	30'	Silty Clay Till	10.0							
	S-7	35' '	Silty Clay Till	10.0	16	9	7	9	35	44	12
	S-8	40'	Silty Clay Till	12.0							
	S-9	45'	Silty Clay Till	9.0	14	10	4	5	37	49	9
	S-10	50'	Sand	14.0							
15-RD-03	S-1	5'	Silty Clay	10.0							
	S-2	10'	Silty Clay Till	7.0	17	10	7	32	28	30	10
	S-3	15'	Silty Clay Till	9.0							
	S-4	20'	Silty Clay Till	8.0	15	10	5	29	28	34	9

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Project: **Assiniboine River & Lake Manitoba Basins Flood Route C**			**Client: KGS Group**	**Laboratory Tests Results**							
TH Number	**Sample No.**	**Depth (ft)**	**Sample Description** (provided by Client)	**Moisture Content (%)**	**Atterberg Limits**			**Soil Composition**			
					LL	**PL**	**PI**	**% Gravel**	**% Sand**	**% Silt**	**% Clay**
15-RD-03	S-5	25'	Silty Clay Till	3.0							
	S-5A	26'	Silty Clay Till	9.0							
	S-6	30'	Silty Clay Till	8.0	17	10	7	30	30	31	9
	S-7	45'	Clay Till	8.0	16	9	7	31	22	38	9
	S-8	49'	Clay Till	8.0							
15-RD-04	S-1	5'	Silty Clay	16.0							
	S-2	10'	Silty Clay	10.0							
	S-3	15'	Silty Clay	9.0	18	10	8	10	28	49	13
	S-4	20'	Silty Clay	9.0							
	S-5	25'	Silty Clay	9.0	15	10	5	12	25	56	7
	S-6	30'	Silty Sand	14.0	Non-plastic						
	S-7	35'	Silty Clay	13.0	Non-plastic			9	31	55	5
	S-8	40'	Silty Clay Till	8.0							
	S-9	50'	Silty Clay Till	In the list but not found in the bags of samples							
15-RD-05	S-1	5'	Silty Clay	11.0							
	S-2	10'	Silty Clay	9.0	17	11	6	12	30	45	13
	S-3	15'	Silty Clay	9.0							
	S-4	20'	Silty Clay	7.0	15	9	6	15	31	43	11
	S-5	25'	Silty Clay	7.0							

H. MANALO CONSULTING LTD.
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hmanalo@mts.net

Project: **Assiniboine River & Lake Manitoba Basins Flood Route C**			**Client: KGS Group**	**Laboratory Tests Results**							
TH Number	**Sample No.**	**Depth (ft)**	**Sample Description** (provided by Client)	**Moisture Content (%)**	**Atterberg Limits**			**Soil Composition**			
					LL	**PL**	**PI**	**% Gravel**	**% Sand**	**% Silt**	**% Clay**
15-RD-05	S-6	30'	Silty Clay	8.0	18	10	8	12	29	46	13
	S-7	35'	Silty Clay	8.0							
	S-8	40'	Sandy Clay Till	7.0	14	10	4	31	46	18	5
15-RD-10A	S-1	5'	Silty Clay	17.0							
	S-2	10'	Silty Clay	9.0							
	S-3	15'	Silty Clay	10.0	16	10	6	16	29	44	11
	S-4	20'	Silty Clay	12.0							
	S-5	25'	Silty Clay	11.0	17	10	7	18	41	32	9
	S-6	30'	Silt Till	5.0	17	10	7	8	38	42	12
	S-7	35'	Silt Till	7.0							
	S-8	40'	Silt Till	6.0	16	9	7	1	31	54	14
	S-9	45'	Silt Till	7.0							
	S-10	50'	Silt Till	6.0	17	10	7	4	34	50	12
	S-11	55'	Silt Till	7.0							
	S-12	60'	Silt Till	7.0	15	10	5	11	30	48	11
Additional Tests		Note: Samples were received from Client placed inside packing bags and labeled, but not found in the list provided									
15-RD-02	DS-7A	39'	———	6.0							
15-RD-03	FS-06A	33'	———	18.0							
15-RD-03	DS-6B	36'	———	2.0							
15-RD-04	FS-06A	33'	———	12.0							
15-RD-04	AS-09A & 09B	50' to 50'-6"	———	14.0							
		Number of Tests		**80**	**35**			**34**			

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-04A**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE 2 km north of steep rock junction
LOCATION 5 m south of 15-RD-PW1
DRILLING METHOD Mud Rotary

JOB NO. 12-0300-011
GROUND ELEV. 251.76 m
TOP OF PVC ELEV. 252.62 m
WATER ELEV. 253.75 m
DATE DRILLED 30/07/2015
UTM (m) N 5,699,450
E 531,894

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
251	1	5		**SILTY CLAY TILL** - Light brown.						20 40 60	20 40 60 80
250	2										
249	3	10									
248	4										
247	5	15									
246	6	20									
245.7				**GRANITE BOULDERS**							
244.9	7			**TILL** - Light grey/tan.							
244	8	25									
243	9										
242		30									

SAMPLE TYPE

CONTRACTOR Maple Leaf Enterprises
INSPECTOR A. SINCLAIR
APPROVED
DRAFT
DATE 6/8/15

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2012\12-0300-011\DESIGN\ENV\LOGS\MIT_12-0300-011_LOGS.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-04A**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE / NUMBER / RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
241	11	35						20 40 60	20 40 60 80
240	12	40							
239	13			- Dense, with cobbles below 12.50 m.					
238	14	45							
237.1									
237	15	50		**CLAY TILL** - Medium dense.		15.5			
236	16					15.8			
235.5				**LIMESTONE** - White with yellow streaks.					
235	17	55							
234	18	60		- Softer below 18.29 m.		17.7			
233						18.6			
232.6	19					19.2			
232	20	65		**END OF HOLE AT 19.20 m**.					
231	21	70							
230									

Notes:
1. Installed 50 mm diameter PVC casing with 0.86 m stickup and protective steel casing.
2. Installed pressure gauge at top of casing.
3. Flowing artesian conditions observed during drilling.

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	A. SINCLAIR	DRAFT	6/8/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-04B**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE 2 km north of steep rock junction
LOCATION 100 m south of 15-RD-PW1
DRILLING METHOD Mud Rotary

JOB NO. 12-0300-011
GROUND ELEV. 251.76 m
TOP OF PVC ELEV. 252.60 m
WATER ELEV. 573.78 m
DATE DRILLED 31/07/2015
UTM (m) N 5,699,354
E 531,943

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG
251	1	5		**TILL** - Light brown, dry.	
250	2				
249	3	10			
248	4				
247	5	15			
246.6				**CLAY TILL** - Grey/brown.	
246	6	20			
245	7				
244		25			
243.5	8			**COBBLES**	
243.3					
	9	30		**TILL** - Grey/brown.	
242.3					
242				**SAND** - Fine grained.	

DEPTH (m) | SAMPLE TYPE | NUMBER | RECOVERY %

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE

CONTRACTOR Maple Leaf Enterprises
INSPECTOR A. SINCLAIR
APPROVED DRAFT
DATE 6/8/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO.
15-RD-04B

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80) / PL MC LL % (20 40 60 80)
241.7				**SAND/SILT** - Very fined grained sand.							
241		35									
240.8	11			**SAND** - Fine to medium grained.							
240											
239.9	12	40		**TILL** - Grey/brown.							
239.6				**CLAY** - Light brown.							
239	13										
238.3				**CLAY TILL** - Medium dense.							
238		45									
	14					14.6					
237						14.9					
	15										
236.5		50		**LIMESTONE** - White.							
236											
	16					16.2					
				- Fractures at 16.61 m.							
235		55									
	17					17.1					
				- Softer below 17.37 m. - Fractures at 17.53 m.							
234											
	18										
233.5		60		- Fractures at 18.14 m.		18.3					
				END OF DRILLING 18.29 m.							
233											
	19			Notes: 1. Installed 50 mm diameter PVC casing with 0.84 m stickup. 2. Installed pressure gauge at top of casing. 3. Flowing artesian conditions observed during drilling.							
232		65									
	20										
231											
	21										
230		70									

SAMPLE TYPE

CONTRACTOR
Maple Leaf Enterprises

INSPECTOR
A. SINCLAIR

APPROVED
DRAFT

DATE
6/8/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **15-RD-PW1**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE 2 km north of steep rock junction
LOCATION 5 m west of 15-RD-04
DRILLING METHOD Mud Rotary

JOB NO. 12-0300-011
GROUND ELEV. 251.76 m
TOP OF PVC ELEV. 252.67 m
WATER ELEV. 253.68 m
DATE DRILLED 30/07/2015
UTM (m) N 5,699,447
E 531,897

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
251	1	5		**SILTY CLAY TILL** - Light brown.		0.3					
250	2										
249	3	10									
248	4										
247	5	15		- Densed below 4.57 m.							
246	6	20									
245	7										
244	8	25		- Light grey/brown below 7.62 m.							
243	9	30									
242.0 242				**SAND** - Fine to medium grained sand.							

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	A. SINCLAIR	DRAFT	6/8/15

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2012\12-0300-011\DESIGN\ENV\LOGS\MIT_12-0300-011_LOGS.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO.
15-RD-PW1

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80) / PL MC LL % (20 40 60 80)
241		35									
240.8	11			**TILL** - Light grey/brown.							
240											
	12	40		- Dense below 11.89 m.							
239											
	13										
238		45									
	14										
237											
	15	50									
236						15.7					
	16					16.0					
235.5				**LIMESTONE** - White, hard.							
235		55				16.8					
	17										
234											
	18	60		- Yellow, soft below 17.98 m. - White below 18.14 m. - Red shale between 18.44 and 21.34 m.							
233											
	19										
232		65									
	20			- Softer limestone at 19.81 m.							
231											
	21	70									
230											

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	**A. SINCLAIR**	DRAFT	6/8/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO.
15-RD-PW1

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
229	22	75								20 40 60	20 40 60 80
228.6	23			**END OF HOLE AT 23.16 m.**		23.2					
228	24	80		Note: 1. Installed 125 mm diameter PVC casing with 0.94 m stickup and protective steel casing. 2. Flowing artesian conditions observed during drilling.							
227	25										
226	26	85									
225	27										
224	28	90									
223	29	95									
222	30										
221	31	100									
220	32										
219	33	105									
		110									

SAMPLE TYPE

CONTRACTOR **Maple Leaf Enterprises** | INSPECTOR **A. SINCLAIR** | APPROVED DRAFT | DATE 6/8/15

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APPENDIX F

DETAILED FIELD INVESTIGATION RESULTS

FOR LSM OUTLET CHANNEL – REACH 1, 2 AND 3

DRAFT

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-01**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION

PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY

SITE LAKE ST. MARTIN EMERGENCY CHANNELS

LOCATION STA. 00+532, REACH 1- SOUTH SIDE OF INLET

DRILLING METHOD 150 mm ø Hollow Stem Auger, NQ, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV. **247.74 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/4/2015**
UTM (m) N **5,739,654**
E **553,417**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
247	1	5		**SILTY CLAY FILL** - Brown, damp, stiff, low to intermediate plasticity, some silt pockets, some fine to coarse grained sand, some medium to coarse grained gravel (up to 20 mm).								
				- Frost to 1.2 m. - Silt pocket (approximately 500 mm) at 1.2 m. - Grain size distribution at 1.4 m: Gravel (9%), Sand (24%), Silt (40%), Clay (27%).			S1				
246	2											
245.6				**ORGANIC CLAY** - Dark brown, damp to moist, soft, intermediate plasticity, with organics, with rootlets, organic odor. - 10.3% Organic content at 2.4 m.		2.4	S2				
245.0	3	10		**SILTY CLAY** - Grey, damp, stiff, high plasticity, some silt pockets, some fine grained gravel. - Grain size distribution at 2.9 m: Gravel (2%), Sand (14%), Silt (23%), Clay (61%). - Grain size distribution at 3.3 m: Gravel (3%), Sand (11%), Silt (24%), Clay (63%).		3.0	S3				> 100
244.2				**SILTY CLAY TILL** - Grey, damp, stiff, high plasticity, trace fine to coarse grained gravel. - Grain size distribution at 3.7 m: Gravel (3%), Sand (6%), Silt (19%), Clay (71%). - Estimated hydraulic conductivity was 1.7x10e-9 m/s from 3.7 to 5.0 m. - Limestone cobble from 4.3 to 4.6 m.		3.7	S4		61	▲ 2 ▲ 3 ▲ 5		
244	4						S5					
243.2		15		**SILT TILL** - Tan to grey, damp, compact, non plastic to low plasticity, trace to some clay. - Grain size distribution at 4.8 m: Gravel (12%), Sand (22%), Silt (44%), Clay (21%).		4.6					
243	5					5.0	S6		83	▲ 7 ▲ 7 ▲ 8		
242	6	20		- Grey, dense, non plastic, some fine to coarse grained sand, trace to some fine to coarse grained gravel below 6.1 m. - Trace cobbles between 6.1 and 7.6 m. - Grain size distribution at 6.3 m: Gravel (10%), Sand (23%), Silt (46%), Clay (21%).			S7		89	▲ 12 ▲ 15 ▲ 17		
241												

SAMPLE TYPE ▨ Auger Grab ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2012\12-0300-011\DESIGN\GEO\LOGS\LSM STAGE 2 INVESTIGATIONS\2015_TESTPITINVESTIGATION.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-01**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
240	8	25		- Grain size distribution at 7.8 m: Gravel (14%), Sand (23%), Silt (44%), Clay (20%).		7.5	S	8	100	▲ 7, 7, 10	
239	9	30		- Grain size distribution at 9.4 m: Gravel (11%), Sand (25%), Silt (47%), Clay (18%).		9.1	S	9	92	▲ 8, 12, 21	
238	10					9.6					
237	11	35		- Very dense, non plastic, some medium to coarse grained sand, some fine grained gravel, trace clay below 10.68 m. - Grain size distribution at 10.9 m: Gravel (9%), Sand (34%), Silt (37%), Clay (21%). - Suspected cobble or boulder from 11.3 to 11.6 m.			S	10	100	▲ 9, 27, 29	
236	12	40		- Dry to damp from 12.2 to 15.3 m. - Dense below 12.2 m. - Grain size distribution at 12.4 m: Gravel (10%), Sand (28%), Silt (43%), Clay (19%).			S	11	100	▲ 20, 21, 21	
235	13					13.7					
234	14	45		- Grain size distribution at 13.9 m: Gravel (11%), Sand (29%), Silt (43%), Clay (18%).			S	12	100	▲ 16, 23, 21	
233	15	50								▲ 11	

SAMPLE TYPE: Auger Grab ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2012\12-0300-011\DESIGN\GEO\LOGS\LSM STAGE 2 INVESTIGATIONS\2015_TESTPITINVESTIGATION.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-01**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
232	16			- Compact, trace medium to coarse grained sand, trace medium grained gravel below 15.3 m. - Grain size distribution at 15.5 m: Gravel (7%), Sand (28%), Silt (44%), Clay (21%).				S13	100	▲12 ▲14	
231	17	55		- Dense, non plastic to low plasticity, some clay below 16.8. - Grain size distribution at 17.0 m: Gravel (10%), Sand (24%), Silt (44%), Clay (23%).				S14	72	▲9 ▲13 ▲23	
230	18	60		- Compact below 18.3 m. - Grain size distribution at 18.5 m: Gravel (11%), Sand (24%), Silt (41%), Clay (24%).				S15	83	▲11 ▲12 ▲14	
229	19										
228	20	65		- Non plastic, dense, increased fine to medium grained gravel, decreased clay content below 19.3 m. - Grain size distribution at 20.0 m: Gravel (12%), Sand (31%), Silt (35%), Clay (23%).			S16	89	▲11 ▲17 ▲17	
227	21	70		- Hollow stem refusal at 20.5 m. Switched to NQ coring below 20.5 m. **NO RECOVERY**							
226	22			- No recovery from 20.5 to 24.4 m.							
225	23	75									

SAMPLE TYPE ▨ Auger Grab ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO.
TH15-01

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
224	24										
223.4		80		**SILT TILL** - Light grey, moist, loose, low plasticity, some medium to coarse grained sand. -Suspected deposit became softened as a result of washboring with NQ barrel. - Grain size distribution at 24.6 m: Gravel (4%), Sand (4%), Silt (53%), Clay (39%).			S17		67	▲7 ▲1 ▲3	
223	25					25.1					
222	26	85		- SPT at 25.9 m was bouncing on suspected cobble/boulder after 75 mm penetration into second set.		26.2				▲2 ▲10	
221.0	27			**LIMESTONE** - Tan, lightly to moderately jointed. - Run 1 from 26.7 to 27.3 m. 84% RQD, 4 joints. - Lost drill water circulation at 26.9 m.				R1	98		
220		90		- 150 mm long broken core zone at 27.3 m. - Run 2 from 27.3 to 28.6 m. 72% RQD,7 joints.		27.7		R2	94		
219.1	28			- Yellow, trace pitting and vugs (up to 10 mm) below 27.8 m. - Core barrel plugged drilling past 27.8 m.		28.6					
219	29	95		**END OF HOLE AT 28.6 m**							
218	30	100		Notes: 1. Installed 3 standpipe piezometers, one slotted from 26.2 to 27.7 m, one slotted from 7.6 and 9.1 m and one slotted from 3.1 to 4.6 m. 2. Test hole sloughed in from 13.7 to 25.2 m after retracting NWT casing. 3. Hydraulic conductivity from 3.7 to 5.0 m estimated from falling head test completed on February 14, 2015. 4. Lower piezometer (26.2 to 27.7 m) was taking water at a rate of 15L/min on February 22, 2015 without filling. 5. Top of hole elevation estimated from 2011 LiDAR data plus depth of fill encountered.							
217	31										
216											

SAMPLE TYPE: Auger Grab ▨ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-02**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 16+756, REACH 3 INLET
DRILLING METHOD 150 mm ø Hollow Stem Auger, NQ DR150 BOMBARDIER

JOB NO. **12-0300-011**
GROUND ELEV. **234.16 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/9/2015**
UTM (m) N **5,747,519** E **564,754**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
234				**ICE**								
233.7				**PEAT** - Black, wet, with roots. - Frost to 0.6 m.								
233	1	5										
232.3				**SILT TILL** - Tan to brown, damp, loose, non plastic, with fine to coarse grained sand, trace fine grained gravel. - Grain size distribution at 2.13 m: Gravel (10%), Sand (27%), Silt (43%), Clay (19%).				S1				
232	2			- Dense below 2.6 m.				S2				
231	3	10		- Grain size distribution at 2.90 m: Gravel (7%), Sand (31%), Silt (46%), Clay (17%). - Brown, some cobbles, some boulders below 3.1 m. - SPT at 3.1 m bouncing on suspected cobble at 125 mm penetration in first set. - Grain size distribution at 3.12 m: Gravel (5%), Sand (34%), Silt (43%), Clay (17%).				S3	100	▲ 78		
230	4	15		- Dry below 4.6 m. - SPT at 4.5 m terminated at 140 mm penetration into first set. - Grain size distribution at 4.65 m: Gravel (0%), Sand (31%), Silt (48%), Clay (20%).				S4	100	▲ 77		
229	5			- Suspected cobble at 5.3 m.								
228	6	20		- Grey below 6.1 m. - SPT at 6.1 m terminated at end of first, 150 mm set. - Grain size distribution at 6.17 m: Gravel (7%), Sand (30%), Silt (46%), Clay (17%). - Suspected boulder from 6.3 to 6.4 m.				S5	50	▲ 87		

SAMPLE TYPE: Auger Grab ▨ Split Spoon ▨ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-02**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
227											
	8	25		- Grain size distribution at 7.85 m: Gravel (6%), Sand (29%), Silt (46%), Clay (18%).			S6		87	▲42 ▲55 ▲80	●
226				- Gravel or cobbles at 8.4 m.							
	9	30		- With fine to coarse grained grave below 9.1 m.						▲40	
225				- Grain size distribution at 9.37 m: Gravel (30%), Sand (35%), Silt (24%), Clay (11%). - SPT re-pounded for sample recovery. - Suspected gravel or cobbles from 9.8 to 10.1 m.			S7		33	▲95 ▲106	●
	10										
224											
223.5		35		**CLAYEY SILT TILL** Grey, damp, very dense, low plasticity, with coarse grained sand, trace fine to coarse grained gravel. - Grain size distribution at 10.90 m: Gravel (10%), Sand (25%), Silt (44%), Clay (21%). - Suspected gravel or cobbles from 11.1 to 11.4 m.			S8		61	▲7 ▲24 ▲33	●
	11			- Hollow stem auger refusal at 11.4 m. Switched to NQ coring below. Hole stayed open to 10.4 m 16 hrs after retracting hollow stem auger.							
223											
222.3				**SILTY CLAY TILL** - Grey, intermediate plasticity, poor recovery including granitic boulder (190 mm ø), limestone cobbles(76 mm ø).			S9		38		
	12	40									
222											
221.7				**SILT TILL** - Grey, non plastic, some medium grained gravel, with fine to coarse grained sand, well graded, poor recovery included granitic boulder (200 mm ø) and limestone cobbles (76 mm ø).							
	13			- Grain size distribution at 13.18 m: Gravel (23%), Sand (18%), Silt (43%), Clay (16%).			S10		37		●
221		45									
220.2				**SILTY CLAY TILL** - Grey, intermediate plasticity, fine to medium grained gravel, poor recovery included fine to medium grained gravel.		14.3					
	14					14.6	S11		13		
220											
	15	50									
219											

SAMPLE TYPE: Auger Grab ▨ Split Spoon ☒ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-02**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %
218.7			**LIMESTONE** - Grey, weak, moderately fractured to lightly fractured.					
			- Run 1 from 15.5 to 17.0 m. 80% RQD, 12 joints.					
			- Trace staining at 15.8 m.					
	16				16.2		R1	100
218		55						
	17		- Run 2 from 17.0 to 18.5 m. 84% RQD, 9 joints.					
217							R2	100
	18		- Some pitting from 18.0 to 18.3 m.					
216		60						
215.6			**END OF HOLE AT 18.53 m**		18.5			
			Notes:					
	19		1. Backfilled test hole with silica sand from 18.5 to 14.3 m, slough from 14.3 to 5.2 and bentonite from 5.2 to grade.					
215			2. Artesian conditions observed in NWT casing embedded in bedrock immediately after drilling. Water level in casing stabilized from 0.75 m above grade to 1.96 m above grade in 45 min.					
		65	3. Top of hole elevation estimated from 2011 LiDAR data.					
	20							
214								
	21							
213		70						
	22							
212								
		75						
	23							
211								

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE ▨ Auger Grab ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-02A**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 16+755, REACH 3 INLET
DRILLING METHOD 150 mm ø Hollow Stem Auger, NQ DR150 BOMBARDIER

JOB NO. **12-0300-011**
GROUND ELEV. **235.34 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/11/2015**
UTM (m) N **5,747,502** E **564,749**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE / NUMBER / RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
235				**SILTY CLAY** - Grey, damp to moist, firm, intermediate plasticity.				20 40 60	20 40 60 80
				- Organics and peat from 0 to 0.3 m.					
234	1	5							
	2								
233									
232.9				**SILT TILL** - Brown, dry to damp, compact, with fine to coarse grained sand, trace fine to medium grained gravel.					
	3	10							
232									
	4								
231		15				4.6			
	5			- Estimated hydraulic conductivity was 5.9x10e-8 m/s from 4.6 to 6.7 m.		5.2			
230									
	6	20							
229									
228.6				**END OF HOLE AT 6.71 m**		6.7			
						6.7			

SAMPLE TYPE

CONTRACTOR **Maple Leaf Enterprises** | INSPECTOR **C. ROBAK** | APPROVED DRAFT | DATE 8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO.
TH15-02A

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
228				Notes:						20 40 60	20 40 60 80
	8	25		1. Installed 1 standpipe piezometer, slotted from 5.1 to 6.7 m.							
227				2. Backfilled test hole with silica sand from 6.7 to 4.6 m, and bentonite from 4.6 m to grade.							
	9	30		3. Standpipe dry immediately after installation.							
226				4. Hydraulic conductivity from 4.6 to 6.7 m estimated from falling head test completed on February 17, 2015.							
	10			5. Top of hole elevation estimated from 2011 LiDAR data.							
225		35									
	11										
224											
	12	40									
223											
	13										
222											
		45									
	14										
221											
	15										
		50									

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-03**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 17+311, REACH 3
DRILLING METHOD 150 mm ø Hollow Stem Auger, NQ DR150 BOMBARDIER

JOB NO. **12-0300-011**
GROUND ELEV. **237.01 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/11/2015**
UTM (m) N **5,757,424** E **565,309**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
236	1	5		**SILT FILL** - Brown, damp, compact to dense, non plastic to low plasticity, with clay, trace coarse grained sand, trace fine grained gravel.							
				- Frost to 0.9 m.							
				- Grain size distribution at 1.22 m: Gravel (5%), Sand (26%), Silt (53%), Clay (16%).				S1			
235.2				**ORGANIC CLAY** - Black, moist, soft, low plasticity, trace roots, trace coarse grained sand, organic odor.							
235	2							S2			
234.6				**SILTY CLAY TILL** - Grey, moist, soft, low plasticity, some medium to coarse grained sand, trace fine to medium grained gravel.							
				- Grain size distribution at 2.74 m: Gravel (9%), Sand (32%), Silt (41%), Clay (18%).				S3			
234.0	3	10		- SPT at 3.1 m bouncing on suspected cobble/boulder at start of first set.		3.0				▲10	
				SILT TILL - Brown, dry, very dense, some medium to coarse grained sand, trace fine grained gravel.							
233	4	15									
				- Dry to damp, some medium to coarse grained gravel, with granitic and limestone cobbles (up to 75 mm ø) below 4.6 m.				S4	100	▲75	
				- SPT at 4.6 m terminated after 100 mm penetration into first set.							
232	5			- Grain size distribution at 4.80 m: Gravel (1%), Sand (31%), Silt (50%), Clay (18%).		5.3		S5	25		
231	6	20									
230.8				**LIMESTONE** - White to tan, lightly fractured.							
				- Run 1 from 6.2 to 7.8 m. 97% RQD, 8 joints.							
				- Oxidized joint at 6.3 m.							
				- Yellow below 6.7 m.		6.9					

SAMPLE TYPE Auger Grab ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-03**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
				- Oxidized joint at 7.3 m.						20 40 60	20 40 60 80
		25									
229	8			- Increased pits and vugs (up to 15 mm ø) from 7.8 to 8.1 m. - Run 2 from 7.8 to 9.3 m. 100% RQD, 3 joints per run.				R1	100		
				- Increased pits and vugs (up to 15 mm ø) from 8.5 to 8.8 m.				R2	100		
228	9	30		- Mottled grey below 8.8 m.							
227.7				**END OF HOLE AT 9.30 m**		9.3					
227	10			Notes: 1. Installed 1 standpipe piezometer, slotted from 5.3 to 6.9 m. 2. Backfilled test hole with silica sand from 9.3 to 5.3 m, slough from 5.3 to 3.1 m and bentonite from 3.1 m to grade. 3. Falling head test in standpipe was fully dissipated in 4 minutes on February 14, 2015. 4. Top of hole elevation estimated from 2011 design top of dike profile.							
		35									
226	11										
225	12	40									
224	13										
		45									
223	14										
222	15	50									

SAMPLE TYPE Auger Grab Split Spoon Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-03A**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 17+311, REACH 3
DRILLING METHOD 150 mm ø Hollow Stem Auger, NQ DR150 BOMBARDIER

JOB NO. **12-0300-011**
GROUND ELEV. **237.01 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/12/2015**
UTM (m) N **5,757,424** E **565,309**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
236	1	5		**SILT FILL** - Brown, damp, compact to dense, non plastic to low plasticity, with clay, trace coarse grained sand, trace fine grained gravel, friable. - Frost to 0.9 m.						20 40 60	20 40 60 80	20 40 60 80
235.2												
235	2			**ORGANIC CLAY** - Black, moist, soft, low plasticity, trace roots, trace coarse grained sand, organic odor.								
234.6												
234	3	10		**SILT TILL** - Grey, moist, soft, low plasticity, some medium to coarse grained sand, trace fine to medium grained gravel. - Cobbles below 2.8 m. - Decreased clay content below 3.1 m. - Estimated hydraulic conductivity was 3.7x10e-9 m/s from 2.7 to 4.7 m.		2.7 3.2						
233	4											
232.3		15		**END OF HOLE AT 4.73 m**		4.7						
232	5			Notes: 1. Installed 1 standpipe piezometer, slotted from 3.2 to 4.7 m. 2. Backfilled test hole with silica sand from 4.7 to 2.8 m, and bentonite from 2.8 m to grade. 3. Standpipe dry immediately after installation. 4. Hydraulic conductivity from 2.7 to 4.7 m estimated from falling head test completed on February 18, 2015. 5. Top of hole elevation estimated from 2011 design top of dike profile.								
231	6	20										

SAMPLE TYPE

CONTRACTOR **Maple Leaf Enterprises** | INSPECTOR **C. ROBAK** | APPROVED DRAFT | DATE 8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-04**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 18+459, REACH 3
DRILLING METHOD 125 mm ø Solid Stem Auger, NQ DR150 BOMBARDIER

JOB NO. **12-0300-011**
GROUND ELEV. **236.67 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/13/2015**
UTM (m) N **5,747,909**
E **566,241**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
236	1	5		**SILTY CLAY FILL** - Brown, damp to moist, stiff, intermediate to high plasticity, some sand, trace gravel (up to 20 mm ø).			S1				
				- Grain size distribution at 0.61 m: Gravel (2%), Sand (19%), Silt (40%), Clay (39%). - Very stiff below 0.8 m.							
				- Grain size distribution at 1.37 m: Gravel (1%), Sand (15%), Silt (28%), Clay (56%).			S2				
235.1				**PEAT** - Light brown, saturated, fibrous to hemic.			S3				400
235											
234.8	2	10		**SILTY CLAY TILL** - Grey, moist, soft to firm, intermediate to high plasticity, some medium to coarse grained sand, some light grey sand seams, trace fine to coarse grained gravel. - Grain size distribution at 2.13 m: Gravel (4%), Sand (24%), Silt (29%), Clay (43%). - Stiff to very stiff below 2.3 m.			S4				
234											
	3			- Grain size distribution at 2.90 m: Gravel (1%), Sand (13%), Silt (23%), Clay (63%).			S5				
233.3				**SILT TILL** - Tan to brown, dry, very dense, non plastic, with medium to coarse grained sand, trace fine grained gravel.			S6				
233				- Grain size distribution at 3.66 m: Gravel (2%), Sand (32%), Silt (45%), Clay (20%).							
	4	15									
232				- SPT at 4.6 m terminated after 75 mm penetration into second set. - Grain size distribution at 4.69 m: Gravel (5%), Sand (26%), Silt (49%), Clay (20%).			S7	7		▲38 ▲50	
	5										
231											
	6	20		- Solid stem auger refusal at 6.1 m. Switched to NQ coring below.							
230											

SAMPLE TYPE: Auger Grab ▨ | Split Spoon ☒ | Core Barrel ▮

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-04**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
229	8	25		- Grey, damp, some to with fine to coarse grained gravel below 7.9 m. - Cemented silt till recovery from 7.9 to 10.0 m.					7	20 40 60	20 40 60 80
228	9	30		- Limestone cobble (75 mm ø) at 8.9 m.				S8	94		
227				- Some fine to coarse grained sand, trace coarse grained gravel below 9.4 m.							
226	10	35				10.1		S9	45		
225	11					10.6					
224.2	12	40		**LIMESTONE** - Grey to yellow, weak, moderately fractured to fractured. - Run 1 from 12.4 to 13.9 m. 43% RQD, 7 joints.		12.1		S10	28		
224	13							R1	91		
223		45		- Decomposed rock with silt/clay infilling from 13.4 to 13.8 m. - Grey, weak limestone below 13.8 m. - Run 2 from 13.9 to 15.5 m. 90% RQD, 10 joints. - Oxidized joint at 14.0 m. - Lightly fractured below 14.0 m.							
222	14							R2	100		
	15	50									

SAMPLE TYPE Auger Grab ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO.
TH15-04

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80) / PL MC LL % (20 40 60 80)
221.2				**END OF HOLE AT 15.48 m**		15.5					
221	16	55		Notes: 1. Installed 1 standpipe piezometer, slotted from 10.64 to 12.17 m. 2. Backfilled test hole with silica sand from 15.5 to 10.1 m, and grout from 10.1 m to grade. 3. Top of hole elevation estimated from 2011 design top of dike profile.							
220	17										
219	18	60									
218	19										
217	20	65									
216	21	70									
215	22										
214	23	75									

SAMPLE TYPE Auger Grab Split Spoon Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-04A**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 18+459, REACH 3
DRILLING METHOD 125 mm ø Solid Stem Auger, NQ DR150 BOMBARDIER

JOB NO. **12-0300-011**
GROUND ELEV. **236.67 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/14/2015**
UTM (m) N **5,747,909** E **566,241**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE / NUMBER / RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
236				**SILTY CLAY FILL** - Brown, damp to moist, stiff, intermediate plasticity, some sand, trace gravel.				20 40 60	20 40 60 80
	1	5							
235									
234.7	2			**PEAT** - Light brown, saturated, fibrous.					
234.1									
234				**SILTY CLAY** - Grey.					
	3	10							
233.0									
233				**SILT TILL** - Brown, dry, very dense.		4.2			
	4					4.5			
		15							
232				- Estimated hydraulic conductivity was 9.1x10e-8 m/s from 4.2 to 6.1 m.					
	5								
231									
	6					6.0			
230.6		20				6.1			
				END OF HOLE AT 6.10 m					
230				Notes:					
				1. Installed 1 standpipe piezometer, slotted from 4.5 to 6.0 m. 2. Backfilled test hole with silica sand from 6.1 to 4.2 m, and bentonite from 4.2 m to grade.					

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO.
TH15-04A

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80) / PL MC LL % (20 40 60 80)
229	8	25		3. Standpipe dry immediately after installation. 4. Hydraulic conductivity from 4.2 to 6.1 m estimated from falling head test on February 19, 2015. 5. Top of hole elevation estimated from 2011 design top of dike profile.							
228	9	30									
227	10	35									
226	11										
225	12	40									
224	13										
223	14	45									
222	15	50									

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-05**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 19+424, REACH 3
DRILLING METHOD 125 mm ø Solid Stem Auger, NQ, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV. **234.70 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/15/2015**
UTM (m) N **5,748,866** E **566,369**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
234	1	5		**SILTY CLAY FILL** - Brown, very stiff, intermediate plasticity, some fine to coarse grained sand, some light brown silt seams, frozen. - Grain size distribution at 0.61 m: Gravel (2%), Sand (21%), Silt (22%), Clay (55%).			S1					
233.2				**PEAT** - Dark brown, moist, hemic.								
233	2						S2					
232.6				**SILTY CLAY TILL** - Grey, damp to moist, firm, high plasticity, trace medium to coarse grained sand, trace fine grained gravel. - Increasing stiffness with depth.								
232	3	10		- Grain size distribution at 2.90 m: Gravel (2%), Sand (7%), Silt (16%), Clay (75%).		3.2	S3					
231.4				**SILT TILL** - Brown, damp, compact, non plastic to low plasticity, with clay, with medium grained sand, trace fine grained gravel, trace cobbles.								
231	4			- Grain size distribution at 3.81 m: Gravel (6%), Sand (21%), Silt (45%), Clay (28%).			S4					
230	5	15		- Dry to damp, very dense, non plastic, some medium to coarse grained sand below 4.6 m. - Grain size distribution at 4.80 m: Gravel (7%), Sand (11%), Silt (54%), Clay (28%).			S5		92	▲ 10 ▲ 42 ▲ 42		
229	6	20		- Grain size distribution at 5.94 m: Gravel (1%), Sand (20%), Silt (49%), Clay (30%). - Grey, damp, dense below 6.3 m. - Grain size distribution at 6.32 m: Gravel (8%), Sand (16%), Silt (47%), Clay (29%).		5.9	S6					
228				- Solid stem auger refusal at 6.9 m. Hole sloughed into 5.8 m while		6.8	S7		100	▲ 25 ▲ 20 ▲ 18		

SAMPLE TYPE ⊠ Auger Grab ⊠ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO.
TH15-05

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
227.6				switching to NQ coring.						20 40 60	20 40 60 80
				LIMESTONE - White, moderately fractured. - Run 1 from 7.1 to 7.5 m. 37% RQD, 3 joints. - Weathered yellow broken core zone from 7.1 to 7.2 m. - Run 2 from 7.5 to 9.0 m. 76% RQD, 14 joints. - Lightly fractured below 7.5 m.		7.5		R1	80		
227	8	25				7.5					
				- Yellow, weak below 8.5 m.				R2	100		
226	9	30		- Run 3 from 9.0 to 10.6 m. 68% RQD, 15 joints. - Brown, moderate strength from 9.1 to 9.2 m. - Circulation temporarily lost drilling past a 50 mm broken core zone at 9.2 m. - Grey, weak to moderate strength, moderately fractured below 9.6 m.		9.0					
225	10							R3	100		
224.1		35		**END OF HOLE AT 10.57 m**		10.6					
224	11			Notes: 1. Installed 1 standpipe piezometer, slotted from 7.6 to 9.2 m. 2. Backfilled test hole with silica sand from 10.6 to 7.6 m, slough from 7.6 to 6.8 m, bentonite from 6.8 m to 5.9, slough from 5.9 to 3.2, and bentonite from 3.2 m to grade. 3. Falling head test in standpipe was fully dissipated in 30 seconds on February 18, 2015. 4. Top of hole elevation estimated from 2011 design top of dike profile.							
223	12	40									
222	13										
221	14	45									
220	15	50									

SAMPLE TYPE ▨ Auger Grab ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-05A**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION

PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY

SITE LAKE ST. MARTIN EMERGENCY CHANNELS

LOCATION STA. 19+424, REACH 3

DRILLING METHOD 125 mm ø Solid Stem Auger, NQ, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV. **234.70 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/15/2015**
UTM (m) N **5,748,866**
E **566,369**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE / NUMBER / RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
234	1	5		**SILTY CLAY FILL** - Brown, very stiff, intermediate plasticity, some fine to coarse grained sand, some light brown silt seams, frozen.				20 40 60	20 40 60 80
233.2				**PEAT** - Dark brown, moist, hemic.					
233	2								
232.6				**SILTY CLAY TILL** - Grey, damp to moist, firm, high plasticity, trace medium to coarse grained sand, trace fine grained gravel.					
232		10		- Increasing stiffness with depth.					
231.4	3			**SILT TILL** - Brown, damp, compact, non plastic to low plasticity, with clay, with medium grained sand, trace fine grained gravel, trace cobbles.		4.0			
231						4.0			
230	4	15		- Dry to damp, very dense, non plastic, some medium to coarse grained sand, some fine to medium grained gravel below 4.58 m.					
229	5			- Estimated hydraulic conductivity was 8.7x10e-9 m/s from 4.0 to 6.1 m.		5.5			
228.6	6	20		**END OF HOLE AT 6.10 m**		6.1			
228				Notes: 1. Installed 1 standpipe piezometer, slotted from 4.0 to 5.5 m. 2. Backfilled test hole with silica sand from 6.1 to 4.0 m, , and bentonite from 4.0 m to grade.					

SAMPLE TYPE

CONTRACTOR **Maple Leaf Enterprises**
INSPECTOR **C. ROBAK**
APPROVED DRAFT
DATE 8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-05A**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80) / PL MC LL % (20 40 60 80)
227	8	25		3. Standpipe dry immediately after installation. 4. Hydraulic conductivity from 4.0 to 6.1 m estimated from falling head test completed on February 22, 2015. 5. Top of hole elevation estimated from 2011 design top of dike profile.							
226	9	30									
225	10	35									
224	11										
223	12	40									
222	13										
221	14	45									
220	15	50									

SAMPLE TYPE

CONTRACTOR **Maple Leaf Enterprises**

INSPECTOR **C. ROBAK**

APPROVED DRAFT

DATE 8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-06**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION

PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY

SITE LAKE ST. MARTIN EMERGENCY CHANNELS

LOCATION STA. 23+144, WILLOW POINT

DRILLING METHOD 150 mm ø Hollow Stem Auger, NQ, MAROOKA MS1 300VD

JOB NO. **12-0300-011**

GROUND ELEV. **228.50 m (See notes)**

TOP OF PVC ELEV.

WATER ELEV.

DATE DRILLED **2/16/2015**

UTM (m) N **5,751,087** E **568,501**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
228				**PEAT** - Dark brown to black, hemic.								
227.7				- Frost to 0.6 m.			S	S1			177 ●	
	1			**SILTY CLAY** - Grey, damp to moist, stiff, intermediate plasticity, some silt seams, trace medium to coarse grained sand, trace fine to medium grained gravel.								
227		5		- Grain size distribution at 1.37 m: Gravel (5%), Sand (10%), Silt (27%), Clay (58%).			S	S2			● ◆	
226.7	2			**SILTY CLAY TILL** - Brown, damp, stiff to very stiff, intermediate plasticity, some medium to coarse grained sand, trace fine grained gravel.								
226				- Grain size distribution at 2.13 m: Gravel (4%), Sand (14%), Silt (37%), Clay (45%).			S	S3			●	
225.9				**SILT TILL** - Tan, dry, dense, low plastic, with to and medium to coarse grained sand, trace fine grained gravel.								
	3	10		- Grain size distribution at 2.82 m: Gravel (8%), Sand (34%), Silty (38%), Clay (20%).			S	S4			●	
				- SPT at 3.0 m terminated after 100 mm penetration into first set.			S	S5		▲ 50	●	
225				- Dry to damp, trace clay, trace medium grained gravel from 3.1 to 3.2 m.								
				- Very dense below 3.1 m.								
				- Some fine to coarse gravel from 3.1 to 4.9 m.								
				- Grain size distribution at 3.12 m: Gravel (15%), Sand (31%), Silt (39%), Clay (15%).								
	4											
224		15		- SPT at 4.6 m terminated after 40 mm penetration into first set.			S	S6		▲ 50	●	
				- Sample S7 is comprised of spin up cuttings around auger blade.								
	5			- Grain size distribution at 4.61 m: Gravel (26%), Sand (43%), Silt/Clay (31%)								
				- Grain size distribution at 5.22 m: Gravel (5%), Sand (33%), Silt (44%), Clay (18%).			S	S7			●	
223				- Hollow stem auger refusal at 5.8 m. Switched to NQ coring.								
	6	20		- Granite boulder from 5.8 to 6.4 m.								
						6.8	S	S8	75			
222				- Some medium to coarse grained gravel from 6.4 to 7.6 m.								

SAMPLE TYPE: Auger Grab; Split Spoon; Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-06**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
221	8	25		- Core barrel plugged advancing to 7.6 m. - Sandstone boulder (approximately 240 mm ø) below 7.6 m. - Core barrel occassionally plugged drilling below 7.6 m.		7.2		S9		20 40 60	20 40 60 80
220								S10	16		
219.7	9	30		**LIMESTONE** - Tan, porous, very weathered, very fractured, 0% RQD.		8.8					
219.4				**END OF HOLE AT 9.15 m**		9.1					
219	10	35		Notes: 1. Installed 1 standpipe piezometer, slotted from 7.2 to 8.8 m. 2. Backfilled test hole with slough from 9.2 to 8.7 m, silica sand from 8.7 to 6.9 m, and bentonite and grout from 6.9 m to grade. 3. Falling head test from 6.8 to 9.1 m fully dissipated in 30 seconds. 4. Top of hole elevation estimated from 2011 LiDAR data.							
218											
217	11	40									
216	12	45									
215	13	50									
214	14										
	15										

SAMPLE TYPE: Auger Grab ▨ Split Spoon ☒ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-06A**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 23+144, WILLOW POINT
DRILLING METHOD 150 mm ø Hollow Stem Auger, NQ, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV. **228.50 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/17/2015**
UTM (m) N **5,751,087** E **568,501**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE / NUMBER / RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
228				**PEAT** - Dark brown to black, hemic.					
227.7				- Frost to 0.6 m.					
	1			**SILTY CLAY** - Grey, damp to moist, stiff, intermediate plasticity, some silt seams, trace medium to coarse grained sand, trace fine to medium grained gravel.					
227		5							
226.7				**SILTY CLAY TILL** - Brown, damp, stiff to very stiff, intermediate plasticity, some medium to coarse grained sand, trace fine grained gravel.					
	2								
226									
225.9				**SILT TILL** - Tan, dry, dense, low plastic, with to and medium to coarse grained sand, trace fine grained gravel.		2.7			
	3	10		- Dry to damp, trace clay, trace medium grained gravel from 3.1 to 3.2 m. - Very dense below 3.1 m. - Some fine to coarse gravel from 3.1 to 4.9 m.		3.1			
225									
	4								
224		15							
223.8						4.7			
				END OF HOLE AT 4.73 m		4.7			
	5			Notes: 1. Installed 1 standpipe piezometer, slotted from 3.2 to 4.7 m. 2. Backfilled test hole with silica sand from 4.7 to 2.8 m, and bentonite and grout from 2.8 m to grade. 3. Water level at 4.6 m below grade immediately after installation. 4. Top of hole elevation estimated from 2011 LiDAR data.					
223									
	6	20							
222									

SAMPLE TYPE

CONTRACTOR **Maple Leaf Enterprises**
INSPECTOR **C. ROBAK**
APPROVED DRAFT
DATE 8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-07**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION

PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY

SITE LAKE ST. MARTIN EMERGENCY CHANNELS

LOCATION STA. 23+540, WILLOW POINT

DRILLING METHOD 125 mm ø Solid Stem Auger, NQ, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV. **228.03 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/17/2015**
UTM (m) N **5,751,121**
E **568,896**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
228				**PEAT** - Dark brown, wet, hemic.							
				- Frost to 0.3 m.							
							S1				95
227.0	1			**SILTY CLAY TILL** - Grey, moist, very stiff, intermediate plasticity, some medium to coarse grained sand, trace fine to medium grained gravel.							
		5		- Grain size distribution at 1.37 m: Gravel (2%), Sand (12%), Silt (29%), Clay (57%).			S2				
226	2										
				- Brown, stiff to very stiff below 2.3 m.			S3				
225	3	10		- Moist, intermediate to high plasticity, trace medium to coarse grained sand below 3.1 m. - Grain size distribution at 3.28 m: Gravel (5%), Sand (9%), Silt (28%), Clay (58%). - Silt pockets (up to 50 mm) from 3.4 to 3.7 m.			S4			▲ 6 ▲ 7 ▲ 11	
224	4			- Grain size distribution at 4.11 m: Gravel (5%), Sand (9%), Silt (23%), Clay (63%).			S5				
		15		- Trace cobbles below 4.6 m. - SPT at 4.6 m bouncing on suspected cobble after 100 mm penetration into third set.			S6			▲ 4 ▲ 3 ▲ 10	
223.0	5			- Grain size distribution at 4.80 m: Gravel (7%), Sand (12%), Silt (36%), Clay (45%).							
223				**SILT TILL** - Brown to grey, dry, dense to very dense, low plasticity with fine to medium grained sand, trace fine grained gravel , trace cobbles below 5.0 m.			S7				
				- Grain size distribution at 5.64 m: Gravel (1%), Sand (28%), Silt (44%), Clay (27%).							
222	6	20		- SPT at 6.1 m bouncing on suspected cobble after 25 mm penetration into first set.					0	▲ 20	
						6.9					

SAMPLE TYPE: Auger Grab ▨ Split Spoon ▩ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-07**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
221									20 40 60	20 40 60 80
		25		- Grey, some boulders (up to 225 mm ø), some cobbles below 7.63 m.		7.3	S8			
220	8									
				- Recovery included boulders (up to 250 mm ø) below 8.2 m.			S9			
219	9					8.9				
218.9		30		**END OF HOLE AT 9.15 m**		9.1				
218	10			Notes: 1. Installed 1 standpipe piezometer, slotted from 7.4 to 8.9 m. 2. Backfilled test hole with silica sand from 9.2 to 6.9 m, and bentonite and grout from 6.9 m to grade. 3. Water level in standpipe was 0.8 m above grade immediately after installation. 4. Top of hole elevation estimated from 2011 LiDAR data.						
		35								
217	11									
216	12	40								
215	13									
		45								
214	14									
213	15	50								

SAMPLE TYPE Auger Grab Split Spoon Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-07A**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 23+540, WILLOW POINT
DRILLING METHOD 125 mm ø Solid Stem Auger, NQ, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV. **228.03 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/18/2015**
UTM (m) N **57,571,121** E **568,896**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
228				**PEAT** - Dark brown, wet, hemic.							
				- Frost to 0.3 m.							
227.0	1			**SILTY CLAY TILL** - Grey, moist, very stiff, intermediate plasticity, some medium to coarse grained sand, trace fine to medium grained gravel.							
		5									
226	2			- Brown, stiff to very stiff below 2.3 m.							
						2.8					
225	3	10		- Moist, high plasticity, trace to some medium to coarse grained sand, trace to some fine to medium grained gravel below 3.1 m.		3.0					
				- Silt pockets (up to 50 mm) from 3.4 to 3.7 m.							
224	4										
223.5		15		**END OF HOLE AT 4.58 m**		4.6					
223	5			Notes:							
				1. Installed 1 standpipe piezometer, slotted from 3.1 to 4.6 m.							
				2. Backfilled test hole with silica sand from 4.6 to 2.8 m, and bentonite from 2.8 m to grade.							
				3. Water level was 4.8 m below grade immediately after installing standpipe.							
222	6	20		4. Top of hole elevation estimated from 2011 LiDAR data.							

SAMPLE TYPE

CONTRACTOR **Maple Leaf Enterprises**
INSPECTOR **C. ROBAK**
APPROVED DRAFT
DATE 8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-08**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 23+738, WILLOW POINT
DRILLING METHOD 150 mm ø Hollow Stem Auger, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV. **227.41 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/18/2015**
UTM (m) N **5,751,133** E **569,093**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
227				**PEAT** - Brown, wet, fibrous to hemic.			S	S1			◆922	
226.5	1			**SILTY CLAY** - Grey, moist, stiff, high plasticity, trace medium to coarse grained sand, trace fine grained gravel.			S	S2				
226		5		- Grain size distribution at 1.37 m: Gravel (8%), Sand (9%), Silt (27%), Clay (56%).								
225.9	2			**SILTY CLAY TILL** - Brown, moist, stiff, high plasticity, trace fine to coarse grained sand, trace fine to medium grained gravel.			S	S3				
225				- Grain size distribution at 2.29 m: Gravel (3%), Sand (5%), Silt (18%), Clay (74%). - Increased silt content below 2.5 m.		2.9						
	3	10		- Some silt lenses below 3.1 m.			S	S4	78	▲4 ▲6 ▲6		
224				- Grain size distribution at 3.28 m: Gravel (1%), Sand (8%), Silt (28%), Clay (63%). - Intermediate plasticity below 3.3 m. - Some fine to medium grained sand below 3.7 m.								
	4					4.4						
223		15		- Very stiff, some gravel, cobbles below 4.6 m.								
222.7				**SILT TILL** - Tan to brown, dry, dense, some fine to coarse grained sand, trace fine grained gravel.		4.9	S	S5	100	▲6 ▲9 ▲20		
	5			- Grain size distribution at 4.80 m: Gravel (5%), Sand (18%), Silt (42%), Clay (35%).								
222												
	6	20		- Grey, dry to damp, very dense, non plastic to low plasticity, some clay, some medium to coarse grained sand below 6.1 m. - SPT at 6.1 m terminated after full penetration into second set. - Grain size distribution at 6.25 m: Gravel (7%), Sand (19%), Silt (46%), Clay (28%). - Increased cobbles and boulders below 6.7 m.			S	S6	100	▲34 ▲55		
221												

SAMPLE TYPE ⊠ Auger Grab ⊠ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO.
TH15-08

ELEVATION (m)	DEPTH (m)	(ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
220										20 40 60	20 40 60 80
	8	25		- With fine to coarse grained sand below 7.6 m.		7.6					
219						7.8					
				- Suspected cobble or boulder from 8.5 to 8.9 m.							
	9	30								▲29	
						9.3	S7			▲51	●
218				- Grain size distribution at 9.37 m: Gravel (7%), Sand (31%), Silt (46%), Clay (16%).						▲57	
217.8				**END OF HOLE AT 9.6 m**		9.6					
	10			Notes:							
217		35		1. Installed 2 standpipe piezometers 1 piezometer slotted from 7.8 to 9.1 m and 1 piezometer slotted from 2.9 to 4.4 m.							
	11			2. Backfilled test hole with silica sand from 9.6 to 7.6 m, bentonite from 7.6 to 4.9 m, silica sand from 4.9 to 2.9 m, bentonite from 2.9 to 2.1 m and bentonite and cuttings from 2.1 m to grade.							
216				3. Water level at 9.0 m below grade in lower piezometer immediately after installation.							
	12	40		4. Water level at 0.4 m below grade in upper piezometer after installation.							
215				5. Top of hole elevation estimated from 2011 LiDAR data.							
	13										
214		45									
	14										
213											
	15	50									

SAMPLE TYPE ⊠ Auger Grab ⊠ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	C. ROBAK	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-09**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION

PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY

SITE LAKE ST. MARTIN EMERGENCY CHANNELS

LOCATION STA. 24+040, WILLOW POINT

DRILLING METHOD 125 mm ø Solid stem, 150 mm ø Hollow Stem Auger, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV. **226.68 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/19/2015**
UTM (m) N **5,751,155**
E **569,395**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
226	1	5		**PEAT** - Dark brown, wet, hemic.			S1				989 ◆	
225												
224.9	2	10		**SILTY CLAY TILL** - Brown, damp, intermediate plasticity, trace medium to coarse grained sand, trace fine grained gravel. - Grain size distribution at 2.13 m: Gravel (2%), Sand (10%), Silt (30%), Clay (58%).		2.1 2.3	S2				◆	
224												
223.6	3			**SILT TILL** - Mottled grey-brown, dry to damp, very dense, low plasticity, with medium to coarse grained sand, trace fine to coarse grained gravel, trace cobbles or boulders. - Grain size distribution at 3.28 m: Gravel (7%), Sand (29%), Silt (37%), Clay (27%). - Increased boulders with depth.		3.0	S3		100	▲32 ▲50 ▲55	●	
223	4	15				4.3	S4		100	▲45 ▲70		
222	5			- SPT at 4.6 m terminated after 25 mm penetration into second set. - Grain size distribution at 4.72 m: Gravel (9%), Sand (25%), Silt (41%), Clay (25%).		5.2						
221												
220.7	6	20		**END OF HOLE AT 5.95 m**		5.9						
220				Notes: 1. Installed 2 standpipe piezometers, 1 piezometer slotted from 2.3 to 3.1 m and 1 piezometer slotted from 5.2 m to 5.9 m. 2. Backfilled test hole with silica sand from 5.9 to 4.3 m, bentonite from 4.3 to 3.1 m, sand from 3.1 to 2.1 m and bentonite from 2.1 m to grade.								

SAMPLE TYPE ⊠ Auger Grab ⊠ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO.
TH15-09

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE / NUMBER / RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80) / PL MC LL % (20 40 60 80)
219	8	25		3. Top of hole elevation estimated from 2011 LiDAR data.					
218	9	30							
217	10	35							
216	11								
215	12	40							
214	13								
213	14	45							
212	15	50							

SAMPLE TYPE ⊠ Auger Grab ⊠ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-10**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION

PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY

SITE LAKE ST. MARTIN EMERGENCY CHANNELS

LOCATION STA. 25+036, WILLOW POINT

DRILLING METHOD 125 mm ø Solid stem, 150 mm ø Hollow Stem Auger, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV. **224.32 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/20/2015**
UTM (m) N **5,751,228**
E **570,388**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
224				**PEAT** - Dark brown, wet, hemic.								
223.3	1			**SILTY CLAY TILL** - Brown, damp, stiff, high plasticity, with silt, some medium to coarse grained sand, trace fine grained gravel.								
223		5		- Grain size distribution at 1.37 m: Gravel (2%), Sand (9%), Silt (27%), Clay (62%).			S1					
222	2			- Grain size distribution at 2.29 m: Gravel (5%), Sand (13%), Silt (32%), Clay (50%).			S2					
221	3	10		- Grain size distribution at 3.28 m: Gravel (1%), Sand (7%), Silt (26%), Clay (66%).		3.0 3.4	S3		100	▲4 ▲4 ▲6		
220	4			- Intermediate plasticity below 4.1 m. - Grain size distribution at 4.11 m: Gravel (3%), Sand (11%), Silt (31%), Clay (55%).			S4					
		15								▲7 ▲6 ▲7		
219	5			- Grain size distribution at 4.80 m: Gravel (4%), Sand (12%), Silt (34%), Clay (50%).		4.9	S5		100			
218.8				**SILT TILL** - Tan to grey, dry to damp, very dense, low plasticity, with medium to coarse grained sand, trace fine to coarse grained gravel, trace cobbles.			S6					
	6	20		- Grain size distribution at 5.79 m: Gravel (4%), Sand (17%), Silt (40%), Clay (39%).						▲18 ▲26 ▲37		
218				- Grain size distribution at 6.32 m: Gravel (9%), Sand (26%), Silt (43%), Clay (22%).			S7		89			

SAMPLE TYPE ⊠ Auger Grab ⊠ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO.
TH15-10

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
217										20 40 60	20 40 60 80
	8	25		- Solid stem auger refusal at 7.6 m, hole sloughed to 7.3 m while switching to hollow stem auger. - With fine to coarse grained gravel below 7.8 m. - Grain size distribution at 7.85 m: Gravel (24%), Sand (21%), Silt (35%), Clay (20%).		7.6 7.9		S8	89		
216											
	9	30		- Dense, some fine to coarse grained gravel below 9.2 m. - Grain size distribution at 9.37 m: Gravel (13%), Sand (26%), Silt (40%), Clay (21%).		9.4 9.6		S9	94	▲9 ▲16 ▲16	
215											
214.7				**END OF HOLE AT 9.61 m**							
	10	35		Notes: 1. Installed 2 standpipe piezometers, 1 piezometer slotted from 7.9 to 9.4 m and 1 piezometer slotted from 3.4 to 4.9 m. 2. Backfilled test hole with silica sand from 9.6 to 7.6 m, bentonite from 7.6 to 4.9 m, sand from 4.9 to 3.1 m and bentonite from 3.1 m to grade. 3. Top of hole elevation estimated from 2011 LiDAR data.							
214											
	11										
213											
	12	40									
212											
	13										
211											
	14	45									
210											
	15										
		50									

SAMPLE TYPE Auger Grab Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-11**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION

PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY

SITE LAKE ST. MARTIN EMERGENCY CHANNELS

LOCATION STA. 25+550, WILLOW POINT

DRILLING METHOD 125 mm ø Solid stem, 150 mm ø Hollow Stem Auger, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV. **221.85 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/20/2015**
UTM (m) N **5,751,270**
E **570,900**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
221	1	5		**PEAT** - Dark brown, wet, hemic. - Frost to 0.6 m.							
220.0											
220	2			**SILTY CLAY** - Brown, damp, stiff, high plasticity, some silt, trace medium to coarse grained sand, trace fine to coarse grained gravel. - Grain size distribution at 2.29 m: Gravel (2%), Sand (6%), Silt (20%), Clay (72%).		2.4		S1			
219	3	10		- Grain size distribution at 3.28 m: Gravel (2%), Sand (9%), Silt (23%), Clay (66%).		2.7		S2	100	▲4 ▲4 ▲7	
218	4							S3			
217.1		15				4.3		S4	100	▲9 ▲14 ▲18	
217	5			**SILT TILL** - Grey, dry to damp, low plasticity, dense, with fine to coarse grained sand, trace to some fine to coarse grained gravel, trace cobbles. - Grain size distribution at 4.80 m: Gravel (11%), Sand (26%), Silt (40%), Clay (23%).				S5			
216	6	20		- Some fine to coarse grained gravel below 6.1 m. - Grain size distribution at 6.32 m: Gravel (8%), Sand (20%), Silt (44%), Clay (28%).		5.9 6.4		S6	83	▲7 ▲26 ▲17	
215								S7			

SAMPLE TYPE Auger Grab Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-11**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
214	8	25		- Solid stem auger refusal at 7.6 m, switched to hollow stem auger.		7.9	S8			▲8	
				- Suspected boulder at 7.9 m.			S9		100	▲55 ▲50	
213.6				- SPT at 7.9 m terminated at 50 mm penetration into third set.		8.3					
				END OF HOLE ON SUSPECTED BOULDER AT 8.3 m							
213	9	30		Notes: 1. Installed 2 standpipe piezometers, 1 piezometer slotted from 2.7 to 4.3 m and 1 piezometer slotted from 6.4 to 7.9 m. 2. Backfilled test hole with silica sand from 8.3 to 5.9 m, bentonite from 5.9 to 4.3 m, sand from 4.3 to 2.4 m and bentonite from 2.4 m to grade. 3. Top of hole elevation estimated from 2011 LiDAR data.							
212	10										
		35									
211	11										
210	12	40									
209	13										
		45									
208	14										
207	15	50									

SAMPLE TYPE ⊠ Auger Grab ⊠ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-12**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION

PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY

SITE LAKE ST. MARTIN EMERGENCY CHANNELS

LOCATION STA. 26+544, WILLOW POINT

DRILLING METHOD 125 mm ø Solid stem, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV. **221.13 m (See notes)**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/21/2015**
UTM (m) N **571,891**
E **5,751,342**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
221	0			**PEAT** - Dark brown,wet, hemic.					
				- Frost to 0.5 m.					
						S1			◆ 61.5
220	1	5							
219.3				**SILTY CLAY** - Brown, damp, stiff, intermediate high plasticity, trace to some medium to coarse grained sand, trace fine to coarse grained gravel.					
219	2			- Grain size distribution at 2.29 m: Gravel (2%), Sand (14%), Silt (28%), Clay (56%).		S2			
218	3	10						▲ 5	
217.8				- Grain size distribution at 3.28 m: Gravel (5%), Sand (9%), Silt (28%), Clay (58%).		S3	100	▲ 4	
				SILT TILL - Grey, dry to damp, dense to very dense, low plasticity, with medium to coarse grained sand, trace fine to coarse grained gravel.				▲ 20	
				- Very dense below 3.5 m.		S4			
				- Grain size distribution at 3.81 m: Gravel (7%), Sand (23%), Silt (42%), Clay (28%).					
217	4			- With medium to coarse grained sand, trace fine to coarse grained gravel, trace cobbles below 4.1 m.					
		15						▲ 25	
				- Grain size distribution at 4.80 m: Gravel (10%), Sand (31%), Silt (43%), Clay (16%).		S5	100	▲ 47	
216	5							▲ 48	
				- Some fine to coarse grained gravel below 5.5 m.					
215	6	20						▲ 16	
				- Non plastic below 6.1 m.				▲ 20	
				- Grain size distribution at 6.32 m: Gravel (11%), Sand (28%), Silt (47%), Clay (14%).		S6	100	▲ 28	

SAMPLE TYPE ⊠ Auger Grab ⊠ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO.
TH15-12

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80)	PL MC LL % (20 40 60 80)
214										
213.5		25		- Drilled through boulder from 7.5 to 7.6 m.						
				END OF HOLE ON SUSPECTED BOULDER AT 7.63 m						
213	8			Notes: 1. Installed 2 standpipe piezometers, 1 piezometer slotted from 3.1 to 4.6 m and 1 piezometer slotted from 6.1 to 7.6 m. 2. Backfilled test hole with silica sand from 7.6 to 5.9 m, bentonite from 5.9 to 4.5 m, sand from 4.5 to 2.7 m and bentonite from 2.7 m to grade. 3. Top of hole elevation estimated from 2011 LiDAR data.						
212	9	30								
211	10	35								
210	11									
209	12	40								
208	13	45								
207	14									
206	15	50								

SAMPLE TYPE ⊠ Auger Grab ⊠ Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-13**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 22+014, REACH 3 QUARRY
DRILLING METHOD 125 mm ø Solid stem, NQ, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/24/2015**
UTM (m) N **5,750,855** E **567,158**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
				PEAT - Black, moist, hemic. - Frost to 0.2 m				20 40 60	20 40 60 80
	1	5		**SILT TILL** - Grey, damp, dense, with medium to coarse grained sand, some fine to coarse grained gravel. - Grain size distribution at 1.22 m: Gravel (11%), Sand (24%), Silt (48%), Clay (17%).		S1			
	2			- Grain size distribution at 1.83 m: Gravel (6%), Sand (23%), Silt (49%), Clay (22%).		S2			
				NO RECOVERY - Suspected cobbles and weathered bedrock.					
	3	10		**LIMESTONE** - Weathered bedrock and cobbles. - Solid stem auger refusal at 3.1 m. Switched to NQ coring below 3.1 m. - Limestone and flint fine to coarse grained gravel from 3.1 to 3.2 m. - Run 1 from 3.1 to 4.6 m. 55% RQD, 13 joints per run.		R1	95		
	4	15		- Run 2 from 4.6 to 6.1 m. 80% RQD. 13 joints per run. - Tan to yellow, weak to moderate strength.					
	5			- Grey below 5.0 m.		R2	50		
	6	20		- Run 3 from 6.1 to 7.6 m. 0% RQD, 0 joints.		R3	40		

SAMPLE TYPE Auger Grab Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO.
TH15-13

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
	8	25		- Mottled light grey to dark grey below 7.6 m. - Run 4 from 7.6 to 9.2 m. 53% RQD, 16 joints.		R4	95		
	9	30		**END OF HOLE AT 9.2 m**					
	10	35		Notes: 1. Backfilled test hole with slough from 9.2 to 2.7 m and bentonite from 2.7 m to grade. 2. Test hole sloughed to 2.7 m below grade. 2. Water level was 0.5 m below grade upon completion of drilling.					
	11								
	12	40							
	13								
	14	45							
	15	50							

SAMPLE TYPE Auger Grab Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-14**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION CAMPSITE QUARRY (SOUTHEAST)
DRILLING METHOD 125 mm ø Solid stem, NQ, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/25/2015**
UTM (m) N **5,725,435**
E **557,386**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %
				BOULDER TILL - Light brown, dry to damp, dense, with silt.			
				- Cobbles below 0.3 m.		S1	
				- Cobble from 0.6 to 0.8 m.			
	1			- Cobble from 1.2 to 1.5 m.		S2	
		5					
	2			- Cobble from 2.0 to 2.1 m.			
				- Cobble at 2.3 m.		S3	
				- Cobble from 2.4 to 2.6 m.			
				- Solid stem auger refusal at 2.6 m. Switched to NQ coring below 2.6 m.			
	3	10		- Cobbles form 3.1 to 4.7 m.			
				- Run 1 from 3.1 to 4.6 m. 0 % RQD.		R1	50
	4						
		15		**LIMESTONE** - Tan, pitted.			
				- Run 2 from 4.6 to 6.1 m. 69% RQD, 10 joints.			
	5			- Coarse grained gravel from 4.6 to 4.7 m.		R2	100
	6	20		- Tan to grey from 6.1 to 7.6 m.			
				- Run 3 from 6.1 to 7.6 m. 81% RQD, 10 joints.		R3	98

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE Auger Grab Core Barrel

CONTRACTOR **Maple Leaf Enterprises**
INSPECTOR **K. HAMILTON**
APPROVED DRAFT
DATE 8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO.
TH15-14

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
	8	25		- White to grey below 7.6 m. - Run 4 from 7.6 to 9.2 m. 75% RQD, 13 joints.		R4	100		
	9	30		**END OF HOLE AT 9.2 m**					
	10	35		Notes: 1. Backfilled test hole with bentonite from 9.2 m to grade. 2. Water level was 4.13 m below grade 30 minutes after the completion of drilling.					
	11								
	12	40							
	13								
	14	45							
	15	50							

SAMPLE TYPE Auger Grab Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-15**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION

PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY

SITE LAKE ST. MARTIN EMERGENCY CHANNELS

LOCATION CAMPSITE QUARRY (NORTHWEST)

DRILLING METHOD 125 mm ø Solid stem, NQ, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/25/2015**
UTM (m) N **5,725,330**
E **557,387**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %
				PEAT - Brown, damp, hemic.			
				COBBLES			
				BOULDER TILL - Brown, dry to damp, dense, and cobbles, with silt, trace fine to coarse grained sand, trace fine to coarse grained gravel.		S1	
						S2	
				- Solid stem auger refusal at 2.3 m. Switched to NQ coring below 2.3 m.			
				COBBLES AND GRAVEL - Fine to coarse grained gravel.			
				- Run 1 2.3 to 3.1 m. 16% RQD, 11 joints.		R1	100
				LIMESTONE - Dark tan, moderate strength.			
	3	10		- Run 2 from 3.1 to 4.6 m. 8% RQD, 5 joints.		R2	70
	4						
		15		- Run 3 from 4.6 to 6.1 m. 39% RQD, 12 joints.		R3	100
	5						
	6	20		- Run 4 from 6.1 to 7.6 m. 98% RQD, 6 joints.		R4	100

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE Auger Grab Core Barrel

CONTRACTOR **Maple Leaf Enterprises**
INSPECTOR **K. HAMILTON**
APPROVED DRAFT
DATE 8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO.
TH15-15

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80)	PL MC LL % (20 40 60 80)
	8	25		- Tan below 7.6 m. - Run 5 from 7.6 to 9.2 m. 43% RQD, 9 joints.		R5	90			
	9	30		**END OF HOLE AT 9.2 m**						
	10	35		Notes: 1. Backfilled test hole with bentonite from 9.2 m to grade. 2. Water level was 5.07 m below grade 15 minutes after the completion of drilling.						
	11									
	12	40								
	13									
	14	45								
	15	50								

SAMPLE TYPE Auger Grab Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-16**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION
DRILLING METHOD 125 mm ø Solid stem, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/25/2015**
UTM (m) N **5,725,841**
E **557,849**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER / RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
				BOULDER		20 40 60	20 40 60 80
				END OF HOLE AT 0.3 m			
				Notes:			
				1. Boulders near ground elevation, moved the drill rig 2 m northwest and encountered boulders at ground surface.			
	1	5					
	2						
	3	10					
	4	15					
	5						
	6	20					

SAMPLE TYPE

CONTRACTOR **Maple Leaf Enterprises**
INSPECTOR **K. HAMILTON**
APPROVED
DRAFT
DATE 8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-17**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION
DRILLING METHOD 125 mm ø Solid stem, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/26/2015**
UTM (m) N **5,704,117**
E **560,413**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
				SAND AND GRAVEL - Brown, dry to damp, dense, fine to coarse grained sand, trace fine to coarse grained gravel.					
	1			- Light brown, with coarse grained gravel below 1.1 m.					
				- Grain size distribution at 1.3 m: Gravel (31%), Sand (50%), Silt (17%), Clay (2%).		S1			
		5		- Grain size distribution at 1.6 m: Gravel (14%), Sand (50%), Silt (26%), Clay (10%).		S2			
	2			- Increased drilling difficulty, coarse grained gravel, cobbles below 1.8 m.					
				- Grain size distribution at 2.1 m: Gravel (21%), Sand (45%), Silt (28%), Clay (7%).		S3			
				- Grain size distribution at 2.7 m: Gravel (12%), Sand (53%), Silt (28%), Clay (8%).		S4			
	3	10		**END OF HOLE AT 3.1 m**					
				Notes:					
				1. Solid stem auger refusal.					
				2. Backfilled with slough from 3.1 to 2.4 m and bentonite from 2.4 m to grade.					
				3. Test hole sloughed to 2.4 m.					
	4			4. Sample S4 also contains spun up cuttings from above 2.4 to 3.1 m.					
		15		5. Test hole was dry 2 hours after the completion of drilling.					
	5								
	6	20							

SAMPLE TYPE Auger Grab

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-18**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION
DRILLING METHOD 125 mm ø Solid stem, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/26/2015**
UTM (m) N **5,703,860**
E **560,306**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
				ORGANICS					
	0			**SAND AND GRAVEl** - Brown, dry to damp, dense, fine to coarse grained sand, with fine to coarse grained gravel.					
				- Grain size distribution at 0.8 m: Gravel (11%), Sand (67%), Silt (20%), Clay (2%).		S1			
	1			- Some fine to coarse grained gravel below 1.2 m.					
		5							
				- Grain size distribution at 1.8 m: Gravel (13%), Sand (53%), Silt (27%), Clay (7%).		S2			
	2			- Cobbles below 2.1 m.					
				- Grain size distribution at 2.6 m: Gravel (28%), Sand (51%), Silt/Clay (21%).		S3			
	3	10		**END OF HOLE ON SUSPECTED COBBLE/BOULDER AT 3.1 m**					
				Notes:					
				1. Backfilled with slough from 3.1 to 2.2 m and bentonite from 2.2 m to grade.					
				2. Test hole sloughed to 2.4 m.					
				3. Sample S3 also contains spun up cuttings from 0 to 2.1 m.					
	4			4. Test hole was dry 1.5 hours after the completion of drilling.					
		15							
	5								
	6	20							

SAMPLE TYPE Auger Grab

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH15-19**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION
DRILLING METHOD 125 mm ø Solid stem, MAROOKA MS1 300VD

JOB NO. **12-0300-011**
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/26/2015**
UTM (m) N **5,723,467**
E **560,154**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
	1	5		**ORGANICS**				20 40 60	20 40 60 80
				SAND AND GRAVEL - Dark brown, some to coarse grained sand, and fine to coarse grained gravel, trace cobbles.					
				- Brown below 1.1 m.		S1			
				- Grain size distribution at 1.3 m: Gravel (10%), Sand (66%), Silt/Clay (24%).					
	2			**SAND** - Brown, dry to damp, dense, fine to coarse grained sand, poorly graded, fine to coarse grained gravel.		S2			
				- Grain size distribution at 1.8 m: Gravel (1%), Sand (76%), Silt/Clay (23%).					
				END OF HOLE ON SUSPECTED COBBLE/BOULDER AT 2.1 m					
	3	10		Notes:					
				1. Backfilled with slough from 2.1 to 1.3 m and bentonite from 1.3 m to grade.					
				2. Test hole sloughed to 1.3 m.					
				3. Test hole was dry 1 hour after the completion of drilling.					
	4	15							
	5								
	6	20							

SAMPLE TYPE Auger Grab

CONTRACTOR	INSPECTOR	APPROVED	DATE
Maple Leaf Enterprises	K. HAMILTON	DRAFT	8/13/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-01**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 22+508 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **229.64**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/5/2015**
UTM (m) N **5,751,046**
E **567,866**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %
229	0			**PEAT** - Black to brown, moist to wet, some roots, with rootlets.			
228.4	1			**SILTY CLAY** - Grey, moist, with silt pockets (25 to 50 mm), high plasticity, some sand, trace fine grained gravel.			
228		5					
227.2	2			- Grain size distribution at 2.29 m: Gravel (1%), Sand (5%), Silt (19%), Clay (75%).		S1	
227				**SILT TILL** - Grey, wet, some fine to coarse grained sand, trace fine to coarse grained gravel, some cobbles, some boulders.			
	3	10		- Cobble and boulder content increasing with depth below 3.05 m.		S2	
226				- Grain size distribution at 3.20 m: Gravel (8%), Sand (17%), Silt (46%), Clay (28%).			
225.1	4						
225		15		**END OF TEST PIT AT 4.57 m.**			
	5			Notes:			
224				1. Water infiltration into test pit from peat/silty clay interface. 2. Water ponded at bottom of test pit from above noted infiltration. 3. Backfilled test pit to grade upon completion. 4. Top of pit elevation estimated from 2011 LiDAR data.			
	6	20					
223							

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80

PL MC LL
%
20 40 60 80

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/S.REPA	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-02**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 23+771 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **227.34**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/5/2015**
UTM (m) N **5,751,136**
E **569,126**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
227				**PEAT** - Black to brown, moist to wet, some decayed wood, some roots, with rootlets.						
226	1	5		**SILTY CLAY** - Grey, moist, stiff, high plasticity, trace fine grained sand, trace fine grained gravel.						
225	2			- Grain size distribution at 1.98 m: Gravel (4%), Sand (8%), Silt (23%), Clay (65%).		S1				
224.6				- Increased sand and gravel content below 2.29 m.						
224	3	10		**SILT TILL** - Brown, moist, dense, some fine to coarse grained sand, trace to some fine to coarse grained gravel, some cobbles. - Grain size distribution at 2.90 m: Gravel (5%), Sand (15%), Silt (43%), Clay (37%).		S2				
223	4			- Trace boulders below 4.27 m.						
222.8		15		**END OF TEST PIT AT 4.57 m.**						
222	5			Notes: 1. Water infiltration into test pit from peat/silty clay interface. 2. Backfilled test pit to grade upon completion. 3. Top of pit elevation estimated from 2011 LiDAR data.						
221	6	20								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR **TERRY LAVALLEE CONSTRUCTION** INSPECTOR **J.MACLENNAN/S.REPA** APPROVED DRAFT DATE 6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-03**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 24+444 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **225.45**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/5/2015**
UTM (m) N **5,751,185**
E **569,797**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
225				**PEAT** - Black to brown, saturated, soft, some roots, with rootlets.						
224.5	1	5		**SILTY CLAY** - Grey, moist, stiff, low plasticity, some medium to coarse grained sand, trace fine grained gravel.						
224				- Grain size distribution at 1.37 m: Gravel (8%), Sand (11%), Silt (43%), Clay (39%).		S1				
	2			- Increased sand and gravel content below 1.83 m.						
223										
222.9	3	10		**SILT TILL** - Brown, moist, dense, with fine to coarse grained sand, with fine to coarse grained gravel, trace cobbles, trace boulders, boulder and cobble content increasing with depth.						
222										
	4									
221		15								
220.6	5			**END OF TEST PIT AT 4.88 m.**						
220				Notes: 1. Water infiltration into test pit from peat/silty clay interface, rate increasing as excavation progresses. 2. End test pit due to the continuous excavation sidewall sloughing. 3. Backfilled test pit to grade upon completion. 4. Top of pit elevation estimated from 2011 LiDAR data.						
	6	20								
219										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/S.REPA	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-04**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 25+121 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **223.98**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/5/2015**
UTM (m) N **5,751,236**
E **570,472**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
223								20 40 60	20 40 60 80	20 40 60 80
222.9	0			**PEAT** - Black to brown, wet, soft, some roots, with rootlets.						
	1			**SILTY CLAY** - Grey, moist, stiff, high plasticity, some medium to coarse grained sand, trace fine grained gravel, increasing sand and gravel content with depth. - Grain size distribution at 1.37 m: Gravel (2%), Sand (11%), Silt (22%), Clay (65%).	⋈	S1				
		5								
222	2									
221.1					⋈	S2				
221	3	10		**SILT TILL** - Brown, moist, compact, intermediate plasticity, some fine to coarse grained sand, trace fine to coarse grained gravel, trace cobbles, trace boulders, boulder and cobble content increasing with depth. - Grain size distribution at 2.90 m: Gravel (3%), Sand (13%), Silt (30%), Clay (53%).						
220	4									
		15								
219.3				**END OF TEST PIT ON SUSPECTED HARD PAN AT 4.72 m.**						
219	5			Notes: 1. Light water infiltration into test pit from peat/silty clay interface begins once test pit is completed. 2. Test pit is left open to observe future ground water conditions. 3. Feb 6, 2015 Water level in test pit is observed at 2.29 m below grade. 4. Top of pit elevation estimated from 2011 LiDAR data.						
218	6	20								
217										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/S.REPA	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-05**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 26+115 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **221.30**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/5/2015**
UTM (m) N **5,751,314**
E **571,454**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
221	0			**PEAT** - Black to brown, wet, soft, some roots, with rootlets.						
220	1	5								
219.6				**SILTY CLAY** - Grey, moist, high plasticity, trace fine grained sand, some silt pockets (25 to 50 mm), increasing sand content with depth.						
219	2								◆	
218	3	10		- Grain size distribution at 3.51 m: Gravel (1%), Sand (3%), Silt (17%), Clay (79%).	⋈	S1				
217.2	4			**END OF TEST PIT AT 4.72 m.**						
217		15		Notes: 1. Test pit ended due to heavy water infiltration from peat/silty clay interface and significant side wall sloughing. 2. Backfilled test pit to grade upon completion. 3. Top of pit elevation estimated from 2011 LiDAR data.						
216	5									
215	6	20								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/S.REPA	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-06**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 27+240 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **219.29**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/6/2015**
UTM (m) N **5,751,398**
E **572,585**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
219				**PEAT** - Black to brown, wet, soft, some decayed wood, some roots, with rootlets.						
218.1	1									
218		5		**SILTY CLAY** - Grey, moist, firm, high plasticity, trace fine to coarse grained sand, increasing grain size with depth. - Grain size distribution at 1.37 m: Gravel (0%), Sand (3%), Silt (15%), Clay (82%).		S1				
	2									
217										
	3	10		- Trace boulders at 2.74 m. - Decreased plasticity, increased stiffness below 2.74 m. - Grain size distribution at 2.90 m: Gravel (1%), Sand (4%), Silt (17%), Clay (78%).		S2				
216										
215.6				**SILT TILL** - Brown, moist, stiff, low plasticity, with clay, with fine to coarse grained sand, with fine to coarse grained gravel, with cobbles, trace boulders, increasing boulders with depth.						
	4									
215		15								
	5									
214										
	6	20								
213										
212.9				**END OF TEST PIT AT 6.40 m.**						

Notes:

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR **TERRY LAVALLEE CONSTRUCTION** INSPECTOR **J.MACLENNAN** APPROVED DRAFT DATE 6/29/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO.
TP15-06

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80)	PL MC LL % (20 40 60 80)
212		25		1. Test pit ends because depth exceeds excavator reach. 2. Bottom of test pit saturated due to water infiltration at peat/silty clay interface. 3. Backfilled test pit to grade upon completion. 4. Top of pit elevation estimated from 2011 LiDAR data.						
	8									
211										
	9	30								
210										
	10									
209		35								
	11									
208										
	12	40								
207										
	13									
206		45								
	14									
205										
	15	50								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-07**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 27+350 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **219.24**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/6/2015**
UTM (m) N **5,751,400**
E **572,692**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
219				**PEAT** - Black to brown, wet, soft, some roots, with rootlets.						
218.2	1									
218.1				**SAND**						
218				**SILTY CLAY** - Grey, moist, firm, high plasticity, trace sand, with silt seams.						
		5								
	2			- Tan below 1.82 m.						
217				- Increased grain size, some cobbles below - Grain size distribution at 2.29 m: Gravel (1%), Sand (5%), Silt (16%), Clay (78%).		S1				
	3	10								
216.0										
216				**SILT TILL** - Tan, damp, compact, well graded, with fine to coarse grained sand, with fine to coarse grained gravel, some cobbles, trace boulders.						
	4									
215		15								
	5									
214										
213.5				**END OF TEST PIT ON SUSPECTED BOULDER AT 5.79 m.**						
	6	20		Notes: 1. Minor water infiltration at peat/silty clay interface. 2. Test pit left open to observe future ground water conditions. 3. Top of pit elevation estimated from 2011 LiDAR data.						
213										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR **TERRY LAVALLEE CONSTRUCTION**
INSPECTOR **J.MACLENNAN**
APPROVED
DRAFT
DATE 6/29/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-08**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 27+016 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **220.17**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/6/2015**
UTM (m) N **5,751,375** E **572,362**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
220				**PEAT** - Black to brown, wet, soft, some roots, with rootlets.						
219.6				**SILTY CLAY** - Grey, moist, firm, high plasticity, trace sand, increasing sand and gravel content with depth.						
219	1	5								
218	2									
217	3	10		- Grain size distribution at 3.20 m: Gravel (0%), Sand (4%), Silt (18%), Clay (78%).		S1				
216.2	4			**SILT TILL** - Brown to tan, damp, dense, with fine to coarse grained sand, with fine to coarse grained gravel, trace cobbles.						
216		15								
215.0	5			**END OF TEST PIT ON SUSPECTED BOULDER AT 5.18 m.**						
215				Notes:						
214	6	20		1. Water infiltration at peat/silty clay interface. 2. No final depth measurement taken due to excavation sidewall sloughing, value given is estimated. 3. Water ponded at bottom of test pit from above noted infiltration. 4. Backfilled test pit to grade upon completion. 5. Top of pit elevation estimated from 2011 LiDAR data.						

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN	DRAFT	6/29/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-09**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 26+755 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **220.81**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/6/2015**
UTM (m) N **5,751,360**
E **572,102**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
220				**PEAT** - Black to brown, wet, soft, some roots, with rootlets.						
219.4	1	5		**SILTY CLAY** - Grey, moist, firm, intermediate to high plasticity, trace sand, trace fine grained sand. - Grain size distribution at 1.52 m: Gravel (2%), Sand (10%), Silt (28%), Clay (60%).		S1				
219	2			- Tan, increased stiffness, increasing grain size below 2.13 m.						
218				- Grain size distribution at 2.59 m: Gravel (0%), Sand (2%), Silt (13%), Clay (85%).		S2				
217	3	10								
216	4	15								
215.3	5			**SILT TILL** - Tan, moist, compact, with clay, with fine to coarse grained sand, with fine to coarse grained gravel, trace cobbles.						
215	6	20		- Trace boulders at 6.10 m.						
214.3				**END OF TEST PIT AT 6.55 m.**						
214				Notes:						

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR **TERRY LAVALLEE CONSTRUCTION**
INSPECTOR **J.MACLENNAN**
APPROVED
DRAFT
DATE 6/29/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO.
TP15-09

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80)	PL MC LL % (20 40 60 80)
213	8	25		1. Water infiltration at peat/silty clay interface. 2. Backfilled test pit to grade upon completion. 3. Top of pit elevation estimated from 2011 LiDAR data.						
212	9	30								
211	10	35								
210	11									
209	12	40								
208	13									
207	14	45								
206	15	50								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-10**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 26+528 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **221.04**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/6/2015**
UTM (m) N **5,751,343**
E **571,876**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
221				**PEAT** - Black to brown, wet, soft, some roots, with rootlets.						
220	1									
219.8				**SAND & GRAVEL** - Grey, wet, dense, well graded.						
		5		- Grain size distribution at 1.37 m: Gravel (26%), Sand (69%), Silt/Clay (5%).		S1				
219.4				**SILT TILL** - Brown, moist, dense, low plasticity, some clay, with fine to coarse grained sand, trace fine to coarse grained gravel, trace cobbles.						
219	2									
				- Grain size distribution at 2.59 m: Gravel (2%), Sand (16%), Silt (40%), Clay (42%).		S2				
218	3	10								
217	4									
216.6		15		**END OF TEST PIT AT 6.55 m.**						
216	5									
215	6	20								

Notes:
1. Water infiltration at peat/sand & gravel interface.
2. Water ponded at bottom of test pit from above noted infiltration.
3. Sloughing of side walls during excavation.
4. Backfilled test pit to grade upon completion.
5. Top of pit elevation estimated from 2011 LiDAR data.

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-11**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 26+303 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **221.34**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/6/2015**
UTM (m) N **5,751,327**
E **571,651**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %
221				**PEAT** - Black to brown, wet, soft, some roots.		
	1					
220		5				
219.7				**SILTY CLAY** - Grey, moist, soft, intermediate plasticity, trace sand.		
	2			- Increasing stiffness with depth.		
219				-Decreasing plasticity with depth.		
				- Some fine to coarse grained sand, trace to with gravel below 2.74 m.		
	3	10		- Increased silt content below 2.74 m.		
218						
217.4				- Grain size distribution at 3.81 m: Gravel (5%), Sand (14%), Silt (43%), Clay (38%).	S1	
	4			**SILT TILL** - Tan, moist, dense, with sand, with gravel, trace cobbles, trace boulders.		
217		15				
	5					
216						
	6	20				
215.2				**END OF TEST PIT ON SUSPECTED HARDPAN OR BEDROCK AT 6.10 m**		
215				Notes:		
				1. Water infiltration into test pit from peat.		
				2. Backfilled test pit to grade upon completion.		
				3. Top of pit elevation estimated from 2011 LiDAR data.		

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-12**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 25+917 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **221.41**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/6/2015**
UTM (m) N **5,751,296**
E **571,266**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
221				**PEAT** - Black to brown, wet, soft, some roots.				
220	1							
219.9		5		**SILTY CLAY** - Grey, moist, firm, high plasticity, trace sand.				
219	2							
	3	10		- Grain size distribution at 2.90 m: Gravel (0%), Sand (4%), Silt (16%), Clay (80%).	S1			
218				- Brown, dense, some sand, some gravel below 3.66 m.				
	4			- Grain size distribution at 3.81 m: Gravel (1%), Sand (4%), Silt (19%), Clay (77%).	S2			
217.0								
217		15		**SILT TILL** - Tan to grey, damp, high plasticity, trace medium to coarse grained sand, trace gravel, trace to some boulders.				
	5			- Grain size distribution at 4.88 m: Gravel (2%), Sand (9%), Silt (36%), Clay (53%).	S3			
216								
215.3	6	20		**END OF TEST PIT ON SUSPECTED BOULDER AT 6.10 m**				
215				Notes:				

1. Significant water infiltration into test pit from peat.
2. Backfilled test pit halfway to allow seepage upon completion.
3. Top of pit elevation estimated from 2011 LiDAR data.

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/C. ROBAK	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-13**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 25+656 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **221.65**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/7/2015**
UTM (m) N **5,751,276**
E **571,005**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
221	1	5		**PEAT** - Black to brown, damp, soft, some roots.						
220.1				**SILTY CLAY** - Grey, moist, firm, high plasticity, trace fine to coarse grained sand.						
220	2			- Grain size distribution at 2.29 m: Gravel (0%), Sand (3%), Silt (14%), Clay (83%).	⋈	S1				
219	3	10								
218	4									
217	5	15								
216.5				**END OF TEST PIT AT 5.18**						
216	6	20		Notes: 1. Backfilled test pit to grade upon completion. 2. Top of pit elevation estimated from 2011 LiDAR data.						
215										

SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △: 20 40 60
Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆: 20 40 60 80
PL MC LL %: 20 40 60 80

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/C. ROBAK	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-14**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 25+370 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **222.74**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/7/2015**
UTM (m) N **5,751,254**
E **571,721**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
222.0				**PEAT** - Black to brown, damp, soft, some roots.				
222	1	5		**SILTY CLAY** - Grey to brown, moist, stiff, low plasticity, some sand, trace fine to medium grained gravel.				
				- Grain size distribution at 1.37 m: Gravel (5%), Sand (17%), Silt (45%), Clay (33%).	S1			
221				- Trace to some cobbles, trace to some boulders below 1.83 m.				
220.8	2			**SILT TILL** - Tan, moist, dense, non plastic, well graded, with sand, some gravel, some cobbles.				
				- Increasing grain size with depth.				
				- Grain size distribution at 2.59 m: Gravel (11%), Sand (26%), Silt (43%), Clay (21%).	S2			
220	3	10						
219.4				**END OF TEST PIT ON DENSE SILT TILL AT 3.36 m**				
219				Notes:				
				1. Backfilled test pit to grade upon completion.				
				2. Top of pit elevation estimated from 2011 LiDAR data.				
218	4	15						
	5							
217								
	6	20						
216								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/C. ROBAK	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-15**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 25+515 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **221.92**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/7/2015**
UTM (m) N **5,751,266**
E **570,865**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
221	1	5		**PEAT** - Black to brown, wet, soft, some roots.						
220.7				**SILTY CLAY** - Grey, moist, firm, low plasticity, with fine to coarse grained sand. - Grain size distribution at 1.37 m: Gravel (4%), Sand (23%), Silt (40%), Clay (33%). - Tan below 1.52 m.	⋈	S1				
220	2									
219.2				**SILT TILL** - Tan, moist, dense, non plastic, well graded, with sand, trace fine grained gravel, trace cobbles, trace boulders. - Grain size distribution at 2.90 m: Gravel (9%), Sand (27%), Silt (40%), Clay (24%).	⋈	S2				
219	3	10								
218	4			**END OF TEST PIT ON DENSE SILT TILL AT 3.96 m**						
217	5	15								
216	6	20								
215										

Notes:

1. Backfilled test pit to grade upon completion.
2. Top of pit elevation estimated from 2011 LiDAR data.

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/C. ROBAK	DRAFT	6/29/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-16**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 25+258 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **223.17**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/7/2015**
UTM (m) N **5,751,245**
E **570,609**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
223				**PEAT** - Black to brown, damp, soft, some roots.				20 40 60	20 40 60 80	20 40 60 80
222.3										
222	1	5		**SILTY CLAY** - Grey to brown, moist, stiff, high plasticity, some silt seams, trace sand, trace gravel.						
				- Grain size distribution at 1.68 m: Gravel (1%), Sand (5%), Silt (17%), Clay (77%).	⋈	S1				
221	2			- Trace cobbles below 2.13 m.						
220.4				**SILT TILL** - Grey, moist, dense, well graded, with sand, with gravel, some cobbles, trace to some boulders.						
220	3	10								
219	4									
218.9				**END OF TEST PIT ON DENSE SILT TILL AT 4.27 m**						
		15		Notes: 1. Backfilled test pit to grade upon completion. 2. Top of pit elevation estimated from 2011 LiDAR data.						
218	5									
217	6	20								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/C. ROBAK	DRAFT	6/29/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-17**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 24+870 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **224.61**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/7/2015**
UTM (m) N **5,751,212**
E **570,223**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
224	1	5		**PEAT** - Black to brown, wet, soft, some roots.						
223.4				**SILTY CLAY** - Grey, moist, firm, low to intermediate plasticity, trace sand.						
223	2			- Increased stiffness with depth.						
				- Trace gravel, trace cobbles below 1.83 m.						
222.2				**SILT TILL** - Tan, moist, dense, well some sand, trace gravel, trace cobbles, trace to some boulders.						
222	3	10								
				- Grain size distribution at 3.20 m: Gravel (5%), Sand (15%), Silt (39%), Clay (41%).		S1				
221										
220.6	4			**END OF TEST PIT ON DENSE SILT TILL AT 3.96 m**						
220		15		Notes:						
	5			1. Light water infiltration into test pit from peat. 2. Backfilled test pit to grade upon completion. 3. Top of pit elevation estimated from 2011 LiDAR data.						
219										
	6	20								
218										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/C. ROBAK	DRAFT	6/29/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-18**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 24+649 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **225.21**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/7/2015**
UTM (m) N **5,751,198**
E **570,002**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
225				**PEAT** - Black to brown, wet, soft, some roots.				20 40 60	20 40 60 80	20 40 60 80
	1									
224										
223.8				**SILTY CLAY** - Grey, moist, firm, low plasticity, some sand, some fine graded gravel.						
		5								
	2			- Grain size distribution at 1.98 m: Gravel (11%), Sand (18%), Silt (36%), Clay (35%).		S1				
223										
		10								
	3									
222										
221.5				**SILT TILL** - Brown, moist, dense, well graded, with sand, some gravel, trace cobbles, trace boulders.						
	4			-Increasing cobbles and boulders with depth.		S2				
221				- Grain size distribution at 4.11 m: Gravel (14%), Sand (23%), Silt (40%), Clay (23%).						
		15		**END OF TEST PIT ON DENSE SILT TILL AT 4.27 m**						
	5			Notes:						
220				1. Light water infiltration into test pit from peat.						
				2. Backfilled test pit to grade upon completion.						
				3. Top of pit elevation estimated from 2011 LiDAR data.						
	6	20								
219										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/C. ROBAK	DRAFT	6/29/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-19**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 24+211 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **225.54**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/8/2015**
UTM (m) N **5,751,168**
E **569,565**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
225				**PEAT** - Black to brown, wet, soft.						
224.6	1	5		**SILTY CLAY** - Grey, damp, stiff, high plasticity, trace sand, trace gravel.						
224				- Grain size distribution at 1.68 m: Gravel (1%), Sand (7%), Silt (25%), Clay (66%).	⋈	S1				
	2			- Low plasticity below 2.13 m.						
223										
222.8	3	10		**SILT TILL** - Brown to tan, moist, dense, well graded, with sand, trace gravel, trace to some cobbles, trace boulders.						
222				- Grain size distribution at 3.51 m: Gravel (9%), Sand (21%), Silt (42%), Clay (27%).	⋈	S2				
221.6	4			**END OF TEST PIT AT 3.96 m**						
221		15		Notes: 1. Light water infiltration into test pit from peat, increasing with depth of test pit. 2. Backfilled test pit to grade upon completion. 3. Top of pit elevation estimated from 2011 LiDAR data.						
	5									
220										
	6	20								
219										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/C. ROBAK	DRAFT	6/29/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-20**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 23+966 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **226.84**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/8/2015**
UTM (m) N **5,751,155**
E **569,320**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80)	PL MC LL % (20 40 60 80)
226	1	5		**PEAT** - Black to brown, wet, soft, some roots.						
225.5				**SILTY CLAY** - Grey to brown, moist, firm to stiff, low to intermediate plasticity, trace sand, trace gravel.						
225	2									
224.4				**SILT TILL** - Brown, moist, compact to dense, well graded, with sand, with gravel, some cobbles, some boulders.						
224	3	10				S1				
223.0				- Very dense below 3.66 m.						
223	4			**END OF TEST PIT ON DENSE SILT TILL AT 3.81 m**						
222	5	15								
221	6	20								
220										

Notes:

1. Water infiltration into test pit from peat.
2. Backfilled test pit to approximately 2.44 m below grade upon completion.
3. Top of pit elevation estimated from 2011 LiDAR data.

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/C. ROBAK	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-21**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 23+540 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **227.50**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/8/2015**
UTM (m) N **5,751,118**
E **568,896**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
227	1	5		**PEAT** - Black to brown, wet, soft, some roots.						
226.3				**SILTY CLAY** - Grey, moist, firm, low plasticity, some sand, some gravel.						
226	2			- Grain size distribution at 1.68 m: Gravel (12%), Sand (21%), Silt (42%), Clay (25%).	⋈	S1				
225				- Trace cobbles, trace boulders below 2.13 m.						
224.8	3	10		**SILT TILL** - Brown, damp, dense, high plasticity, trace sand, trace gravel, trace cobbles, trace boulders.						
224				- Grain size distribution at 3.20 m: Gravel (1%), Sand (8%), Silt (30%), Clay (61%).	⋈	S2				
223	4	15								
222.5	5			**END OF TEST PIT ON SUSPECTED HARDPAN AT 5.03 m**						
222				Notes:						
	6	20		1. Light water infiltration into test pit from peat. 2. Backfilled test pit to grade upon completion. 3. Top of pit elevation estimated from 2011 LiDAR data.						
221										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/C. ROBAK	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-22**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 23+310 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **228.28**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/8/2015**
UTM (m) N **5,751,099**
E **568,667**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
228.0				**PEAT** - Black to brown. damp, soft.			20 40 60	20 40 60 80	20 40 60 80
228				**SILTY CLAY** - Brown, moist, stiff, intermediate plasticity, some sand, trace gravel.					
				- Grain size distribution at 0.76 m: Gravel (3%), Sand (11%), Silt (34%), Clay (52%).	S1				
	1								
227		5		- Some sand, trace gravel below 1.22 m.					
				- Trace cobbles, trace boulders below 1.83 m.					
	2								
226									
225.2	3	10		**SILT TILL** - Brown, moist, dense, well graded, some sand, trace gravel.					
225				- Grain size distribution at 3.51 m: Gravel (3%), Sand (17%), Silt (44%), Clay (36%).	S2				
224.5				**END OF TEST PIT ON DENSE SILT TILL AT 3.81 m**					
	4			Notes:					
224		15		1.Backfilled test pit to grade upon completion. 2. Top of pit elevation estimated from 2011 LiDAR data.					
	5								
223									
	6	20							
222									

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/C. ROBAK	DRAFT	6/29/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-23**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 23+081 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **228.41**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/8/2015**
UTM (m) N **5,751,083**
E **568,438**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %
228				**PEAT** - Black to brown, damp, soft, some roots.		
227.8				**SILTY CLAY** - Brown, moist, firm, intermediate plasticity, trace sand, trace gravel, trace cobbles, trace silt seams.		
	1					
227.0				- Grain size distribution at 1.30 m: Gravel (3%), Sand (9%), Silt (26%), Clay (62%).	S1	
227		5		**SILT TILL** - Brown, moist, dense, well graded,some gravel, with sand, some cobbles, trace boulders.		
	2			- Increasing boulders with depth.		
				- Grain size distribution at 1.98 m: Gravel (14%), Sand (29%), Silt (40%), Clay (17%).	S2	
226						
	3	10				
225						
	4					
224.1				**END OF TEST PIT ON DENSE SILT TILL AT 4.27 m**		
224		15		Notes:		
	5			1. Light water infiltration into test pit from till at approximately 3.05 m below grade. 2. Backfilled test pit to grade upon completion. 3. Top of pit elevation estimated from 2011 LiDAR data.		
223						
	6	20				
222						

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/C. ROBAK	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-24**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 22+898 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **228.54**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/8/2015**
UTM (m) N **5,751,066**
E **568,256**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %
228.1				**PEAT** - Black to brown, wet, soft, trace roots.			
228				**CLAYEY SAND** - Brown, moist, compact, well graded, trace gravel, some cobbles.			
	1			- Grain size distribution at 1.07 m: Gravel (9%), Sand (27%), Silt (46%), Clay (18%).		S1	
227		5		- Boulders below 1.52 m. - Increasing fine to coarse grained gravel and cobbles below 1.52 m. - Decreasing clay content with depth.			
	2						
226				- Dense below 2.74 m. - Grain size distribution at 2.90 m: Gravel (23%), Sand (46%), Silt (23%), Clay (8%).			
225.5	3	10		**END OF TEST PIT AT 3.05 m**		S2	
225				Notes: 1. Water infiltration into test pit from clayey sand at approximately 2.13 m. 2. Sidewall sloughing between 1.83 to 2.44 m. 3. Test pit left open. 4. Top of pit elevation estimated from 2011 LiDAR data.			
	4						
224		15					
	5						
223							
	6	20					
222							

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/C. ROBAK	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-25**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 22+804 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **228.36**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/8/2015**
UTM (m) N **5,751,086**
E **568,160**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
228				**PEAT** - Black to brown, wet, soft, trace roots.						
227.3	1			**SILTY SAND AND GRAVEL** - Brown to tan, damp, compact, well graded, some cobbles, some boulders. - Increased moisture with depth. -Increasing boulders, up to 1 m diameter, with depth. - Grain size distribution at 1.37 m: Gravel (33%), Sand (39%), Silt (19%), Clay (8%).						
227		5				S1				
	2									
226										
	3	10								
225										
	4									
224										
223.8		15		**END OF TEST PIT AT 4.57 m**						
	5			Notes: 1. Water infiltration into test pit from silty sand and gravel. 2. Sidewall sloughing during excavation. 3. Backfilled test pit to grade upon completion. 4. Top of pit elevation estimated from 2011 LiDAR data.						
223										
	6	20								
222										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR **TERRY LAVALLEE CONSTRUCTION**
INSPECTOR **J.MACLENNAN/C. ROBAK**
APPROVED DRAFT
DATE 6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-26**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION STA. 22+687 WILLOW POINT ALIGNMENT
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **228.94**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/8/2015**
UTM (m) N **5,751,056**
E **568,045**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
228.0				**PEAT** - Black to brown, wet, soft, trace roots.				
228	1	5		**SILTY CLAY** - Grey, moist, low to intermediate plasticity, trace coarse grained sand, trace gravel.				
				- Grain size distribution at 1.37 m: Gravel (4%), Sand (7%), Silt (23%), Clay (66%).	S1			
227	2							
226								
225.9	3	10		**SILT TILL** - Brown, moist, dense, well graded, with sand, some gravel, some cobbles, some boulders, up to 1 m diameter.				
225	4				S2			
		15		- Grain size distribution at 4.42 m: Gravel (14%), Sand (26%), Silt (49%), Clay (11%).				
224	5							
223								
222.8	6	20		**END OF TEST PIT AT 6.10m**				
222				Notes: 1. Water infiltration into test pit from peat, silty clay and silt till interface and silt till. 2. Backfilled test pit to grade upon completion. 3. Top of pit elevation estimated from 2011 LiDAR data.				

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN/C. ROBAK	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-27**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION REACH 2
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **30.48**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/9/2015**
UTM (m) N **5,746,945** E **563,818**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
30.0				**PEAT** - Black to brown, wet, soft, trace roots.				
30				**SILTY CLAY** - Brown, moist, firm, intermediate plasticity, trace sand, trace gravel.				
				-Increasing sand and gravel with depth.				
	1			- Grain size distribution at 0.9 m: Gravel (2%), Sand (10%), Silt (30%), Clay (58%).	S1			
29		5						
				- Cobbles and boulders below 1.83 m.				
28.3	2			**SILT TILL** - Brown, moist, dense, well graded, with sand, some cobbles, trace boulders.				
28				- Grain size distribution at 2.6 m: Gravel (22%), Sand (27%), Silt (35%), Clay (15%).	S2			
	3	10						
27								
	4			- Very dense below 4.27 m.				
26		15						
				- Grain size distribution at 4.7 m: Gravel (16%), Sand (28%), Silt (42%), Clay (14%).	S3			
25.5	5			**END OF TEST PIT ON SUSPECTED BOULDER AT 5.03 m**				
25				Notes:				
				1. Minor water infiltration into test pit from silt till.				
				2. Backfilled test pit to grade upon completion.				
	6	20						
24								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN	DRAFT	6/29/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-28**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION REACH 2
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **30.48**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/9/2015**
UTM (m) N **5,746,952**
E **563,738**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
30.0	0			**PEAT** - Black to brown, damp, soft.						
30				- 50 mm layer of gravel at 0.46 m.						
	1			**SILTY CLAY** - Brown, moist, soft, intermediate plasticity, some sand, some gravel. - Increasing sand and gravel with depth. - Grain size distribution at 0.8 m: Gravel (14%), Sand (31%), Silt (39%), Clay (16%).		S1				
29		5		- Cobbles below 1.52 m. - Decreasing silt content with depth. - Low plasticity below 1.83 m.						
	2									
28.0				**SILT TILL** - Brown, moist, loose to compact, well graded, with sand, some gravel, some cobbles. - Increasing density with depth. - Decreasing silt content with depth. - Grain size distribution at 2.6 m: Gravel (15%), Sand (26%), Silt (41%), Clay (18%).		S2				
28	3	10								
27.1				**END OF TEST PIT ON SUSPECTED BOULDER AT 3.4 m**						
27				Notes: 1. Backfilled test pit to grade upon completion.						
	4									
26		15								
	5									
25										
	6	20								
24										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR **TERRY LAVALLEE CONSTRUCTION**
INSPECTOR **J.MACLENNAN**
APPROVED
DRAFT
DATE 6/29/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-29**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION REACH 2
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **30.48**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/9/2015**
UTM (m) N **5,746,378**
E **563,559**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %
30				**PEAT** - Black to brown, wet, soft.			
	1						
29.1							
29		5		**SILTY CLAY** - Grey, moist, stiff, low to intermediate plasticity, some sand, some gravel, some silt seams.			
				- Grain size distribution at 1.7 m: Gravel (3%), Sand (10%), Silt (30%), Clay (57%).		S1	
	2						
28							
27.4	3	10		**SILT TILL** - Brown, moist, compact, well graded, with gravel, some cobbles.			
27							
				- Dense below 3.66 m.			
				- Increasing grain size with depth.		S2	
	4			- Grain size distribution at 3.8 m: Gravel (16%), Sand (20%), Silt (40%), Clay (24%).			
26		15					
				- Grain size distribution at 4.7 m: Gravel (12%), Sand (26%), Silt (45%), Clay (17%).		S3	
	5						
25.0							
25				**END OF TEST PIT ON SUSPECTED BOULDER AT 5.49 m**			
				Notes:			
	6	20		1. Water infiltration into test pit from peat. 2. Sidewall sloughing in the silty clay. 3. Backfilled test pit to grade upon completion.			
24							

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN	DRAFT	6/29/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-30**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION REACH 2
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **30.48**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/9/2015**
UTM (m) N **5,745,900** E **563,202**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %
30				**PEAT** - Black to brown, damp, soft, some roots.		
29.9						
	1			**SILTY CLAY** - Brown, moist, stiff, low plasticity, some sand, some gravel, some silt pockets. -Decreasing silt and clay with depth. - Grain size distribution at 0.8 m: Gravel (4%), Sand (11%), Silt (33%), Clay (52%).	S1	
29		5				
	2					
28						
27.7				**SILT TILL** - Brown, moist, dense, well graded, with gravel. - Some cobbles below 3.05 m. - Some boulders below 3.35 m. - Grain size distribution at 3.5 m: Gravel (29%), Sand (26%), Silt (31%), Clay (14%).	S2	
	3	10				
27						
	4					
26						
25.9		15		**END OF TEST PIT ON SUSPECTED BOULDERS AT 4.57 m**		
	5			Notes: 1. Backfilled test pit to grade upon completion.		
25						
	6	20				
24						

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN	DRAFT	6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-31**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION REACH 2
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **30.48**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/10/2015**
UTM (m) N **5,746,005**
E **562,925**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
30.2				**PEAT** - Black to brown, damp, soft.						
30				**SILTY SAND** - Brown, moist, loose to compact, well graded with gravel, some cobbles.						
29.9				**SILTY CLAY** - Brown, moist, firm, low plasticity, with sand, with gravel, some cobbles.						
	1			- Grain size distribution at 0.8 m: Gravel (11%), Sand (32%), Silt (25%), Clay (33%).		S1				
				- Trace boulders below 1.22 m.						
29		5								
28.7				**SILT TILL** - Brown, moist, dense, well graded, with gravel some cobbles.						
	2			-Increasing cobbles with depth.		S2				
28				- Grain size distribution at 1.9 m: Gravel (18%), Sand (24%), Silt (44%), Clay (14%).						
	3	10								
27										
	4									
26		15								
25.6				**END OF TEST PIT ON SUSPECTED BOULDER AT 4.88 m**						
	5			Notes:						
25				1. Backfilled test pit to grade upon completion.						
	6	20								
24										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR **TERRY LAVALLEE CONSTRUCTION** INSPECTOR **J.MACLENNAN** APPROVED DRAFT DATE 6/29/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-32**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 22.1 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 238.35
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/10/2015
UTM (m) N 5,746,428
E 565,993

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
238				**PEAT** - Black to brown, wet, soft.						
237.4										
	1			**SILTY CLAY** - Grey, moist, soft, low to intermediate plasticity, with sand, with gravel.		S1				
237		5		- Stiff and with silt seams below 1.52 m.		S2				
	2					S3				
236										
	3	10								
235.0				**SILT TILL** - Brown, moist, dense, well graded, with gravel, some cobbles.		S4				
235				- Grain size distribution at 3.51 m: Gravel (14%), Sand (19%), Silt (33%), Clay (34%).						
	4					S5				
234.1				- Grain size distribution at 4.12 m: Gravel (8%), Sand (12%), Silt (24%), Clay (56%).						
234				**END OF TEST PIT ON SUSPECTED BOULDERS AT 4.27 m**						
		15		Notes:						
	5			1. Significant water infiltration into test pit from peat.						
233				2. Backfilled test pit to grade upon completion.						
	6	20								
232										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN	DRAFT	7/2/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-33**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 20.9 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 240.41
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/10/2015
UTM (m) N 5,745,237
E 565,848

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
240				**PEAT** - Black to brown, wet, soft.						
	1									
239.0										
239		5		**SILTY CLAY** - Brown, moist, firm, intermediate plasticity, with silt seams, trace sand, trace gravel.		S1				
	2			- Some sand, some gravel below 2.14 m. - Grain size distribution at 2.29 m: Gravel (4%), Sand (11%), Silt (27%), Clay (58%).		S2				
238										
237.4	3	10		**SILT TILL** - Brown, moist, compact, well graded, with gravel. - Grain size distribution at 3.20 m: Gravel (12%), Sand (24%), Silt (35%), Clay (28%).		S3				
237										
	4			- Some cobbles below 3.97 m.						
236		15								
	5									
235.2				**END OF TEST PIT ON SUSPECTED BOULDER AT 5.19 m**						
235				Notes: 1. Significant water infiltration into test pit from peat. 2. 0.92 m of water ponded base of test pit from infiltration from peat. 3. Sidewall sloughing during excavation. 4. Backfilled test pit to grade upon completion.						
	6	20								
234										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN	DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-34**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 20.7 From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 241.40
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/11/2015
UTM (m) N 5,744,699
E 565,642

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %
241.2	0	0		**PEAT** - Black to brown, damp, soft, some rootlets.		
241				**SILTY CLAY** - Brown, moist, firm, low plasticity, trace coarse grained sand, trace gravel, some silt seams.		
				- Grain size distribution at 0.46 m: Gravel (5%), Sand (22%), Silt (25%), Clay (49%).	S1	
240.5	1	5		**SILT TILL** - Brown, moist, loose to compact, well graded, with gravel, trace cobbles. -Increasing density with depth.		
240				- Grain size distribution at 1.37 m: Gravel (18%), Sand (20%), Silt (41%), Clay (21%).	S2	
239	2				S3	
238	3	10		- Grain size distribution at 3.51 m: Gravel (22%), Sand (21%), Silt (38%), Clay (12%).	S4	
237	4				S5	
236.8		15		**END OF TEST PIT ON DENSE SILT TILL AT 4.58 m**		
236	5			Notes: 1. Backfilled test pit to grade upon completion.		
235	6	20				

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN	DRAFT	7/2/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-35**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 20.4 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **240.52**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/11/2015**
UTM (m) N **5,744,989**
E **565,740**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
240				**PEAT** Black to brown, wet, soft.				
239.3	1			**SILTY CLAY** - Grey, moist, firm, intermediate plasticity, trace coarse grained sand, trace fine grained gravel.				
239		5		- Grain size distribution at 1.67 m: Gravel (7%), Sand (11%), Silt (27%), Clay (54%).	S1			
	2							
238					S2			
237.5	3	10		**SILT TILL** - Brown, moist, compact to dense, well graded, with gravel, some cobbles, trace boulders.				
237								
	4							
236		15		**END OF TEST PIT ON DENSE SILT TILL AT 4.58 m**				
	5			Notes: 1. Water infiltration into test pit from silt till. 2. Backfilled test pit to grade upon completion.				
235								
	6	20						
234								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN	DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-36**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 19.7 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 243.04
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/11/2015
UTM (m) N 5,743,977
E 565,435

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
243				**PEAT** - Black to brown, wet, soft.				
242.4				**SILTY CLAY** - Grey, moist, firm, intermediate plasticity, trace coarse grained sand.				
242	1			- Increasing sand with depth. - Grain size distribution at 1.07 m: Gravel (20%), Sand (28%), Silt (18%), Clay (34%).	S1			
		5						
241	2				S2			
240.3				**SILT TILL** - Brown, moist, compact to dense, well graded, with gravel, some cobbles, trace boulders.				
240	3	10		- Grain size distribution at 3.20 m: Gravel (17%), Sand (20%), Silt (35%), Clay (28%).	S3			
239	4							
					S4			
238.5		15		**END OF TEST PIT ON SUSPECTED BOULDERS AT 4.58 m**				
238	5			Notes: 1. Water infiltration into test pit from peat. 2. Backfilled test pit to grade upon completion.				
237	6	20						

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN	DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-37**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 18.9 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 242.78
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/11/2015
UTM (m) N 5,743,136
E 565,431

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %
242.0				**PEAT** - Black to brown, wet soft.			
242	1			**SILTY CLAY** - Grey, moist, soft, high plasticity, some fine to coarse grained sand, trace gravel.		S1	
		5		- Stiff below 1.52 m.		S2	
241	2			- Grain size distribution at 1.68 m: Gravel (6%), Sand (12%), Silt (19%), Clay (63%).			
				- Some sand, some gravel, trace cobbles below 2.44 m.		S3	
240.0				**SILT TILL** - Brown, moist, dense, well graded, some fine to coarse grained sand, some fine to coarse grained gravel, some cobbles.			
240	3	10		- Grain size distribution at 3.20 m: Gravel (16%), Sand (20%), Silt (38%), Clay (26%).		S4	
239	4						
		15				S5	
238	5						
237.6				**END OF TEST PIT ON DENSE SILT TILL AT 5.19 m.**			
237				Notes: 1. Water infiltration into test pit from peat. 2. Backfilled test pit to grade upon completion.			
	6	20					
236							

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	J.MACLENNAN	DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-38**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 18.4 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 243.48
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/11/2015
UTM (m) N 5,742,551
E 565,102

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
243	1	5		**PEAT** - Black to brown, damp, soft.				
241.7	2	10		**SILTY CLAY** - Grey, moist, firm, intermediate plasticity, some fine to coarse grained sand, trace coarse grained gravel. - Grain size distribution at 2.29 m: Gravel (7%), Sand (13%), Silt (22%), Clay (58%).	S1			
240.3	3			- Some sand, trace gravel below 3.05 m.	S2			
240	4	15		**SILT TILL** - Brown, moist, dense, well graded, some fine to coarse grained sand, some fine to coarse grained gravel, some cobbles. - Grain size distribution at 3.81 m: Gravel (15%), Sand (20%), Silt (42%), Clay (23%).	S3			
238.6	5			**END OF TEST PIT ON DENSE SILT TILL AT 4.88 m**				
238	6	20		Notes: 1. Backfilled test pit to grade upon completion.				
237								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR TERRY LAVALLEE CONSTRUCTION S.REPA
INSPECTOR
APPROVED DRAFT
DATE 7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-39**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 16.9 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 243.53
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/12/2015
UTM (m) N 5,741,216
E 564,107

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
243	1	5		**PEAT** - Dark brown, wet to saturated, some roots (2 to 5 mm), with rootlets, trace roots (5 to 10 mm), fibrous to hemic.	S1			795	
242									
241.9				**SILTY CLAY** - Grey, moist, high plasticity, firm, laminated with silt lenses, trace fine to coarse grained sand, trace fine to coarse grained gravel.					
	2			- Grain size distribution at 1.98 m: Gravel (2%), Sand (6%), Silt (18%), Clay (74%).	S2				
241				- Increasing silt, fine to coarse grained sand, fine to coarse grained gravel with depth.					
240.5	3	10		**SILT TILL** - Brown, moist, compact to dense, low plasticity, some fine to coarse grained sand, some fine to coarse grained gravel, some cobbles.	S3				
240				- Grain size distribution at 3.20 m: Gravel (10%), Sand (18%), Silt (39%), Clay (33%).					
239	4	15		**END OF TEST PIT DUE TO SLOUGHING AT 4.58 m**					
	5			Notes: 1.Significant water infiltration into test pit from peat. 2. Water ponded at bottom of test pit from above noted infiltration. 3. Backfilled test pit to grade upon completion.					
238									
	6	20							
237									

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR TERRY LAVALLEE CONSTRUCTION S.REPA
INSPECTOR
APPROVED DRAFT
DATE 7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-40**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 16.4 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 243.66
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/12/2015
UTM (m) N 5,740,771
E 563,752

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %
243	0	0		**PEAT** - Brown, wet, trace roosts, with rootlets, fibrous.			
						S1	
	1			- Dark brown, wet to saturated, fibrous to hemic below 0.61 m.			
242.3							
		5		**SILTY CLAY** - Grey, moist, stiff, intermediate plasticity, some fine to coarse grained sand, trace fine grained gravel.			
242						S2	
	2			- Grain size distribution at 1.98 m: Gravel (9%), Sand (15%), Silt (22%), Clay (54%).			
241.4							
241.2				**SAND AND GRAVEL** - Grey, wet, well graded, fine to coarse grained sand, fine to coarse grained gravel.			
241				**SILTY CLAY TO SILT TILL** - Brown, wet, stiff, high plasticity, trace fine to coarse grained sand, some cobbles.			
	3	10				S3	
				- Grain size distribution at 3.20 m: Gravel (0%), Sand (4%), Silt (18%), Clay (78%).			
240							
	4			- Trace boulders below 4.27 m.			
		15					
239							
238.8				**END OF TEST PIT ON SUSPECTED BOULDER AT 4.88 m**			
	5						
				Notes:			
238				1. Water infiltration into test pit from peat. 2. Water ponded at bottom of test pit from above noted infiltration. 3. Continuous side wall sloughing between 1.37 to 2.44 m. 4. Backfilled test pit to grade upon completion.			
	6	20					
237							

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

874

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-41**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 15.5 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **245.03**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/12/2015**
UTM (m) N **5,740,101**
E **563,410**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
245				**PEAT** - Brown, wet, with rootlets, some roots (2 to 10 mm), trace roots (10 to 25 mm), fibrous.				
				- Dark brown, decreased fibres below 0.15 m.	S1			4 16
244.4				**SILTY CLAY** - Grey, moist, firm, low plasticity, silt pockets.				
244	1							
		5		- Transition to silt till - Brown mottled with tan, stiff, some fine to coarse grained sand, some fine to coarse grained gravel, trace cobbles, blocky structure below 1.53.	S2			
243	2			- Grain size distribution at 1.68 m: Gravel (11%), Sand (17%), Silt (32%), Clay (40%).				
242.6				**SILT TILL** - Tan, moist, dense, low plasticity, some fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, trace boulders.				
				- Increasing cobbles and boulders with depth.				
242	3	10			S3			
				- Grain size distribution at 3.20 m: Gravel (20%), Sand (18%), Silt (40%), Clay (22%).				
241	4							
240.5		15		**END OF TEST PIT ON SUSPECTED BOULDER AT 4.56 m**				
240	5			Notes:				
				1. Minor water infiltration into test pit from peat.				
				2. Backfilled test pit to grade upon completion.				
239	6	20						

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR **TERRY LAVALLEE CONSTRUCTION** INSPECTOR **S.REPA** APPROVED DRAFT DATE 7/2/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-42**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 15.1 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **246.08**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/12/2015**
UTM (m) N **5,739,678**
E **563,185**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
246				**PEAT** - Brown, wet, with rootlets, some roots (2 to 10 mm), trace roots (10 to 25 mm), fibrous.	S1			1342 ◆	
					S2			507 ◆	
245.3				**SILTY CLAY TO CLAYEY SILT** - Grey, moist, soft to firm, low plasticity, some fine to coarse grained sand.					
245	1	5		- Grain size distribution at 1.07 m: Gravel (0%), Sand (18%), Silt (46%), Clay (36%).	S3			◆	
244.1				**SILT TILL** - Tan, moist, friable, with fine to coarse grained sand, some cobbles.					
244	2			- Trace boulders below 2.14 m.					
				- Grain size distribution at 2.29 m: Gravel (0%), Sand (21%), Silt (50%), Clay (30%).	S4				
243	3	10							
242	4								
241.8				**END OF TEST PIT ON DENSE SILT TILL AT 4.27 m**					
		15		Notes:					
				1. Minor water infiltration into test pit from peat and silty clay to clayey silt interface.					
241	5			2. Backfilled test pit to grade upon completion.					
240	6	20							

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR **TERRY LAVALLEE CONSTRUCTION**
INSPECTOR **S.REPA**
APPROVED DRAFT
DATE 7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-43**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 14.4 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **246.65**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/13/2015**
UTM (m) N **5,739,037**
E **562,884**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
246.0				**PEAT** - Dark brown to black, wet, some roots (2 -10 mm), trace roots (10-50 mm), some rootlets, hemic.		S1			831	
246				**SILTY CLAY** - Grey, moist, intermediate plasticity, some fine to coarse grained sand, trace silt pockets (up to 50 mm).						
	1			- Grain size distribution at 1.07 m: Gravel (0%), Sand (13%), Silt (30%), Clay (57%).		S2			◆	
				- Increasing fine to coarse grained sand, fine to coarse grained gravel and silt below 1.22 m.						
245.1		5		**SILT TILL** - Tan, damp to moist, friable, with fine to coarse grained sand, some cobbles.						
245				- Increasing density with depth.						
	2			- Trace boulders below 2.14 m.		S3				
				- Grain size distribution at 2.29 m: Gravel (0%), Sand (30%), Silt (43%), Clay (27%).						
244										
	3	10								
243										
	4									
242.1		15		**END OF TEST PIT ON DENSE SILT TILL AT 4.58 m**						
242				Notes:						
	5			1. Water infiltration into test pit from peat and silty clay interface.						
				2. 0.61 m of water ponded at bottom of test pit from above noted infiltration.						
241				3. Backfilled test pit to grade upon completion.						
	6	20								
240										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION S.REPA		DRAFT	7/2/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-44**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 13.9 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 246.35
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/13/2015
UTM (m) N 5,738,375
E 562,548

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
246							20 40 60	20 40 60 80	20 40 60 80
245.9				**PEAT** - Black, moist, some rootlets, some roots, hemic.	S1			356	
	1	5		**SILTY CLAY** - Tan mottled with brown, damp to moist, intermediate plasticity, with fine to coarse grained sand, trace cobbles.	S2				
				- Grain size distribution at 0.76 m: Gravel (0%), Sand (21%), Silt (43%), Clay (36%).					
245				- Increased silt content, fine to coarse grained sand, fine to coarse grained gravel with depth.					
244.8				**SILT TILL** - Tan, damp to moist, compact, friable, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles.					
	2			- Trace boulders up to 500 mm below 2.14 m.					
244				- Increased density with depth.					
	3	10			S3				
243									
	4								
242.1				**END OF TEST PIT ON SUSPECTED BOULDER AT 4.27 m**					
242		15		Notes:					
	5			1. Backfilled test pit to grade upon completion.					
241									
	6	20							
240									

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-45**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 12.8 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 247.29
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/13/2015
UTM (m) N 5,737,451
E 562,048

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
247				**PEAT** - Black, wet, with rootlets, some roots (up to 50 mm), hemic.					
246.8					S1				
				SILTY CLAY - Grey, moist, firm, intermediate plasticity some fine to coarse grained sand.					
				- Grain size distribution at 0.76 m: Gravel (0%), Sand (19%), Silt (29%), Clay (52%).	S2				
	1			- Brown, mottled with tan, increased silt content, low to intermediate plasticity, friable below 1.07 m.					
246									
		5							
245.6				- Grain size distribution at 1.68 m: Gravel (0%), Sand (10%), Silt (25%), Clay (65%).	S3				
	2			**SILT TILL** - Tan, damp to moist, compact, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, trace boulders.					
245				- Increasing density with depth.					
	3	10							
244									
					S4				
	4								
243.0				**END OF TEST PIT ON SUSPECTED BOULDER AT 4.27 m**					
243		15							
				Notes:					
	5			1. Minor water infiltration into test pit from peat and silty clay interface and clay and till interface.					
242				2. Backfilled test pit to grade upon completion.					
	6	20							
241									

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-46**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 11.9 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **250.05**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/13/2015**
UTM (m) N **5,736,617**
E **561,603**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
250				**PEAT** - Black to dark brown, dry to damp, with rootlets, hemic.		S1				
249.9				**CLAYEY SILT AND SAND** - Brown to tan, moist, soft, low plasticity, fine to medium grained sand, some coarse grained sand, trace fine grained gravel.						
				- Grain size distribution at 0.76 m: Gravel (9%), Sand (28%), Silt (47%), Clay (16%).		S2				
249	1			- Some cobbles, some flat and angular to subrounded boulders up to 500 mm, some fine to medium grained sand below 1.07 m.						
		5								
248.2				**SILT TILL** - Tan, damp to moist, compact, with fine to coarse grained sand, some cobbles, trace subrounded to subangular boulders.						
248	2									
				- Grain size distribution at 2.59 m: Gravel (0%), Sand (28%), Silt (48%), Clay (24%).		S3				
247	3	10								
246	4									
245.8				**END OF TEST PIT ON SUSPECTED BOULDER AT 4.58 m**						
		15		Notes:						
				1. Water infiltration into test pit.						
245	5			2. Backfilled test pit to grade upon completion.						
244	6	20								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-47**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 11.1 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **248.75**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/13/2015**
UTM (m) N **5,735,860**
E **561,118**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
248.7				**TOPSOIL/PEAT** - Black to dark brown, moist (frozen), with rootlets, some roots (up to 50 mm).				20 40 60	20 40 60 80	20 40 60 80
				SILTY CLAY - Brown mottled with tan, moist, stiff, low to intermediate plasticity, some fine to coarse grained sand, trace fine to coarse grained gravel.						
248	1									
				- Grain size distribution at 1.07 m: Gravel (8%), Sand (19%), Silt (35%), Clay (39%).		S1				
				- Increased silt content below 1.22 m.						
		5								
247	2									
246.6				**SILT TILL** - Tan, damp to moist, compact, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, trace boulders.						
				- Density increasing with depth.						
246	3	10								
245				**END OF TEST PIT ON DENSE SILT TILL AT 3.81 m**						
	4			Notes:						
				1. Water infiltration into test pit from silt till.						
		15		2. Backfilled test pit to grade upon completion.						
244	5									
243										
	6	20								
242										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION S.REPA		DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-48**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 10.5 km From Camp to Reach 2/3
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 248.15
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/14/2015
UTM (m) N 5,735,317
E 560,746

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
248				**PEAT** - Dark brown, wet, with rootlets, some roots (up to 50 mm), hemic.	S1			555	
247.7				**SILTY CLAY TO CLAYEY SILT** - Grey to tan, moist, low plasticity, soft to firm, with fine to coarse grained sand, trace cobbles.					
247	1	5		- Increased silt, fine to coarse grained sand and fine to coarse grained gravel below 0.915 m. - Grain size distribution at 1.07 m: Gravel (0%), Sand (21%), Silt (43%), Clay (36%).	S2			H ◆	
246.3				**SILT TILL** - Tan, damp to moist, loose to compact, with fine to coarse grained sand, some cobbles, trace boulders. - Grain size distribution at 1.83 m: Gravel (0%), Sand (31%), Silt (45%), Clay (24%).	S3			● ▮	
246	2			- Increasing density with depth.					
245	3	10							
244	4								
243.6		15		**END OF TEST PIT ON DENSE SILT TILL AT 4.58 m**					
243	5			Notes: 1. Backfilled test pit to grade upon completion.					
242	6	20							

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR TERRY LAVALLEE CONSTRUCTION S.REPA
INSPECTOR
APPROVED DRAFT
DATE 7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-49**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 10.2 km From Camp
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 248.52
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/14/2015
UTM (m) N 5,735,062
E 560,594

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %
248.4	0	0		**TOPSOIL/PEAT** - Black to dark brown, hemic.		
				SILTY CLAY TO CLAYEY SILT - Grey mottled with brown, moist, soft, intermediate plasticity, some fine to coarse grained sand, trace cobbles.		
248					S1	
				- Grain size distribution at 0.76 m: Gravel (0%), Sand (19%), Silt (41%), Clay (40%).		
	1			- Increased silt, fine to coarse grained sand below 1.22 m.		
247		5			S2	
246.7				**SILT TILL** - Tan, damp to moist, loose to compact, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, trace boulders, trace clay.		
	2			- Decreasing clay content with depth.		
246				- Increasing density with depth.		
	3	10				
245						
244.9				**END OF TEST PIT ON DENSE SILT TILL AT 3.66 m**		
	4			Notes:		
				1. Backfilled test pit to grade upon completion.		
244		15				
	5					
243						
	6	20				
242						

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION	S.REPA	DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-50**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 9.5 km From Camp
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 248.62
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/14/2015
UTM (m) N 5,734,429
E 560,593

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %
248.5				**PEAT** - Black, damp to moist, with rootlets, trace roots (up to 25 mm), hemic.		S1	
				SILTY CLAY TO CLAYEY SILT - Grey to tan, moist firm, low plasticity, with fine to coarse grained sand.			
248				- Grain size distribution at 0.76 m: Gravel (0%), Sand (21%), Silt (49%), Clay (30%).		S2	
	1			- Increased silt, fine to coarse grained sand, fine to coarse grained gravel below 1.22 m.			
		5					
247							
246.5	2			**SILT TILL** - Tan, damp to moist, loose to compact, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, some boulders, trace clay.			
246				- Decreasing clay with depth - Increasing density with depth.			
	3	10					
245.1				**END OF TEST PIT ON SUSPECTED BOULDER AT 3.51 m**			
245				Notes:			
	4			1. Backfilled test pit to grade upon completion.			
244		15					
	5						
243							
	6	20					
242							

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80
240

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-51**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 8.9 km From Camp
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 248.53
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/14/2015
UTM (m) N 5,733,800
E 560,599

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆
248.1				**PEAT** - Black, saturated to wet, some rootlets, trace roots (up to 25 mm), hemic.	S1			490
248				**SILT CLAY** - Grey, moist, soft, intermediate plasticity, some silt pockets (up to 50 mm), some fine to coarse grained sand.				
	1				S2			
				- Grain size distribution at 0.92 m: Gravel (0%), Sand (14%), Silt (31%), Clay (56%).				
247		5		- Increased silt, fine to coarse grained sand, fine to coarse grained gravel below 1.53 m - Some cobbles below 1.53 m.				
	2							
246.4				**SILT TILL** - Tan, damp to moist, compact, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, trace boulders.				
246				- Increasing density with depth.				
	3	10						
245					S3			
	4							
244.3				**END OF TEST PIT ON DENSE SILT TILL AT 4.27 m**				
244		15		Notes:				
	5			1. Minor water infiltration into test pit from silty clay. 2. Backfilled test pit to grade upon completion.				
243								
	6	20						
242								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-52**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 8.4 km From Camp
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 248.46
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/14/2015
UTM (m) N 5,733,204
E 560,622

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
248				**PEAT** - Black, wet, with rootlets, trace roots (up to 25 mm), hemic.	S1			65◆
247.4	1			**SILTY CLAY** - Grey, moist, intermediate plasticity, soft, trace fine to medium grained sand, trace fine grained gravel, some silt pockets (up to 50 mm).				
247		5		- Grain size distribution at 1.37 m: Gravel (5%), Sand (10%), Silt (26%), Clay (59%).	S2			◆ PL MC LL
	2			-Increased silt, fine to coarse grained sand, fine to coarse grained gravel below 1.53 m. - Some cobbles below 1.53 m.				
246.3				**SILT TILL** - Tan, damp to moist, compact, some fine to coarse grained sand, trace fine to coarse grained gravel, some cobbles, trace boulders.				
246								
	3	10		- Grain size distribution at 2.90 m: Gravel (7%), Sand (23%), Silt (44%), Clay (27%).	S3			● ■
245				- Increased density with depth.				
244.5	4			**END OF TEST PIT ON SUSPECTED BOULDER AT 3.97 m**				
244		15		Notes: 1. Water infiltration into test pit from peat clay interface. 2. Backfilled test pit to grade upon completion.				
	5							
243								
	6	20						
242								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-53**

SHEET 1 of 1

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 8.1 km From Camp
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 250.23
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/14/2015
UTM (m) N 5,732,606
E 560,616

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
250										
249.9				**PEAT** - Black, damp to moist, with rootlets, trace roots (up to 25 mm), hemic.		S1				
				CLAY SILT - Tan, moist, low plasticity, with fine to coarse grained sand, some fine to coarse grained gravel, friable.					287	
				- Grain size distribution at 0.76 m: Gravel (9%), Sand (16%), Silt (50%), Clay (25%).		S2				
249	1	5		- Increased silt, sand below 1.22 m. - Increasing density with depth.						
248.4				**SILT TILL** - Tan, damp to moist, compact, with fine to coarse grained sand, trace fine to coarse grained gravel, some cobbles, trace boulders.						
248	2			- Increasing density with depth.						
247	3	10		- Grain size distribution at 3.20 m: Gravel (10%), Sand (22%), Silt (45%), Clay (23%).		S3				
246.1	4			**END OF TEST PIT ON DENSE SILT TILL AT 4.12 m**						
246		15		Notes: 1. Backfilled test pit to grade upon completion.						
245	5									
244	6	20								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR TERRY LAVALLEE CONSTRUCTIONS.REPA
INSPECTOR
APPROVED DRAFT
DATE 7/2/15

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SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-54**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 7.2 km From Camp
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **250.23**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/14/2015**
UTM (m) N **5,731,872**
E **560,601**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
250.1				**TOPSOIL/PEAT** - Black, damp to moist, with rootlets, trace roots (up to 25 mm), hemic.				
250				**SILTY SAND AND GRAVEL** - Brown, moist to wet, loose, fine to coarse grained sand, fine to coarse grained gravel, trace cobbles. - Grain size distribution at 0.46 m: Gravel (33%), Sand (41%), Silt (18%), Clay (8%).	S1			
249.2	1			**SILTY CLAY** - Brown mottled with tan, moist, firm, intermediate plasticity, some fine to coarse grained sand, trace fine to coarse grained gravel, trace cobbles.				
249		5		- Grain size distribution at 1.37 m: Gravel (9%), Sand (12%), Silt (32%), Clay (47%). - Increased silt, fine to coarse grained sand, fine to coarse grained gravel below 1.53 m.	S2			
	2							
248								
247.8				**SILT TILL** - Tan, damp to moist, compact, with fine to coarse grained sand, some fine to coarse grained gravel, trace boulders.				
	3	10		- Increasing density with depth.				
247				- Some boulders (up to 750 mm) below 3.66 m.				
246.0	4			**END OF TEST PIT ON DENSE SILT TILL AT 4.27 m**				
		15		Notes: 1. Minor water infiltration into test pit at bottom of pit. 2. Backfilled test pit to grade upon completion.				
	5							
245								
	6	20						
244								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-55**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 6.2 km From Camp
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/15/2015
UTM (m) N 5,731,039
E 561,064

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80)	PL MC LL % (20 40 60 80)
	0			**PEAT** - Black, damp, with rootlets, some roots (up to 50 mm), hemic.		S1				136
				SILTY CLAY TO CLAYEY SILT - Brown to tan, damp to moist, friable, low plasticity, with fine to coarse grained sand, some fine to coarse grained gravel.						
	1			- Grain size distribution at 1.07 m: Gravel (11%), Sand (21%), Silt (40%), Clay (28%).		S2				
		5		- Grain size distribution at 1.37 m: Gravel (10%), Sand (12%), Silt (28%), Clay (50%). - Some cobbles below 1.53 m.						
	2			**SILT TILL** - Tan, damp to moist, non plastic, compact, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, trace boulders.						
	3	10								
	4			**END OF TEST PIT ON DENSE SILT TILL AT 4.12 m**						
		15		Notes: 1. Backfilled test pit to grade upon completion.						
	5									
	6	20								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-56**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 5.5 km From Camp
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/15/2015
UTM (m) N 5,730,260
E 561,341

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
	0			**PEAT** - Black, damp, with rootlets, some roots (up to 50 mm), hemic.				20 40 60	20 40 60 80	20 40 60 80
				SILTY CLAY - Brown, moist, firm, intermediate plasticity, some fine to coarse grained sand, trace fine to coarse grained gravel.						
				- Increased fine to coarse grained sand, fine to coarse grained gravel with depth.						
	1	5				S1				
				SILT TILL - Tan, damp to moist, compact to dense, non plastic, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, some boulders (up to 750 mm).		S2				
	2			- Increasing density with depth.						
				- Grain size distribution at 2.90 m: Gravel (18%), Sand (22%), Silt (38%), Clay (22%).		S3				
	3	10								
				END OF TEST PIT ON SUSPECTED BOULDER AT 3.81 m						
	4			Notes:						
				1. Backfilled test pit to grade upon completion.						
		15								
	5									
	6	20								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-57**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 4.8 km From Camp
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/15/2015
UTM (m) N 5,729,577
E 561,382

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
				PEAT - Black, damp, with rootlets, some roots (up to 50 mm)		S1			
				SILTY CLAY TO CLAYEY SILT - Brown to tan, damp to moist, soft, low plasticity, with fine to coarse grained sand, friable.					
				- Grain size distribution at 0.76 m: Gravel (0%), Sand (24%), Silt (48%), Clay (29%).		S2			
	1	5		- Increased silt, fine to coarse grained sand below 1.53 m. - Some cobbles below 1.53 m.					
	2			**SILT TILL** - Tan, damp to moist, compact, non plastic, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, some boulders (up to 1000 mm).					
	3	10		- Increasing density with depth.					
	4			**END OF TEST PIT ON DENSE SILT TILL AT 3.81 m**					
		15		Notes: 1. Backfilled test pit to grade upon completion.					
	5								
	6	20							

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR TERRY LAVALLEE CONSTRUCTION S.REPA
INSPECTOR
APPROVED DRAFT
DATE 7/2/15

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2012\12-0300-011\DESIGN\GEO\LOGS\LSM STAGE 2 INVESTIGATIONS\2015_TESTPITINVESTIGATION.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-58**

SHEET 1 of 1

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 4.1 km From Camp
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/15/2015
UTM (m) N 5,728,999
E 561,423

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
	0	0		**PEAT** - Black, wet to saturated, with roots.	S1			339
	1	5		**SILTY CLAY** - Grey, moist, firm, low plasticity, trace fine to coarse grained sand, trace fine to coarse grained gravel. - Grain size distribution at 0.92 m: Gravel (8%), Sand (41%), Silt (16%), Clay (35%).	S2			
	2			- Increased fine to coarse grained sand, fine to coarse grained gravel below 1.53 m. - Trace cobbles below 1.53 m.	S3			
	3	10		**SILT TILL** - Tan, damp to moist, compact to dense, non plastic, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, trace boulders.				
	4			**END OF TEST PIT ON DENSE SILT TILL AT 4.12 m**				
	5	15		Notes: 1. Minor water infiltration into test pit from peat and silty clay. 2. Minor sloughing from 0 to 1.53 m below grade. 3. Backfilled test pit to grade upon completion.				
	6	20						

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2012\12-0300-011\DESIGN\GEO\LOGS\LSM STAGE 2 INVESTIGATIONS\2015_TESTPITINVESTIGATION.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-59**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 3.4 km From Camp
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/15/2015
UTM (m) N 5,728,339
E 561,389

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
				PEAT (hemic) - Black, moist, with rootlets, some roots (up to 50 mm).		S1				
				SILTY CLAY - Brown, moist, firm, friable, low plasticity, with fine to coarse grained sand, some fine to coarse grained gravel.		S2				
	1			- Increased silt, sand below 0.92 m. - Trace cobbles below 0.92 m.						
		5		- Grain size distribution at 1.68 m: Gravel (15%), Sand (22%), Silt (38%), Clay (25%).		S3				
	2			**SILT TILL** - Tan, damp to moist, non plastic, compact, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, trace boulders.						
	3	10								
	4			**END OF TEST PIT ON DENSE SILT TILL AT 4.12 m**						
		15		Notes: 1. Backfilled test pit to grade upon completion.						
	5									
	6	20								

SPT (N) blows/0.15 m ▲ scale: 20 40 60
DYNAMIC CONE (N) blows/ft △ scale: 20 40 60
Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ scale: 20 40 60 80
PL MC LL % scale: 20 40 60 80

239

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR TERRY LAVALLEE CONSTRUCTIONS.REPA
INSPECTOR
APPROVED DRAFT
DATE 7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-60**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 3.0 km From Camp
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/15/2015
UTM (m) N 5,727,987
E 561,012

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
	0	0		**PEAT (hemic)** - Black, damp, with rootlets, some roots (up to 50 mm).						
				SILTY CLAY - Brown, moist, firm, intermediate plasticity, with fine to coarse grained sand, some fine grained gravel, friable. - Grain size distribution at 0.38 m: Gravel (14%), Sand (26%), Silt (22%), Clay (38%).		S1				
	1			**CLAYEY SILT** - Tan, damp to moist, low plasticity, firm, some fine to coarse grained sand, trace fine to coarse grained gravel. - Increased silt, sand, gravel content with depth.		S2				
		5		**SILT TILL** - Tan, damp to moist, compact to dense, non plastic, with fine to coarse grained sand, some fine to coarse grained gravel. - Density increasing with depth. - Grain size distribution at 1.68 m: Gravel (11%), Sand (30%), Silt (37%), Clay (22%).						
	2									
	3	10								
	4			**END OF TEST PIT ON DENSE SILT TILL AT 3.97 m**						
		15		Notes: 1. Backfilled test pit to grade upon completion.						
	5									
	6	20								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-61**

SHEET 1 of 1

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 1.9 km From Camp
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/16/2015
UTM (m) N 5,727,274
E 560,081

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
	0			**PEAT (hemic)** - Dark brown to black, wet with rootlets, some roots (up to 50 mm).						
						S1			558	
	1			**SAND** - Grey, wet, loose, fine to coarse grained sand, with fine to coarse grained gravel, trace silt, trace clay. - Grain size distribution at 1.00 m: Gravel (23%), Sand (65%), Silt (6%), Clay (7%).		S2				
		5		**SILTY CLAY** - Brown mottled with tan, firm, low plasticity, some silt pockets (up to 50 mm), some fine to coarse grained sand, trace fine to coarse grained gravel. - Increased silt content with depth. - Grain size distribution at 1.68 m: Gravel (8%), Sand (19%), Silt (35%), Clay (38%). - Some boulders, trace boulders (up to 750 mm) below 1.83 m.		S3				
	2									
	3	10		**SILT TILL** - Tan, damp to moist, non plastic, compact, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, trace boulders (up to 750 mm).						
	4	15		**END OF TEST PIT DUE TO CONTINUOUS SLOUGHING AT 4.58 m**						
	5			Notes: 1. Water infiltration into test pit from 0 to 2.44 m below grade. 2. Backfilled test pit to grade upon completion.						
	6	20								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-62**

SHEET 1 of 1

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 0.7 km From Camp
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV.
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/16/2015
UTM (m) N 5,726,478
E 559,077

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
	1	5		**PEAT (fibrous)** - wet to saturated, with rootlets, some roots (up t o 50 mm).					
				- Hemic, brown below 0.46 m.		S1			494
	2	5		**SILTY CLAY** - Grey, moist, firm, intermediate plasticity, some fine to coarse grained sand, trace fine grained gravel, some silt pockets, friable.		S2			
				- Grain size distribution at 1.68 m: Gravel (10%), Sand (15%), Silt (27%), Clay (49%).					
	2			**SILTY SAND** - Grey, saturated, loose, fine to coarse grained sand, with fine to coarse grained gravel.					
	3	10		**SILT TILL** - Tan, damp to moist, compact , low plasticity, some fine to coarse grained sand, some fine to coarse grained gravel, trace cobbles, trace boulders.					
				- Increasing density with depth.					
				- Grain size distribution at 3.20 m: Gravel (12%), Sand (19%), Silt (44%), Clay (26%).		S3			
	4			**END OF TEST PIT ON DENSE SILT TILL AT 4.12 m**					
		15		Notes:					
	5			1. Water infiltration into test pit. 2. 0.48 m of water ponded at bottom of test pit from above noted infiltration. 3. Continuous side wall sloughing between 0 to 2.44 m. 4. Backfilled test pit to grade upon completion.					
	6	20							

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR TERRY LAVALLEE CONSTRUCTION S.REPA
INSPECTOR
APPROVED DRAFT
DATE 7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-63**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 10.8 km From Camp to Reach 1
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **247.36**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/16/2015**
UTM (m) N **5,735,514**
E **560,187**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
247.3				**PEAT (hemic)** - Black, damp, with rootlets, come roots (up to 50 mm).					
247				**SILTY CLAY** - Brown, moist, soft to firm, intermediate plasticity, some fine grained gravel, trace fine to coarse grained sand, some silt pockets (up to 50 mm), friable.					
				- Increased fine to coarse grained sand, with depth.	S1				
	1								
246		5		- Grain size distribution at 1.37 m: Gravel (15%), Sand (9%), Silt (21%), Clay (54%).	S2				
	2								
245.2				**SILT TILL** - Tan, damp to moist, compact, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, trace boulders (up to 750 mm).					
245				- Increasing density with depth.					
	3	10							
244									
243.2	4			**END OF TEST PIT ON DENSE SILT TILL AT 4.12 m**					
243				Notes:					
		15		1. Backfilled test pit to grade upon completion.					
	5								
242									
	6	20							
241									

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR **TERRY LAVALLEE CONSTRUCTION S.REPA** | INSPECTOR | APPROVED DRAFT | DATE 7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-64**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 11.4 km From Camp to Reach 1
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. 12-0300-011
GROUND ELEV. 246.67
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 2/17/2015
UTM (m) N 5,735,473
E 59,690

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %
246.6				**ORGANIC CLAY** - Black, moist to wet, with rootlets, trace roots (up to 25 mm).		S1	
246.4				**SANDY CLAY** - Brown, moist to wet, soft, fine to coarse grained sand, fine to coarse grained gravel.			
246	1			**SILTY CLAY** - Brown, moist, stiff, intermediate plasticity, some fine to coarse grained sand, some fine to coarse grained gravel, some silt pockets (up to 50 mm), trace silt lens (up to 200 mm), friable.			
				- Grain size distribution at 1.07 m: Gravel (13%), Sand (14%), Silt (20%), Clay (52%).		S2	
245		5					
	2						
244.2				**CLAY TILL** - Brown mottled with tan, damp to moist, stiff, low plasticity, some fine to coarse grained sand, trace fine to coarse grained gravel, trace cobbles, trace boulders.			
244				- Increasing density with depth.			
	3	10		- Grain size distribution at 2.90 m: Gravel (9%), Sand (17%), Silt (36%), Clay (38%).		S3	
243							
	4						
242.2		15		**END OF TEST PIT ON DENSE CLAY TILL AT 4.42 m**			
242				Notes:			
	5			1. Backfilled test pit to grade upon completion.			
241							
	6	20					
240							

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-65**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 12.2 km From Camp to Reach 1
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **245.73**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/17/2015**
UTM (m) N **5,736,541**
E **558,985**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
245.1				**PEAT** - Black, wet, with roots.	S1			494	
245				**SILTY CLAY** - Grey, moist, firm, high plasticity, some fine to coarse grained sand, trace fine grained gravel. - Grain size distribution at 0.76 m: Gravel (1%), Sand (13%), Silt (15%), Clay (71%).	S2				
244.7	1			**CLAYEY SILT** - Tan, moist to wet, non plastic to low plasticity, with fine to coarse grained sand, with fine to coarse grained gravel. - Increased silt below 1.53. - Some cobbles, trace boulders below 1.53 m.	S3				
244		5							
243.9	2			**SILT TILL** - Tan, moist, loose, wet, with fine to coarse grained sand, with fine to coarse grained gravel, with cobbles, some boulders.					
243									
	3	10							
242									
241.8	4			**END OF TEST PIT DUE TO CONTINUOUS SIDEWALL SLOUGHING AT 3.97 m**					
		15		Notes: 1. Minor water infiltration into test pit from peat and silty clay interface. 2. 0.31 m of water ponded at bottom of test pit from above noted infiltration. 3. Backfilled test pit to grade upon completion.					
241	5								
240									
	6	20							
239									

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR **TERRY LAVALLEE CONSTRUCTION** INSPECTOR **S.REPA** APPROVED DRAFT DATE 7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-66**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 12.9 km From Camp to Reach 1
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **245.80**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/17/2015**
UTM (m) N **5,737,051**
E **558,362**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
245.8				**PEAT** - Black, moist, with roots.						
				SILTY CLAY - Brown, moist, firm, high plasticity, trace fine to coarse grained sand, some fine to coarse grained gravel, some silt pockets (up to 50mm), trace silt lenses (up to 200 mm), friable.						
245	1			- Grain size distribution at 0.76 m: Gravel (11%), Sand (7%), Silt (23%), Clay (59%).		S1				
244.6				**CLAYEY SILT** - Tan, moist, some fine to coarse sand, some fine to coarse grained gravel, trace cobbles.						
244.0		5								
	2			**SILT TILL** - Tan, damp to moist, compact, low plasticity, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, trace boulders.						
243				- Increasing density with depth.						
	3	10		- Grain size distribution at 2.59 m: Gravel (17%), Sand (22%), Silt (38%), Clay (23%).		S2				
242.0				**END OF TEST PIT ON SUSPECTED BOULDER AT 3.81 m**						
242	4			Notes:						
				1. Backfilled test pit to grade upon completion.						
		15								
241	5									
240										
	6	20								
239										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION S.REPA		DRAFT	7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-67**

SHEET 1 of 1

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 13.7 km From Camp to Reach 1
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **245.63**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/17/2015**
UTM (m) N **5,737,895**
E **557,922**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
245.2				**PEAT** - Black to dark brown, wet, with rootlets, trace traces (up to 50 mm).						
245	1	5		**SILTY CLAY** - Brown, moist, firm, intermediate plasticity, some fine to coarse grained sand, trace fine to coarse grained gravel, some silt pockets, trace silt lenses (up to 200 mm), friable. - Grain size distribution at 0.92 m: Gravel (3%), Sand (10%), Silt (23%), Clay (64%).		S1				
244										
243.6	2			**SILT TILL** - Tan, damp to moist, compact, low plasticity, some fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, trace boulders. - Grain size distribution at 2.14 m: Gravel (20%), Sand (16%), Silt (40%), Clay (23%). - Density increasing with depth.		S2				
243	3	10								
242										
241.5	4			**END OF TEST PIT ON DENSE SILT TILL AT 4.12 m**						
241		15		Notes: 1. Minor water infiltration into test pit from peat. 2. Backfilled test pit to grade upon completion.						
	5									
240										
	6	20								
239										

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR **TERRY LAVALLEE CONSTRUCTION S.REPA** | INSPECTOR | APPROVED DRAFT | DATE 7/2/15

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-68**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 15.1 km From Camp to Reach 1
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **245.85**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/17/2015**
UTM (m) N **5,738,780**
E **557,397**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %
245.2	0	0		**PEAT**	S1	
245	1	5		**CLAYEY SILT** - Tan, moist, firm, low plasticity, with fine to coarse grained sand, trace fine to coarse grained gravel.	S2	
				- Grain size distribution at 1.07 m: Gravel (10%), Sand (33%), Silt (35%), Clay (22%).		
244.0						
244	2			**SILT TILL** - Tan, damp to moist, low plasticity, some fine to coarse grained sand, some fine to coarse grained gravel.	S3	
				- Grain size distribution at 1.98 m: Gravel (13%), Sand (18%), Silt (43%), Clay (25%).		
243	3	10		- Increasing density with depth.		
242					S4	
241.7	4			**END OF TEST PIT ON DENSE SILT TILL AT 4.12 m**		
		15		Notes:		
241	5			1. Water infiltration into test pit from peat. 2. Minor sidewall sloughing. 3. Backfilled test pit to grade upon completion.		
240	6	20				
239						

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

530

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTION S.REPA		DRAFT	7/2/15

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2012\12-0300-011\DESIGN\GEO\LOGS\LSM STAGE 2 INVESTIGATIONS\2015_TESTPITINVESTIGATION.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-69**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 16.1 km From Camp to Reach 1
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **245.72**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/17/2015**
UTM (m) N **5,739,893**
E **556,584**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
245.4	0			**PEAT** - Hemic.		S1				
245	1	5		**SILTY CLAY** - Brown, moist, intermediate plasticity, some fine to coarse grained sand, trace fine grained gravel, some silt pockets (up to 50 mm), friable.		S2				
				- Grain size distribution at 0.76 m: Gravel (5%), Sand (10%), Silt (21%), Clay (64%).						
244				- Increased silt, fine to coarse grained sand, fine to coarse grained gravel below 1.37 m. - SOme cobbles below 1.37 m.						
243.7	2	10		**SILT TILL** - Tan, damp to moist, compact, some fine to coarse grained sand, some fine to coarse grained gravel, some cobbles, trace boulders. - Grain size distribution at 2.14 m: Gravel (12%), Sand (18%), Silt (42%), Clay (29%).		S3				
243				- Increasing density with depth.						
242	3									
241.9				**END OF TEST PIT ON SUSPECTED BOULDER AT 3.81 m**						
241	4	15		Notes: 1. Backfilled test pit to grade upon completion.						
240	5									
239	6	20								

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2012\12-0300-011\DESIGN\GEO\LOGS\LSM STAGE 2 INVESTIGATIONS\2015_TESTPITINVESTIGATION.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-70**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 17.2 km From Camp to Reach 1
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **245.72**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/17/2015**
UTM (m) N **5,740,552**
E **555,624**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %
245.6				**PEAT**		
				CLAYEY SILT - Tan, moist, soft, some fine to coarse grained sand, with fine to coarse grained gravel, friable.		
245				- Grain size distribution at 0.76 m: Gravel (22%), Sand (13%), Silt (38%), Clay (27%).	S1	
244.7	1			**SILT TILL** - Tan, damp to moist, compact, with fine to coarse grained sand, some fine to coarse grained gravel, some cobbles.		
		5		- Grain size distribution at 1.37 m: Gravel (20%), Sand (27%), Silt (33%), Clay (21%).	S2	
244				- Trace boulders below 1.53 m.		
	2			- Increasing density with depth.		
243						
242.7	3	10		**END OF TEST PIT ON DENSE SILT TILL AT 3.05 m**		
				Notes:		
				1. Backfilled test pit to grade upon completion.		
242	4					
		15				
241						
	5					
240						
	6	20				
239						

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2012\12-0300-011\DESIGN\GEO\LOGS\LSM STAGE 2 INVESTIGATIONS\2015_TESTPITINVESTIGATION.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TP15-71**

CLIENT MANITOBA INFRASTRUCTURE AND TRANSPORTATION
PROJECT ASSINIBOINE RIVER & LAKE MB FLOOD STUDY
SITE LAKE ST. MARTIN EMERGENCY CHANNELS
LOCATION 18.2 km From Camp to Reach 1
DRILLING METHOD HITACHI 270 EXCAVATOR

JOB NO. **12-0300-011**
GROUND ELEV. **245.68**
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED **2/17/2015**
UTM (m) N **5,740,917**
E **554,705**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆	PL MC LL %
245				**SILTY CLAY** - Brown, moist, firm, intermediate plasticity, some fine to coarse grained sand, trace fine grained gravel, some silt pockets (up to 50 mm), friable.					
				- Grain size distribution at 0.76 m: Gravel (6%), Sand (13%), Silt (20%), Clay (61%).	S1				
244.6	1			**CLAYEY SILT TO SILT TILL** - Tan, moist, loose to compact, low plasticity, some fine to coarse grained sand, some fine to coarse grained gravel.					
		5		- Grain size distribution at 1.37 m: Gravel (10%), Sand (18%), Silt (38%), Clay (34%).	S2				
244									
243.8	2			**CLAY TILL** - Brown, moist, very stiff, low plasticity, some fine to coarse grained sand, trace fine to coarse grained gravel, silt till pockets (up to 50 mm), trace cobbles, trace boulders.					
				- Grain size distribution at 2.29 m: Gravel (8%), Sand (10%), Silt (25%), Clay (57%).	S3				
243		10							
	3								
242.2				**END OF TEST PIT ON SUSPECTED BOULDER AT 3.51 m**					
242				Notes:					
	4			1. Backfilled test pit to grade upon completion.					
		15							
241									
	5								
240									
	6	20							
239									

SAMPLE TYPE ⋈ Grab from Bucket

CONTRACTOR	INSPECTOR	APPROVED	DATE
TERRY LAVALLEE CONSTRUCTIONS.REPA		DRAFT	7/2/15

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2012\12-0300-011\DESIGN\GEO\LOGS\LSM STAGE 2 INVESTIGATIONS\2015_TESTPITINVESTIGATION.GPJ

LSM Channels - TH-TP Peat Profile Summary

Testhole	Sta.	Depths (m):			
		Peat	Auger Refusal	End of Test hole	Bedrock
TH15-06	23+144	0.76	5.8	9.14	8.8
TH15-07	23+540	1.07	7.6	9.14	-
TH15-08	23+738	0.91	-	9.60	-
TH15-09	24+040	1.83	5.94	5.94	-
TH15-10	25+036	1.07	-	9.60	-
TH15-11	25+550	1.83	8.28	8.28	-
TH15-12	26+544	1.83	7.62	7.62	-

TestPit	Sta.	Depths (m):				
		Peat		End of Pit*	Bedrock	
TP15-01	22+508	1.22	-	4.57	-	
TP15-02	23+771	1.37	-	4.57	-	
TP15-03	24+444	0.91	-	4.88	-	
TP15-04	25+121	1.07	-	**4.72**	-	
TP15-05	26+115	1.68	-	4.11	-	
TP15-06	27+240	1.22	-	6.40	-	
TP15-07	27+350	1.07	-	**5.79**	-	
TP15-08	27+016	0.61	-	**5.18**	-	
TP15-09	26+755	1.37	-	6.55	-	
TP15-10	26+528	1.22	-	4.42	-	**<---Sand from 1.2 m to 1.7 m**
TP15-11	26+303	1.68	-	**6.10**	-	
TP15-12	25+917	1.52	-	**6.10**	-	
TP15-13	25+656	1.52	-	5.18	-	
TP15-14	25+370	0.76	-	**3.35**	-	
TP15-15	25+515	0.91	-	**3.96**	-	
TP15-16	25+258	1.22	-	**4.27**	-	
TP15-17	24+870	1.37	-	**3.96**	-	
TP15-18	24+649	1.37	-	**4.27**	-	
TP15-19	24+211	0.91	-	**3.96**	-	
TP15-20	23+966	1.37	-	**3.81**	-	
TP15-21	23+540	1.22	-	**5.03**	-	
TP15-22	23+310	0.30	-	**3.81**	-	
TP15-23	23+081	0.61	-	**4.27**	-	
TP15-24	22+898	0.46	-	3.05	-	**<--- Silty sand from 0.4 m to 3 m**
TP15-25	22+804	1.07	-	4.57	-	**<--- Sand from 1.1 m to 3 m**
TP15-26	22+687	0.91	-	6.10	-	

*** - Practical refusal where bolded**

Manitoba

INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

Geotechnical Testing Report

Appended:

A) Summary Sheets
B) Grain Size Analysis
C) Sieve Analysis
D) Lab Visual Classifications

Client:	Water Management and Structures
Project:	Lake St Martin Channel
Location:	Willow Point
Site No.	
Geotech No.	
Internal Order No.	200037101
Date Sampled:	February 4, 2015
Date Requisitioned:	March 6, 2015
Date Reported:	May 15, 2015

Manitoba Infrastructure and Transportation

Materials Engineering Branch

GEOTECHNICAL SOIL PROPERTY SUMMARY SHEET

Client:	Water Management and Structures	Site/File No. :		Date Requisitioned:	2015-03-06
Project:	Lake St. Martin Channel	Internal Order No. :	200037101	Date Reported:	2015-05-15
Location:	Willow Point	Sampled By:	KGS Group	Report To:	George Akinbola
Municipality:		Date Sampled:	2015-02-04	Page:	1 of 3

	SAMPLE DATA							ATTERBERG LIMITS			GRAIN SIZE							STRENGTH								
Lab No.	Test Hole No.	Sample No.	Station	Centerline	Depth(ft)	Unified Classification	Moisture Content %	Liquid Limit % (-1 = NP)	Plastic Limit % (-1 = NP)	Plasticity Index % (-1 = NP)	Gravel % (pass 75mm)	Sand % (pass 4.75mm)	Silt % (pass 0.075mm)	Clay % (pass 0.005 mm)	Silt/Clay % (pass 0.075 mm)	Organic Content %	Reactivity with HCl *	Field SPT (N)	Field PP (kpa)	Field Torvane Value (kpa)	Unconfined qu (kpa)	Bulk Dry Density (kg/cu.m.)	Direct Shear Performed	Consolidation Performed	Permeability Performed	Visual Classification
WGT141220	TH15-06	S1	23+100		1.5-2.5		177																			PT
WGT141221	TH15-06	S2	23+100		4.0-5.0	CI	26	47	19	28	5	10	27	58													
WGT141222	TH15-06	S3	23+100		6.5-7.5	CI	14	35	16	19	4	14	37	45													
WGT141223	TH15-06	S4	23+100		8.5-10.0	CL	8	22	13	9	8	34	38	20													
WGT141224	TH15-06	S5	23+100		10.0-10.5		8				15	31	39	15				50									ML
WGT141225	TH15-06	S6	23+100		15.0-15.25		6				26	43			31			50									SC-SM
WGT141226	TH15-06	S7	23+100		15.25-19.0	ML	9	16	13	3	5	33	44	18													
WGT141227	TH15-06	S8	23+100		19.0-21.0																						No Sample
WGT141228	TH15-06	S9	23+100		21.0-25.0																						No Sample
WGT141229	TH15-06	S10	23+100		25.0-30.0																						No Sample
WGT141230	TH15-07	S1	23+500		1.5-2.5		951																			PT
WGT141231	TH15-07	S2	23+500		4.0-5.0	CI	27	47	20	27	2	12	29	57													
WGT141232	TH15-07	S3	23+500		8.0-9.0		14																			CI
WGT141233	TH15-07	S4	23+500		10.0-11.5	CH	25	50	22	28	5	9	28	58				18									
WGT141234	TH15-07	S5	23+500		13.0-14.0	CH	31	53	24	29	5	9	23	63													
WGT141235	TH15-07	S6	23+500		15.0-16.5	CI	20	41	18	23	7	12	36	45				13									
WGT141236	TH15-07	S7	23+500		18.0-19.0	CL	9	22	14	8	1	28	44	27													
WGT141237	TH15-07	S8	23+500		25.0-27.0																						No Sample
WGT141238	TH15-07	S9	23+500		27.0-30.0																						No Sample
WGT141239	TH15-08	S1	23+700		2.0-3.0		922																			PT

* 1 - Non effervescent 2 - Very slightly effervescent 3 - Slightly effervescent 4 - Strongly effervescent 5 - Violently effervescent

NT = Not Tested, US = Unsuitable sample, IS = Insufficient Sample

Manitoba Infrastructure and Transportation

Materials Engineering Branch

GEOTECHNICAL SOIL PROPERTY SUMMARY SHEET

Client:	Water Management and Structures	Site/File No. :		Date Requisitioned:	2015-03-06
Project:	Lake St. Martin Channel	Internal Order No. :	200037101	Date Reported:	2015-05-15
Location:	Willow Point	Sampled By:	KGS Group	Report To:	George Akinbola
Municipality:		Date Sampled:	2015-02-04	Page:	2 of 3

Lab No.	SAMPLE DATA					Unified Classification	Moisture Content %	ATTERBERG LIMITS			GRAIN SIZE					Organic Content %	Reactivity with HCl *	STRENGTH								Visual Classification
	Test Hole No.	Sample No.	Station	Centerline	Depth(m)			Liquid Limit % (-1 = NP)	Plastic Limit % (-1 = NP)	Plasticity Index % (-1 = NP)	Gravel % (pass 75mm)	Sand % (pass 4.75mm)	Silt % (pass 0.075mm)	Clay % (pass 0.005 mm)	Silt/Clay % (pass 0.075 mm)			Field SPT (N)	Field PP (kpa)	Field Torvane Value (kpa)	Unconfined qu (kpa)	Bulk Dry Density (kg/cu.m.)	Direct Shear Performed	Consolidation Performed	Permeability Performed	
WGT141240	TH15-08	S2	23+700		4.0-5.0	CH	34	52	24	28	8	9	27	56													
WGT141241	TH15-08	S3	23+700		7.0-8.0	CH	28	58	25	33	3	5	18	74													
WGT141242	TH15-08	S4	23+700		10.0-11.5	CH	25	50	20	30	1	8	28	63				12									
WGT141243	TH15-08	S5	23+700		15.0-16.5	CI	17	30	15	15	5	18	42	35				29									
WGT141244	TH15-08	S6	23+700		20.0-21.0	CL-ML	10	20	14	6	7	19	46	28				89									
WGT141245	TH15-08	S7	23+700		30.0-31.5	ML	6	15	13	2	7	31	46	16				108									
WGT141246	TH15-09	S1	24+000		2.0-3.0		989																				PT
WGT141247	TH15-09	S2	24+000		6.5-7.5	CI	20	47	19	28	2	10	30	58													
WGT141248	TH15-09	S3	24+000		10.0-11.5	CL-ML	7	19	14	5	7	29	37	27				105									
WGT141249	TH15-09	S4	24+000		15.0-16.0	CL-ML	7	20	14	6	9	25	41	25				120									
WGT141250	TH15-10	S1	25+000		4.0-5.0	CH	22	51	21	30	2	9	27	62													
WGT141251	TH15-10	S2	25+000		7.0-8.0	CI	31	39	19	20	5	13	32	50													
WGT141252	TH15-10	S3	25+000		10.0-11.5	CH	25	55	23	32	1	7	26	66				10									
WGT141253	TH15-10	S4	25+000		13.0-14.0	CI	17	38	17	21	3	11	31	55													
WGT141254	TH15-10	S5	25+000		15.0-16.5	CI	25	40	17	23	4	12	34	50				13									
WGT141255	TH15-10	S6	25+000		18.5-19.5	CL	19	28	15	13	4	17	40	39													
WGT141256	TH15-10	S7	25+000		20.0-21.5	CL-ML	10	19	13	6	9	26	43	22				63									
WGT141257	TH15-10	S8	25+000		25.0-26.5	CL-ML	8	19	12	7	24	21	35	20													
WGT141258	TH15-10	S9	25+000		30.0-31.5	CL-ML	11	17	13	4	13	26	40	21				32									
WGT141259	TH15-11	S1	25+500		7.0-8.0	CH	29	63	25	38	2	6	20	72													

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Manitoba Infrastructure and Transportation

Materials Engineering Branch

GEOTECHNICAL SOIL PROPERTY SUMMARY SHEET

Client:	Water Management and Structures	Site/File No. :		Date Requisitioned:	2015-03-06
Project:	Lake St. Martin Channel	Internal Order No. :	200037101	Date Reported:	2015-05-15
Location:	Willow Point	Sampled By:	KGS Group	Report To:	George Akinbola
Municipality:		Date Sampled:	2015-02-04	Page:	3 of 3

	SAMPLE DATA							ATTERBERG LIMITS			GRAIN SIZE							STRENGTH								
Lab No.	Test Hole No.	Sample No.	Station	Centerline	Depth(m)	Unified Classification	Moisture Content %	Liquid Limit % (-1 = NP)	Plastic Limit % (-1 = NP)	Plasticity Index % (-1 = NP)	Gravel % (pass 75mm)	Sand % (pass 4.75mm)	Silt % (pass 0.075mm)	Clay % (pass 0.005 mm)	Silt/Clay % (pass 0.075 mm)	Organic Content %	Reactivity with HCl *	Field SPT (N)	Field PP (kpa)	Field Torvane Value (kpa)	Unconfined qu (kpa)	Bulk Dry Density (kg/cu.m.)	Direct Shear Performed	Consolidation Performed	Permeability Performed	Visual Classification
WGT141260	TH15-11	S2	25+500		10.0-11.5	CH	33	58	23	35	2	9	23	66				11								
WGT141261	TH15-11	S3	25+500		12.0-13.0		28																			CH
WGT141262	TH15-11	S4	25+500		15.0-16.5	CL-ML	10	17	13	4	11	26	40	23				32								
WGT141263	TH15-11	S5	25+500		17.0-18.0		19																			CL
WGT141264	TH15-11	S6	25+500		20.0-21.5	CL	11	21	13	8	8	20	44	28				43								
WGT141265	TH15-11	S7	25+500		22.0-23.0		13																			CL
WGT141266	TH15-11	S8	25+500		25.0-26.0																					No Sample
WGT141267	TH15-11	S9	25+500		26.0-27.0		10											105								CL
WGT141268	TH15-12	S1	26+500		2.0-3.0		615																			PT
WGT141269	TH15-12	S2	26+500		7.0-8.0	CI	46	47	21	26	2	14	28	56												
WGT141270	TH15-12	S3	26+500		10.0-11.5	CI	28	49	19	30	5	9	28	58				24								
WGT141271	TH15-12	S4	26+500		12.0-13.0		7				7	23	42	28												CL
WGT141272	TH15-12	S5	26+500		15.0-16.5	CL-ML	8	17	13	4	10	31	43	16				95								
WGT141273	TH15-12	S6	26+500		20.0-21.5	ML	8	15	13	2	11	28	47	14				48								

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NT = Not Tested, US = Unsuitable sample, IS = Insufficient Sample

MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

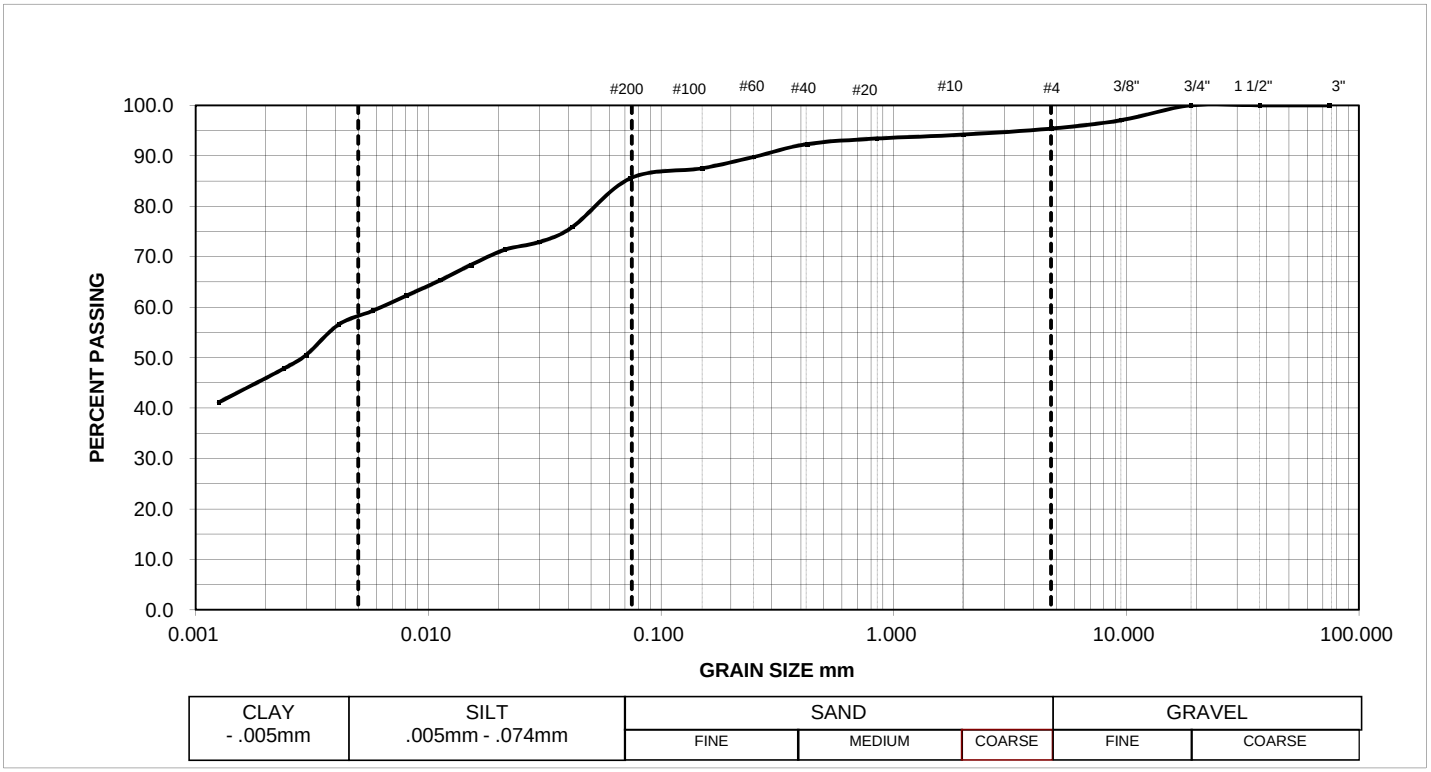
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141221 FIELD NO. S2 HOLE NO. TH15-06 DEPTH (m) 4.0-5.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	29.5	25.1	0.0418	75.9
1.50	37.50	100.0	2	28.5	24.1	0.0299	72.9
0.75	19.00	100.0	4	28.0	23.6	0.0213	71.4
0.375	9.50	97.0	8	27.0	22.6	0.0152	68.4
#4	4.75	95.4	15	26.0	21.6	0.0113	65.3
#10	2.00	94.2	30	25.0	20.6	0.0081	62.3
#20	0.850	93.4	60	24.0	19.6	0.0058	59.3
#40	0.425	92.3	120	23.0	18.7	0.0041	56.6
#60	0.250	89.8	240	21.0	16.7	0.0030	50.5
#100	0.150	87.5	382	20.2	15.8	0.0024	47.8
#200	0.075	85.5	1440	18.0	13.6	0.0013	41.1

% GRAVEL	% SAND	% SILT	% CLAY
5	10	28	58



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

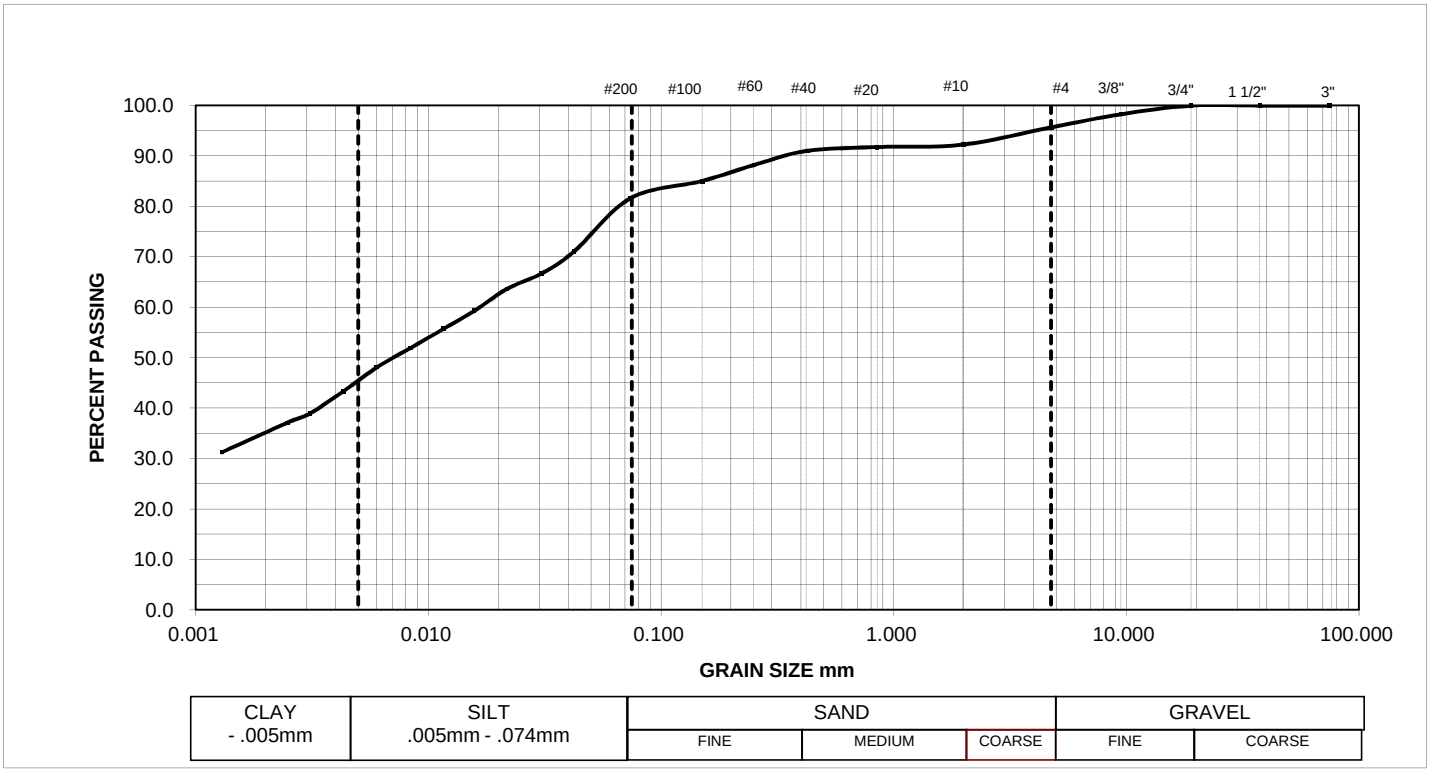
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141222 FIELD NO. S3 HOLE NO. TH15-06 DEPTH (m) 6.5-7.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	28.5	24.1	0.0423	71.1
1.50	37.50	100.0	2	27.0	22.6	0.0305	66.6
0.75	19.00	100.0	4	26.0	21.6	0.0218	63.7
0.375	9.50	98.3	8	24.5	20.1	0.0157	59.3
#4	4.75	95.7	15	23.3	18.9	0.0116	55.7
#10	2.00	92.3	30	22.0	17.6	0.0084	51.9
#20	0.850	91.8	60	20.7	16.3	0.0060	48.1
#40	0.425	91.0	120	19.0	14.7	0.0043	43.3
#60	0.250	88.2	240	17.5	13.2	0.0031	38.9
#100	0.150	85.0	377	17.0	12.6	0.0025	37.2
#200	0.075	81.6	1440	15.0	10.6	0.0013	31.3

% GRAVEL	% SAND	% SILT	% CLAY
4	14	37	45



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

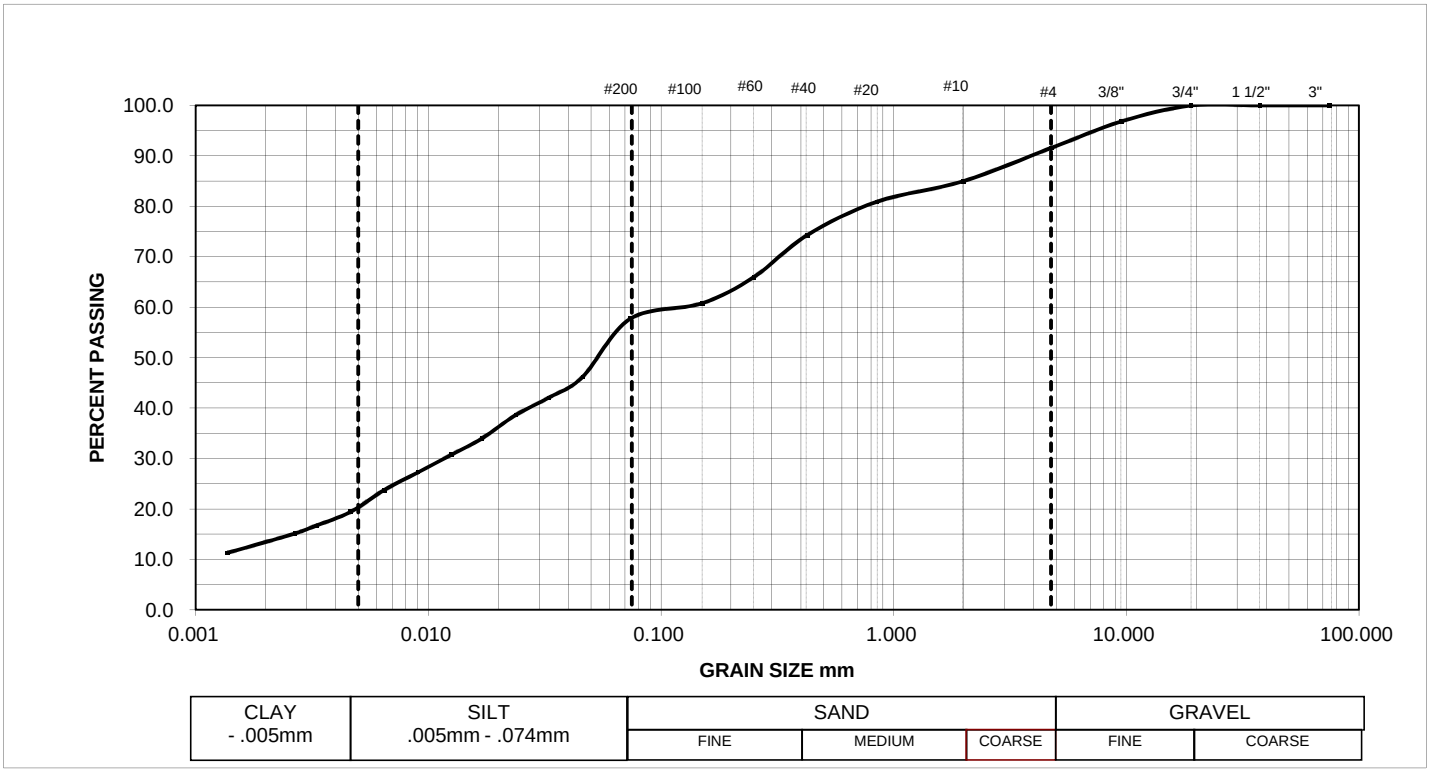
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141223 FIELD NO. S4 HOLE NO. TH15-06 DEPTH (m) 8.5-10.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	21.5	17.1	0.0460	46.2
1.50	37.5	100.0	2	20.0	15.6	0.0330	42.1
0.75	19.0	100.0	4	18.7	14.3	0.0237	38.6
0.375	9.5	96.8	8	17.0	12.6	0.0170	34.0
#4	4.75	91.6	15	15.8	11.4	0.0126	30.8
#10	2.00	85.0	30	14.5	10.1	0.0090	27.3
#20	0.850	80.9	60	13.2	8.8	0.0065	23.8
#40	0.425	74.3	120	11.5	7.2	0.0046	19.4
#60	0.250	65.9	240	10.5	6.2	0.0033	16.7
#100	0.150	60.8	375	10.0	5.6	0.0027	15.1
#200	0.075	57.8	1440	8.6	4.2	0.0014	11.3

% GRAVEL	% SAND	% SILT	% CLAY
8	34	38	20



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

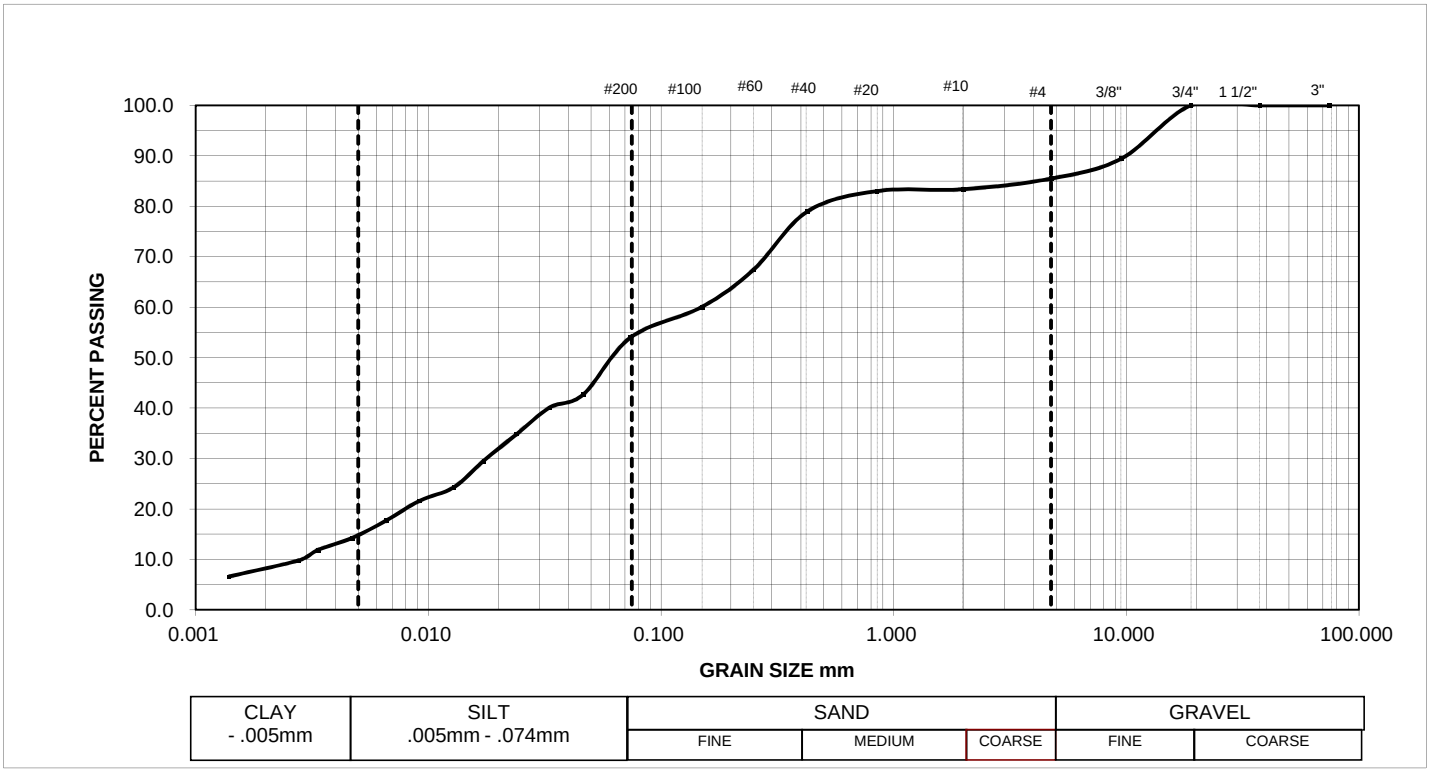
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141224 FIELD NO. S5 HOLE NO. TH15-06 DEPTH (m) 10.0-10.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	21.0	16.2	0.0464	42.7
1.50	37.50	100.0	2	20.0	15.2	0.0332	40.1
0.75	19.00	100.0	4	18.0	13.2	0.0240	34.8
0.375	9.50	89.4	8	16.0	11.2	0.0173	29.5
#4	4.75	85.5	15	14.0	9.2	0.0129	24.3
#10	2.00	83.4	30	13.0	8.2	0.0092	21.6
#20	0.850	83.0	60	11.5	6.7	0.0066	17.7
#40	0.425	78.9	120	10.2	5.4	0.0047	14.2
#60	0.250	67.4	240	9.3	4.5	0.0034	11.9
#100	0.150	60.0	360	8.5	3.7	0.0028	9.8
#200	0.075	54.0	1440	7.3	2.5	0.0014	6.6

% GRAVEL	% SAND	% SILT	% CLAY
15	31	39	15



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **Mj**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141226 FIELD NO. S7 HOLE NO. TH15-06 DEPTH (m) 15.25-19.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	20.5	16.1	0.0465	46.3
1.50	37.50	100.0	2	19.5	15.1	0.0332	43.4
0.75	19.00	100.0	4	18.0	13.6	0.0239	39.1
0.375	9.50	98.4	8	16.5	12.1	0.0171	34.8
#4	4.75	95.2	15	15.2	10.8	0.0127	31.0
#10	2.00	90.7	30	14.0	9.6	0.0091	27.6
#20	0.850	89.2	60	12.3	7.9	0.0065	22.7
#40	0.425	88.2	120	10.5	6.2	0.0047	17.8
#60	0.250	82.8	240	9.5	5.2	0.0033	14.9
#100	0.150	73.6	372	9.0	4.6	0.0027	13.2
#200	0.075	62.3	1440	7.5	3.1	0.0014	8.9

% GRAVEL	% SAND	% SILT	% CLAY
5	33	44	18



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **Mj**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141231 FIELD NO. S2 HOLE NO. TH15-07 DEPTH (m) 4.0-5.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	29.0	24.6	0.0420	77.0
1.50	37.5	100.0	2	28.0	23.6	0.0301	73.8
0.75	19.0	100.0	4	27.4	23.0	0.0215	72.0
0.375	9.5	99.6	8	26.2	21.8	0.0154	68.2
#4	4.75	98.5	15	25.8	21.4	0.0113	67.0
#10	2.00	97.3	30	24.0	19.6	0.0082	61.3
#20	0.850	96.0	60	23.2	18.9	0.0058	59.1
#40	0.425	94.5	120	22.0	17.7	0.0042	55.4
#60	0.250	90.9	240	20.5	16.2	0.0030	50.7
#100	0.150	88.0	368	19.5	15.1	0.0024	47.2
#200	0.075	86.2	1440	12.3	7.9	0.0013	24.7

% GRAVEL	% SAND	% SILT	% CLAY
2	12	29	57



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

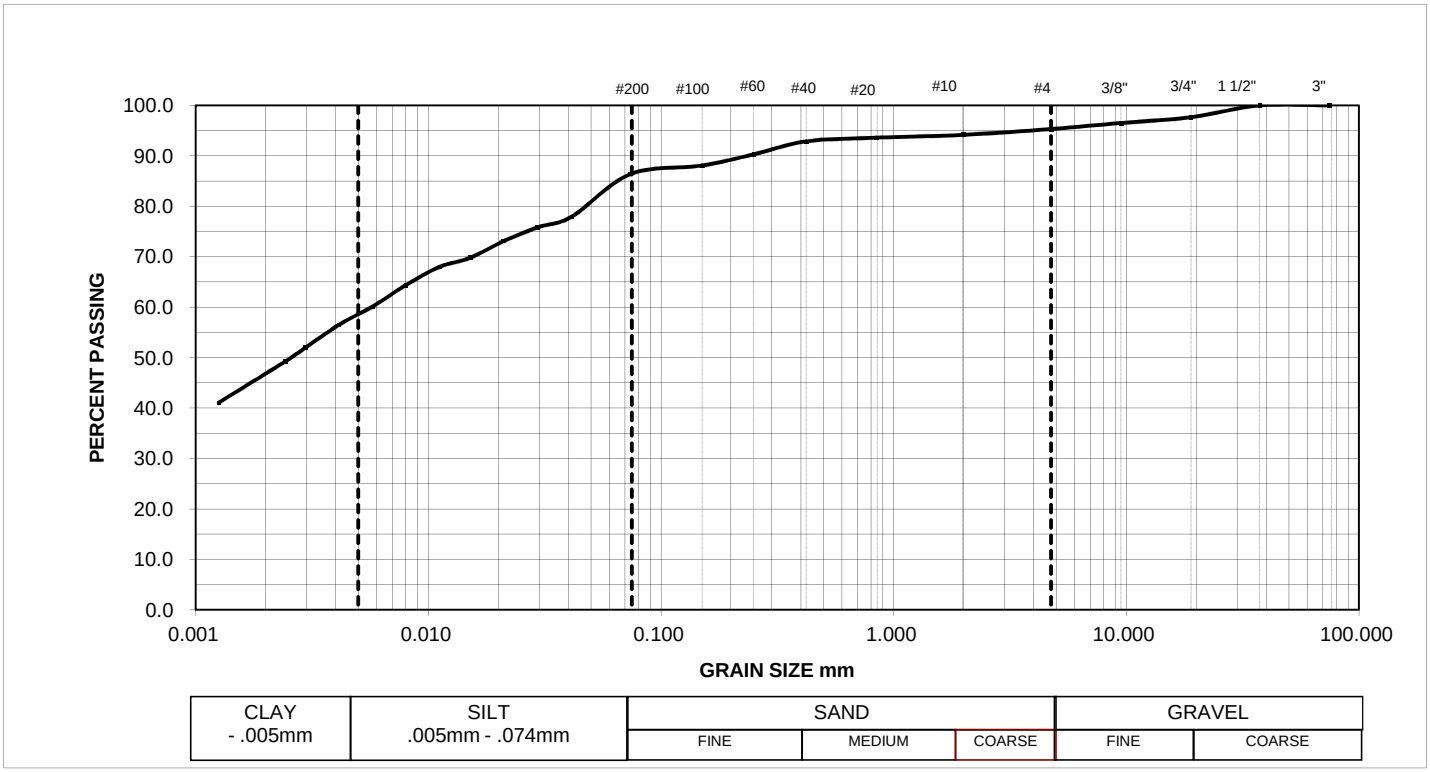
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141233 FIELD NO. S4 HOLE NO. TH15-07 DEPTH (m) 10.0-11.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	30.2	25.8	0.0414	78.0
1.50	37.5	100.0	2	29.5	25.1	0.0295	75.8
0.75	19.0	97.7	4	28.6	24.2	0.0211	73.1
0.375	9.5	96.5	8	27.5	23.1	0.0152	69.8
#4	4.75	95.3	15	26.9	22.5	0.0111	68.0
#10	2.00	94.2	30	25.7	21.3	0.0080	64.4
#20	0.850	93.6	60	24.2	19.9	0.0058	60.1
#40	0.425	92.9	120	23.0	18.7	0.0041	56.5
#60	0.250	90.3	240	21.5	17.2	0.0030	52.0
#100	0.150	88.1	365	20.7	16.3	0.0024	49.2
#200	0.075	86.4	1440	18.0	13.6	0.0013	41.1

% GRAVEL	% SAND	% SILT	% CLAY
5	9	28	58



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

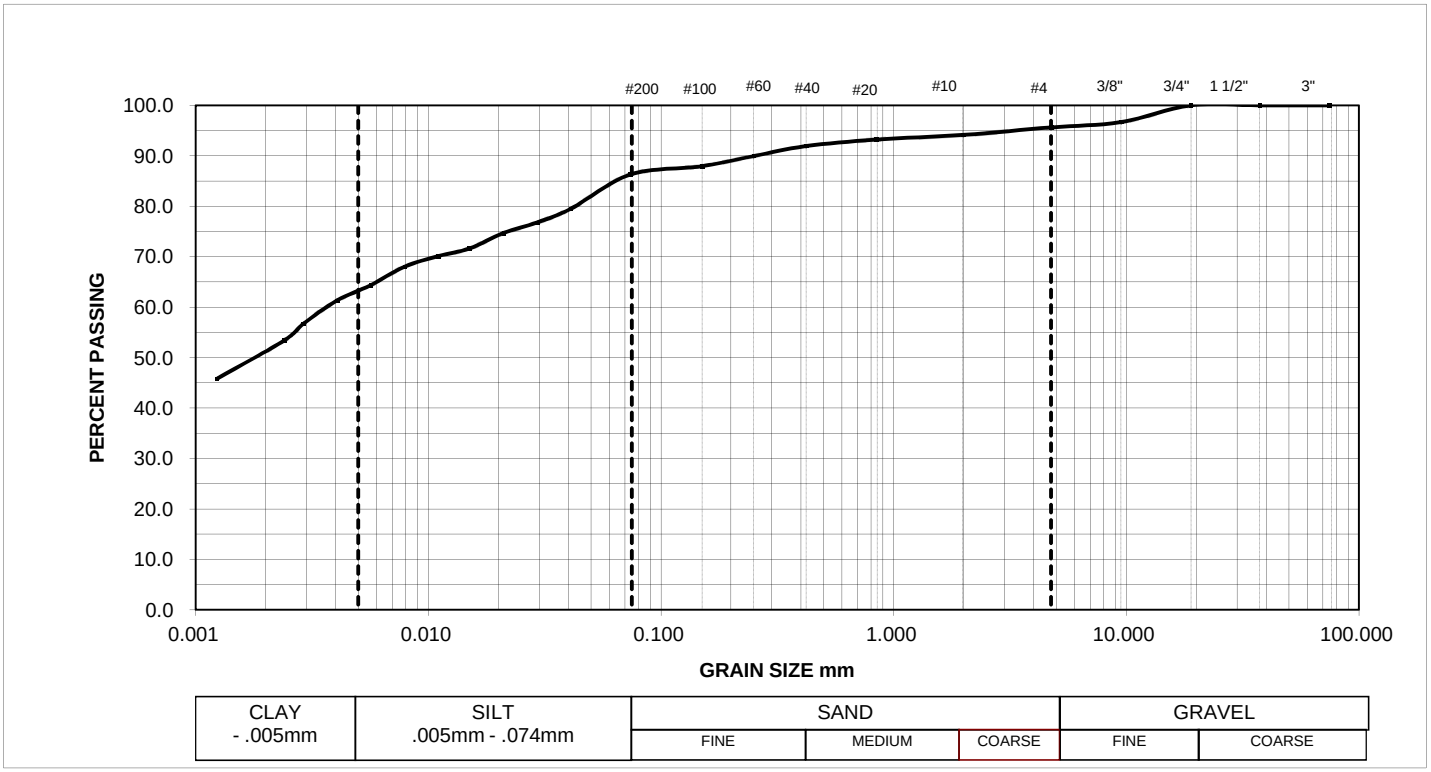
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141234 FIELD NO. S5 HOLE NO. TH15-07 DEPTH (m) 13.0-14.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	30.6	26.2	0.0411	79.5
1.50	37.5	100.0	2	29.7	25.3	0.0294	76.8
0.75	19.0	100.0	4	29.0	24.6	0.0210	74.7
0.375	9.5	96.7	8	28.0	23.6	0.0151	71.6
#4	4.75	95.6	15	27.5	23.1	0.0111	70.1
#10	2.00	94.1	30	26.8	22.4	0.0079	68.0
#20	0.850	93.2	60	25.5	21.2	0.0057	64.4
#40	0.425	91.9	120	24.5	20.2	0.0041	61.3
#60	0.250	89.9	240	23.0	18.7	0.0029	56.8
#100	0.150	87.9	360	22.0	17.6	0.0024	53.4
#200	0.075	86.3	1440	19.5	15.1	0.0012	45.8

% GRAVEL	% SAND	% SILT	% CLAY
4	9	23	63



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

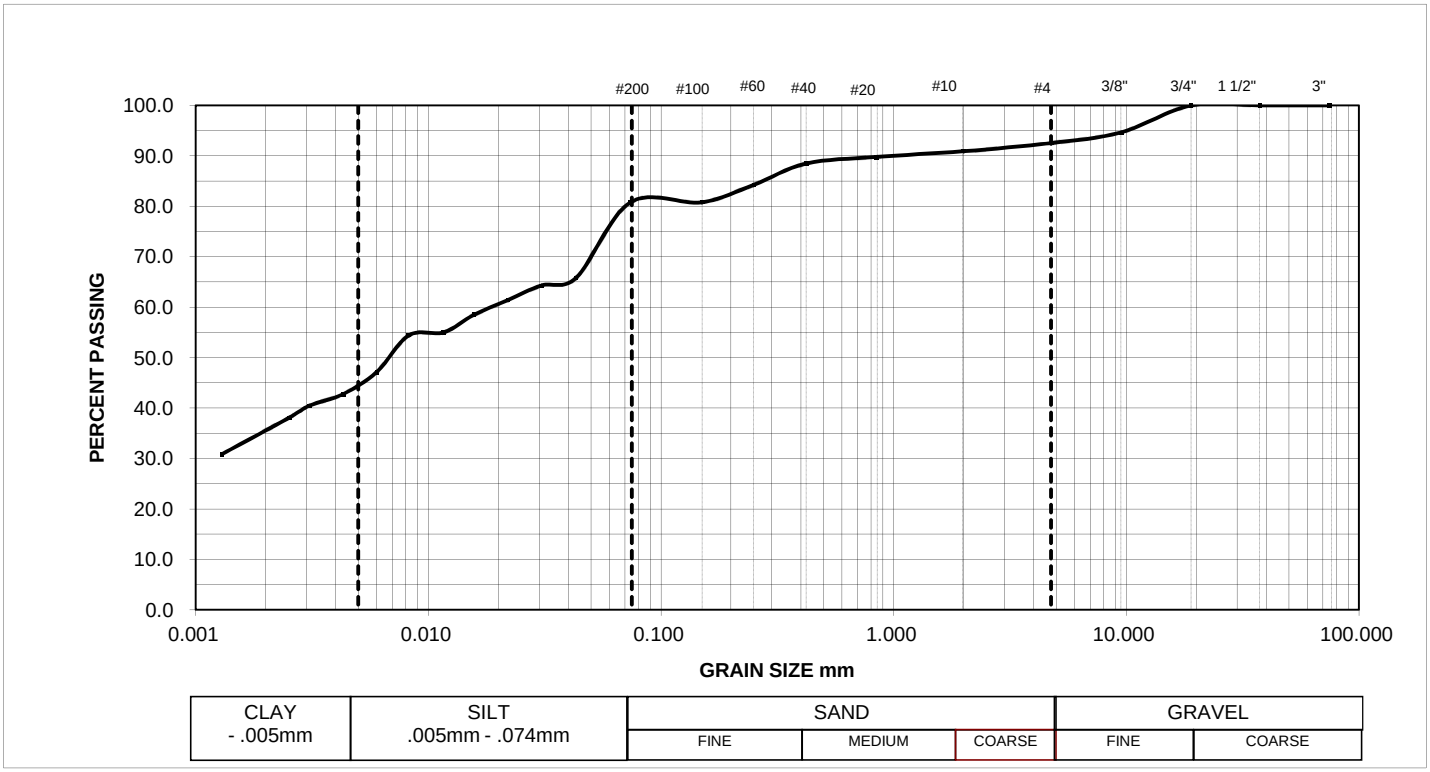
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141235 FIELD NO. S6 HOLE NO. TH15-07 DEPTH (m) 15.0-16.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	27.0	22.6	0.0431	65.8
1.50	37.5	100.0	2	26.5	22.1	0.0307	64.3
0.75	19.0	100.0	4	25.5	21.1	0.0220	61.4
0.375	9.5	94.7	8	24.5	20.1	0.0157	58.5
#4	4.75	92.5	15	23.3	18.9	0.0116	55.0
#10	2.00	90.9	30	23.1	18.7	0.0082	54.4
#20	0.850	89.8	60	20.5	16.2	0.0060	47.2
#40	0.425	88.5	120	19.0	14.7	0.0043	42.8
#60	0.250	84.2	240	18.2	13.9	0.0031	40.5
#100	0.150	80.8	360	17.5	13.1	0.0025	38.1
#200	0.075	80.8	1440	15.0	10.6	0.0013	30.9

% GRAVEL	% SAND	% SILT	% CLAY
7	12	36	45



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

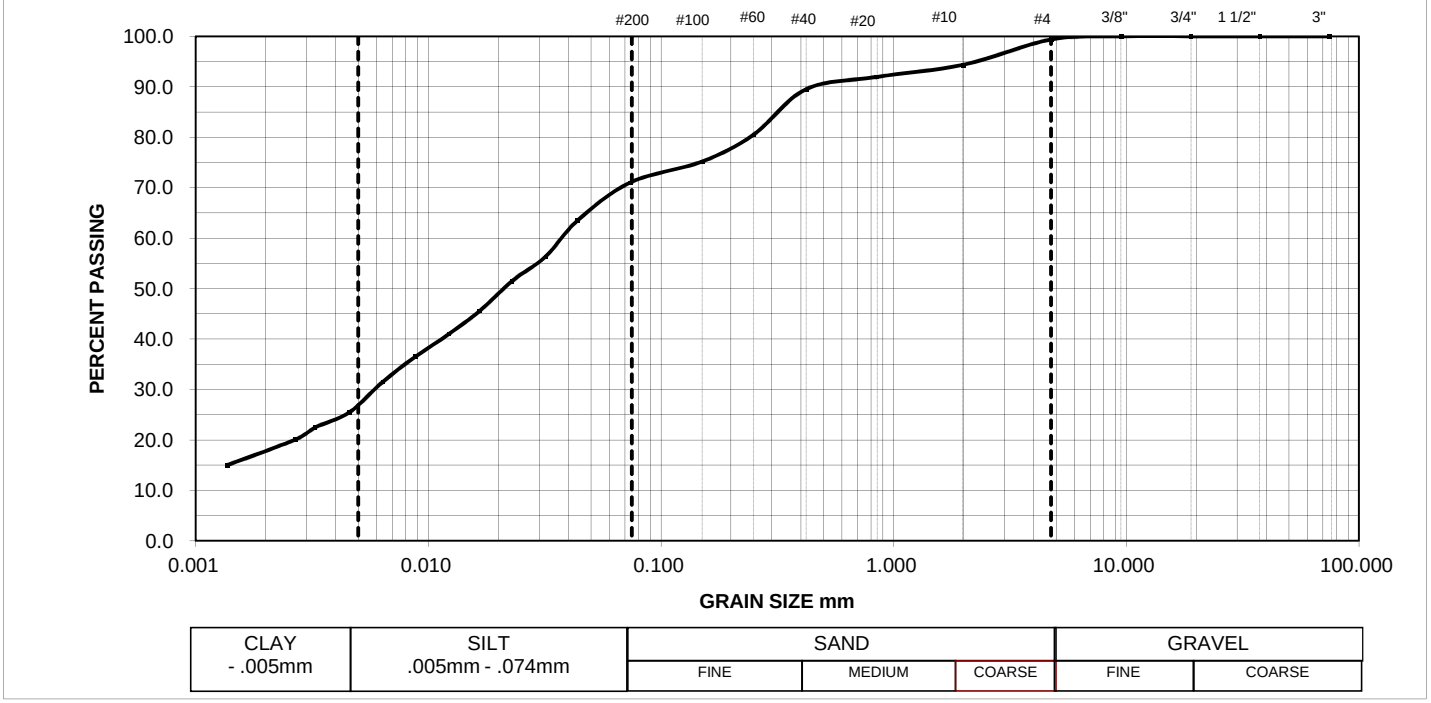
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141236 FIELD NO. S7 HOLE NO. TH15-07 DEPTH (m) 18.0-19.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	26.0	21.2	0.0439	63.5
1.50	37.5	100.0	2	23.6	18.8	0.0319	56.3
0.75	19.0	100.0	4	22.0	17.2	0.0230	51.5
0.375	9.5	100.0	8	20.0	15.2	0.0166	45.5
#4	4.75	99.4	15	18.5	13.7	0.0123	41.0
#10	2.00	94.4	30	17.0	12.2	0.0088	36.5
#20	0.850	91.9	60	15.3	10.5	0.0064	31.5
#40	0.425	89.5	120	13.3	8.5	0.0046	25.5
#60	0.250	80.5	240	12.3	7.5	0.0033	22.5
#100	0.150	75.2	360	11.5	6.7	0.0027	20.1
#200	0.075	71.0	1440	9.8	5.0	0.0014	15.0

% GRAVEL	% SAND	% SILT	% CLAY
1	28	44	27



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

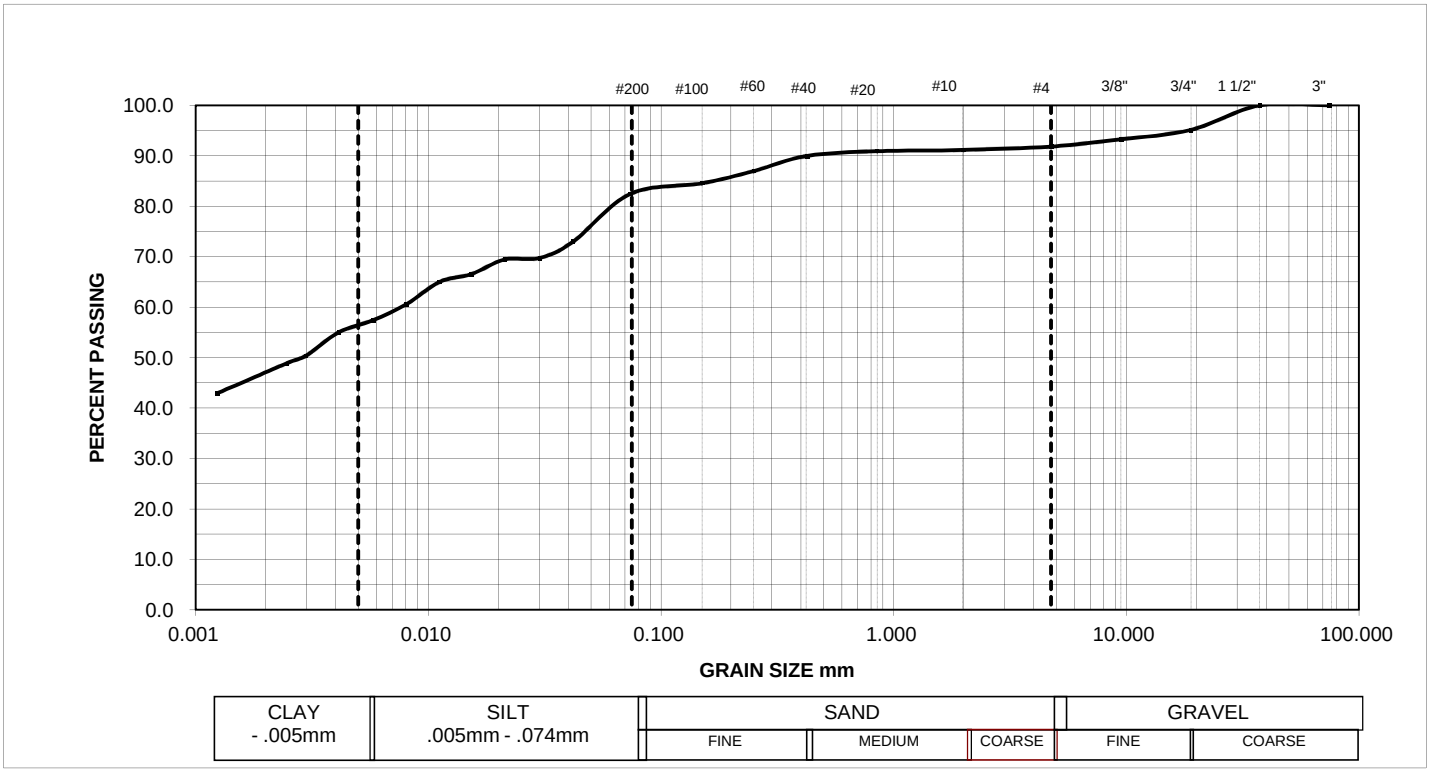
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141240 FIELD NO. S2 HOLE NO. TH15-08 DEPTH (m) 4.0-5.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	29.2	24.8	0.0419	73.0
1.50	37.5	100.0	2	28.1	23.7	0.0301	69.7
0.75	19.0	95.1	4	28.0	23.6	0.0213	69.4
0.375	9.5	93.3	8	27.0	22.6	0.0152	66.5
#4	4.75	91.8	15	26.5	22.1	0.0112	65.0
#10	2.00	91.1	30	25.0	20.6	0.0081	60.6
#20	0.850	90.9	60	23.8	19.5	0.0058	57.4
#40	0.425	90.0	120	23.0	18.7	0.0041	55.0
#60	0.250	87.0	240	21.4	17.1	0.0030	50.3
#100	0.150	84.5	355	21.0	16.6	0.0025	48.8
#200	0.075	82.5	1440	19.0	14.6	0.0012	43.0

% GRAVEL	% SAND	% SILT	% CLAY
8	9	26	56



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

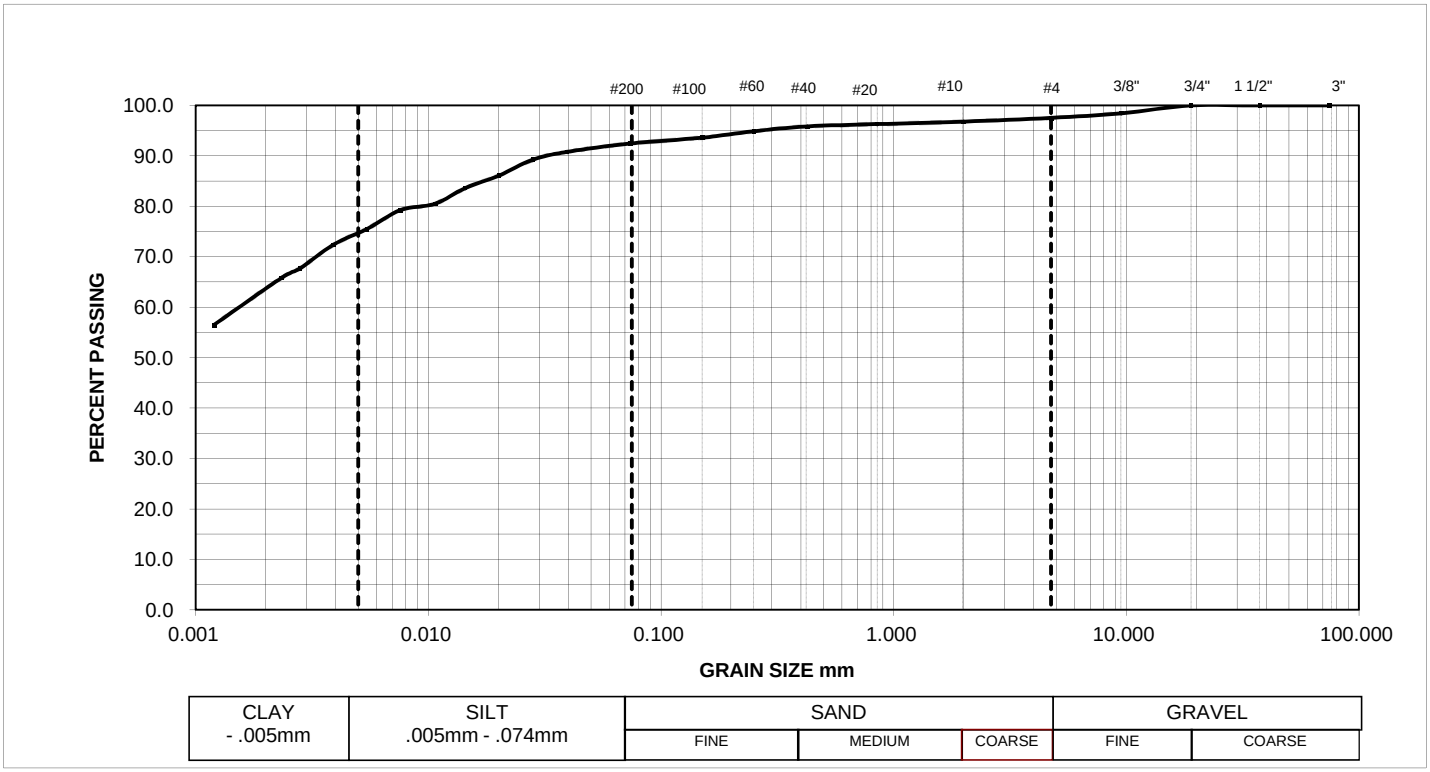
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141241 FIELD NO. S3 HOLE NO. TH15-08 DEPTH (m) 7.0-8.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	33.5	29.1	0.0395	90.8
1.50	37.50	100.0	2	33.0	28.6	0.0281	89.2
0.75	19.00	100.0	4	32.0	27.6	0.0202	86.1
0.375	9.50	98.4	8	31.2	26.8	0.0144	83.6
#4	4.75	97.5	15	30.2	25.8	0.0107	80.5
#10	2.00	96.8	30	29.8	25.4	0.0076	79.2
#20	0.850	96.3	60	28.5	24.2	0.0055	75.5
#40	0.425	95.8	120	27.5	23.2	0.0039	72.4
#60	0.250	94.9	240	26.0	21.7	0.0028	67.7
#100	0.150	93.6	351	25.5	21.1	0.0023	65.8
#200	0.075	92.5	1440	22.5	18.1	0.0012	56.5

% GRAVEL	% SAND	% SILT	% CLAY
2	5	18	74



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

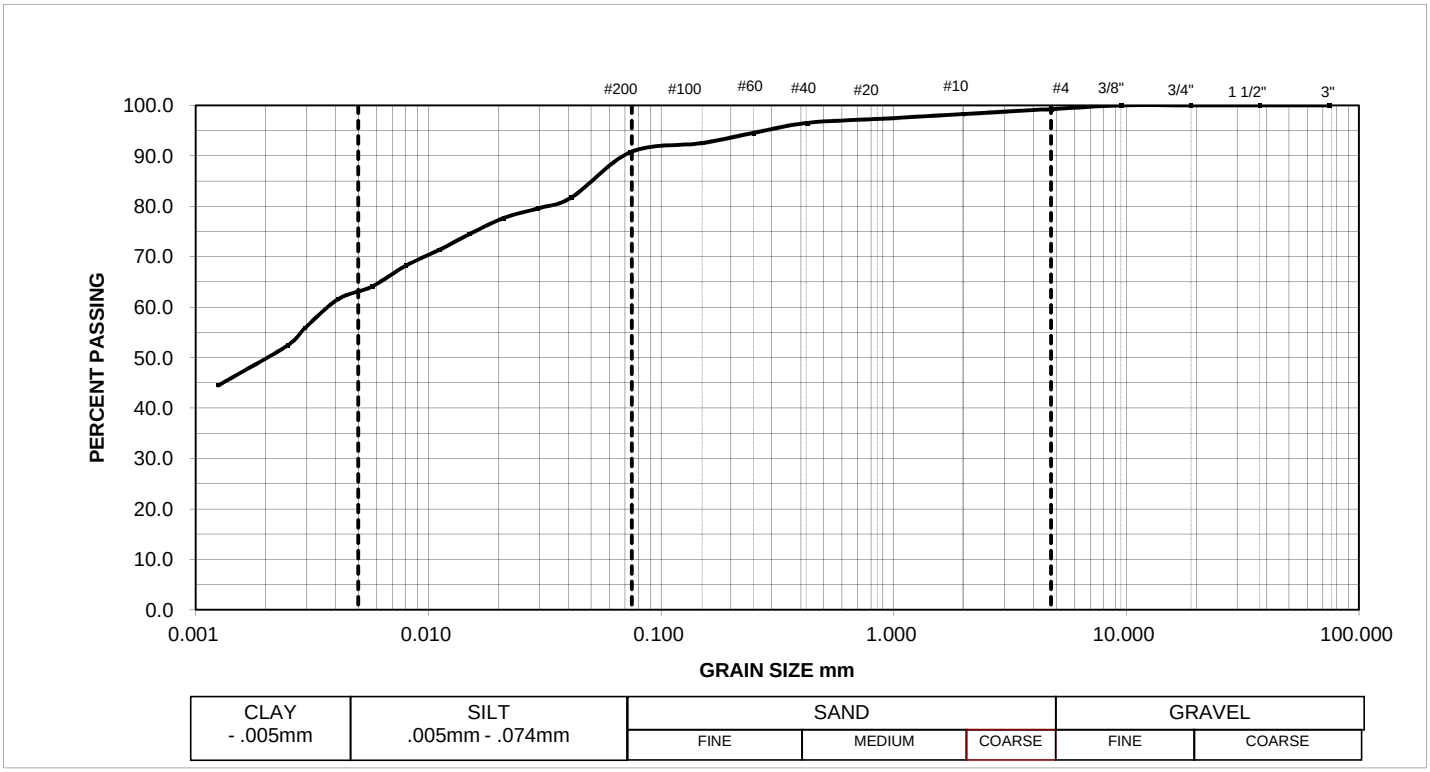
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141242 FIELD NO. S4 HOLE NO. TH15-08 DEPTH (m) 10.0-11.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	30.3	25.9	0.0413	81.8
1.50	37.50	100.0	2	29.6	25.2	0.0295	79.6
0.75	19.00	100.0	4	29.0	24.6	0.0210	77.7
0.375	9.50	100.0	8	28.0	23.6	0.0151	74.5
#4	4.75	99.3	15	27.0	22.6	0.0111	71.4
#10	2.00	98.3	30	26.0	21.6	0.0080	68.2
#20	0.850	97.3	60	24.6	20.3	0.0057	64.1
#40	0.425	96.5	120	23.8	19.5	0.0041	61.6
#60	0.250	94.5	240	22.0	17.7	0.0029	55.9
#100	0.150	92.5	348	21.0	16.6	0.0025	52.4
#200	0.075	90.7	1440	18.5	14.1	0.0013	44.5

% GRAVEL	% SAND	% SILT	% CLAY
1	9	28	63



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

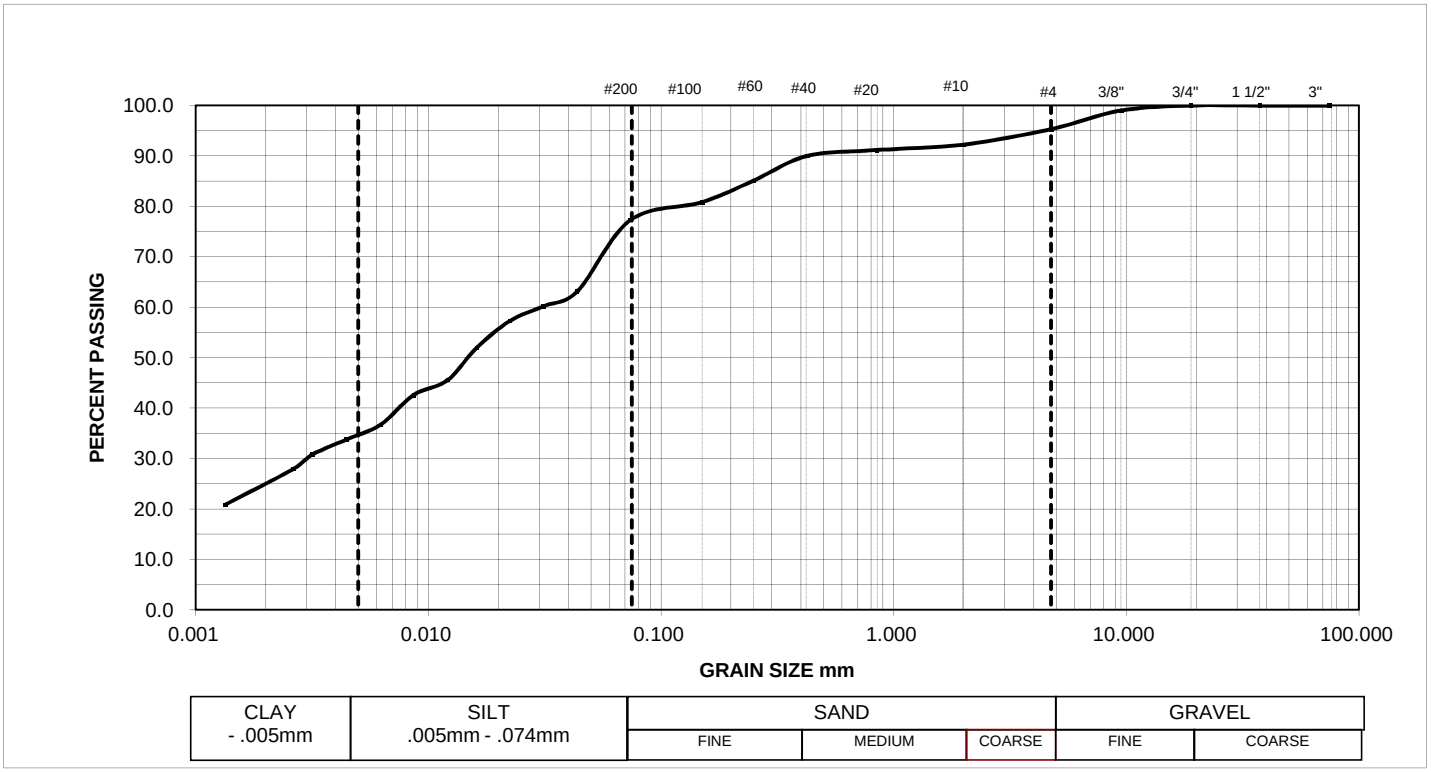
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141243 FIELD NO. S5 HOLE NO. TH15-08 DEPTH (m) 15.0-16.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	26.0	21.5	0.0437	63.2
1.50	37.5	100.0	2	25.0	20.5	0.0313	60.2
0.75	19.0	100.0	4	24.0	19.5	0.0224	57.3
0.375	9.5	99.0	8	22.2	17.7	0.0162	52.0
#4	4.75	95.3	15	20.0	15.5	0.0121	45.5
#10	2.00	92.2	30	19.0	14.5	0.0086	42.6
#20	0.850	91.2	60	17.0	12.5	0.0062	36.7
#40	0.425	90.0	120	16.0	11.5	0.0044	33.8
#60	0.250	85.1	240	15.0	10.5	0.0032	30.8
#100	0.150	80.9	360	14.0	9.5	0.0026	27.9
#200	0.075	77.3	1440	11.5	7.1	0.0013	20.9

% GRAVEL	% SAND	% SILT	% CLAY
5	18	42	35



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

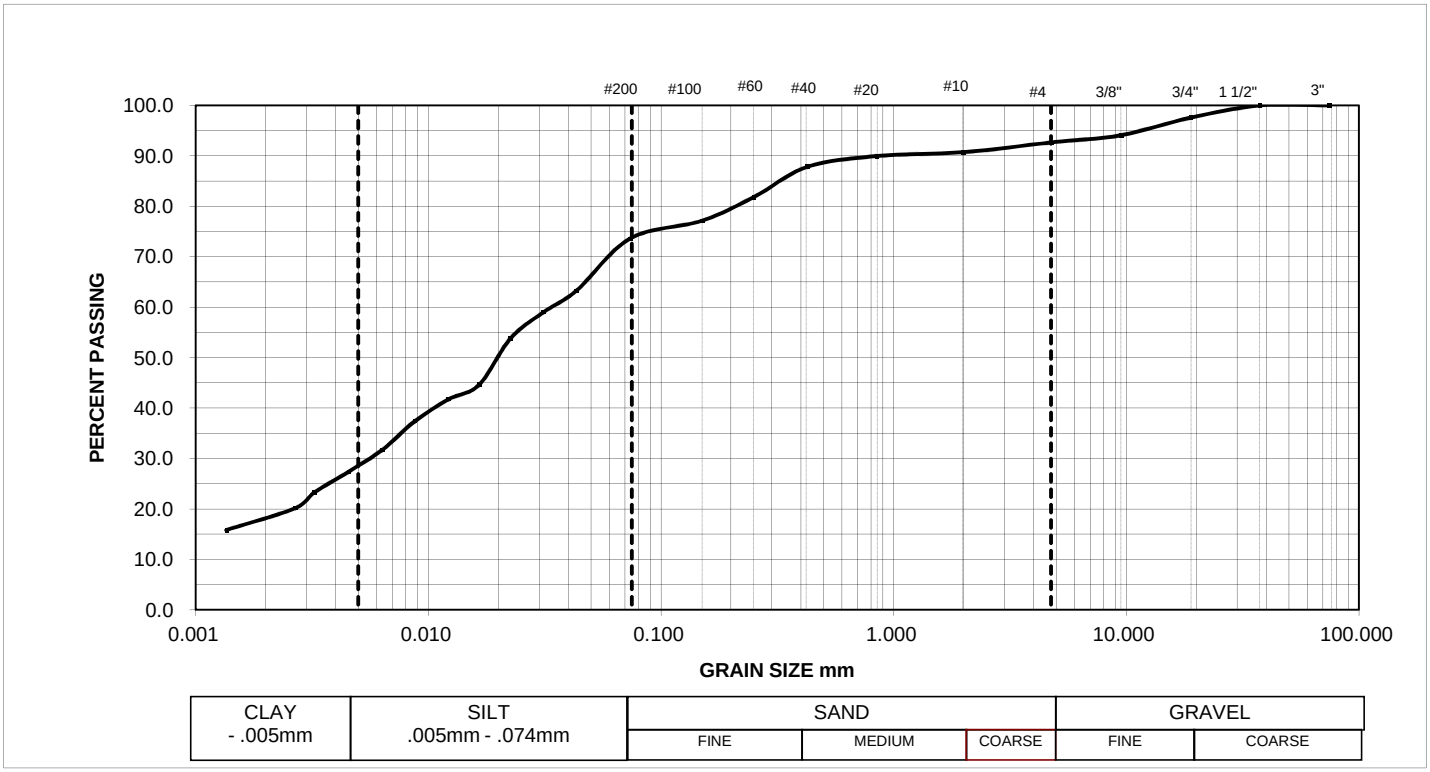
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141244 FIELD NO. S6 HOLE NO. TH15-08 DEPTH (m) 20.0-21.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	26.5	22.0	0.0434	63.3
1.50	37.50	100.0	2	25.0	20.5	0.0313	59.0
0.75	19.00	97.6	4	23.2	18.7	0.0226	53.8
0.375	9.50	94.1	8	20.0	15.5	0.0165	44.6
#4	4.75	92.7	15	19.0	14.5	0.0122	41.7
#10	2.00	90.7	30	17.5	13.0	0.0088	37.4
#20	0.850	90.0	60	15.5	11.0	0.0063	31.7
#40	0.425	87.8	120	14.0	9.5	0.0045	27.3
#60	0.250	81.8	240	12.6	8.1	0.0032	23.3
#100	0.150	77.1	360	11.5	7.0	0.0027	20.1
#200	0.075	73.6	1440	9.9	5.5	0.0014	15.8

% GRAVEL	% SAND	% SILT	% CLAY
7	19	46	28



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

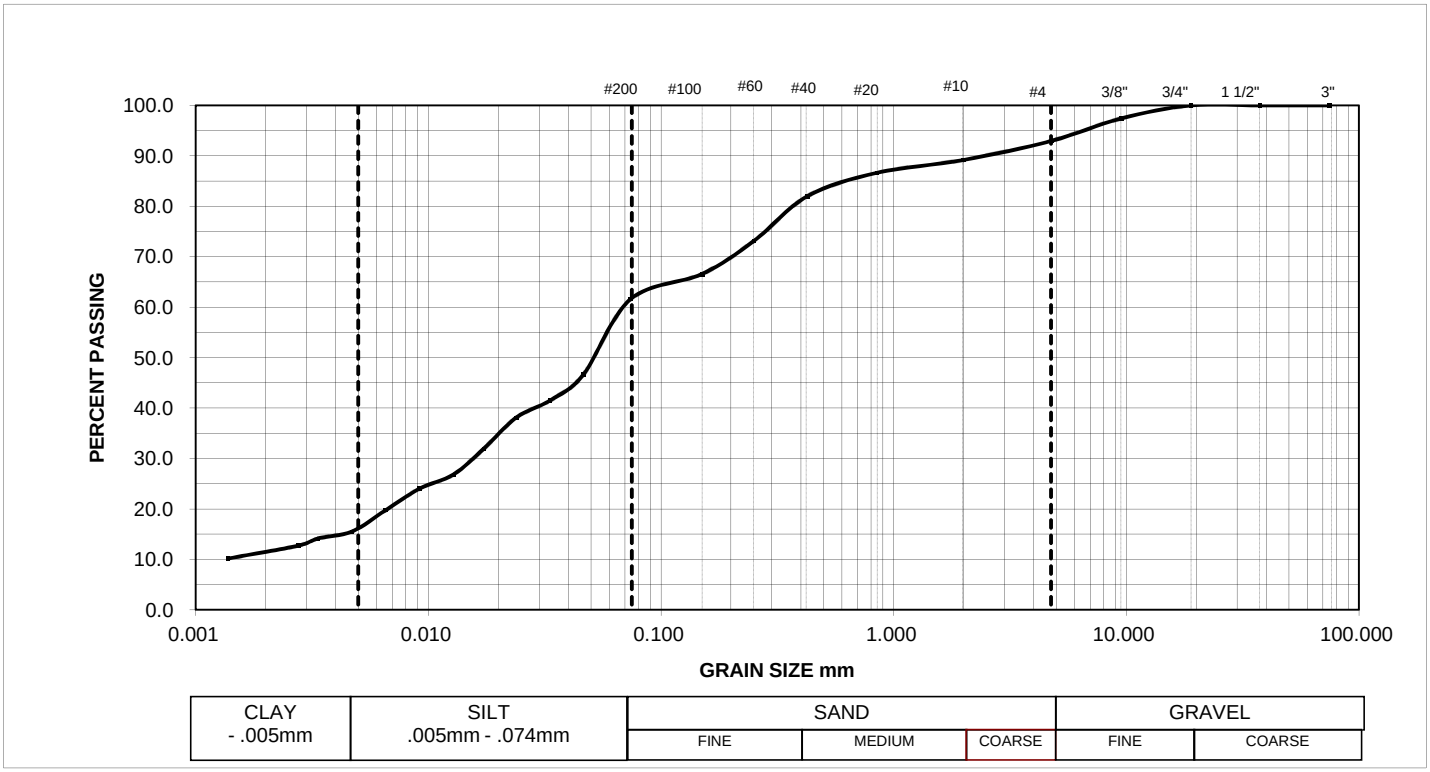
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141245 FIELD NO. S7 HOLE NO. TH15-08 DEPTH (m) 30.0-31.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	21.0	16.5	0.0463	46.6
1.50	37.50	100.0	2	19.2	14.7	0.0334	41.5
0.75	19.00	100.0	4	18.0	13.5	0.0239	38.1
0.375	9.50	97.4	8	15.8	11.3	0.0173	31.9
#4	4.75	92.9	15	14.0	9.5	0.0128	26.8
#10	2.00	89.2	30	13.0	8.5	0.0092	24.0
#20	0.850	86.6	60	11.5	7.0	0.0066	19.8
#40	0.425	82.0	120	10.0	5.5	0.0047	15.5
#60	0.250	73.1	240	9.5	5.0	0.0033	14.1
#100	0.150	66.6	355	9.0	4.5	0.0028	12.7
#200	0.075	61.6	1440	8.0	3.6	0.0014	10.2

% GRAVEL	% SAND	% SILT	% CLAY
7	31	46	16



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

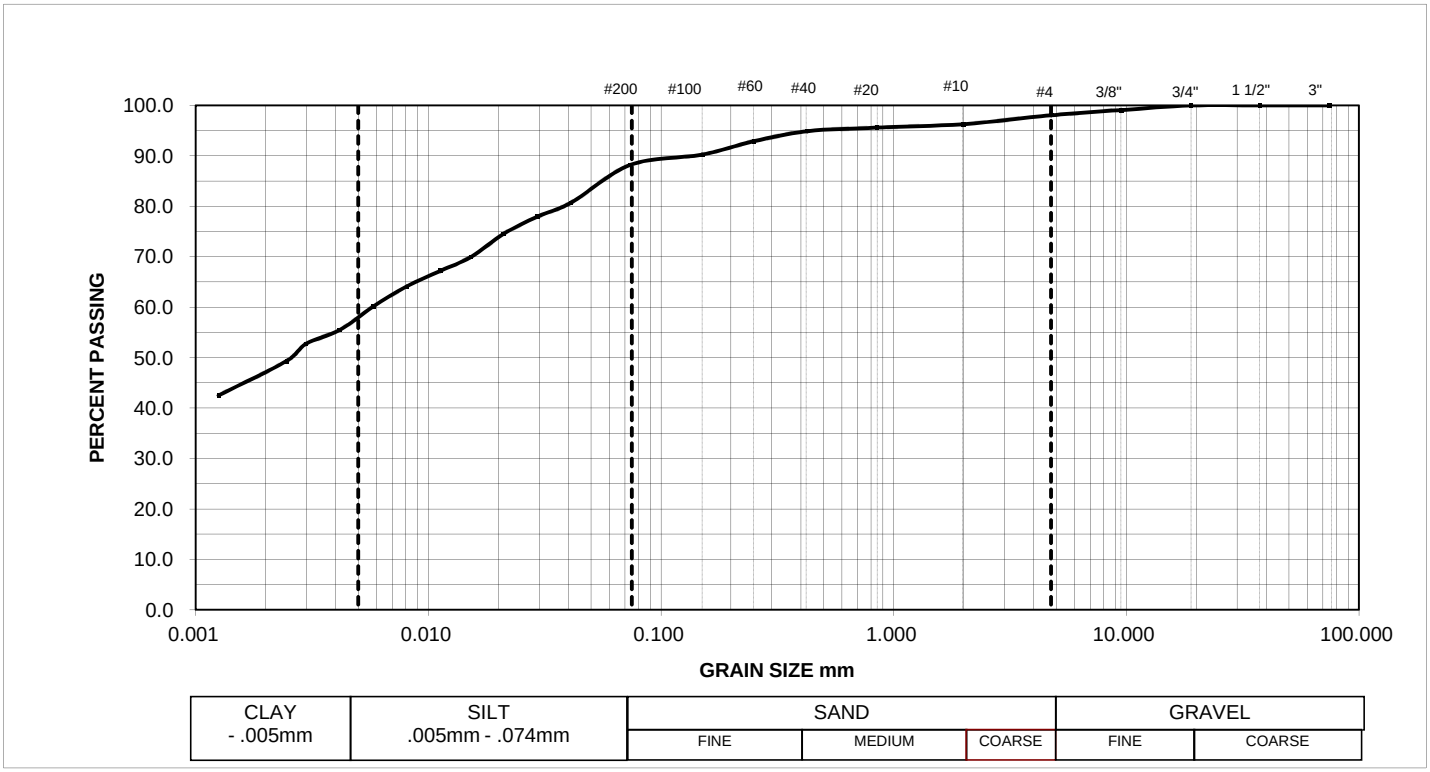
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141247 FIELD NO. S2 HOLE NO. TH15-09 DEPTH (m) 6.5-7.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	30.7	26.2	0.0411	80.8
1.50	37.50	100.0	2	29.8	25.3	0.0294	78.0
0.75	19.00	100.0	4	28.7	24.2	0.0211	74.6
0.375	9.50	99.1	8	27.2	22.7	0.0152	70.0
#4	4.75	98.1	15	26.3	21.8	0.0112	67.2
#10	2.00	96.3	30	25.3	20.8	0.0080	64.1
#20	0.850	95.6	60	24.0	19.5	0.0058	60.1
#40	0.425	94.9	120	22.5	18.0	0.0042	55.5
#60	0.250	92.9	240	21.6	17.1	0.0030	52.7
#100	0.150	90.3	360	20.5	16.0	0.0025	49.3
#200	0.075	88.2	1440	18.2	13.8	0.0013	42.5

% GRAVEL	% SAND	% SILT	% CLAY
2	10	30	58



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141248 FIELD NO. S3 HOLE NO. TH15-09 DEPTH (m) 10.0-11.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	24.8	20.3	0.0443	58.7
1.50	37.50	100.0	2	23.0	18.5	0.0320	53.5
0.75	19.00	100.0	4	22.0	17.5	0.0229	50.6
0.375	9.50	96.1	8	20.3	15.8	0.0165	45.7
#4	4.75	93.3	15	19.0	14.5	0.0122	42.0
#10	2.00	91.3	30	16.8	12.3	0.0088	35.6
#20	0.850	78.9	60	15.0	10.5	0.0064	30.4
#40	0.425	76.5	120	13.3	8.8	0.0046	25.5
#60	0.250	69.2	240	11.8	7.3	0.0033	21.1
#100	0.150	64.1	347	11.0	6.5	0.0027	18.8
#200	0.075	64.1	1440	9.0	4.6	0.0014	13.3

% GRAVEL	% SAND	% SILT	% CLAY
7	29	37	27



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

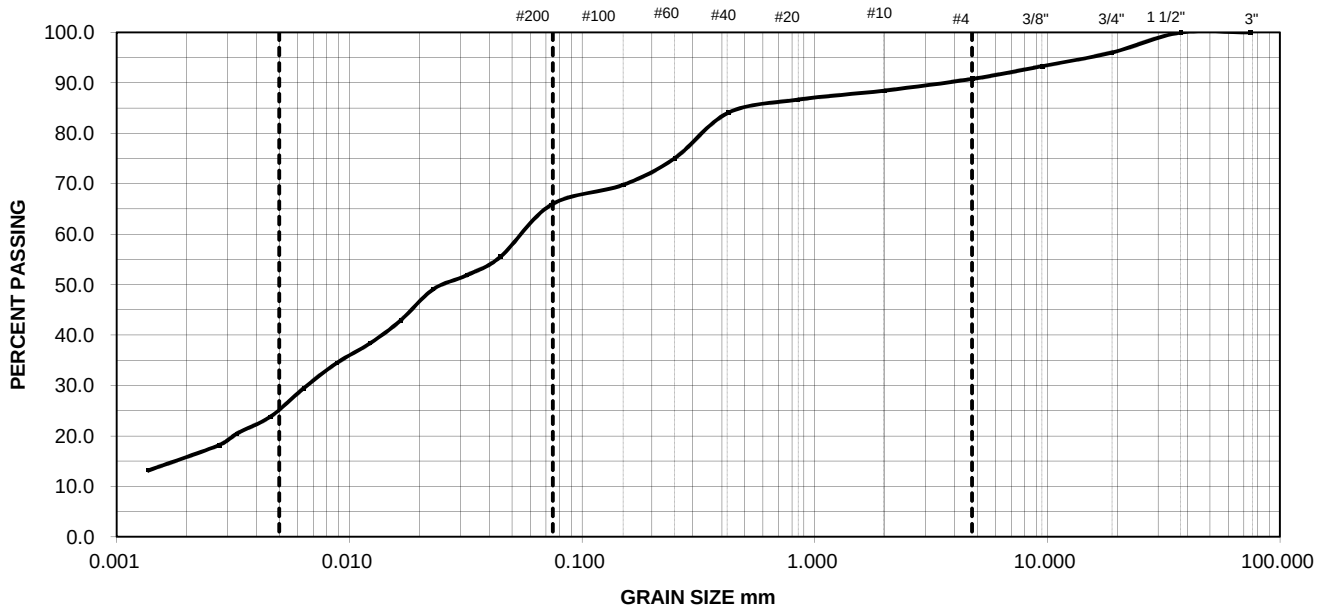
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141249 FIELD NO. S4 HOLE NO. TH15-09 DEPTH (m) 15.0-16.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	24.3	19.8	0.0446	55.5
1.50	37.50	100.0	2	23.0	18.5	0.0320	51.9
0.75	19.00	96.0	4	22.0	17.5	0.0229	49.1
0.375	9.50	93.3	8	19.8	15.3	0.0166	42.9
#4	4.75	90.8	15	18.2	13.7	0.0123	38.4
#10	2.00	88.5	30	16.8	12.3	0.0088	34.5
#20	0.850	86.7	60	15.0	10.5	0.0064	29.5
#40	0.425	84.1	120	13.0	8.5	0.0046	23.8
#60	0.250	75.1	240	11.8	7.3	0.0033	20.5
#100	0.150	69.8	343	11.0	6.5	0.0028	18.2
#200	0.075	65.9	1440	9.1	4.7	0.0014	13.2

% GRAVEL	% SAND	% SILT	% CLAY
9	25	41	25



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

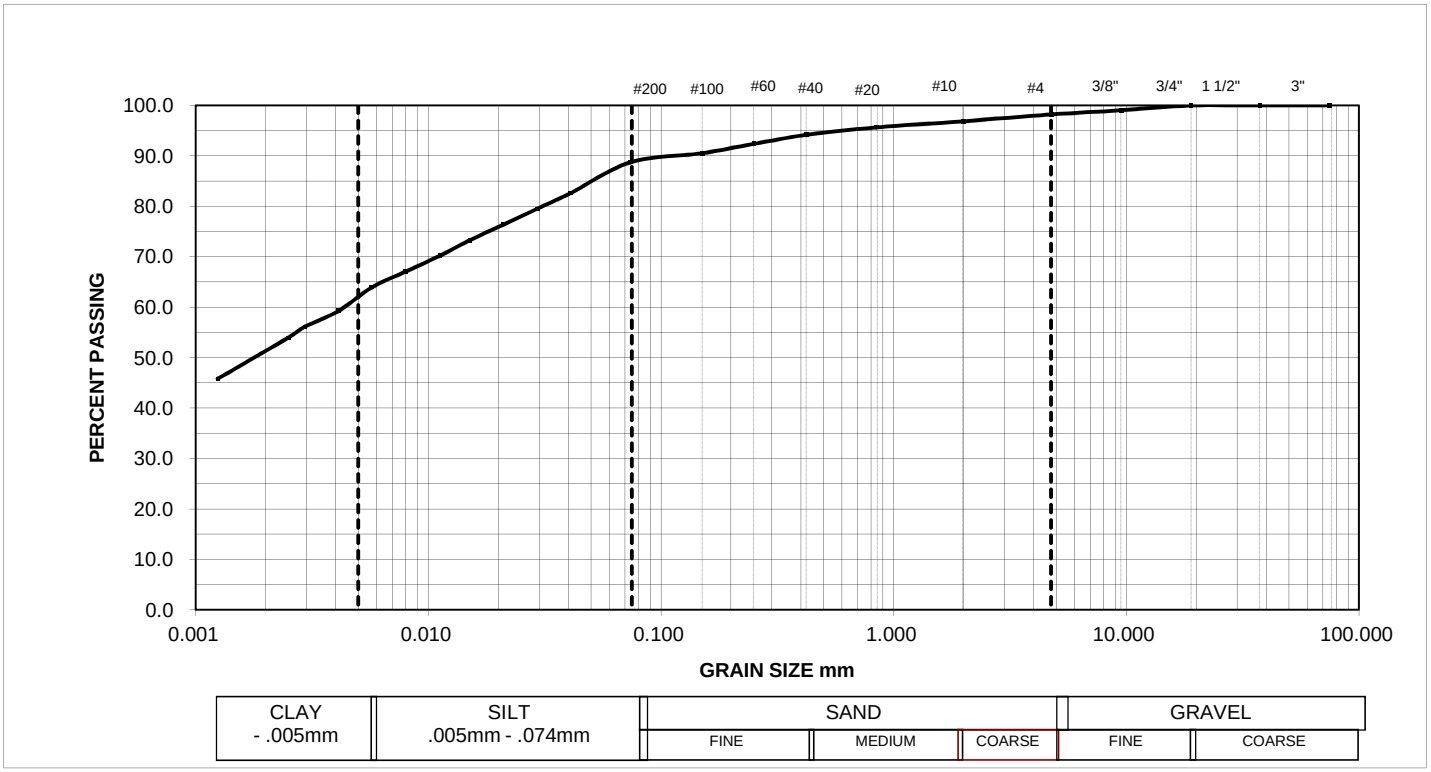
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141250 FIELD NO. S1 HOLE NO. TH15-10 DEPTH (m) 4.0-5.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	31.0	26.5	0.0410	82.7
1.50	37.5	100.0	2	30.0	25.5	0.0294	79.5
0.75	19.0	100.0	4	29.0	24.5	0.0210	76.4
0.375	9.5	99.1	8	28.0	23.5	0.0151	73.3
#4	4.75	98.2	15	27.0	22.5	0.0111	70.2
#10	2.00	96.9	30	26.0	21.5	0.0080	67.1
#20	0.850	95.7	60	25.0	20.5	0.0057	63.9
#40	0.425	94.2	120	23.5	19.0	0.0041	59.3
#60	0.250	92.4	240	22.5	18.0	0.0029	56.1
#100	0.150	90.5	338	21.8	17.3	0.0025	54.0
#200	0.075	88.8	1440	19.1	14.7	0.0012	45.9

% GRAVEL	% SAND	% SILT	% CLAY
2	9	27	62



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

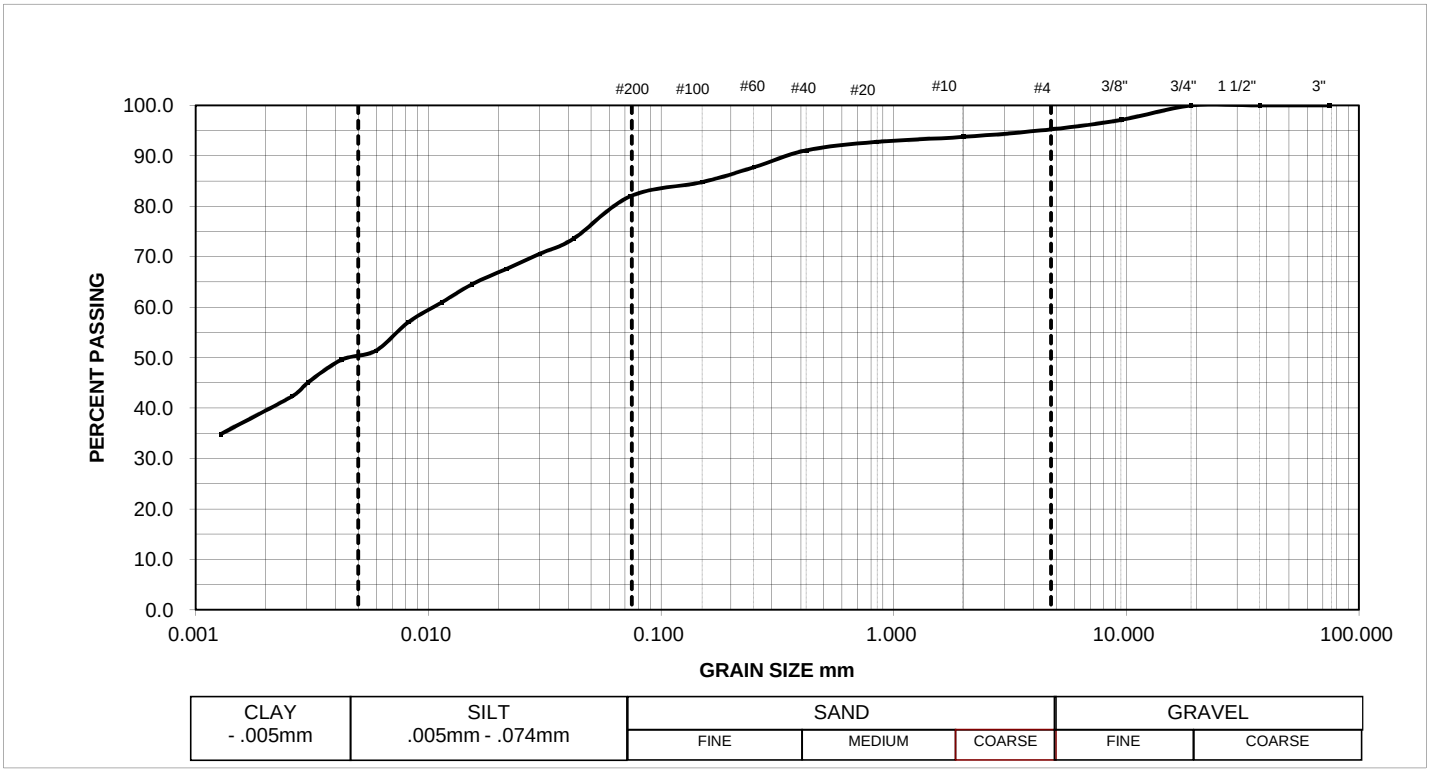
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141251 FIELD NO. S2 HOLE NO. TH15-10 DEPTH (m) 7.0-8.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	29.0	24.5	0.0421	73.6
1.50	37.5	100.0	2	28.0	23.5	0.0301	70.6
0.75	19.0	100.0	4	27.0	22.5	0.0216	67.6
0.375	9.5	97.1	8	26.0	21.5	0.0155	64.6
#4	4.75	95.3	15	24.8	20.3	0.0114	61.0
#10	2.00	93.8	30	23.5	19.0	0.0082	57.1
#20	0.850	92.8	60	21.6	17.1	0.0059	51.4
#40	0.425	91.1	120	21.0	16.5	0.0042	49.6
#60	0.250	87.7	240	19.5	15.0	0.0030	45.1
#100	0.150	84.8	334	18.6	14.1	0.0026	42.4
#200	0.075	82.0	1440	16.0	11.6	0.0013	34.9

% GRAVEL	% SAND	% SILT	% CLAY
5	13	32	50



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

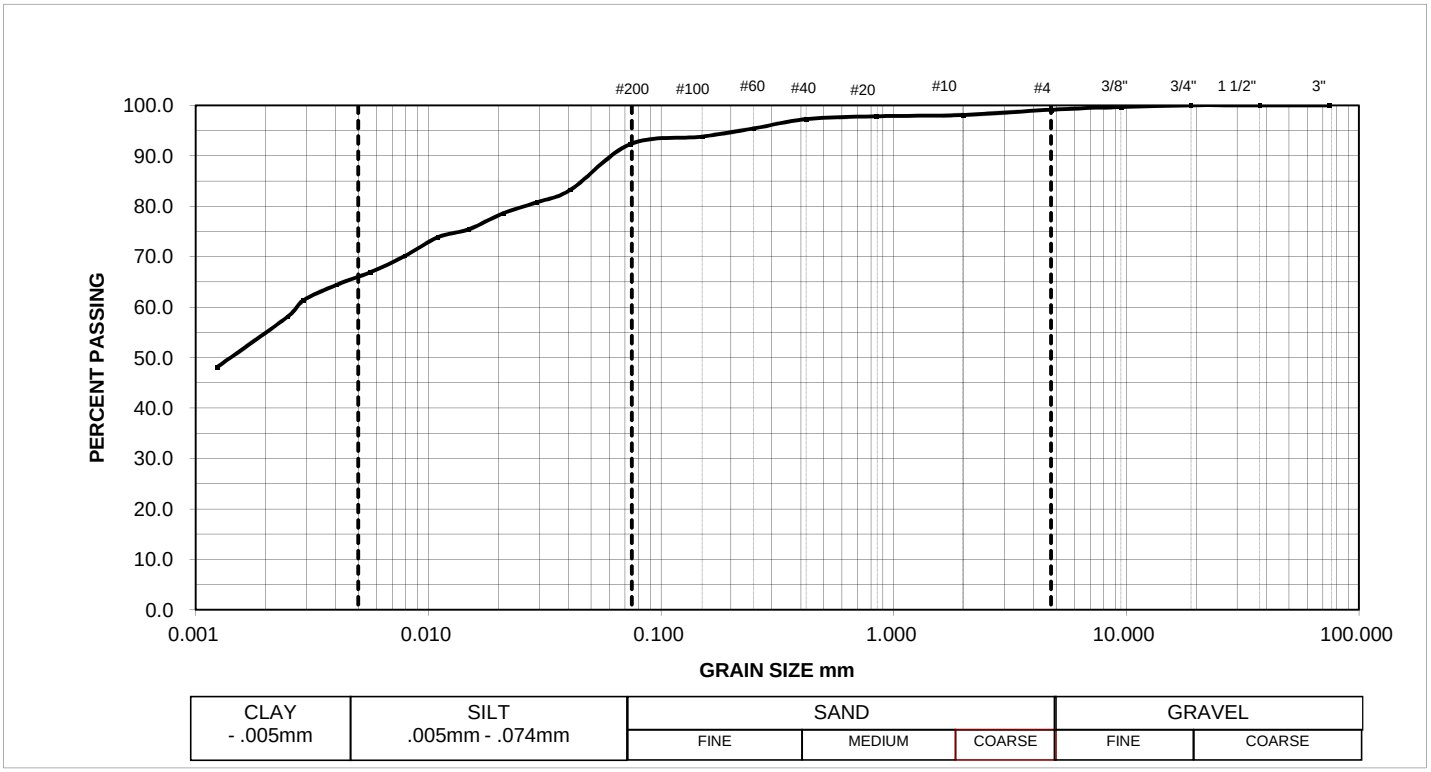
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141252 FIELD NO. S3 HOLE NO. TH15-10 DEPTH (m) 10.0-11.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	31.0	26.5	0.0410	83.3
1.50	37.5	100.0	2	30.2	25.7	0.0293	80.8
0.75	19.0	100.0	4	29.5	25.0	0.0209	78.6
0.375	9.5	99.7	8	28.5	24.0	0.0150	75.4
#4	4.75	99.1	15	28.0	23.5	0.0110	73.9
#10	2.00	98.1	30	26.8	22.3	0.0079	70.1
#20	0.850	97.8	60	25.8	21.3	0.0057	67.0
#40	0.425	97.3	120	25.0	20.5	0.0040	64.4
#60	0.250	95.4	240	24.0	19.5	0.0029	61.3
#100	0.150	93.8	330	23.0	18.5	0.0025	58.2
#200	0.075	92.3	1440	19.7	15.3	0.0012	48.1

% GRAVEL	% SAND	% SILT	% CLAY
1	7	26	66



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

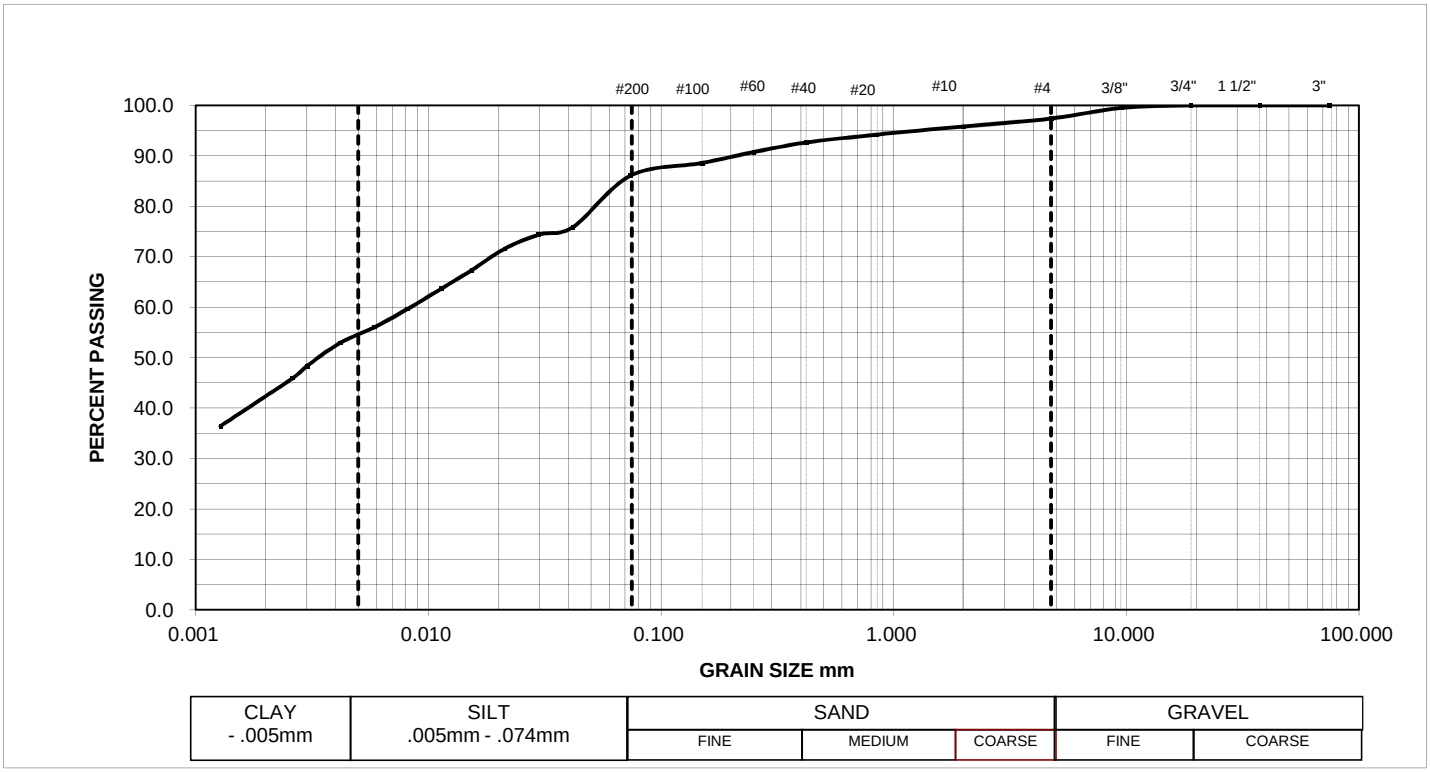
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141253 FIELD NO. S4 HOLE NO. TH15-10 DEPTH (m) 13.0-14.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	29.3	24.8	0.0419	75.9
1.50	37.5	100.0	2	28.8	24.3	0.0298	74.4
0.75	19.0	100.0	4	27.9	23.4	0.0213	71.6
0.375	9.5	99.5	8	26.5	22.0	0.0154	67.3
#4	4.75	97.4	15	25.3	20.8	0.0114	63.7
#10	2.00	95.9	30	24.0	19.5	0.0082	59.7
#20	0.850	94.2	60	22.8	18.3	0.0059	56.0
#40	0.425	92.7	120	21.8	17.3	0.0042	52.9
#60	0.250	90.7	240	20.3	15.8	0.0030	48.4
#100	0.150	88.6	325	19.5	15.0	0.0026	45.9
#200	0.075	86.1	1440	16.3	11.9	0.0013	36.4

% GRAVEL	% SAND	% SILT	% CLAY
3	11	31	55



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

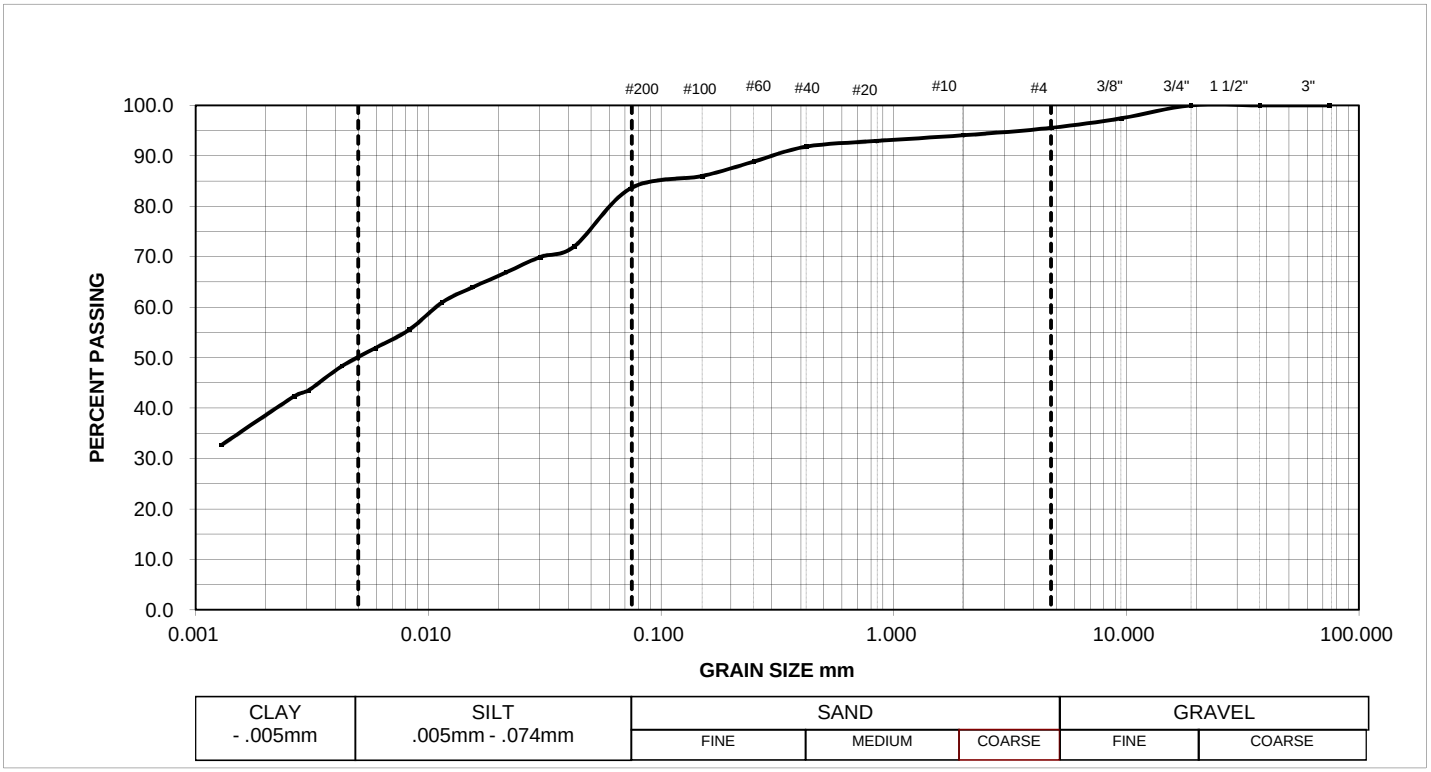
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **Mj**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141254 FIELD NO. S5 HOLE NO. TH15-10 DEPTH (m) 15.0-16.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	28.5	24.0	0.0424	72.0
1.50	37.5	100.0	2	27.8	23.3	0.0302	69.9
0.75	19.0	100.0	4	26.8	22.3	0.0216	66.9
0.375	9.5	97.4	8	25.8	21.3	0.0155	63.9
#4	4.75	95.5	15	24.8	20.3	0.0114	60.9
#10	2.00	94.1	30	23.0	18.5	0.0083	55.5
#20	0.850	92.9	60	21.8	17.3	0.0059	51.9
#40	0.425	91.8	120	20.6	16.1	0.0042	48.3
#60	0.250	88.8	240	19.0	14.5	0.0031	43.5
#100	0.150	86.0	322	18.6	14.1	0.0026	42.3
#200	0.075	83.5	1440	15.3	10.9	0.0013	32.7

% GRAVEL	% SAND	% SILT	% CLAY
4	12	34	50



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

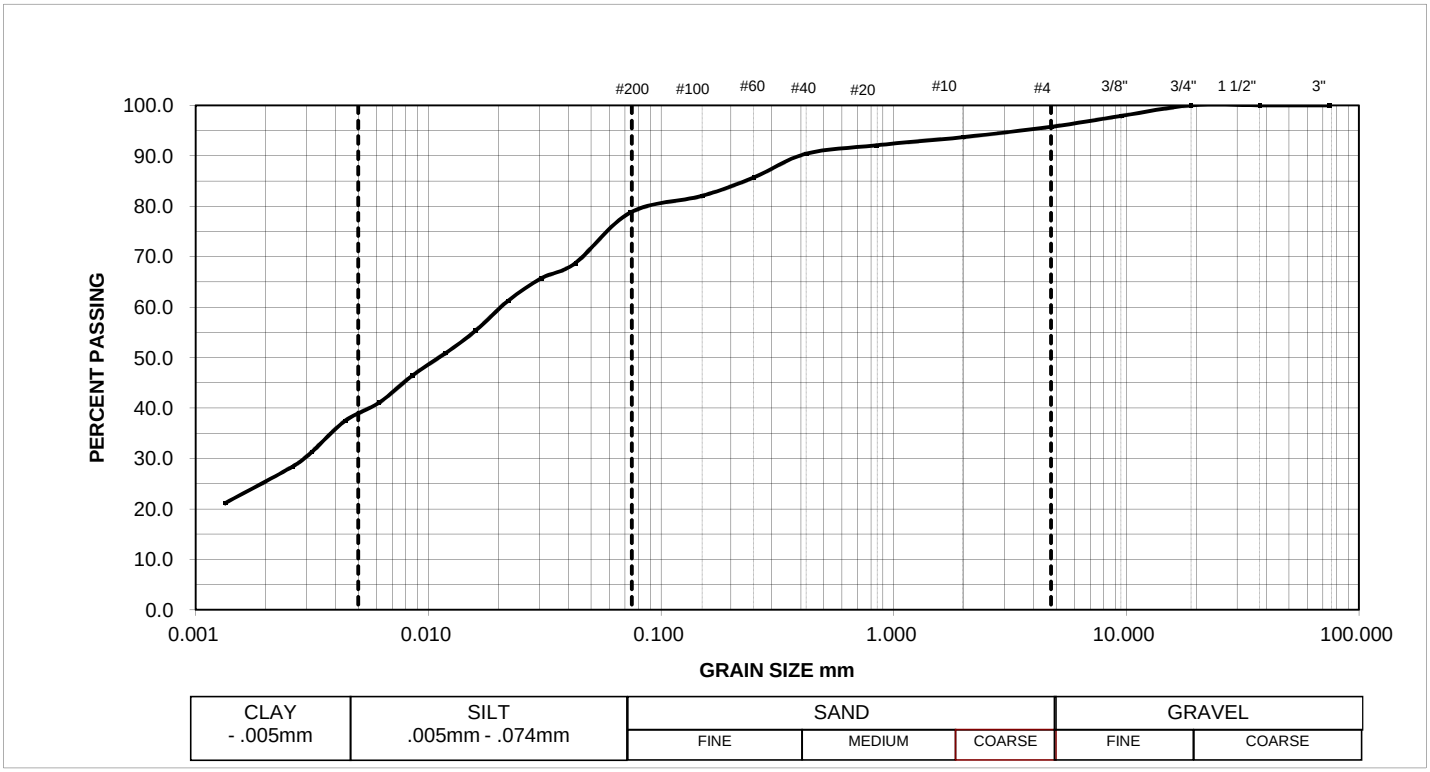
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **Mj**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141255 FIELD NO. S6 HOLE NO. TH15-10 DEPTH (m) 18.5-19.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	27.5	23.1	0.0429	68.7
1.50	37.5	100.0	2	26.5	22.1	0.0307	65.7
0.75	19.0	100.0	4	25.0	20.6	0.0221	61.3
0.375	9.5	97.9	8	23.0	18.6	0.0160	55.3
#4	4.75	95.7	15	21.5	17.1	0.0119	50.9
#10	2.00	93.7	30	20.0	15.6	0.0085	46.4
#20	0.850	92.1	60	18.2	13.8	0.0061	41.0
#40	0.425	90.4	120	17.0	12.6	0.0044	37.5
#60	0.250	85.7	240	15.0	10.6	0.0032	31.4
#100	0.150	82.0	360	14.0	9.6	0.0026	28.4
#200	0.075	78.8	1440	11.4	7.1	0.0013	21.1

% GRAVEL	% SAND	% SILT	% CLAY
4	17	40	39



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

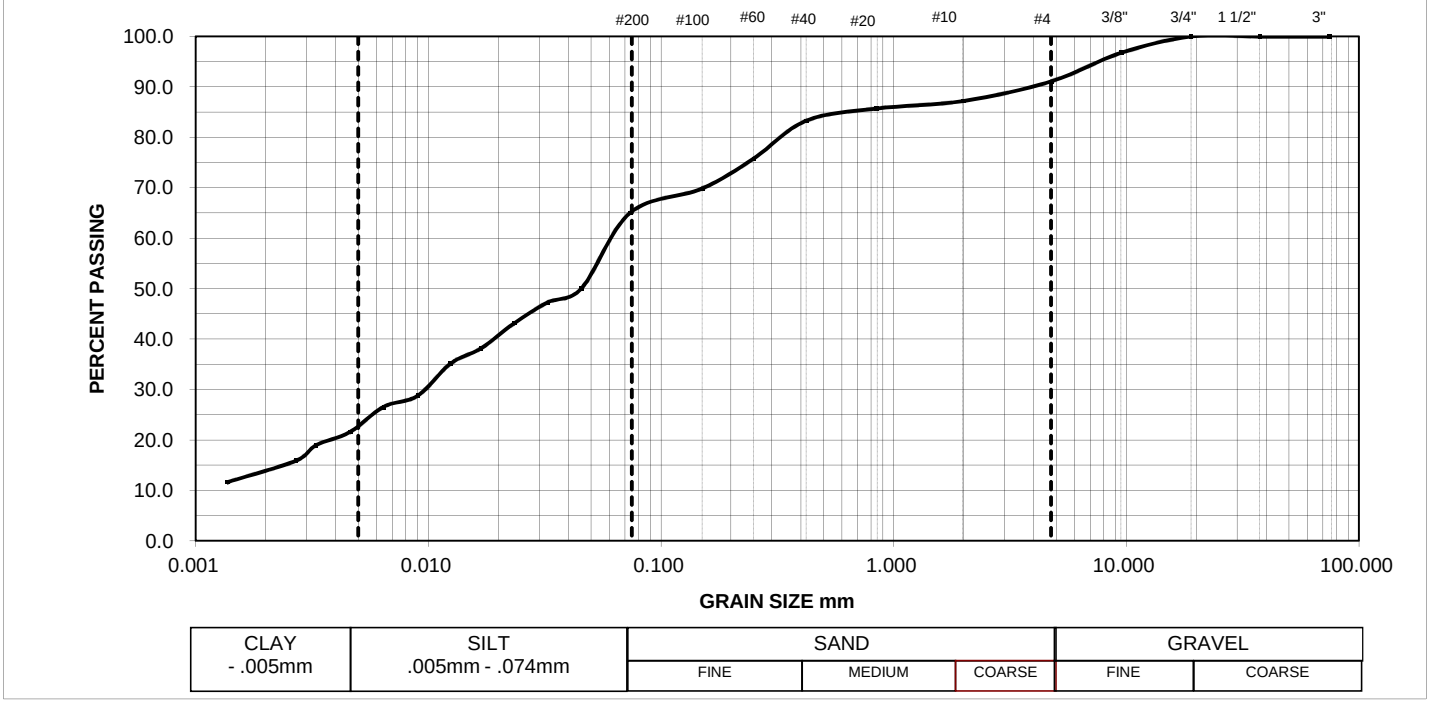
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141256 FIELD NO. S7 HOLE NO. TH15-10 DEPTH (m) 20.0-21.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	22.5	18.1	0.0455	50.0
1.50	37.5	100.0	2	21.5	17.1	0.0325	47.3
0.75	19.0	100.0	4	20.0	15.6	0.0234	43.1
0.375	9.5	96.8	8	18.2	13.8	0.0168	38.1
#4	4.75	91.1	15	17.1	12.7	0.0124	35.1
#10	2.00	87.2	30	14.8	10.4	0.0090	28.7
#20	0.850	85.7	60	14.0	9.6	0.0064	26.5
#40	0.425	83.3	120	12.2	7.8	0.0046	21.6
#60	0.250	75.8	240	11.3	6.9	0.0033	18.9
#100	0.150	69.8	360	10.2	5.8	0.0027	15.9
#200	0.075	65.1	1440	8.5	4.2	0.0014	11.6

% GRAVEL	% SAND	% SILT	% CLAY
9	26	43	22



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

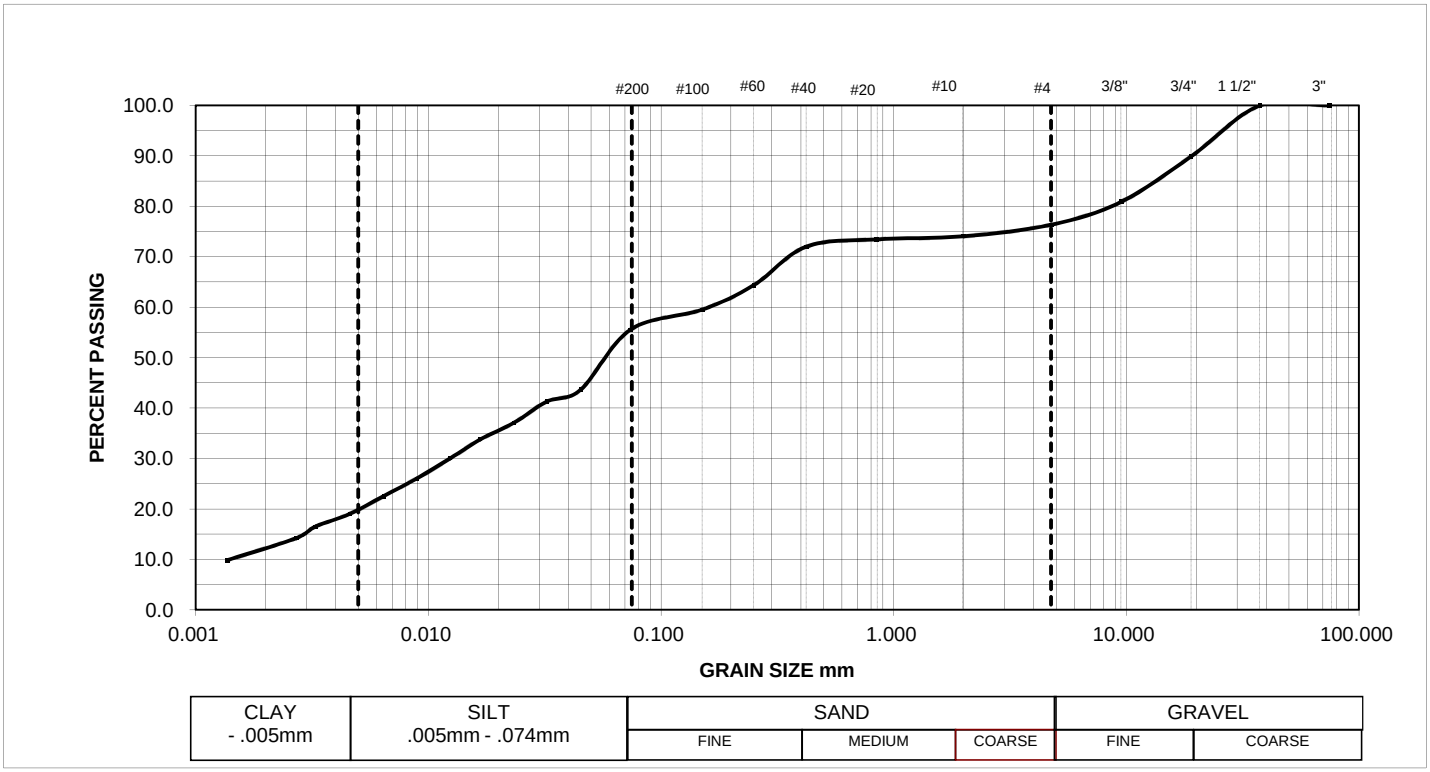
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141257 FIELD NO. S8 HOLE NO. TH15-10 DEPTH (m) 25.0-26.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	23.0	18.6	0.0452	43.7
1.50	37.5	100.0	2	22.0	17.6	0.0323	41.3
0.75	19.0	89.9	4	20.2	15.8	0.0233	37.1
0.375	9.5	80.9	8	18.8	14.4	0.0167	33.8
#4	4.75	76.4	15	17.2	12.8	0.0124	30.0
#10	2.00	74.1	30	15.5	11.1	0.0089	26.1
#20	0.850	73.5	60	14.0	9.6	0.0064	22.5
#40	0.425	72.0	120	12.5	8.1	0.0046	19.0
#60	0.250	64.3	240	11.5	7.1	0.0033	16.5
#100	0.150	59.5	360	10.5	6.1	0.0027	14.2
#200	0.075	55.6	1440	8.5	4.2	0.0014	9.9

% GRAVEL	% SAND	% SILT	% CLAY
24	21	36	20



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **Mj**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141258 FIELD NO. S9 HOLE NO. TH15-10 DEPTH (m) 30.0-31.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	22.5	18.1	0.0455	48.1
1.50	37.5	100.0	2	21.0	16.6	0.0327	44.1
0.75	19.0	100.0	4	20.0	15.6	0.0234	41.4
0.375	9.5	92.2	8	18.0	13.6	0.0169	36.1
#4	4.75	87.4	15	16.3	11.9	0.0125	31.6
#10	2.00	83.9	30	15.0	10.6	0.0090	28.2
#20	0.850	82.3	60	14.0	9.6	0.0064	25.5
#40	0.425	79.9	120	12.0	7.6	0.0046	20.2
#60	0.250	71.1	240	11.0	6.6	0.0033	17.4
#100	0.150	65.8	360	10.0	5.6	0.0027	14.7
#200	0.075	61.4	1440	8.2	3.9	0.0014	10.4

% GRAVEL	% SAND	% SILT	% CLAY
13	26	40	21



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

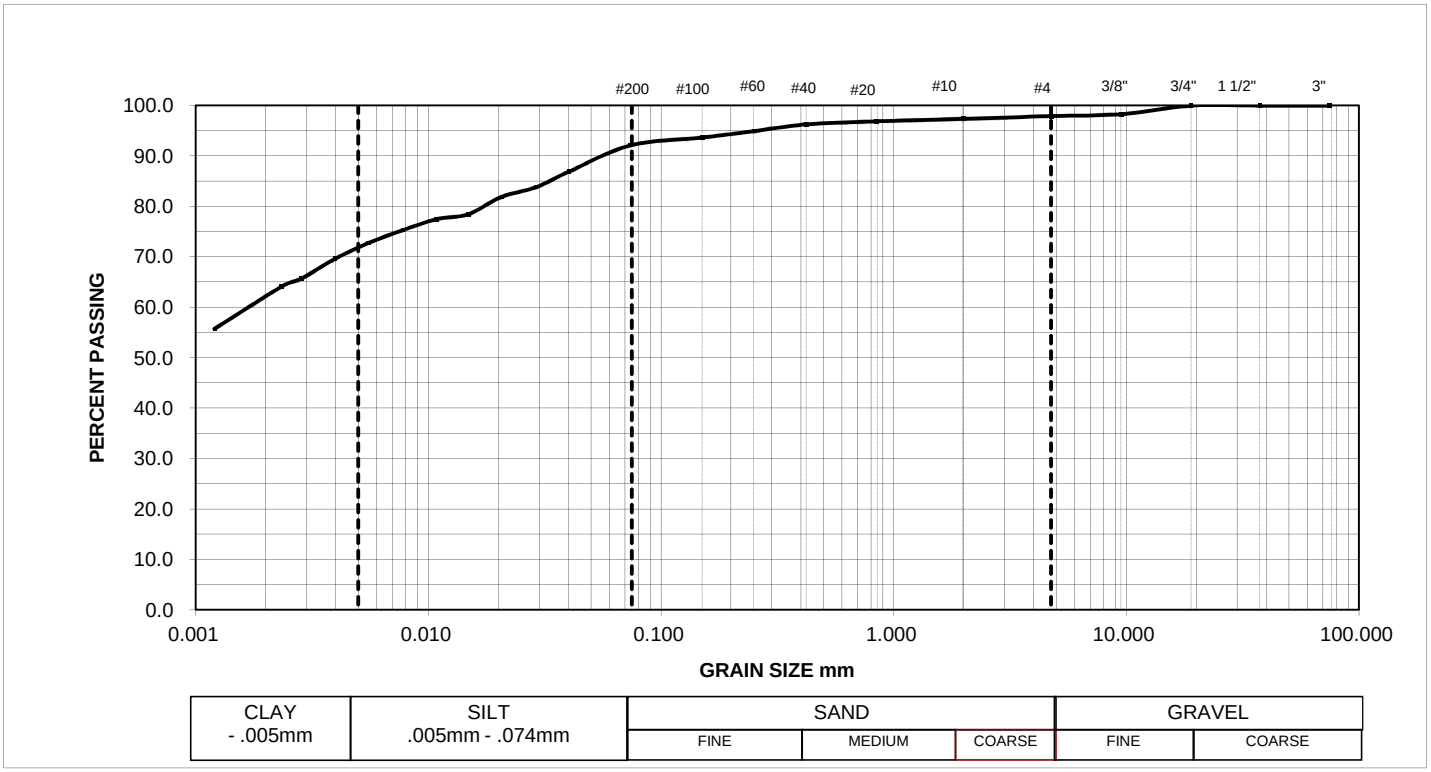
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141259 FIELD NO. S1 HOLE NO. TH15-11 DEPTH (m) 7.0-8.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	32.0	27.6	0.0403	86.9
1.50	37.5	100.0	2	31.0	26.6	0.0289	83.8
0.75	19.0	100.0	4	30.4	26.0	0.0206	81.9
0.375	9.5	98.3	8	29.3	24.9	0.0148	78.4
#4	4.75	97.9	15	29.0	24.6	0.0109	77.5
#10	2.00	97.3	30	28.3	23.9	0.0077	75.3
#20	0.850	96.9	60	27.5	23.1	0.0055	72.8
#40	0.425	96.3	120	26.5	22.1	0.0040	69.6
#60	0.250	94.9	240	25.3	20.9	0.0028	65.7
#100	0.150	93.7	360	24.8	20.4	0.0023	64.1
#200	0.075	92.1	1440	22.0	17.7	0.0012	55.8

% GRAVEL	% SAND	% SILT	% CLAY
2	6	20	72



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

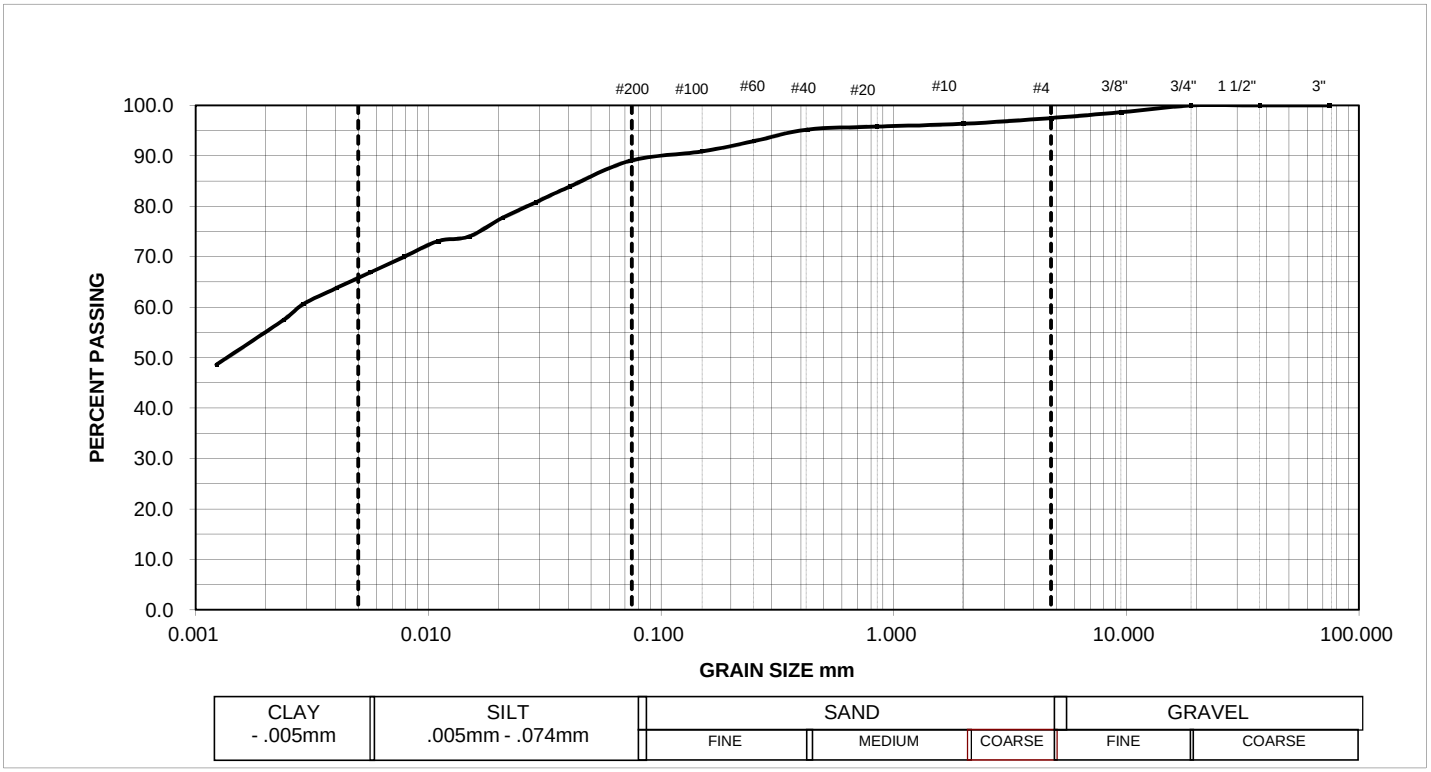
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141260 FIELD NO. S2 HOLE NO. TH15-11 DEPTH (m) 10.0-11.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	31.5	27.1	0.0406	83.9
1.50	37.5	100.0	2	30.5	26.1	0.0291	80.9
0.75	19.0	100.0	4	29.5	25.1	0.0209	77.8
0.375	9.5	98.7	8	28.3	23.9	0.0150	74.0
#4	4.75	97.5	15	28.0	23.6	0.0110	73.1
#10	2.00	96.4	30	27.0	22.6	0.0079	70.0
#20	0.850	95.8	60	26.0	21.6	0.0056	66.9
#40	0.425	95.2	120	25.0	20.6	0.0040	63.8
#60	0.250	92.9	240	24.0	19.6	0.0029	60.6
#100	0.150	90.9	360	23.0	18.6	0.0024	57.5
#200	0.075	89.1	1440	20.0	15.7	0.0012	48.6

% GRAVEL	% SAND	% SILT	% CLAY
2	8	23	66



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

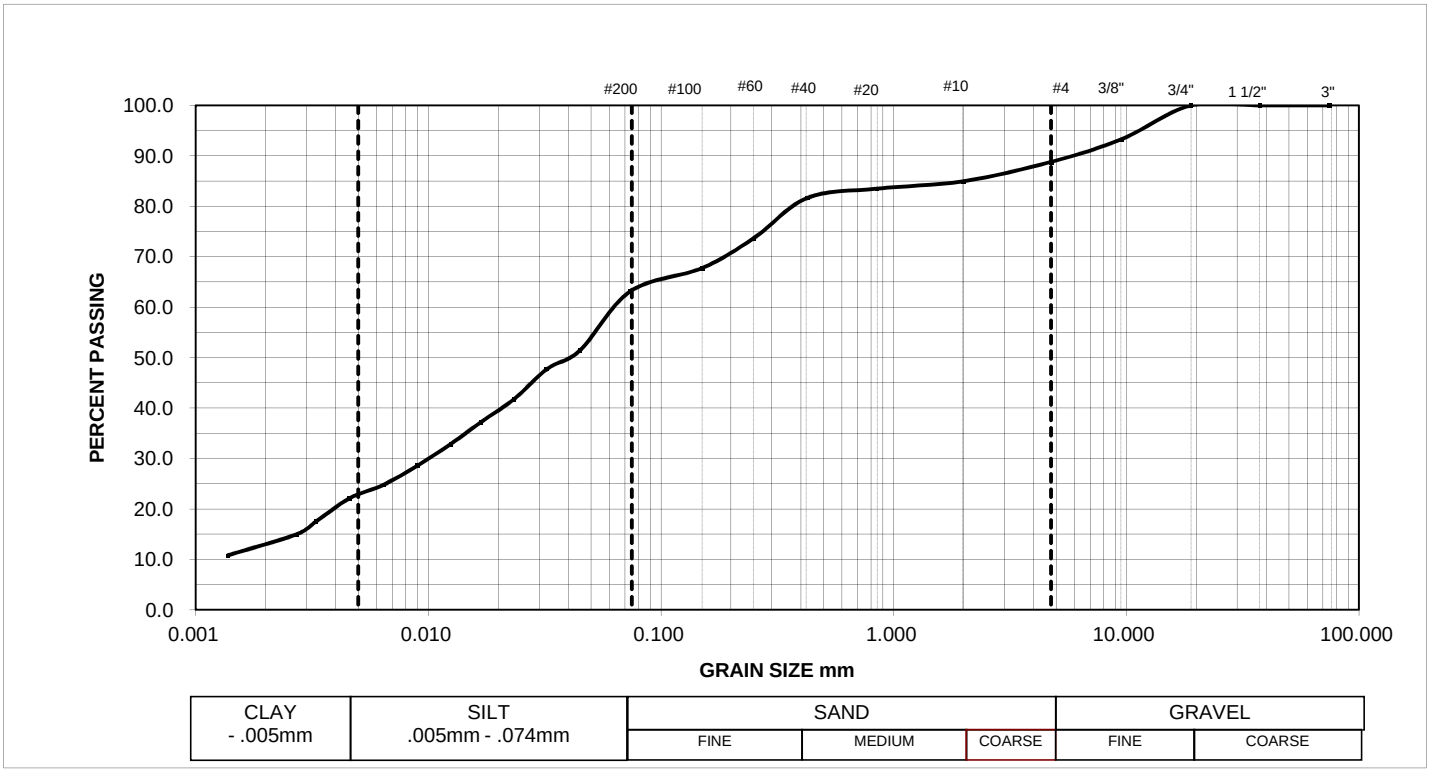
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141262 FIELD NO. S4 HOLE NO. TH15-11 DEPTH (m) 15.0-16.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	23.4	19.1	0.0450	51.5
1.50	37.50	100.0	2	22.0	17.7	0.0323	47.7
0.75	19.00	100.0	4	19.8	15.5	0.0234	41.8
0.375	9.50	93.2	8	18.1	13.8	0.0168	37.2
#4	4.75	88.8	15	16.5	12.2	0.0125	32.9
#10	2.00	84.9	30	14.9	10.6	0.0090	28.6
#20	0.850	83.5	60	13.5	9.2	0.0064	24.8
#40	0.425	81.6	120	12.5	8.2	0.0046	22.1
#60	0.250	73.6	240	10.8	6.5	0.0033	17.5
#100	0.150	67.7	360	9.9	5.6	0.0027	15.0
#200	0.075	63.2	1440	8.5	4.0	0.0014	10.8

% GRAVEL	% SAND	% SILT	% CLAY
11	26	40	23



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141264 FIELD NO. S6 HOLE NO. TH15-11 DEPTH (m) 20.0-21.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	26.2	21.9	0.0435	62.3
1.50	37.50	100.0	2	24.0	19.7	0.0316	56.1
0.75	19.00	98.4	4	22.6	18.3	0.0227	52.1
0.375	9.50	95.0	8	20.5	16.2	0.0164	46.1
#4	4.75	92.1	15	19.0	14.7	0.0122	41.8
#10	2.00	89.6	30	17.0	12.7	0.0088	36.1
#20	0.850	88.5	60	15.3	11.0	0.0063	31.3
#40	0.425	87.0	120	13.7	9.4	0.0045	26.7
#60	0.250	80.2	240	12.1	7.8	0.0033	22.2
#100	0.150	76.0	360	11.3	7.0	0.0027	19.8
#200	0.075	72.5	1440	9.4	4.9	0.0014	13.9

% GRAVEL	% SAND	% SILT	% CLAY
8	20	44	28



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

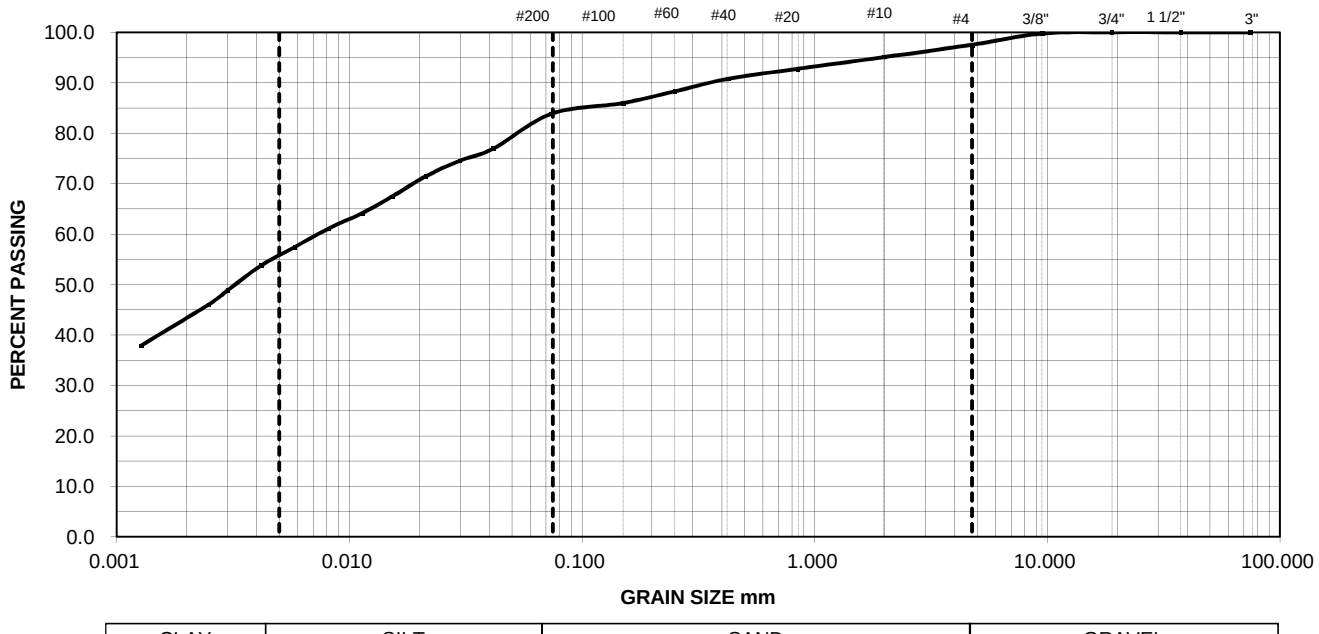
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141269 FIELD NO. S2 HOLE NO. TH15-12 DEPTH (m) 7.0-8.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	29.5	25.2	0.0417	77.0
1.50	37.50	100.0	2	28.7	24.4	0.0298	74.5
0.75	19.00	100.0	4	27.7	23.4	0.0213	71.5
0.375	9.50	99.8	8	26.4	22.1	0.0153	67.5
#4	4.75	97.5	15	25.3	21.0	0.0114	64.1
#10	2.00	95.1	30	24.3	20.0	0.0081	61.1
#20	0.850	92.8	60	23.1	18.8	0.0058	57.4
#40	0.425	90.8	120	21.9	17.6	0.0042	53.8
#60	0.250	88.3	240	20.3	16.0	0.0030	48.9
#100	0.150	86.0	360	19.4	15.1	0.0025	46.0
#200	0.075	83.8	1440	16.9	12.4	0.0013	37.9

% GRAVEL	% SAND	% SILT	% CLAY
2	14	28	56



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

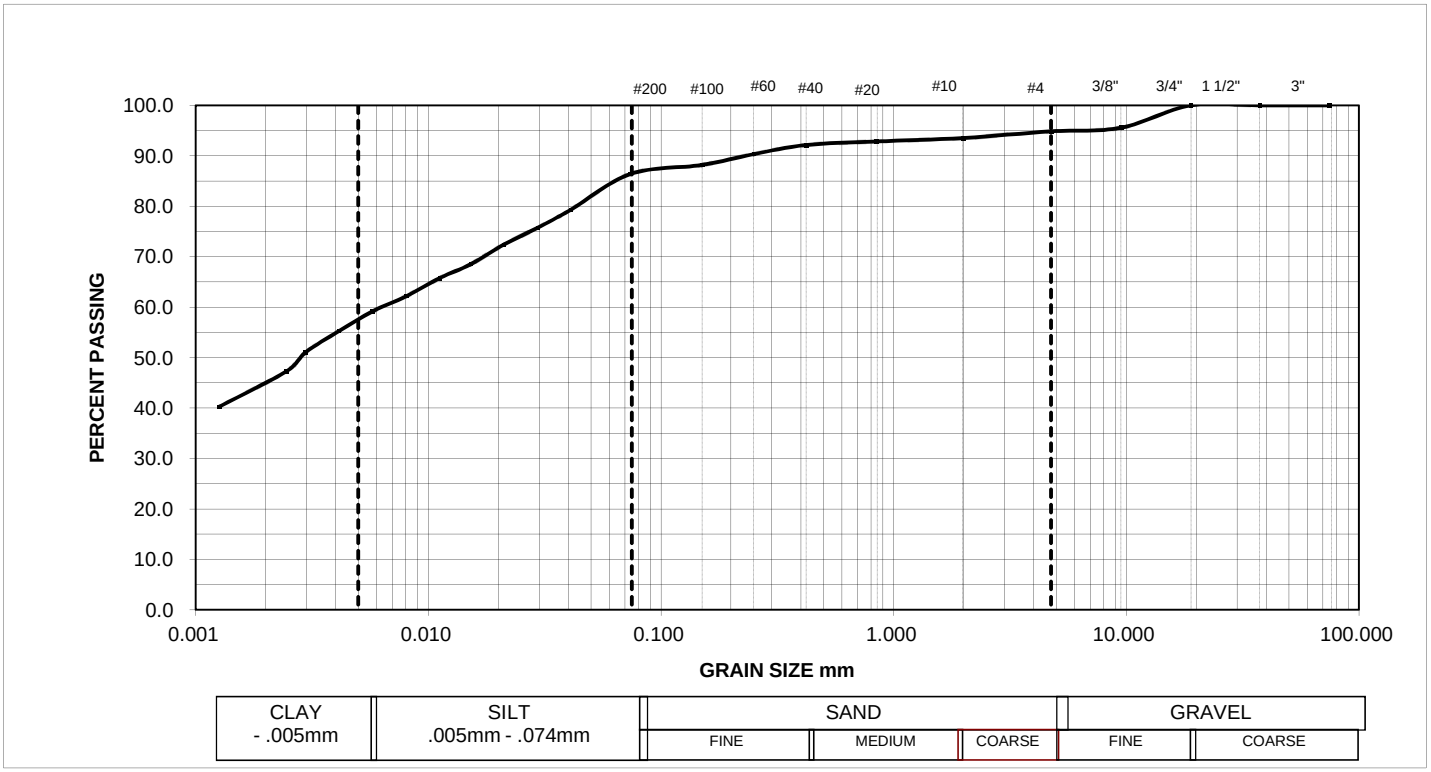
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141270 FIELD NO. S3 HOLE NO. TH15-12 DEPTH (m) 10.0-11.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	30.7	26.4	0.0410	79.3
1.50	37.5	100.0	2	29.5	25.2	0.0295	75.7
0.75	19.0	100.0	4	28.4	24.1	0.0212	72.4
0.375	9.5	95.6	8	27.1	22.8	0.0152	68.5
#4	4.75	94.8	15	26.2	21.9	0.0112	65.8
#10	2.00	93.5	30	25.0	20.7	0.0081	62.2
#20	0.850	92.8	60	24.0	19.7	0.0058	59.2
#40	0.425	92.1	120	22.7	18.4	0.0041	55.3
#60	0.250	90.3	240	21.3	17.0	0.0030	51.1
#100	0.150	88.2	360	20.1	15.8	0.0025	47.3
#200	0.075	86.4	1440	17.9	13.4	0.0013	40.3

% GRAVEL	% SAND	% SILT	% CLAY
5	8	28	58



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

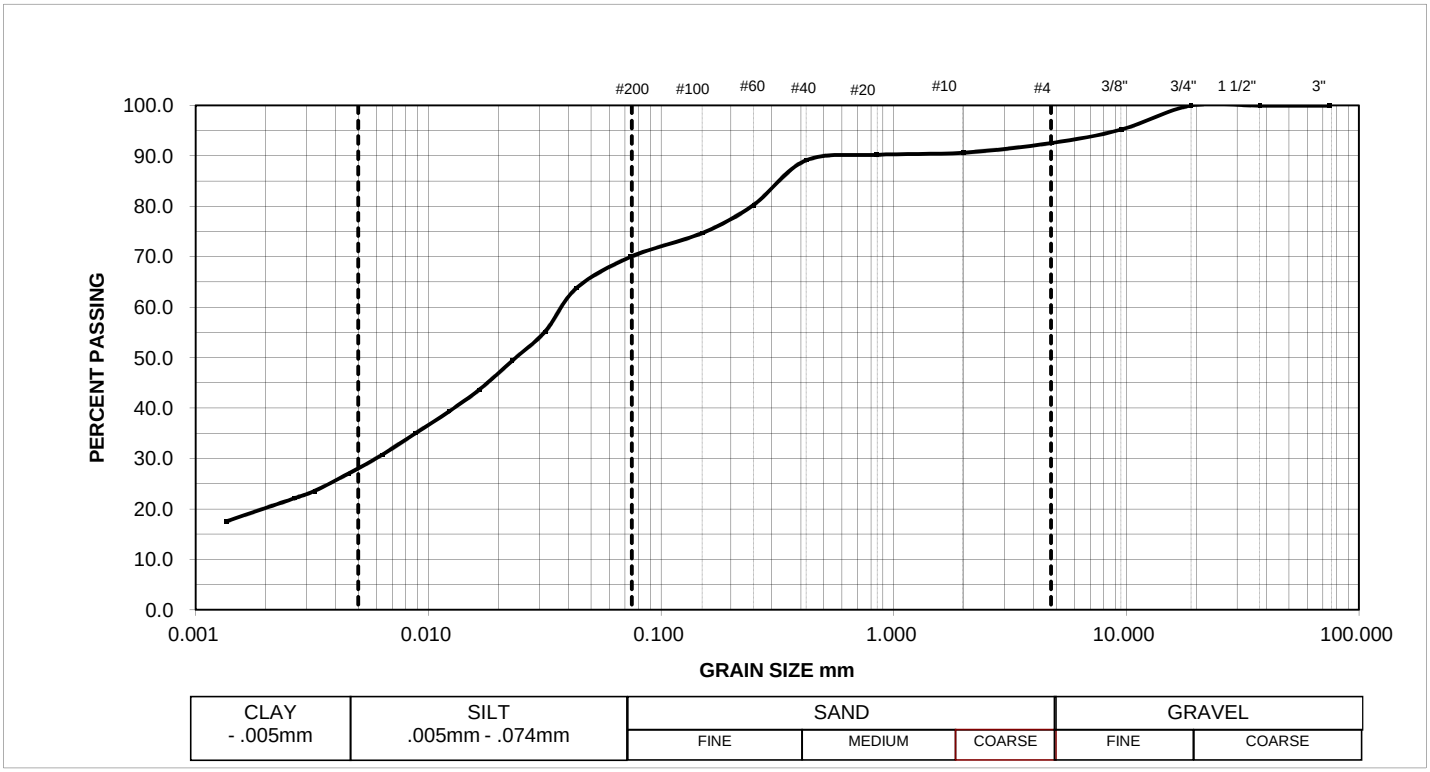
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141271 FIELD NO. S4 HOLE NO. TH15-12 DEPTH (m) 12.0-13.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	27.0	22.2	0.0433	63.8
1.50	37.5	100.0	2	24.0	19.2	0.0318	55.2
0.75	19.0	100.0	4	22.0	17.2	0.0230	49.4
0.375	9.5	95.2	8	20.0	15.2	0.0166	43.7
#4	4.75	92.6	15	18.5	13.7	0.0123	39.4
#10	2.00	90.7	30	17.0	12.2	0.0088	35.1
#20	0.850	90.2	60	15.5	10.7	0.0063	30.8
#40	0.425	89.1	120	14.2	9.4	0.0045	27.0
#60	0.250	80.3	240	13.0	8.2	0.0032	23.6
#100	0.150	74.7	360	12.5	7.7	0.0027	22.1
#200	0.075	70.0	1440	10.9	6.1	0.0014	17.5

% GRAVEL	% SAND	% SILT	% CLAY
7	23	42	28



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141272 FIELD NO. S5 HOLE NO. TH15-12 DEPTH (m) 15.0-16.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	22.2	17.9	0.0456	49.8
1.50	37.5	100.0	2	19.6	15.3	0.0332	42.5
0.75	19.0	100.0	4	18.0	13.7	0.0238	38.1
0.375	9.5	95.9	8	15.6	11.3	0.0173	31.4
#4	4.75	90.5	15	14.0	9.7	0.0128	27.0
#10	2.00	86.2	30	12.3	8.0	0.0092	22.2
#20	0.850	83.2	60	11.1	6.8	0.0066	18.9
#40	0.425	80.1	120	10.0	5.7	0.0047	15.8
#60	0.250	70.3	240	9.1	4.8	0.0033	13.3
#100	0.150	64.0	360	8.7	4.4	0.0027	12.1
#200	0.075	59.4	1440	7.9	3.4	0.0014	9.5

% GRAVEL	% SAND	% SILT	% CLAY
10	31	43	16



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **Mj**
LOCATION: **Willow Point** **Checked By:** **GK**

LAB.NO. WGT141273 FIELD NO. S6 HOLE NO. TH15-12 DEPTH (m) 20.0-21.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	22.9	18.6	0.0452	49.9
1.50	37.5	100.0	2	20.5	16.2	0.0328	43.5
0.75	19.0	100.0	4	17.5	13.2	0.0240	35.4
0.375	9.5	93.7	8	15.1	10.8	0.0173	29.0
#4	4.75	88.6	15	13.3	9.0	0.0129	24.2
#10	2.00	84.7	30	11.7	7.4	0.0092	19.9
#20	0.850	83.9	60	10.4	6.1	0.0066	16.4
#40	0.425	80.9	120	9.5	5.2	0.0047	14.0
#60	0.250	71.5	240	8.5	4.2	0.0034	11.3
#100	0.150	65.1	360	8.1	3.8	0.0028	10.1
#200	0.075	60.6	1440	7.2	2.7	0.0014	7.2

% GRAVEL	% SAND	% SILT	% CLAY
11	28	47	14



Manitoba Infrastructure and Transportation
Materials Engineering Branch - Central Lab

SIEVE OR SCREEN ANALYSIS OF FINE AND COARSE AGGREGATES
ASTM C 117, C 136

PROJECT: Lake St. Martin Channel
LOCATION : Willow Point

Technician: MO
Checked By: GK

LAB. NO.: WGT141225 **FIELD NO:** S6 **HOLE NO.:** TH15-06
DEPTH(m): 15.0-15.25

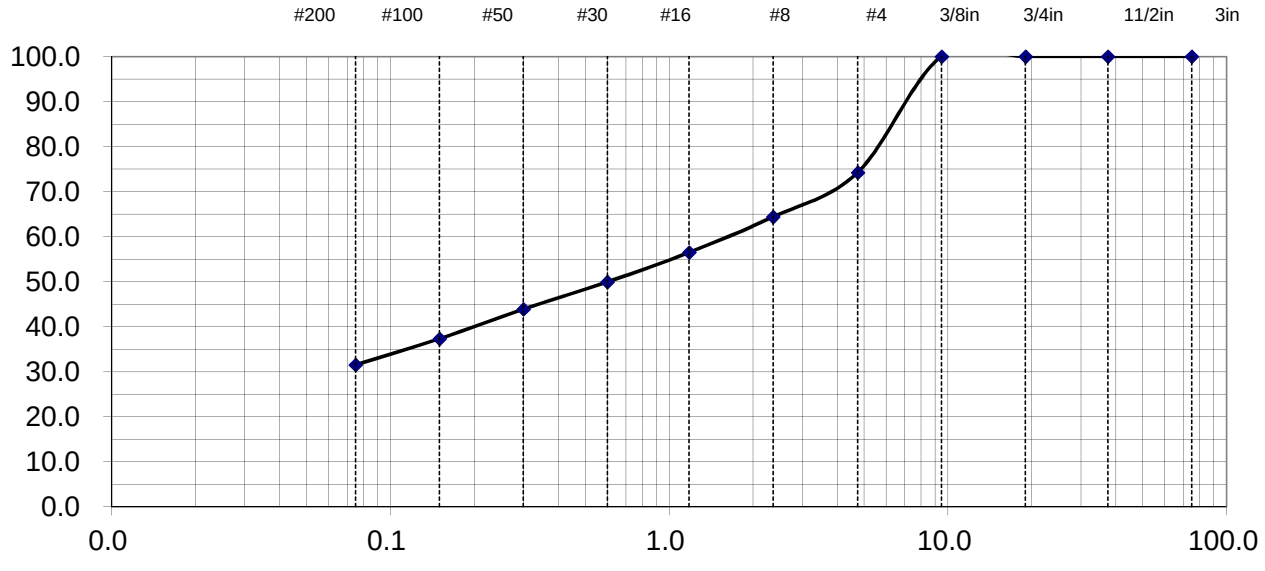
Sieve U.S standard	Size m.m.	Mass Retained Basis Total Sample	Retained (%)	Cumulative Retained (%)	Passing (%)
					100.0
3.00	75.0				100.0
1.50	37.5				100.0
.750	19.0				100.0
.375	9.5				100.0
#4	4.75	19.6	25.8	25.8	74.2
#8	2.36	7.5	9.9	35.6	64.4
#16	1.18	6.0	7.9	43.5	56.5
#30	0.600	5.0	6.6	50.1	49.9
#50	0.300	4.6	6.0	56.1	43.9
#100	0.150	5.0	6.6	62.7	37.3
#200	0.075	4.4	5.8	68.5	31.5
Pan		0.7	0.9	69.4	
Total		52.8	69.4		

Mass of Sample Before Washing	76.1
Mass of Sample After Washing	52.8
Mass Passing (wash) 75 µm	23.3
Mass Passing (sieve) 75 µm	0.7
Total Mass Passing 75 µm	24.0

D10= D30= D60=
Cu= Cc=

% Pass 75 µm =	31.5	Unified
% Sand =	42.7	Classification
% Gravel =	25.8	
F.M. =	2.74	

U.S. Standard Sieve Series ASTM E 11



SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (M)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m³	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L / D_{10}	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_P / C_C	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS I_P / C_U	GRAIN SIZE GRAVEL %	GRAIN SIZE SAND %	GRAIN SIZE P_{200} or SILT % / CLAY %	STRENGTH q_u K.S.F. / kPa	STRENGTH POCKET PENETROMETER T.S.F.
S1	WGT14 1220	PT, Peat, organics, very, soft, wet, black, trace silt, trace sand, trace gravel										
TH15-06	1.5-2.5											
S2	WGT14 1221	CI, Clay, +wp, silty, some sand, firm, moist, grey, trace gravel, trace silt pockets, trace organics										
TH15-06	4.0-5.0											
S3	WGT14 1222	CI, Clay (till), +wp, silty, some sand, hard/loose, moist, grey, trace gravel										
TH15-06	6.5-7.5											
S4	WGT14 1223	CL, Clay (till), silty, sandy, some gravel, loose, moist, light brown										
TH15-06	8.5-10.0											
S5	WGT14 1224	ML, Silt (till), sandy, some clay, some gravel, loose, moist, light brown										
TH15-06	10.0-10.5											
S6	WGT14 1225	SC-SM, Sand, gravelly, some silt, some clay, loose, moist, light brown										
TH15-06	15.0-15.25											
S&	WGT14 1226	ML, Silt (till), sandy, some clay, some gravel, loose, moist, light brown										
TH15-06	15.25-19.0											
S8	WGT14 1227	No Sample										
TH15-06	19.0-21.0											
S9	WGT14 1228	No Sample										
TH15-06	21.0-25.0											
S10	WGT14 1229	No Sample										
TH15-06	25.0-30.0											
S10	WGT14 1230	PT, Peat, organics, very, soft, wet, black, trace silt										
TH15-07	1.5-2.5											
S2	WGT14 1231	CI, Clay (till), +wp, silty, some sand, firm, moist, grey, trace gravel, trace organics										
TH15-07	4.0-5.0											
S3	WGT14 1232	CI, Clay (till),-wp, silty, some sand, loose, moist, grey, trace gravel										
TH15-07	8.0-9.0											
S4	WGT14 1233	CH, Clay (till), -wp, silty, some sand, some gravel, hard, moist, grey, trace silt pockets										
TH15-07	10.0-11.5											
S5	WGT14 1234	CH, Clay (till), +wp, silty, some sand, some gravel, hard, moist, grey, trace silt pockets										
TH15-07	13.0-14.0											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Water Management and Structures
LOCATION: Lake St Martin Channel - Willow Point
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-04-02

SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (M)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m³	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L	D_{10}	W_P	C_C	I_P	C_U	GRAIN SIZE GRAVEL %	SAND %	P_{200} or SILT %	% CLAY	STRENGTH q_u K.S.F.	kPa	POCKET PENETROMETER T.S.F.
S6	WGT14 1235	CI, Clay (till), +wp, silty, some sand, some gravel, hard, moist, grey, trace silt pockets															
TH15-07	15.0-16.5																
S7	WGT14 1236	CL, Clay (till), -wp, silty, sandy, loose, moist, grey, trace gravel															
TH15-07	18.0-19.0																
S8	WGT14 1237	No Sample															
TH15-07	25.0-27.0																
S9	WGT14 1238	No Sample															
TH15-07	27.0-30.0																
S1	WGT14 1239	PT, Peat, organics, very soft, wet, black, trace sand															
TH15-08	2.0-3.0																
S2	WGT14 1240	CH, Clay, +wp, silty, some sand, some gravel, soft, moist, grey, trace organics															
TH15-08	4.0-5.0																
S3	WGT14 1241	CH, Clay (till), +wp, some silt, some sand, hard, moist, grey, trace gravel, trace silt pockets															
TH15-08	7.0-8.0																
S4	WGT14 1242	CH, Clay (till), -wp, silty, some sand, hard, moist, grey, trace gravel, trace silt pockets															
TH15-08	10.0-11.5																
S5	WGT14 1243	CI, Clay (till(, -wp, silty, some sand, some gravel, firm, moist, grey															
TH15-08	15.0-16.5																
S6	WGT14 1244	CL-ML, Silty Clay (till), -wp, some sand, some gravel, loose, moist, grey															
TH15-08	20.0-21.0																
S7	WGT14 1245	ML, Silt (till), sandy, some clay, some gravel, hard/loose, moist, grey															
TH15-08	30.0-31.5																
S1	WGT14 1246	PT, Peat, organics, very soft, wet, black															
TH15-09	2.0-3.0																
S2	WGT14 1247	CI, Clay (till), +wp, silty, some sand, firm, moist, grey, trace gravel															
TH15-09	6.5-7.5																
S3	WGT14 1248	CL-ML, Silty Clay (till), -wp, sandy, some gravel, hard, dry, grey															
TH15-09	10.0-11.5																
S4	WGT14 1249	CL-ML, Silty Clay (till), -wp, sandy, some gravel, hard, dry, light grey															
TH15-09	15.0-16.0																

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Water Management and Structures
LOCATION: Lake St Martin Channel - Willow Point
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-04-02

SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
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5. MOISTURE
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8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

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$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
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S1	WGT14 1250	CH, Clay (till), +wp, silty, some sand, hard, moist, grey, trace gravel										
TH15-10	4.0-5.0											
S2	WGT14 1251	CH, Clay (till), silty, some sand, some gravel, soft, very moist, grey										
TH15-10	7.0-8.0											
S3	WGT14 1252	CH, Clay (till), +wp, silty, some sand, hard, moist, grey, trace gravel, trace silt pockets										
TH15-10	10.0-11.5											
S4	WGT14 1253	CI, Clay (till), +wp, silty, silt pockets, some sand, firm, moist, grey, trace gravel										
TH15-10	13.0-14.0											
S5	WGT14 1254	CI, Clay (till), +wp, silty, some sand, firm, moist, grey, trace gravel, trace silt pockets										
TH15-10	15.0-16.5											
S6	WGT14 1255	CL, Clay (till), +wp, silty, some sand, soft, moist, grey, trace gravel										
TH15-10	18.5-19.5											
S7	WGT14 1256	CL-ML, Silty Clay (till), -wp, sandy, some gravel, hard/loose, moist, grey										
TH15-10	20.0-21.5											
S8	WGT14 1257	CL-ML, Silty Clay (till), -wp, sandy, gravelly, hard, moist, grey										
TH15-10	25.0-26.5											
S9	WGT14 1258	CL-ML, Silty Clay (till), +wp, sandy, gravelly, soft-hard, moist, grey										
TH15-10	30.0-31.5											
S1	WGT14 1259	CH, Clay, +wp, some silt, some sand, firm, moist, grey, trace gravel, trace silt pockets										
TH15-11	7.0-8.0											
S2	WGT14 1260	CH, Clay, +wp, silty, some sand, hard, moist, grey, trace gravel, trace silt pockets										
TH15-11	10.0-11.5											
S3	WGT14 1261	CH, Clay, +wp, some silt, some sand, firm-soft, moist, grey, trace gravel, trace silt pockets										
TH15-11	12.0-13.0											
S4	WGT14 1262	CL-ML, Silty Clay (till), -wp, sandy, some gravel, hard, moist, grey										
TH15-11	15.0-16.5											
S5	WGT14 1263	CL, Clay (till), +wp, some silt, some sand, very soft, very moist, grey, trace gravel										
TH15-11	17.0-18.0											
S6	WGT14 1264	CL, Clay (till), -wp, silty, some sand, some gravel, hard, moist, grey										
TH15-11	20.0-21.5											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Water Management and Structures
LOCATION: Lake St Martin Channel - Willow Point
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-04-02

SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
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5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (M)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m³	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L / D_{10}	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_P / C_C	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS I_P / C_U	GRAIN SIZE GRAVEL %	GRAIN SIZE SAND %	GRAIN SIZE P_{200} or SILT % / CLAY %	STRENGTH q_u K.S.F. / kPa	STRENGTH POCKET PENETROMETER T.S.F.
S7	WGT14 1265	CL, Clay (till), +wp, some silt, some sand, some gravel, soft-firm, moist, grey										
TH15-11	22.0-23.0											
S8	WGT14 1266	No Sample										
TH15-11	25.0-26.0											
S9	WGT14 1267	CL, Clay (till), +wp, some silt, some sand, some gravel, soft, moist, grey										
TH15-11	26.0-27.0											
S1	WGT14 1268	PT, Peat, organics, very soft, wet, black										
TH15-12	2.0-3.0											
S2	WGT14 1269	CI, Clay, +wp, silty, some sand, soft, very moist, grey, trace gravel, trace silt pockets, trace organics										
TH15-12	7.0-8.0											
S3	WGT14 1270	CI, Clay (till), +wp, silty, some sand, some gravel, firm, moist, grey, trace silt pockets										
TH15-12	10.0-11.5											
S4	WGT14 1271	CL, Clay (till), -wp, silty, sandy, some gravel, loose, moist, light grey										
TH15-12	12.0-13.0											
S5	WGT14 1272	CL-ML, Silty Clay (till), -wp, sandy, some gravel, loose, moist, light grey										
TH15-12	15.0-16.5											
S6	WGT14 1273	ML, Silt (till), sandy, some gravel, some clay, hard, moist, light grey										
TH15-12	20.0-21.5											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Water Management and Structures
LOCATION: Lake St Martin Channel - Willow Point
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-04-02

MANITOBA INFRASTRUCTURE AND TRANSPORTATION

MATERIALS ENGINEERING BRANCH

SOIL SURVEY REPORT

Field Book No.:

Client:	Water Management and Structures	**From:**	
Project:	Lake St Martin Channel	**To:**	
Control Section:		**Survey Location:**	Access Road
Project No.:		**Survey Purpose:**	Preliminary
Soil Survey No.:	2014SS05		
Internal Order No.:	200037101	**Sampled By:**	KGS Group
Contract No.:		**Dated Sampled:**	February 10-17, 2015

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

SOIL SURVEY PROPERTY SUMMARY SHEET

Field Book No.:		From:		Report To:	Akinbola George, Rick Postlethwaite
Client:	Water Management and Structures	To:		Date Requsitioned:	2015-03-06
Highway:	Lake St Martin Channel Access Road	Contract No.:		Date Reported:	2015-06-04
Control Section:		Survey Location:	Access Road		
Project No.:		Survey Purpose:	Preliminary		
Soil Survey No.:	2014SS05	Sampled By:	KGS		
Internal Order No.:	200037101	Date Sampled:	2015-02-10	Page: 1 of 6	

Sample Data							Particle Size Analysis					Soil Properties/Classification											
Legal Description	Test Hole#	Station	Centerline offset (m)	Lab Sample Number	Depth(ft)	Field Sample No.	Coarse Aggregate (%)	Coarse Sand (%)	Fine Sand (%)	Silt (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (-1 = NP)	AASHTO	Group Index	Soil Type	Moisture Content (%)	Frost Susceptibility	Organic Content (%)	Maximum Density (kg/m^3)	Optimum Moisture (%)	Field Description
	TP15-32			WSS140413	3-4	S1	NT											17					silty clay
	TP15-32			WSS140414	5-6	S2	NT											24					silty clay
	TP15-32			WSS140415	7-8	S3	NT											22					silty clay
	TP15-32			WSS140416	11-12	S4	14	2	17	33	34	27	13	14	A-6	8	Low Plastic Clay	15					silt till
	TP15-32			WSS140417	13-14	S5	8	1	11	24	56	44	20	24	A-7-6	15	High Plastic Clay	12					silt till
	TP15-33			WSS140418	5-6	S1	NT											25					silty clay
	TP15-33			WSS140419	7-8	S2	4	2	9	27	58	43	19	24	A-7-6	14	High Plastic Clay	22					silty clay
	TP15-33			WSS140420	10-11	S3	12	7	17	35	28	21	13	8	A-4	6	Sandy Silt	13					silt till
	TP15-34			WSS140421	1-2	S1	5	7	15	25	49	41	21	20	A-7-6	12	High Plastic Clay	24					silty clay
	TP15-34			WSS140422	4-5	S2	18	1	19	41	21	14	12	2	A-4	5	Sandy Silt	7	FS				silt till
	TP15-34			WSS140423	8-9	S3	NT											5					silt till
	TP15-34			WSS140424	11-12	S4	22	2	19	38	20	16	12	4	A-4	5	Gravelly Silt	6					silt till
	TP15-34			WSS140425	14-15	S5	NT											6					silt till
	TP15-35			WSS140426	5-6	S1	7	1	10	27	54	41	20	21	A-7-6	13	High Plastic Clay	25					silty clay
	TP15-35			WSS140427	8-9	S2	NT											20					silty clay
	TP15-36			WSS140428	3-4	S1	20	23	5	18	34	40	19	21	A-6	7	Sandy Clay	24					silty clay
	TP15-36			WSS140429	6-7	S2	NT											20					silty clay
	TP15-36			WSS140430	10-11	S3	17	1	19	35	28	22	13	9	A-4	6	Sandy Silt	10					silt till
	TP15-36			WSS140431	14-15	S4	NT											10					silt till
	TP15-37			WSS140432	3-4	S1	NT											33					silty clay

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MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

SOIL SURVEY PROPERTY SUMMARY SHEET

Field Book No.:		From:		Report To:	Akinbola George, Rick Postlethwaite
Client:	Water Management and Structures	To:		Date Requsitioned:	2015-03-06
Highway:	Lake St Martin Channel Access Road	Contract No.:		Date Reported:	2015-06-04
Control Section:		Survey Location:	Access Road		
Project No.:		Survey Purpose:	Preliminary		
Soil Survey No.:	2014SS05	Sampled By:	KGS		
Internal Order No.:	200037101	Date Sampled:	2015-02-10	Page: 2 of 6	

Sample Data							Particle Size Analysis					Soil Properties/Classification											
Legal Description	Test Hole#	Station	Centerline offset (m)	Lab Sample Number	Depth(ft)	Field Sample No.	Coarse Aggregate (%)	Coarse Sand (%)	Fine Sand (%)	Silt (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (-1 = NP)	AASHTO	Group Index	Soil Type	Moisture Content (%)	Frost Susceptibility	Organic Content (%)	Maximum Density (kg/m^3)	Optimum Moisture (%)	Field Description
	TP15-37			WSS140433	5-6	S2	6	2	10	19	63	51	20	31	A-7-6	18	High Plastic Clay	22					silty clay
	TP15-37			WSS140434	8-9	S3	NT											24					silty clay
	TP15-37			WSS140435	10-11	S4	16	2	18	38	26	19	13	6	A-4	6	Sandy Silt	9					silt till
	TP15-37			WSS140436	15-16	S5	NT											10					silt till
	TP15-38			WSS140437	7-8	S1	7	2	11	22	58	43	20	23	A-7-6	14	High Plastic Clay	32					silty clay
	TP15-38			WSS140438	9.5-10.5	S2	NT											15					silty clay
	TP15-38			WSS140439	12-13	S3	15	1	19	42	23	39	13	26	A-6	12	Sandy Clay	11					silt till
	TP15-39			WSS140440	1-2	S1	NT											795					peat
	TP15-39			WSS140441	6-7	S2	2	1	5	18	74	52	22	30	A-7-6	18	High Plastic Clay	31					silty clay
	TP15-39			WSS140442	10-11	S3	10	4	14	39	33	23	13	10	A-4	7	Clayey Silt	14					silt till
	TP15-40			WSS140443	1-2	S1	NT											874					peat
	TP15-40			WSS140444	6-7	S2	9	3	12	22	54	42	19	23	A-7-6	14	High Plastic Clay	20					silty clay
	TP15-40			WSS140445	10-11	S3	0	0	4	18	78	63	25	38	A-7-6	20	High Plastic Clay	40					silty clay to silt till
	TP15-41			WSS140446	1-2	S1	NT											416					peat
	TP15-41			WSS140447	5-6	S2	11	0	17	32	40	28	14	14	A-6	9	Low Plastic Clay	14					silty clay
	TP15-41			WSS140448	10-11	S3	20	1	17	40	22	15	12	3	A-4	5	Sandy Silt	9					silt till
	TP15-42			WSS140449	0.5-1.5	S1	NT											1342					peat
	TP15-42			WSS140450	1.5-2.5	S2	NT											507					peat
	TP15-42			WSS140451	3-4	S3	0	0	18	46	36	19	14	5	A-4	8	Clayey Silt	15					silty clay to clayey silt
	TP15-42			WSS140452	7-8	S4	0	0	21	50	30	18	13	5	A-4	8	Clayey Silt	10					silt till

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MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB



SOIL SURVEY PROPERTY SUMMARY SHEET

Field Book No.:		From:		Report To:	Akinbola George, Rick Postlethwaite
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Highway:	Lake St Martin Channel Access Road	Contract No.:		Date Reported:	2015-06-04
Control Section:		Survey Location:	Access Road		
Project No.:		Survey Purpose:	Preliminary		
Soil Survey No.:	2014SS05	Sampled By:	KGS		
Internal Order No.:	200037101	Date Sampled:	2015-02-10	Page: 3	of 6

Sample Data							Particle Size Analysis					Soil Properties/Classification											
Legal Description	Test Hole#	Station	Centerline offset (m)	Lab Sample Number	Depth(ft)	Field Sample No.	Coarse Aggregate (%)	Coarse Sand (%)	Fine Sand (%)	Silt (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (-1 = NP)	AASHTO	Group Index	Soil Type	Moisture Content (%)	Frost Susceptibility	Organic Content (%)	Maximum Density (kg/m^3)	Optimum Moisture (%)	Field Description
	TP15-43			WSS140453		S1	NT											831					peat
	TP15-43			WSS140454		S2	0	0	13	30	57	40	19	21	A-6	12	Low Plastic Clay	24					silty clay
	TP15-43			WSS140455		S3	0	0	30	43	27	15	12	3	A-4	7	Silt	12					silt till
	TP15-44			WSS140456		S1	NT											356					peat
	TP15-44			WSS140457		S2	0	0	21	43	36	20	14	6	A-4	8	Clayey Silt	19					silty clay to clayey silt
	TP15-44			WSS140458		S3	NT											11					silt till
	TP15-45			WSS140459		S1	NT											85					peat
	TP15-45			WSS140460		S2	0	0	19	29	52	40	18	22	A-6	13	Low Plastic Clay	26					silty clay
	TP15-45			WSS140461		S3	0	0	10	25	65	46	20	26	A-7-6	15	High Plastic Clay	19					silty clay / silt till
	TP15-45			WSS140462		S4	NT											10					silt till
	TP15-46			WSS140463		S1	NT											139					peat
	TP15-46			WSS140464		S2	9	0	28	47	16	14	12	2	A-4	6	Sandy Silt	13					clayey silt and sand
	TP15-46			WSS140465		S3	0	0	28	48	24	15	12	3	A-4	7	Silt	9	FS				silt till
	TP15-47			WSS140466		S1	8	3	16	35	39	30	16	14	A-6	9	Low Plastic Clay	13					silty clay
	TP15-48			WSS140467		S1	NT											555					peat
	TP15-48			WSS140468		S2	0	0	21	43	36	19	14	5	A-4	8	Clayey Silt	16					silty clay to clayey silt
	TP15-48			WSS140469		S3	0	0	31	45	24	15	13	2	A-4	7	Silt	8	FS				silt till
	TP15-49			WSS140470		S1	0	0	19	41	40	27	16	11	A-6	8	Low Plastic Clay	16					silty clay to clayey silt
	TP15-49			WSS140471		S2	NT											9					silty clay to clayey silt
	TP15-50			WSS140472		S1	NT											240					peat

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MATERIALS ENGINEERING BRANCH - CENTRAL LAB

SOIL SURVEY PROPERTY SUMMARY SHEET

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Control Section:		Survey Location:	Access Road		
Project No.:		Survey Purpose:	Preliminary		
Soil Survey No.:	2014SS05	Sampled By:	KGS		
Internal Order No.:	200037101	Date Sampled:	2015-02-10	Page: 4	of 6

Sample Data							Particle Size Analysis					Soil Properties/Classification											
Legal Description	Test Hole#	Station	Centerline offset (m)	Lab Sample Number	Depth(ft)	Field Sample No.	Coarse Aggregate (%)	Coarse Sand (%)	Fine Sand (%)	Silt (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (-1 = NP)	AASHTO	Group Index	Soil Type	Moisture Content (%)	Frost Susceptibility	Organic Content (%)	Maximum Density (kg/m^3)	Optimum Moisture (%)	Field Description
	TP15-50			WSS140473	2-3	S2	0	0	21	49	30	17	13	4	A-4	8	Clayey Silt	11					silty clay to clayey silt
	TP15-51			WSS140474	0.5-1.5	S1	NT											490					peat
	TP15-51			WSS140475	2.5-3.5	S2	0	0	14	31	56	39	20	19	A-6	12	Low Plastic Clay	19					silty clay
	TP15-51	No Sample		WSS140476	12-13	S3	NT																silt till
	TP15-52			WSS140477	2-3	S1	NT											658					peat
	TP15-52			WSS140478	4-5	S2	5	2	8	26	59	47	21	26	A-7-6	16	High Plastic Clay	30					silty clay
	TP15-52			WSS140479	9-10	S3	7	4	19	44	27	15	12	3	A-4	7	Silt	7					silt till
	TP15-53			WSS140480	0.5-1.5	S1	NT											287					peat
	TP15-53			WSS140481	2-3	S2	9	2	14	50	25	16	13	3	A-4	8	Silt	8	FS				clay silt
	TP15-53			WSS140482	10-11	S3	10	1	21	45	23	16	13	3	A-4	7	Silt	5	FS				silt till
	TP15-54			WSS140483	1-2	S1	33	4	37	18	8	NP	NP	NP	A-2-4	0	Silty Sand	9					silty sand and gravel
	TP15-54			WSS140484	4-5	S2	9	3	9	32	47	41	18	23	A-7-6	13	High Plastic Clay	20					silty clay to clayey silt
	TP15-55			WSS140485	0-0.5	S1	NT											136					peat
	TP15-55			WSS140486	3-4	S2	11	2	19	40	28	20	15	5	A-4	7	Clayey Silt	12					silty clay to clayey silt
	TP15-56			WSS140487	4-5	S1	10	3	9	28	50	42	20	22	A-7-6	13	High Plastic Clay	21					silty clay
	TP15-56			WSS140488	5.5-6.5	S2	NT											15					silt till
	TP15-56			WSS140489	9-10	S3	18	2	20	38	22	18	13	5	A-4	5	Sandy Silt	10					silt till
	TP15-57			WSS140490	0-0.5	S1	NT											86					peat
	TP15-57			WSS140491	2-3	S2	0	0	24	48	29	16	13	3	A-4	8	Silt	10					silty clay to clayey silt
	TP15-58			WSS140492	1-2	S1	NT											339					peat

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SOIL SURVEY PROPERTY SUMMARY SHEET

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Control Section:		Survey Location:	Access Road		
Project No.:		Survey Purpose:	Preliminary		
Soil Survey No.:	2014SS05	Sampled By:	KGS		
Internal Order No.:	200037101	Date Sampled:	2015-02-10	Page: 5	of 6

Sample Data							Particle Size Analysis					Soil Properties/Classification											
Legal Description	Test Hole#	Station	Centerline offset (m)	Lab Sample Number	Depth(ft)	Field Sample No.	Coarse Aggregate (%)	Coarse Sand (%)	Fine Sand (%)	Silt (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (-1 = NP)	AASHTO	Group Index	Soil Type	Moisture Content (%)	Frost Susceptibility	Organic Content (%)	Maximum Density (kg/m^3)	Optimum Moisture (%)	Field Description
	TP15-58			WSS140493	2.5-3.5	S2	8	1	40	16	35	29	15	14	A-6	5	Sandy Clay	27					silty clay
	TP15-58			WSS140494	6-7	S3	NT											18					silty clay
	TP15-59			WSS140495	0-0.5	S1	NT											239					peat
	TP15-59			WSS140496	1-2	S2	NT											16					silty clay
	TP15-59			WSS140497	5-6	S3	15	1	21	38	25	16	12	4	A-4	6	Sandy Silt	6					silty clay
	TP15-60			WSS140498	1-1.5	S1	14	10	16	22	38	37	17	20	A-6	9	Sandy Clay	16					silty clay
	TP15-60			WSS140499	5-6	S2	11	3	27	37	22	15	12	3	A-4	5	Sandy Silt	7	FS				clayey silt
	TP15-61			WSS140500	2-3	S1	NT											558					peat
	TP15-61			WSS140501	3-3.5	S2	23	6	59	6	7	NP	NP	NP	A-2-4	0	Fine Sand	14					silty sand
	TP15-61			WSS140502	5-6	S3	8	3	16	35	38	27	14	13	A-6	9	Low Plastic Clay	22					silty clay
	TP15-62			WSS140503	2-3	S1	NT											494					peat
	TP15-62			WSS140504	5-6	S2	10	2	13	27	49	39	16	23	A-6	13	Low Plastic Clay	19					silty clay
	TP15-62			WSS140505	10-11	S3	12	2	17	44	26	16	12	4	A-4	7	Clayey Silt	7					silt till
	TP15-63			WSS140506	2-3	S1	NT											28					silty clay
	TP15-63			WSS140507	4-5	S2	15	1	8	21	54	46	19	27	A-7-6	16	High Plastic Clay	19					silty clay
	TP15-64			WSS140508	0-0.5	S1	NT											48					peat
	TP15-64			WSS140509	3-4	S2	13	2	12	20	52	44	18	26	A-7-6	15	High Plastic Clay	20					silty clay
	TP15-64			WSS140510	9-10	S3	9	3	14	36	38	28	16	12	A-6	9	Low Plastic Clay	16					clay till
	TP15-65			WSS140511	0.5-1.5	S1	NT											494					peat
	TP15-65			WSS140512	2-3	S2	1	2	11	15	71	58	28	30	A-7-6	20	High Plastic Clay	42					silty clay

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Soil Survey No.:	2014SS05	Sampled By:	KGS		
Internal Order No.:	200037101	Date Sampled:	2015-02-10	Page: 6	of 6

Sample Data							Particle Size Analysis					Soil Properties/Classification												
Legal Description	Test Hole#	Station	Centerline offset (m)	Lab Sample Number	Depth(ft)	Field Sample No.	Coarse Aggregate (%)	Coarse Sand (%)	Fine Sand (%)	Silt (%)	Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (-1 = NP)	AASHTO	Group Index	Soil Type	Moisture Content (%)	Frost Susceptibility	Organic Content (%)	Maximum Density (kg/m^3)	Optimum Moisture (%)	Field Description
	TP15-65	No Sample		WSS140513	4-5	S3	NT																clayey silt
	TP15-66			WSS140514	2-3	S1	11	1	6	23	59	51	19	32	A-7-6	18	High Plastic Clay	24					silty clay
	TP15-66			WSS140515	8-9	S2	17	6	16	38	23	17	13	4	A-4	5	Sandy Silt	9					silt till
	TP15-67			WSS140516	2.5-3.5	S1	3	2	8	23	64	45	23	22	A-7-6	14	High Plastic Clay	28					silty clay
	TP15-67			WSS140517	6.5-7.5	S2	20	1	15	40	23	16	12	4	A-4	6	Sandy Silt	10					silt till
	TP15-68			WSS140518	1-2	S1	NT											530					peat
	TP15-68			WSS140519	3-4	S2	10	3	30	35	22	16	13	3	A-4	4	Sandy Silt	11	FS				clayey silt
	TP15-68			WSS140520	6-7	S3	13	2	16	43	25	16	12	4	A-4	7	Silt	9	FS				silt till
	TP15-68			WSS140521	12.5-13.5	S4	NT											8					silt till
	TP15-69			WSS140522	0-1	S1	NT											488					peat
	TP15-69			WSS140523	2-3	S2	5	2	8	21	64	46	20	26	A-7-6	16	High Plastic Clay	21					silty clay
	TP15-69			WSS140524	6.5-7.5	S3	12	2	16	42	29	18	13	5	A-4	7	Clayey Silt	11					silt till
	TP15-70			WSS140525	2-3	S1	22	0	13	38	27	18	15	3	A-4	6	Gravelly Silt	14					clayey silt
	TP15-70			WSS140526	4-5	S2	20	0	27	33	21	16	12	4	A-4	4	Sandy Silt	8					silt till
	TP15-71			WSS140527	2-3	S1	6	4	9	20	61	50	23	27	A-7-6	17	High Plastic Clay	19					silty clay
	TP15-71			WSS140528	4-5	S2	10	2	16	38	34	21	13	8	A-4	7	Clayey Silt	10					clayey silt to silt till
	TP15-71			WSS140529	7-8	S3	8	2	8	25	57	49	19	30	A-7-6	18	High Plastic Clay	26					clay till

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SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (ft)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m³	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L / D_{10}	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_P / C_C	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS I_P / C_U	GRAIN SIZE GRAVEL %	GRAIN SIZE SAND %	GRAIN SIZE P_{200} or SILT % / % CLAY	STRENGTH q_u K.S.F. / kPa	STRENGTH POCKET PENETROMETER T.S.F.
S1	WSS14 0440	PT, Peat, highly organic, roots, moss, clumpy, wet, black, strong odor										
TP15-39	1-2'											
S1	WSS14 0443	PT, Peat, highly organic, roots, moss, clumpy, wet, brown, mild odor										
TP15-40	1-2'											
S1	WSS14 0446	PT, Peat, highly organic, roots, moss, clumpy, wet, black, strong odor, trace silt, trace sand										
TP15-41	1-2'											
S1	WSS14 0449	PT, Peat, highly organic, roots, moss, clumpy, wet, brown, mild odor										
TP15-42	0.5-1.5'											
S2	WSS14 0450	PT, Peat, highly organic, roots, moss, clumpy, wet, black, mild odor										
TP15-42	1.5-2.5'											
S1	WSS14 0453	PT, Peat, highly organic, roots, moss, clumpy, wet, black, strong odor										
TP15-43	1-2'											
S1	WSS14 0456	PT, Peat, highly organic, roots, moss, loose, moist, black, mild odor										
TP15-44	0.5-1.5'											
S1	WSS14 0459	OL/OH, Organic Clay, some silt, roots, moss, clumpy, wet, brown, strong odor, trace sand										
TP15-45	1.0-1.5'											
S1	WSS14 0463	PT, Peat, highly organic, roots, moss, loose, dry, black, no odor										
TP15-46	0.0-0.5'											
S1	WSS14 0467	PT, Peat, highly organic, roots, moss, clumpy, wet, black, strong odor										
TP15-48	0.5-1.5'											
S1	WSS14 0472	PT, Peat, highly organic, roots, moss, clumpy, damp, brown, mild odor										
TP15-50	0.25-0.5'											
S1	WSS14 0474	PT, Peat, highly organic, moss, clumpy, wet, black, strong odor, trace roots										
TP15-51	0.5-1.5'											
S1	WSS14 0477	PT, Peat, highly organic, moss, clumpy, wet, black, no odor, trace roots										
TP15-52	2-3'											
S1	WSS14 0480	PT, Peat, highly organic, roots, moss, loose, damp, black, no odor										
TP15-53	0.5-1.0'											
S1	WSS14 0485	PT, Peat, highly organic, roots, moss, loose, moist, black, strong odor										
TP15-55	0.0-0.5'											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Lake St Martin Channel
LOCATION: Access Road
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-06-03

SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (M)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m³	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L / D_{10}	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_P / C_C	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS I_P / C_U	GRAIN SIZE GRAVEL %	GRAIN SIZE SAND %	GRAIN SIZE P_{200} or SILT % / CLAY %	STRENGTH q_u K.S.F. / kPa	STRENGTH POCKET PENETROMETER T.S.F.
S1	WSS14 0490	PT, Peat, highly organic, roots, moss, clumpy, moist, black, mild odor										
TP15-57	0.0-0.5'											
S1	WSS14 0492	PT, Peat, highly organic, moss, clumpy, wet, black, strong odor, trace roots										
TP15-58	1-2'											
S1	WSS14 0495	PT, Peat, highly organic, moss, roots, loose, moist, black, mild odor										
TP15-59	0.0-0.5'											
S1	WSS14 0500	PT, Peat, highly organic, moss, clumpy, wet, black, mild odor, trace roots & grass										
TP15-61	2-3'											
S1	WSS14 0503	PT, Peat, highly organic, moss, clumpy, wet, black, mild odor, trace roots										
TP15-62	2-3'											
S1	WSS14 0508	OL/OH, Organic Clay, moss, clumpy, wet, black, mild odor, trace roots										
TP15-64	0.0-0.5'											
S1	WSS14 0511	PT, Peat, highly organic, moss, roots, clumpy, wet, black, strong odor										
TP15-65	0.5-1.5'											
S1	WSS14 0518	PT, Peat, highly organic, moss, roots, clumpy, wet, black, no odor										
TP15-68	1-2'											
S1	WSS14 0522	PT, Peat, highly organic, moss, roots, clumpy, wet, black, strong odor										
TP15-69	0-1'											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Lake St Martin Channel
LOCATION: Access Road
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-06-03

INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

Geotechnical Testing Report

Appended:

A) Summary Sheets
B) Grain Size Analysis
C) Sieve Analysis
D) Lab Visual Classifications

Client:	Water Management and Structures
Project:	Lake St Martin Channel
Location:	Reach 3
Sites:	Inlet, Dike, Quarry, Willow Point
Geotech No.	
Internal Order No.	200037101
Date Sampled:	February 4, 2015
Date Requisitioned:	March 6, 2015
Date Reported:	June 16, 2015

Manitoba Infrastructure and Transportation

Materials Engineering Branch

GEOTECHNICAL SOIL PROPERTY SUMMARY SHEET

Client:	Water Management and Structures	Site/File No. :		Date Requisitioned:	2015-03-06
Project:	Lake St. Martin Channel	Internal Order No. :	200037101	Date Reported:	2015-06-16
Location:	Reach 3 Inlet - East Side	Sampled By:	KGS Group	Report To:	Akinbola George
Municipality:		Date Sampled:	2015-02-04	Page:	1 of 1

Lab No.	SAMPLE DATA					Unified Classification	Moisture Content %	ATTERBERG LIMITS			GRAIN SIZE					Organic Content %	Reactivity with HCl *	STRENGTH								Visual Classification
	Test Hole No.	Sample No.	Station	Centerline	Depth(ft)			Liquid Limit % (-1 = NP)	Plastic Limit % (-1 = NP)	Plasticity Index % (-1 = NP)	Gravel % (pass 75mm)	Sand % (pass 4.75mm)	Silt % (pass 0.075mm)	Clay % (pass 0.005 mm)	Silt/Clay % (pass 0.075 mm)			Field SPT (N)	Field PP (kpa)	Field Torvane Value (kpa)	Unconfined qu (kpa)	Bulk Dry Density (kg/cu.m.)	Direct Shear Performed	Consolidation Performed	Permeability Performed	
WGT141178	TH15-02	S1			6.5-7.5	CL-ML	11	18	13	5	10	27	43	19													
WGT141179	TH15-02	S2			9.0-10.0	ML	10	14	13	1	7	31	46	17													
WGT141180	TH15-02	S3			10.0-10.5		19				5	34	43	17				78									ML
WGT141181	TH15-02	S4			15.0-15.5		7					32	48	20				77									CL-ML
WGT141182	TH15-02	S5			20.0-20.5		9				7	30	46	17				87									ML
WGT141183	TH15-02	S6			25.0-26.5	ML	7	16	12	4	6	29	46	18				135									
WGT141184	TH15-02	S7			30.0-31.5		7				30	35	24	11				201									SM
WGT141185	TH15-02	S8			35.0-36.5	CL-ML	11	17	13	4	10	25	44	21				57									
WGT141186	TH15-02	S9			39.0-40.7																						
WGT141187	TH15-02	S10			40.75-45.75		8				23	18	43	16													CL-ML
WGT141188	TH15-02	S11			45.75-50.75																						
WGT141189	TH15-02	R1			50.75-55.75																						
WGT141190	TH15-02	R2			55.75-60.75																						

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Manitoba Infrastructure and Transportation

Materials Engineering Branch

GEOTECHNICAL SOIL PROPERTY SUMMARY SHEET

Client:	Water Management and Structures	Site/File No. :		Date Requisitioned:	2015-03-06
Project:	Lake St. Martin Channel	Internal Order No. :	200037101	Date Reported:	2015-06-16
Location:	Reach 3 - Dike	Sampled By:	KGS Group	Report To:	Akinbola George
Municipality:		Date Sampled:	2015-02-04	Page:	1 of 2

Lab No.	SAMPLE DATA					Unified Classification	Moisture Content %	ATTERBERG LIMITS			GRAIN SIZE					Organic Content %	Reactivity with HCl *	STRENGTH								Visual Classification
	Test Hole No.	Sample No.	Station	Centerline	Depth(ft)			Liquid Limit % (-1 = NP)	Plastic Limit % (-1 = NP)	Plasticity Index % (-1 = NP)	Gravel % (pass 75mm)	Sand % (pass 4.75mm)	Silt % (pass 0.075mm)	Clay % (pass 0.005 mm)	Silt/Clay % (pass 0.075 mm)			Field SPT (N)	Field PP (kpa)	Field Torvane Value (kpa)	Unconfined qu (kpa)	Bulk Dry Density (kg/cu.m.)	Direct Shear Performed	Consolidation Performed	Permeability Performed	
WGT141191	TH15-03	S1	17+311		3.0-5.0	ML	13	16	13	3	5	26	53	16													
WGT141192	TH15-03	S2	17+311		6.0-8.0		45	39	31	8																	OL
WGT141193	TH15-03	S3	17+311		8.0-10.0	CL-ML	21	24	19	5	9	32	41	18													
WGT141194	TH15-03	S4	17+311		15.0-16.5		7				1	31	50	18				75									ML
WGT141195	TH15-03	S5	17+311		16.5-20.0																						
WGT141196	TH15-03	R1	17+311		20.5-25.5																						
WGT141197	TH15-03	R2	17+311		25.5-30.5																						
WGT141198	TH15-04	S1	18+459		1.5-2.5	CI	18	35	14	21	2	19	40	39													
WGT141199	TH15-04	S2	18+459		4.0-5.0	CI	22	47	18	29	1	15	28	56													
WGT141200	TH15-04	S3	18+459		5.0-6.25		400																				PT
WGT141201	TH15-04	S4	18+459		6.5-7.5	CI	26	38	19	19	4	24	29	43													
WGT141202	TH15-04	S5	18+459		9.0-10.0	CH	26	50	16	34	1	13	23	63													
WGT141203	TH15-04	S6	18+459		11.0-13.0	ML	7	16	12	4	2	32	45	20													
WGT141204	TH15-04	S7	18+459		15.0-15.75		7				5	26	49	20													ML
WGT141205	TH15-04	S8	18+459		25.75-30.75																						
WGT141206	TH15-04	S9	18+459		30.75-35.75																						
WGT141207	TH15-04	S10	18+459		35.75-40.75																						
WGT141208	TH15-04	R1	18+459		40.75-45.75																						
WGT141209	TH15-04	R2	18+459		45.75-50.75																						
WGT141210	TH15-05	S1	19+424		1.5-2.5	CI	24	48	18	30	2	21	22	55													

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Manitoba Infrastructure and Transportation

Materials Engineering Branch

GEOTECHNICAL SOIL PROPERTY SUMMARY SHEET

Client:	Water Management and Structures	Site/File No. :		Date Requisitioned:	2015-03-06
Project:	Lake St. Martin Channel	Internal Order No. :	200037101	Date Reported:	2015-06-16
Location:	Reach 3 - Dike	Sampled By:	KGS Group	Report To:	Akinbola George
Municipality:		Date Sampled:	2015-02-04	Page:	2 of 2

Lab No.	SAMPLE DATA					Unified Classification	Moisture Content %	ATTERBERG LIMITS			GRAIN SIZE					Organic Content %	Reactivity with HCl *	STRENGTH								Visual Classification
	Test Hole No.	Sample No.	Station	Centerline	Depth(m)			Liquid Limit % (-1 = NP)	Plastic Limit % (-1 = NP)	Plasticity Index % (-1 = NP)	Gravel % (pass 75mm)	Sand % (pass 4.75mm)	Silt % (pass 0.075mm)	Clay % (pass 0.005 mm)	Silt/Clay % (pass 0.075 mm)			Field SPT (N)	Field PP (kpa)	Field Torvane Value (kpa)	Unconfined qu (kpa)	Bulk Dry Density (kg/cu.m.)	Direct Shear Performed	Consolidation Performed	Permeability Performed	
WGT141211	TH15-05	S2	19+424		5.0-7.0		90																			PT
WGT141212	TH15-05	S3	19+424		9.0-10.0	CH	30	60	26	34	2	7	16	75													
WGT141213	TH15-05	S4	19+424		12.0-13.0	CL	12	22	14	8	6	21	45	28													
WGT141214	TH15-05	S5	19+424		15.0-16.5	CL-ML	11	21	14	7	7	11	54	28				84									
WGT141215	TH15-05	S6	19+424		19.0-20.0	CL-ML	6	18	13	5	1	20	49	30													
WGT141216	TH15-05	S7	19+424		20.0-21.5	CL-ML	8	19	13	6	8	16	47	29				38									
WGT141217	TH15-05	R1	19+424		23.4-24.7																						
WGT141218	TH15-05	R2	19+424		24.7-29.7																						
WGT141219	TH15-05	R3	19+424		29.7-34.7																						

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Manitoba Infrastructure and Transportation

Materials Engineering Branch

GEOTECHNICAL SOIL PROPERTY SUMMARY SHEET

Client:	Water Management and Structures	Site/File No. :		Date Requisitioned:	2015-03-06
Project:	Lake St. Martin Channel	Internal Order No. :	200037101	Date Reported:	2015-06-16
Location:	Reach 3 Quarry	Sampled By:	KGS Group	Report To:	Akinbola George
Municipality:		Date Sampled:	2015-02-04	Page:	1 of 1

Lab No.	SAMPLE DATA					Unified Classification	Moisture Content %	ATTERBERG LIMITS			GRAIN SIZE					Organic Content %	Reactivity with HCl *	STRENGTH								Visual Classification
	Test Hole No.	Sample No.	Station	Centerline	Depth(m)			Liquid Limit % (-1 = NP)	Plastic Limit % (-1 = NP)	Plasticity Index % (-1 = NP)	Gravel % (pass 75mm)	Sand % (pass 4.75mm)	Silt % (pass 0.075mm)	Clay % (pass 0.005 mm)	Silt/Clay % (pass 0.075 mm)			Field SPT (N)	Field PP (kpa)	Field Torvane Value (kpa)	Unconfined qu (kpa)	Bulk Dry Density (kg/cu.m.)	Direct Shear Performed	Consolidation Performed	Permeability Performed	
WGT141274	TH15-13	S1			3.5-4.5	ML	15	17	14	3	11	24	48	17													
WGT141275	TH15-13	S2			6.5-7.5	CL-ML	13	18	13	5	6	23	49	22													
WGT141276	TH15-13	R1			10.0-15.0																						
WGT141277	TH15-13	R2			15.0-20.0																						
WGT141278	TH15-13	R3			20.0-25.0																						
WGT141279	TH15-13	R4			25.0-30.0																						

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Manitoba Infrastructure and Transportation

Materials Engineering Branch

GEOTECHNICAL SOIL PROPERTY SUMMARY SHEET

Client:	Water Management and Structures	Site/File No. :		Date Requisitioned:	2015-03-06
Project:	Lake St. Martin Channel	Internal Order No. :	200037101	Date Reported:	2015-06-16
Location:	Reach 3 - Willow Point	Sampled By:	KGS Group	Report To:	Akinbola George
Municipality:		Date Sampled:	2015-02-04	Page:	1 of 3

Lab No.	SAMPLE DATA					Unified Classification	Moisture Content %	ATTERBERG LIMITS			GRAIN SIZE					Organic Content %	Reactivity with HCl *	STRENGTH								Visual Classification
	Test Hole No.	Sample No.	Station	Centerline	Depth(ft)			Liquid Limit % (-1 = NP)	Plastic Limit % (-1 = NP)	Plasticity Index % (-1 = NP)	Gravel % (pass 75mm)	Sand % (pass 4.75mm)	Silt % (pass 0.075mm)	Clay % (pass 0.005 mm)	Silt/Clay % (pass 0.075 mm)			Field SPT (N)	Field PP (kpa)	Field Torvane Value (kpa)	Unconfined qu (kpa)	Bulk Dry Density (kg/cu.m.)	Direct Shear Performed	Consolidation Performed	Permeability Performed	
WGT141315	TP15-01	S1			7-8	CH	11	55	23	31	1	5	19	75													
WGT141316	TP15-01	S2			10-11	CL	31	22	14	8	8	17	46	28													
WGT141317	TP15-02	S1			6-7	CH	27	50	23	28	4	8	23	65													
WGT141318	TP15-02	S2			9-10	CL	18	27	15	12	5	15	43	37													
WGT141319	TP15-03	S1			4-5	CL	16	23	15	9	8	11	43	39													
WGT141320	TP15-04	S1			4-5	CH	20	54	21	32	2	11	22	65													
WGT141321	TP15-04	S2			9-10	CI	20	41	18	24	3	13	30	53													
WGT141322	TP15-05	S1			11-12	CH	40	68	21	47	1	3	17	79													
WGT141323	TP15-06	S1			4-5	CH	33	62	26	36	0	3	15	82													
WGT141324	TP15-06	S2			9-10	CH	28	63	25	38	1	4	17	78													
WGT141325	TP15-07	S1			7-8	CH	32	59	22	38	1	5	16	78													
WGT141326	TP15-08	S1			10-11	CH	28	63	25	39	0	4	18	78													
WGT141327	TP15-09	S1			4.5-5.5	CI	28	42	16	26	2	10	28	60													
WGT141328	TP15-09	S2			8-9	CH	40	75	28	47		2	13	85													
WGT141329	TP15-10	S1			4-5		13				26	69			5												SW-SM
WGT141330	TP15-10	S2			8-9	CL	16	29	13	16	2	16	40	42													
WGT141331	TP15-11	S1			12-13	CL	15	27	13	14	5	14	43	38													
WGT141332	TP15-12	S1			9-10	CH	28	58	21	37		4	16	80													
WGT141333	TP15-12	S2			12-13	CH	35	63	22	41	1	4	19	77													
WGT141334	TP15-12	S3			15.5-16.5	CI	21	37	17	20	2	9	36	53													

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Manitoba Infrastructure and Transportation

Materials Engineering Branch

GEOTECHNICAL SOIL PROPERTY SUMMARY SHEET

Client:	Water Management and Structures	Site/File No. :		Date Requisitioned:	2015-03-06
Project:	Lake St. Martin Channel	Internal Order No. :	200037101	Date Reported:	2015-06-16
Location:	Reach 3 - Willow Point	Sampled By:	KGS Group	Report To:	Akinbola George
Municipality:		Date Sampled:	2015-02-04	Page:	2 of 3

Lab No.	SAMPLE DATA					Unified Classification	Moisture Content %	ATTERBERG LIMITS			GRAIN SIZE					Organic Content %	Reactivity with HCl *	STRENGTH								Visual Classification
	Test Hole No.	Sample No.	Station	Centerline	Depth(m)			Liquid Limit % (-1 = NP)	Plastic Limit % (-1 = NP)	Plasticity Index % (-1 = NP)	Gravel % (pass 75mm)	Sand % (pass 4.75mm)	Silt % (pass 0.075mm)	Clay % (pass 0.005 mm)	Silt/Clay % (pass 0.075 mm)			Field SPT (N)	Field PP (kpa)	Field Torvane Value (kpa)	Unconfined qu (kpa)	Bulk Dry Density (kg/cu.m.)	Direct Shear Performed	Consolidation Performed	Permeability Performed	
WGT141335	TP15-13	S1			7-8	CH	36	63	28	35	0	3	14	83													
WGT141336	TP15-14	S1			4-5	CL	14	21	14	7	5	17	45	33													
WGT141337	TP15-14	S2			8-9	ML	7	16	12	4	11	26	43	21													
WGT141338	TP15-15	S1			4-5	CL	14	21	13	8	4	23	40	33													
WGT141339	TP15-15	S2			9-10	CL-ML	9	18	11	7	9	27	40	24													
WGT141340	TP15-16	S1			5-6	CH	32	61	21	40	1	5	17	77													
WGT141341	TP15-17	S1			10-11	CL	11	28	15	13	5	15	39	41													
WGT141342	TP15-18	S1			6-7	CL	14	25	14	11	11	18	36	35													
WGT141343	TP15-18	S2			13-14	CL	8	17	10	7	14	23	40	23													
WGT141344	TP15-19	S1			5-6	CI	28	49	22	27	1	7	25	66													
WGT141345	TP15-19	S2			11-12	CL-ML	8	18	12	5	9	21	42	27													
WGT141346	TP15-20	S1			10-11																						
WGT141347	TP15-21	S1			5-6	CL-ML	12	18	14	4	12	21	42	25													
WGT141348	TP15-21	S2			10-11	CH	20	50	18	32	1	8	30	61													
WGT141349	TP15-22	S1			2-3	CI	23	39	19	20	3	11	34	52													
WGT141350	TP15-22	S2			11-12	CL	12	28	13	15	3	17	44	36													
WGT141351	TP15-23	S1			4.0-4.5	CI	27	48	23	25	3	9	26	62													
WGT141352	TP15-23	S2			6-7	ML	8	15	12	3	14	29	40	17													
WGT141353	TP15-24	S1			3-4	ML	11	15	13	2	9	27	46	18													
WGT141354	TP15-24	S2			9-10	SM	8	14	12	2	23	46	23	8													

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Manitoba Infrastructure and Transportation

Materials Engineering Branch

GEOTECHNICAL SOIL PROPERTY SUMMARY SHEET

Client:	Water Management and Structures	Site/File No. :		Date Requisitioned:	2015-03-06
Project:	Lake St. Martin Channel	Internal Order No. :	200037101	Date Reported:	2015-06-16
Location:	Reach 3 - Willow Point	Sampled By:	KGS Group	Report To:	Akinbola George
Municipality:		Date Sampled:	2015-02-04	Page:	3 of 3

Lab No.	SAMPLE DATA					Unified Classification	Moisture Content %	ATTERBERG LIMITS			GRAIN SIZE					Organic Content %	Reactivity with HCl *	STRENGTH								Visual Classification
	Test Hole No.	Sample No.	Station	Centerline	Depth(ft)			Liquid Limit % (-1 = NP)	Plastic Limit % (-1 = NP)	Plasticity Index % (-1 = NP)	Gravel % (pass 75mm)	Sand % (pass 4.75mm)	Silt % (pass 0.075mm)	Clay % (pass 0.005 mm)	Silt/Clay % (pass 0.075 mm)			Field SPT (N)	Field PP (kpa)	Field Torvane Value (kpa)	Unconfined qu (kpa)	Bulk Dry Density (kg/cu.m.)	Direct Shear Performed	Consolidation Performed	Permeability Performed	
WGT141355	TP15-25	S1			4-5	SM	9	13	11	2	33	39	19	8													
WGT141356	TP15-26	S1			4-5	CI	25	47	20	27	4	7	23	66													
WGT141357	TP15-26	S2			14-15	ML	8	15	12	2	14	26	49	11													

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MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

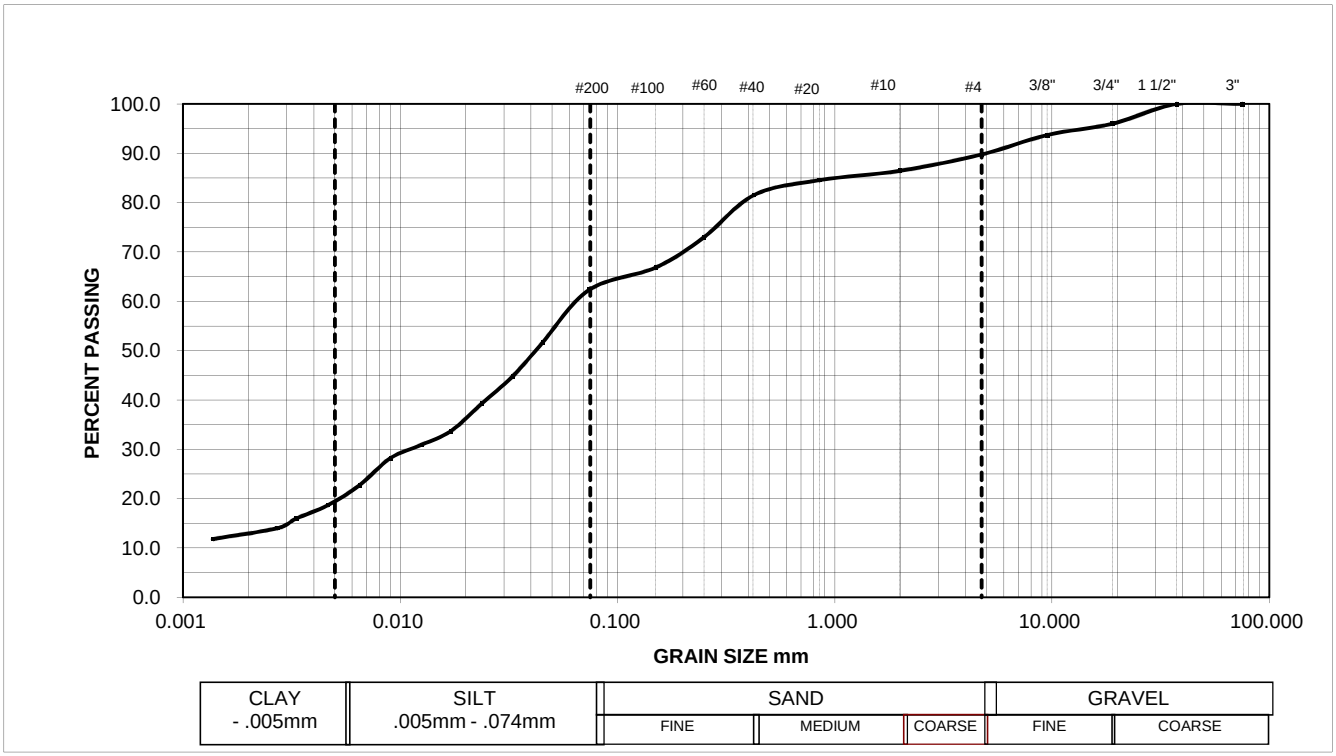
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 Inlet - East Side** **Checked By:** **GK**

LAB.NO. WGT141178 FIELD NO. S1 HOLE NO. TH15-02 DEPTH (m) 6.5-7.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	23.5	18.8	0.0451	51.6
1.50	37.5	100.0	2	21.0	16.3	0.0328	44.7
0.75	19.0	96.0	4	19.0	14.3	0.0237	39.2
0.375	9.5	93.7	8	17.0	12.3	0.0171	33.7
#4	4.75	89.8	15	16.0	11.3	0.0126	31.0
#10	2.00	86.5	30	15.0	10.3	0.0090	28.2
#20	0.850	84.6	60	13.0	8.3	0.0065	22.7
#40	0.425	81.5	120	11.5	6.8	0.0046	18.7
#60	0.250	73.0	240	10.5	5.8	0.0033	16.0
#100	0.150	66.9	360	9.8	5.1	0.0027	14.0
#200	0.075	62.3	1440	9.0	4.3	0.0014	11.8

% GRAVEL	% SAND	% SILT	% CLAY
10	27	43	19



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

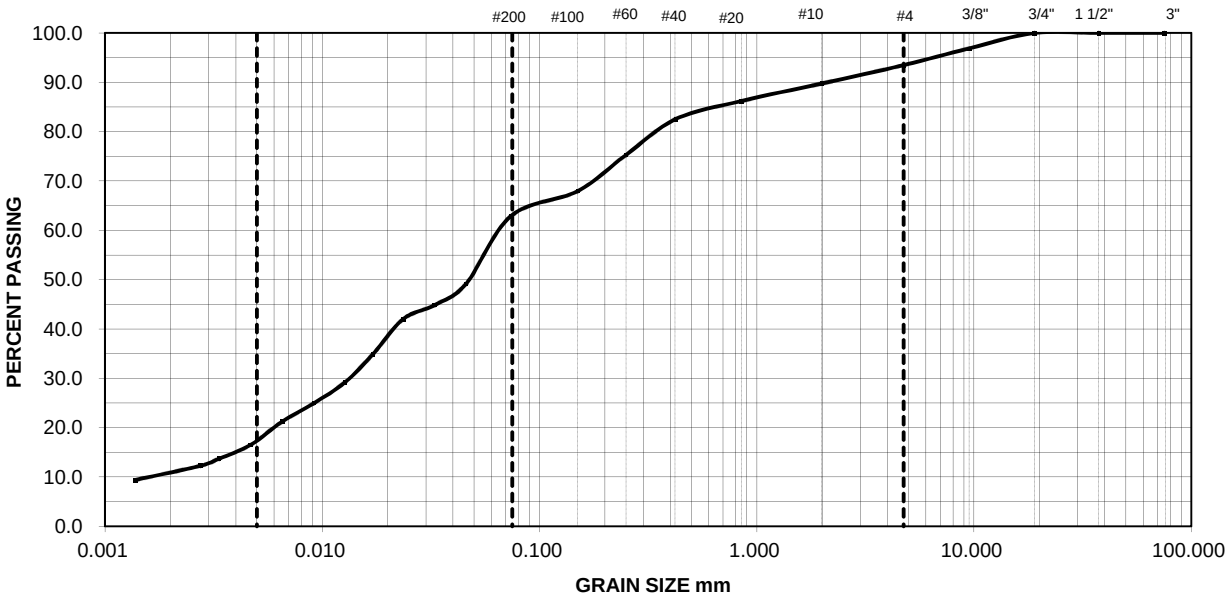
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 Inlet - East Side** **Checked By:** **GK**

LAB.NO. WGT141179 FIELD NO. S2 HOLE NO. TH15-02 DEPTH (m) 9.0-10.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	22.0	17.3	0.0459	49.1
1.50	37.50	100.0	2	20.5	15.8	0.0330	44.9
0.75	19.00	100.0	4	19.5	14.8	0.0236	42.0
0.375	9.50	96.9	8	17.0	12.3	0.0171	34.9
#4	4.75	93.5	15	15.0	10.3	0.0127	29.2
#10	2.00	89.7	30	13.5	8.8	0.0091	24.9
#20	0.850	86.2	60	12.2	7.5	0.0065	21.2
#40	0.425	82.6	120	10.5	5.8	0.0047	16.5
#60	0.250	75.3	240	9.5	4.8	0.0033	13.7
#100	0.150	67.9	360	9.0	4.3	0.0027	12.2
#200	0.075	62.9	1440	8.0	3.3	0.0014	9.4

% GRAVEL	% SAND	% SILT	% CLAY
7	31	46	17



CLAY	SILT	SAND			GRAVEL	
- .005mm	.005mm - .074mm	FINE	MEDIUM	COARSE	FINE	COARSE

MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

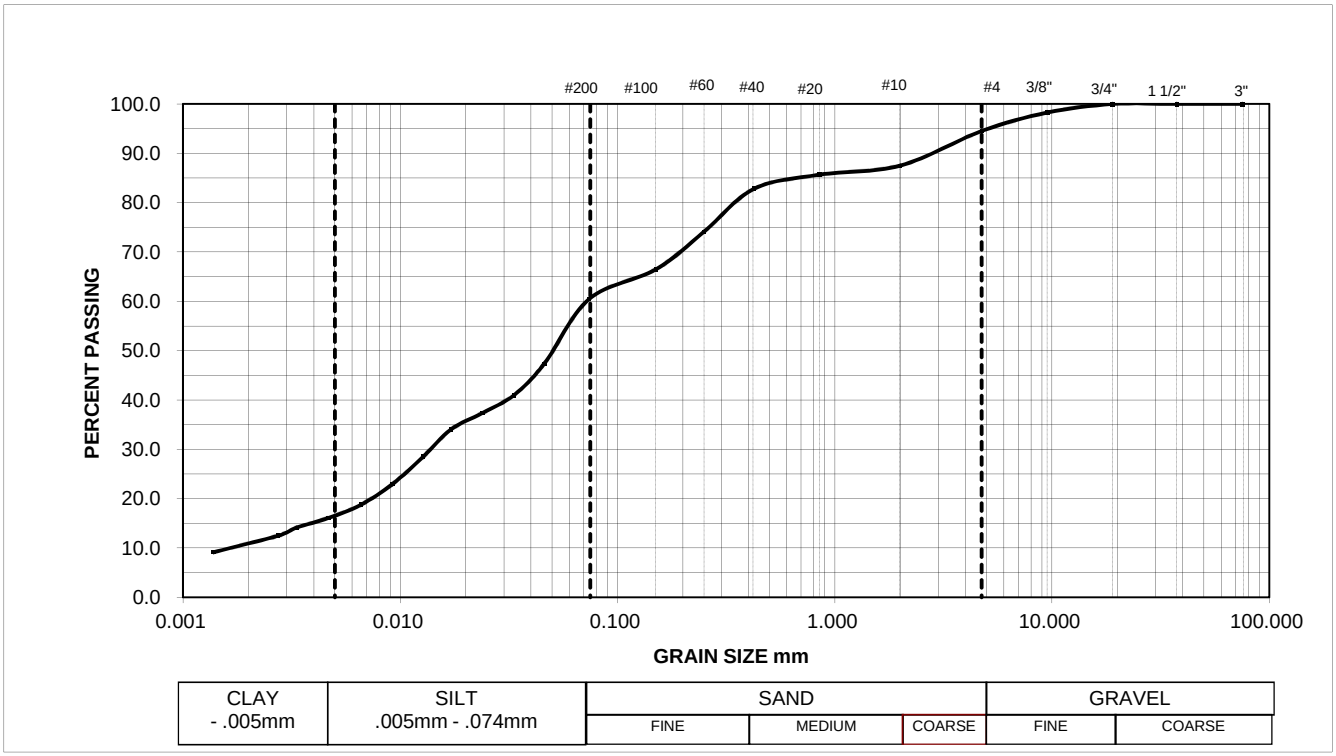
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 Inlet - East Side** **Checked By:** **GK**

LAB.NO. WGT141180 FIELD NO. S3 HOLE NO. TH15-02 DEPTH (m) 10.0-10.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	21.8	17.1	0.0460	47.4
1.50	37.50	100.0	2	19.5	14.8	0.0333	41.0
0.75	19.00	100.0	4	18.2	13.5	0.0239	37.4
0.375	9.50	98.3	8	17.0	12.3	0.0171	34.0
#4	4.75	94.5	15	15.0	10.3	0.0127	28.5
#10	2.00	87.5	30	13.0	8.3	0.0092	22.9
#20	0.850	85.7	60	11.5	6.8	0.0066	18.8
#40	0.425	82.8	120	10.5	5.8	0.0047	16.1
#60	0.250	74.1	240	9.8	5.1	0.0033	14.2
#100	0.150	66.5	360	9.2	4.5	0.0027	12.5
#200	0.075	60.5	1440	8.0	3.3	0.0014	9.2

% GRAVEL	% SAND	% SILT	% CLAY
5	34	43	17



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

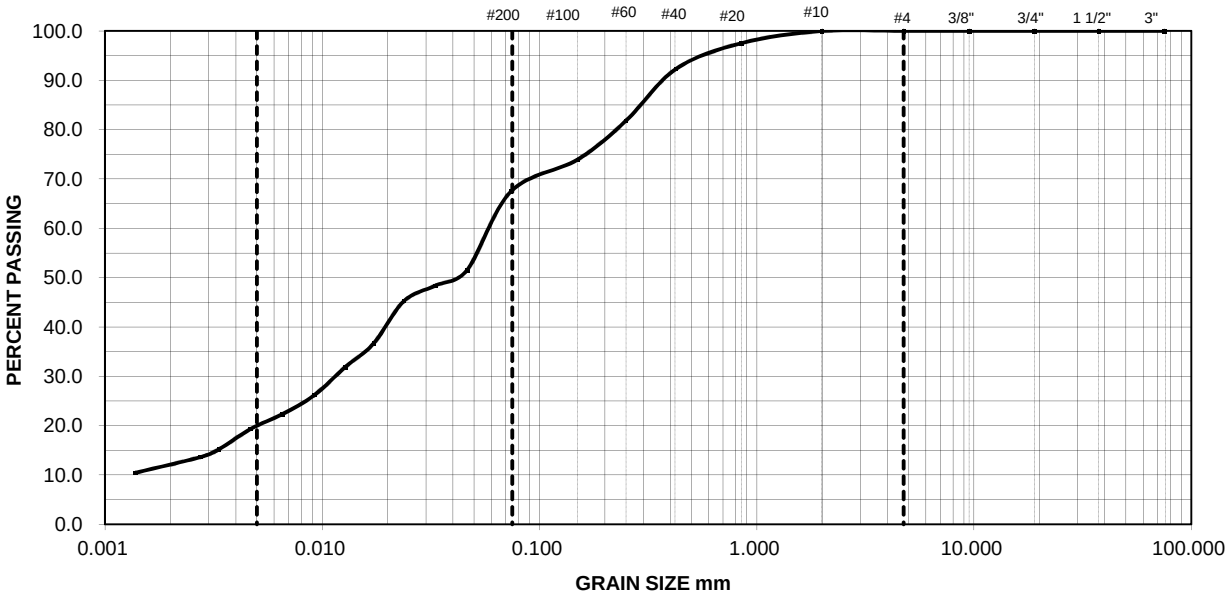
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 Inlet - East Side** **Checked By:** **GK**

LAB.NO. WGT141181 FIELD NO. S4 HOLE NO. TH15-02 DEPTH (m) 15.0-15.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	21.0	16.3	0.0464	51.6
1.50	37.5	100.0	2	20.0	15.3	0.0332	48.4
0.75	19.0	100.0	4	19.0	14.3	0.0237	45.2
0.375	9.5	100.0	8	16.3	11.6	0.0172	36.7
#4	4.75	100.0	15	14.8	10.1	0.0128	31.9
#10	2.00	100.0	30	13.0	8.3	0.0092	26.2
#20	0.850	97.5	60	11.8	7.1	0.0066	22.4
#40	0.425	92.3	120	10.8	6.1	0.0047	19.4
#60	0.250	81.8	240	9.5	4.8	0.0033	15.2
#100	0.150	74.0	360	9.0	4.3	0.0027	13.6
#200	0.075	67.5	1440	8.0	3.3	0.0014	10.5

% GRAVEL	% SAND	% SILT	% CLAY
	32	48	20



CLAY	SILT	SAND			GRAVEL	
- .005mm	.005mm - .074mm	FINE	MEDIUM	COARSE	FINE	COARSE

MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

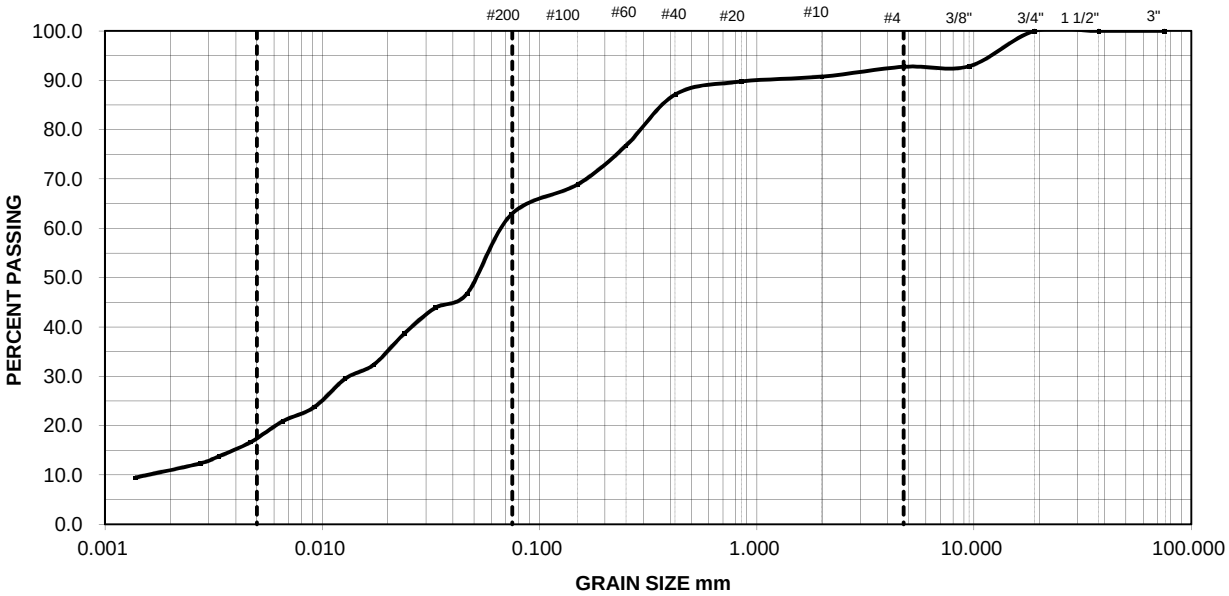
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 Inlet - East Side** **Checked By:** **GK**

LAB.NO. WGT141182 FIELD NO. S5 HOLE NO. TH15-02 DEPTH (m) 20.0-20.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	21.0	16.3	0.0464	46.8
1.50	37.50	100.0	2	20.0	15.3	0.0332	43.9
0.75	19.00	100.0	4	18.2	13.5	0.0239	38.7
0.375	9.50	92.9	8	16.0	11.3	0.0173	32.4
#4	4.75	92.7	15	15.0	10.3	0.0127	29.5
#10	2.00	90.8	30	13.0	8.3	0.0092	23.8
#20	0.850	89.7	60	12.0	7.3	0.0065	20.9
#40	0.425	87.2	120	10.5	5.8	0.0047	16.7
#60	0.250	76.8	240	9.5	4.8	0.0033	13.8
#100	0.150	68.9	360	9.0	4.3	0.0027	12.4
#200	0.075	62.8	1440	8.0	3.3	0.0014	9.5

% GRAVEL	% SAND	% SILT	% CLAY
7	30	46	17



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

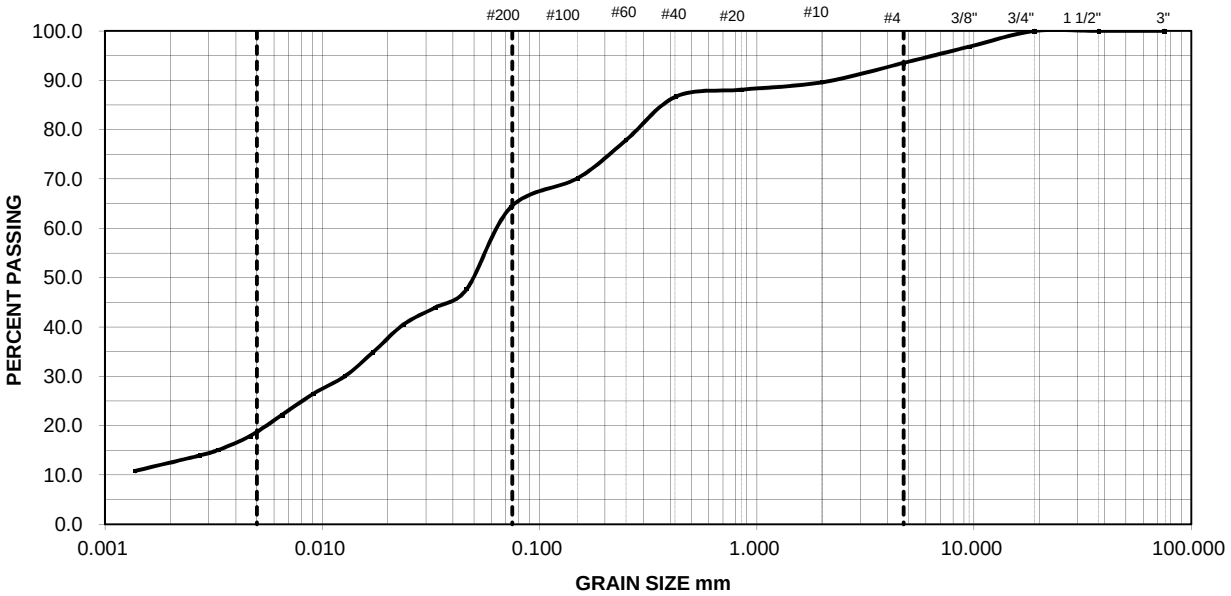
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 Inlet - East Side** **Checked By:** **GK**

LAB.NO. WGT141183 FIELD NO. S6 HOLE NO. TH15-02 DEPTH (m) 25.0-26.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	21.5	16.8	0.0462	47.6
1.50	37.50	100.0	2	20.2	15.5	0.0331	43.9
0.75	19.00	100.0	4	19.0	14.3	0.0237	40.5
0.375	9.50	96.8	8	17.0	12.3	0.0171	34.8
#4	4.75	93.5	15	15.3	10.6	0.0127	30.0
#10	2.00	89.6	30	14.0	9.3	0.0091	26.4
#20	0.850	88.1	60	12.5	7.8	0.0065	22.2
#40	0.425	86.7	120	11.0	6.3	0.0047	17.9
#60	0.250	77.9	240	10.0	5.3	0.0033	15.1
#100	0.150	70.2	360	9.6	4.9	0.0027	13.9
#200	0.075	64.3	1440	8.5	3.8	0.0014	10.8

% GRAVEL	% SAND	% SILT	% CLAY
6	29	46	18



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

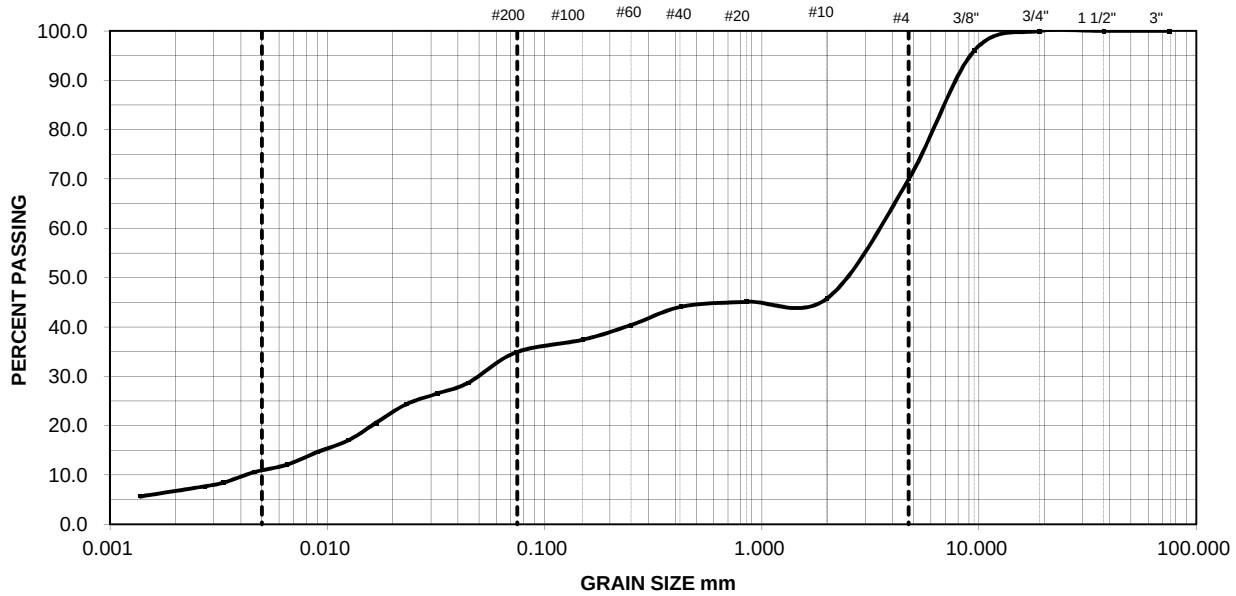
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 Inlet - East Side** **Checked By:** **GK**

LAB.NO. WGT141184 FIELD NO. S7 HOLE NO. TH15-02 DEPTH (m) 30.0-31.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	24.5	19.8	0.0446	28.7
1.50	37.50	100.0	2	23.0	18.3	0.0321	26.5
0.75	19.00	100.0	4	21.5	16.8	0.0231	24.3
0.375	9.50	96.0	8	18.9	14.2	0.0168	20.6
#4	4.75	70.0	15	16.5	11.8	0.0126	17.1
#10	2.00	45.8	30	14.8	10.1	0.0090	14.7
#20	0.850	45.1	60	13.0	8.3	0.0065	12.1
#40	0.425	44.1	120	12.0	7.3	0.0046	10.6
#60	0.250	40.4	240	10.5	5.8	0.0033	8.4
#100	0.150	37.4	360	10.0	5.3	0.0027	7.7
#200	0.075	34.9	1440	8.6	3.9	0.0014	5.7

% GRAVEL	% SAND	% SILT	% CLAY
30	35	24	11



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

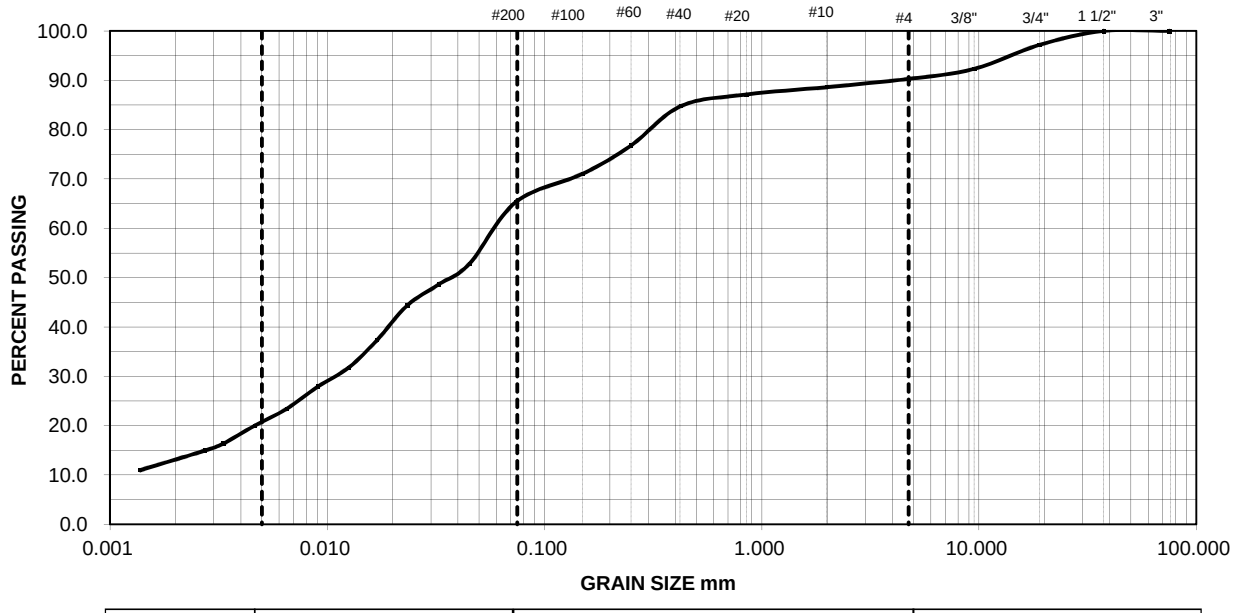
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 Inlet - East Side** **Checked By:** **GK**

LAB.NO. WGT141185 FIELD NO. S8 HOLE NO. TH15-02 DEPTH (m) 35.0-36.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	23.5	18.8	0.0451	52.8
1.50	37.50	100.0	2	22.0	17.3	0.0325	48.6
0.75	19.00	97.2	4	20.5	15.8	0.0233	44.4
0.375	9.50	92.3	8	18.0	13.3	0.0169	37.3
#4	4.75	90.3	15	16.0	11.3	0.0126	31.8
#10	2.00	88.6	30	14.6	9.9	0.0090	27.9
#20	0.850	87.1	60	13.0	8.3	0.0065	23.4
#40	0.425	84.8	120	11.8	7.1	0.0046	20.0
#60	0.250	76.8	240	10.5	5.8	0.0033	16.3
#100	0.150	71.1	360	10.0	5.3	0.0027	14.9
#200	0.075	65.4	1440	8.6	3.9	0.0014	11.0

% GRAVEL	% SAND	% SILT	% CLAY
10	25	44	21



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

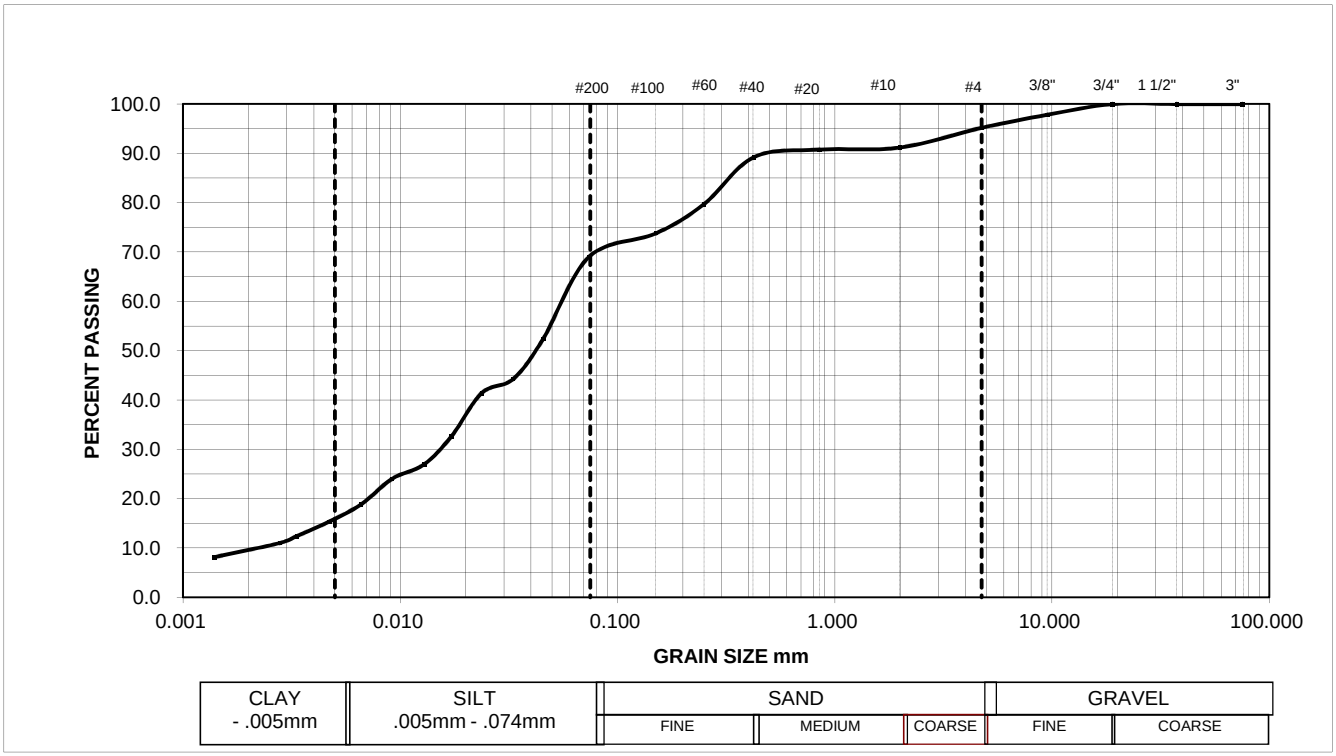
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141191 FIELD NO. S1 HOLE NO. TH15-03 DEPTH (m) 3.0-5.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	22.8	18.1	0.0455	52.4
1.50	37.5	100.0	2	20.0	15.3	0.0332	44.3
0.75	19.0	100.0	4	19.0	14.3	0.0237	41.4
0.375	9.5	97.8	8	16.0	11.3	0.0173	32.7
#4	4.75	95.2	15	14.0	9.3	0.0129	26.9
#10	2.00	91.2	30	13.0	8.3	0.0092	24.0
#20	0.850	90.8	60	11.2	6.5	0.0066	18.8
#40	0.425	89.2	120	10.0	5.3	0.0047	15.3
#60	0.250	79.7	240	9.0	4.3	0.0034	12.4
#100	0.150	73.8	352	8.5	3.8	0.0028	11.0
#200	0.075	69.0	1440	7.5	2.8	0.0014	8.1

% GRAVEL	% SAND	% SILT	% CLAY
5	26	53	16



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

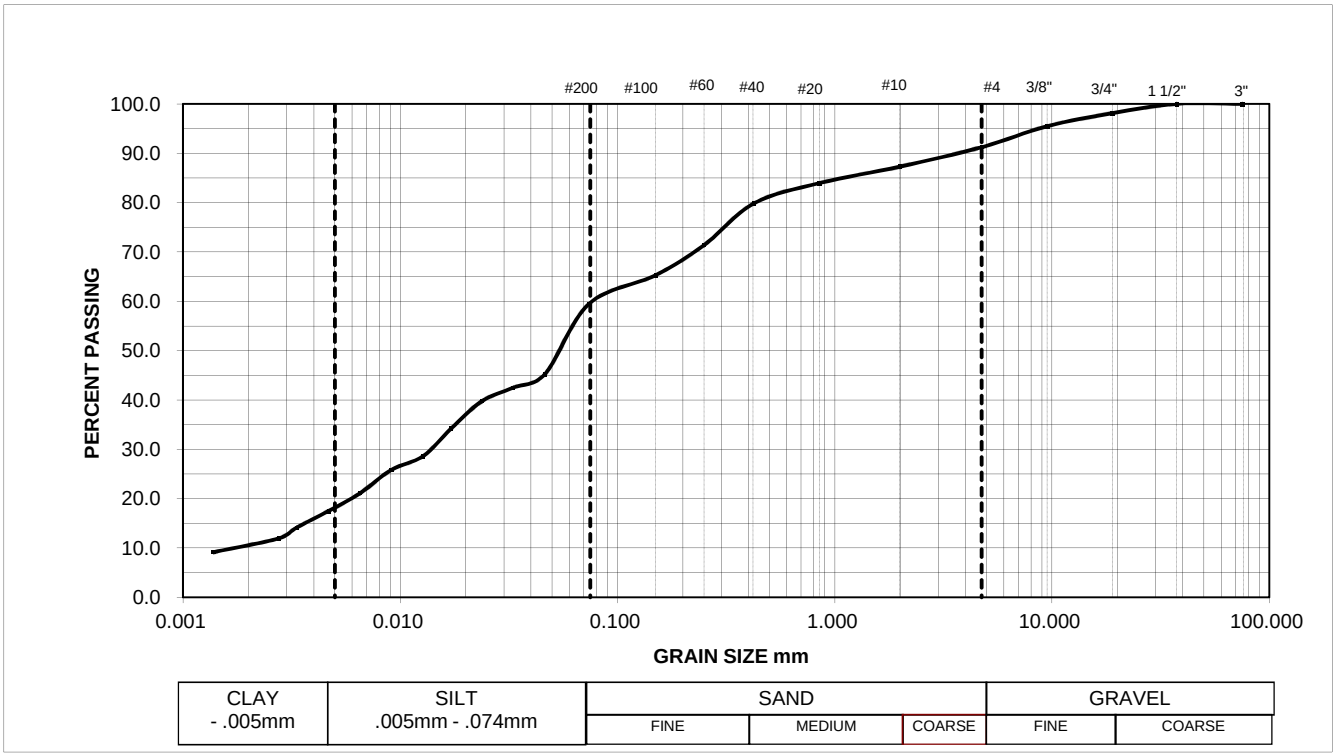
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141193 FIELD NO. S3 HOLE NO. TH15-03 DEPTH (m) 8.0-10.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	21.0	16.3	0.0464	45.3
1.50	37.50	100.0	2	20.0	15.3	0.0332	42.5
0.75	19.00	98.1	4	19.0	14.3	0.0237	39.7
0.375	9.50	95.5	8	17.0	12.3	0.0171	34.2
#4	4.75	91.2	15	15.0	10.3	0.0127	28.6
#10	2.00	87.3	30	14.0	9.3	0.0091	25.8
#20	0.850	83.9	60	12.3	7.6	0.0065	21.1
#40	0.425	79.8	120	11.0	6.3	0.0047	17.5
#60	0.250	71.4	240	9.8	5.1	0.0033	14.2
#100	0.150	65.3	358	9.0	4.3	0.0028	11.9
#200	0.075	59.5	1440	8.0	3.3	0.0014	9.2

% GRAVEL	% SAND	% SILT	% CLAY
9	32	41	18



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

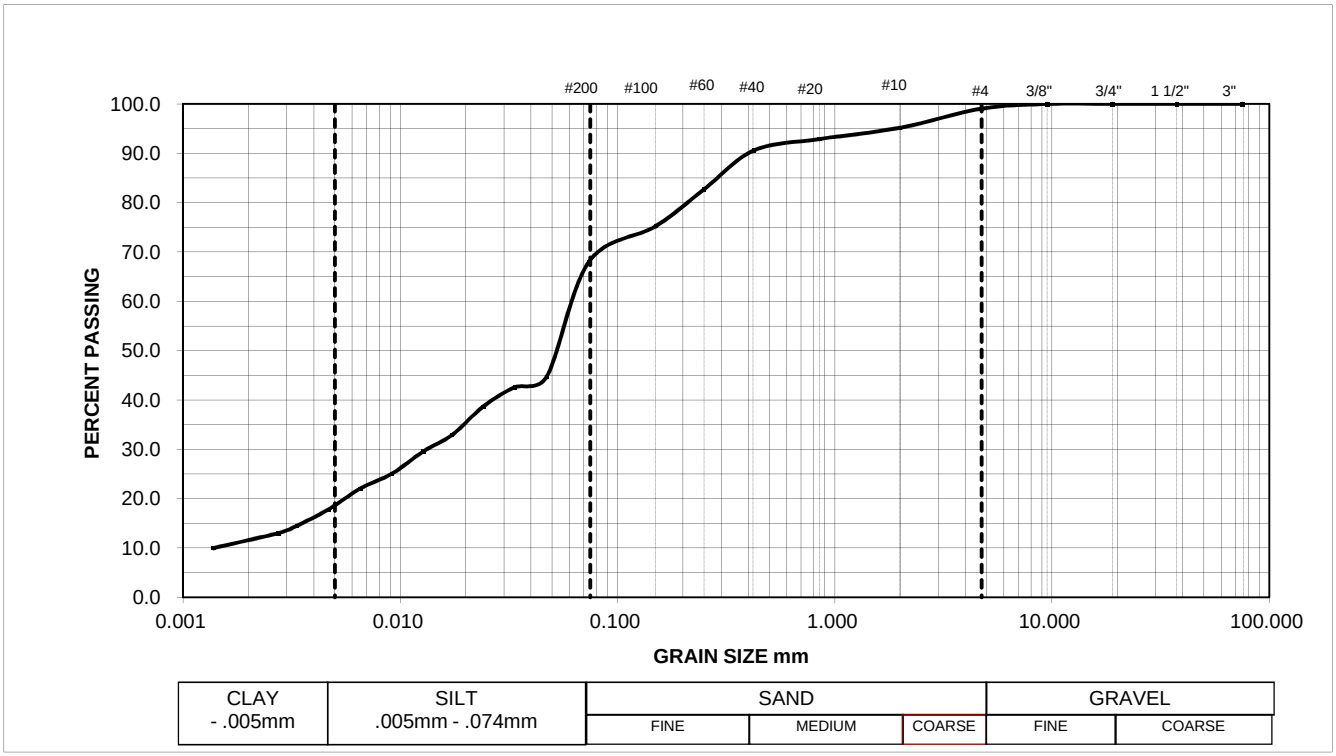
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141194 FIELD NO. S4 HOLE NO. TH15-03 DEPTH (m) 15.0-16.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	19.5	14.8	0.0471	44.7
1.50	37.5	100.0	2	18.8	14.1	0.0336	42.6
0.75	19.0	100.0	4	17.5	12.8	0.0241	38.6
0.375	9.5	100.0	8	15.6	10.9	0.0173	32.9
#4	4.75	99.1	15	14.5	9.8	0.0128	29.6
#10	2.00	95.2	30	13.0	8.3	0.0092	25.1
#20	0.850	92.9	60	12.0	7.3	0.0065	22.0
#40	0.425	90.6	120	10.6	5.9	0.0047	17.8
#60	0.250	82.7	240	9.5	4.8	0.0033	14.5
#100	0.150	75.2	360	9.0	4.3	0.0027	13.0
#200	0.075	68.1	1440	8.0	3.3	0.0014	10.0

% GRAVEL	% SAND	% SILT	% CLAY
1	31	50	18



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

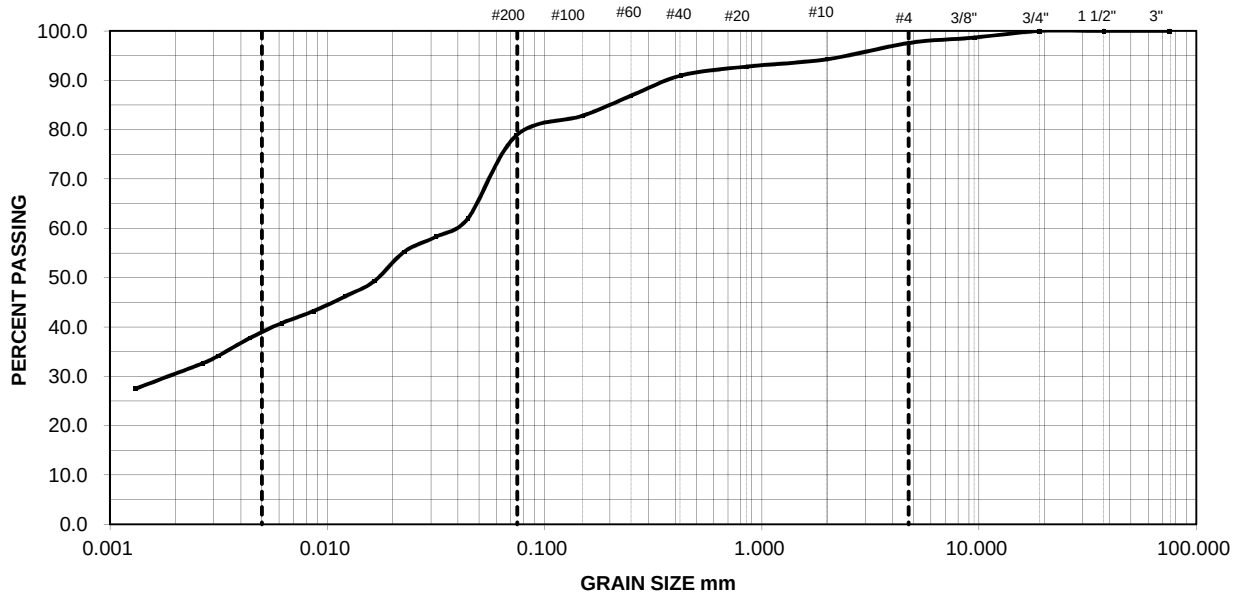
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141198 FIELD NO. S1 HOLE NO. TH15-04 DEPTH (m) 1.5-2.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	25.2	20.5	0.0442	61.9
1.50	37.50	100.0	2	24.0	19.3	0.0317	58.3
0.75	19.00	100.0	4	23.0	18.3	0.0227	55.3
0.375	9.50	98.7	8	21.0	16.3	0.0164	49.2
#4	4.75	97.6	15	20.0	15.3	0.0121	46.2
#10	2.00	94.3	30	19.0	14.3	0.0087	43.2
#20	0.850	92.8	60	18.2	13.5	0.0062	40.8
#40	0.425	91.0	120	17.2	12.5	0.0044	37.8
#60	0.250	86.9	240	16.0	11.3	0.0032	34.1
#100	0.150	82.8	339	15.5	10.8	0.0027	32.6
#200	0.075	78.8	1440	13.8	9.1	0.0013	27.5

% GRAVEL	% SAND	% SILT	% CLAY
2	19	40	39



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

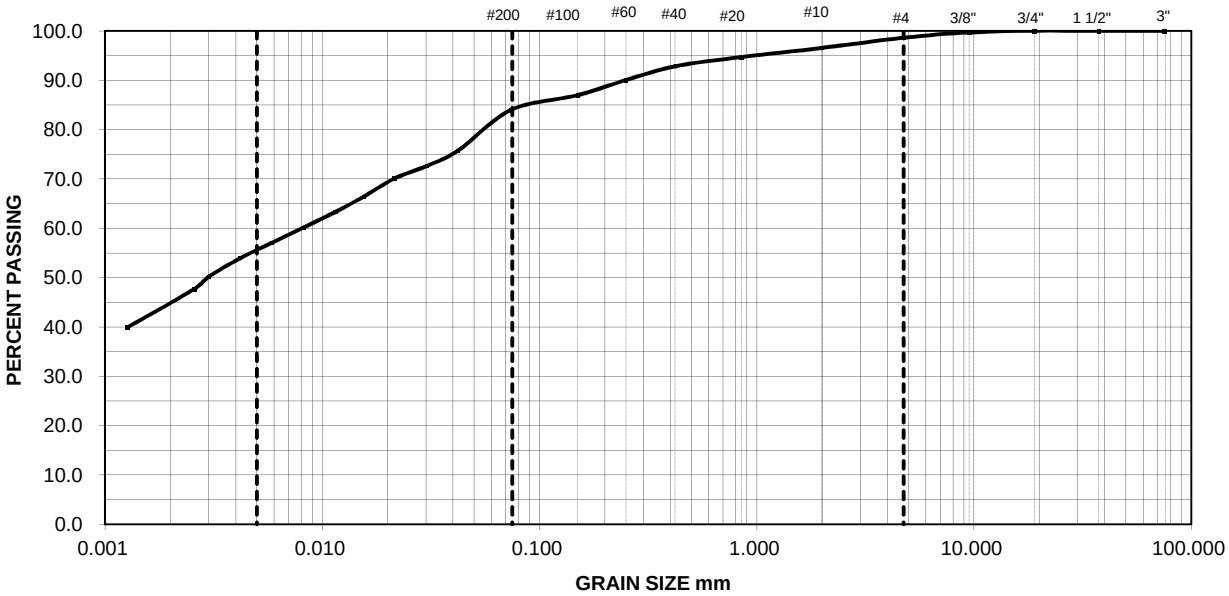
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **mj**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141199 FIELD NO. S2 HOLE NO. TH15-04 DEPTH (m) 4.0-5.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	29.0	24.3	0.0422	75.7
1.50	37.50	100.0	2	28.0	23.3	0.0302	72.6
0.75	19.00	100.0	4	27.2	22.5	0.0216	70.1
0.375	9.50	99.7	8	26.0	21.3	0.0155	66.4
#4	4.75	98.6	15	25.0	20.3	0.0114	63.3
#10	2.00	96.5	30	24.0	19.3	0.0082	60.2
#20	0.850	94.7	60	23.0	18.3	0.0059	57.0
#40	0.425	92.8	120	22.0	17.3	0.0042	53.9
#60	0.250	90.0	240	20.8	16.1	0.0030	50.2
#100	0.150	87.0	332	20.0	15.3	0.0026	47.7
#200	0.075	84.0	1440	17.5	12.8	0.0013	39.9

% GRAVEL	% SAND	% SILT	% CLAY
1	15	28	56



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

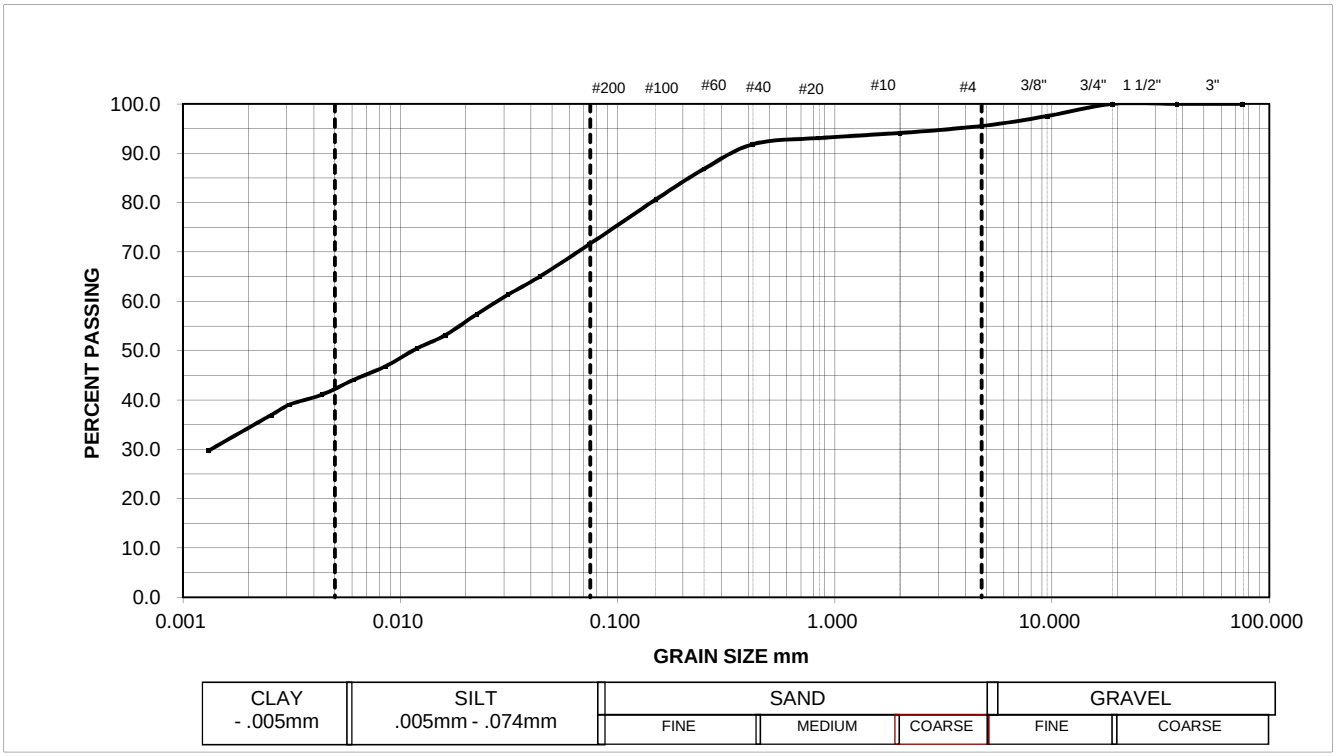
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141201 FIELD NO. S4 HOLE NO. TH15-04 DEPTH (m) 6.5-7.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	26.2	21.5	0.0437	65.0
1.50	37.5	100.0	2	25.0	20.3	0.0314	61.4
0.75	19.0	100.0	4	23.7	19.0	0.0225	57.4
0.375	9.5	97.5	8	22.3	17.6	0.0162	53.2
#4	4.75	95.5	15	21.4	16.7	0.0119	50.4
#10	2.00	94.1	30	20.2	15.5	0.0085	46.8
#20	0.850	93.1	60	19.3	14.6	0.0061	44.1
#40	0.425	91.8	120	18.3	13.6	0.0044	41.1
#60	0.250	86.8	240	17.6	12.9	0.0031	39.1
#100	0.150	80.6	360	16.9	12.2	0.0026	37.0
#200	0.075	71.5	1440	14.5	9.8	0.0013	29.7

% GRAVEL	% SAND	% SILT	% CLAY
4	24	29	43



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

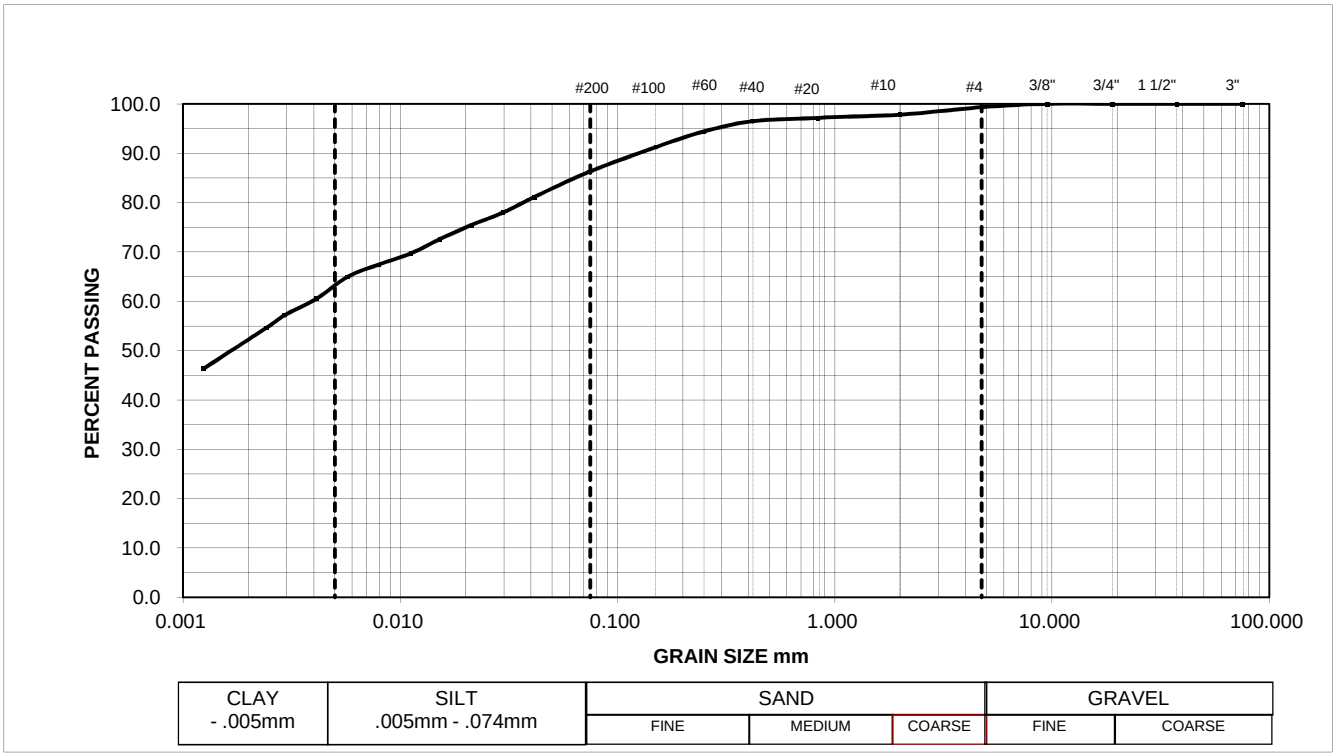
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141202 FIELD NO. S5 HOLE NO. TH15-04 DEPTH (m) 9.0-10.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	30.3	25.6	0.0415	81.1
1.50	37.5	100.0	2	29.3	24.6	0.0297	78.0
0.75	19.0	100.0	4	28.5	23.8	0.0213	75.4
0.375	9.5	100.0	8	27.6	22.9	0.0152	72.6
#4	4.75	99.3	15	26.7	22.0	0.0112	69.7
#10	2.00	97.8	30	26.0	21.3	0.0080	67.5
#20	0.850	97.2	60	25.2	20.5	0.0057	64.9
#40	0.425	96.5	120	23.8	19.1	0.0041	60.5
#60	0.250	94.4	240	22.7	18.0	0.0029	57.2
#100	0.150	91.2	360	21.9	17.2	0.0024	54.6
#200	0.075	86.2	1440	19.3	14.6	0.0012	46.4

% GRAVEL	% SAND	% SILT	% CLAY
1	13	23	63



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

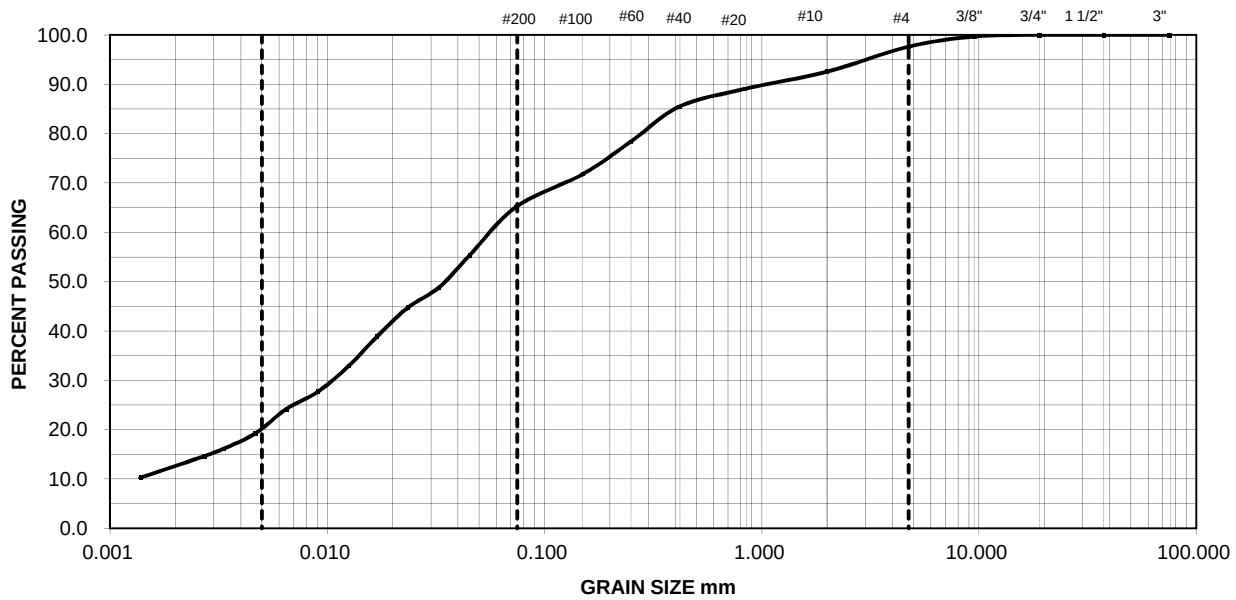
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141203 FIELD NO. S6 HOLE NO. TH15-04 DEPTH (m) 11.0-13.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	23.6	18.9	0.0451	55.2
1.50	37.5	100.0	2	21.4	16.7	0.0327	48.8
0.75	19.0	100.0	4	20.0	15.3	0.0235	44.7
0.375	9.5	99.6	8	18.0	13.3	0.0169	38.8
#4	4.75	97.6	15	16.0	11.3	0.0126	33.0
#10	2.00	92.5	30	14.2	9.5	0.0091	27.7
#20	0.850	89.1	60	13.0	8.3	0.0065	24.2
#40	0.425	85.5	120	11.3	6.6	0.0047	19.2
#60	0.250	78.4	240	10.2	5.5	0.0033	16.1
#100	0.150	71.8	360	9.7	5.0	0.0027	14.7
#200	0.075	65.1	1440	8.2	3.5	0.0014	10.3

% GRAVEL	% SAND	% SILT	% CLAY
2	32	45	20



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

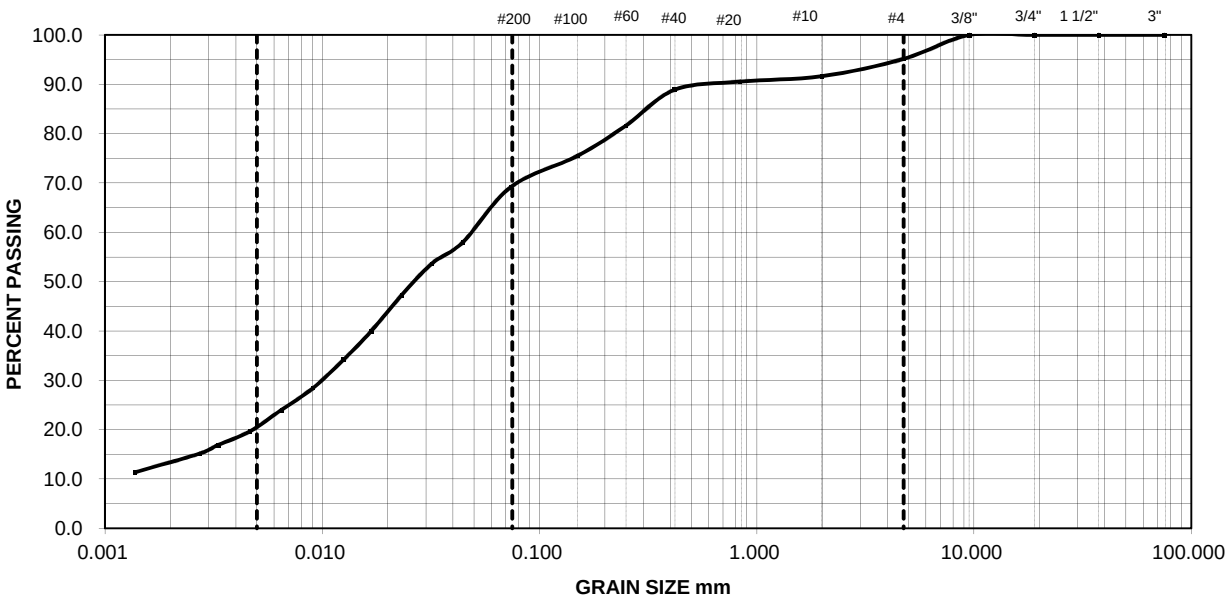
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141204 FIELD NO. S7 HOLE NO. TH15-04 DEPTH (m) 15.0-15.75

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	24.7	20.0	0.0445	58.0
1.50	37.5	100.0	2	23.2	18.5	0.0320	53.7
0.75	19.0	100.0	4	21.0	16.3	0.0232	47.3
0.375	9.5	100.0	8	18.5	13.8	0.0168	40.0
#4	4.75	95.2	15	16.5	11.8	0.0126	34.2
#10	2.00	91.6	30	14.5	9.8	0.0090	28.4
#20	0.850	90.6	60	13.0	8.3	0.0065	24.0
#40	0.425	88.9	120	11.5	6.8	0.0047	19.6
#60	0.250	81.6	240	10.5	5.8	0.0033	16.9
#100	0.150	75.5	360	9.9	5.2	0.0027	15.1
#200	0.075	69.2	1440	8.6	3.9	0.0014	11.3

% GRAVEL	% SAND	% SILT	% CLAY
5	26	49	20



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

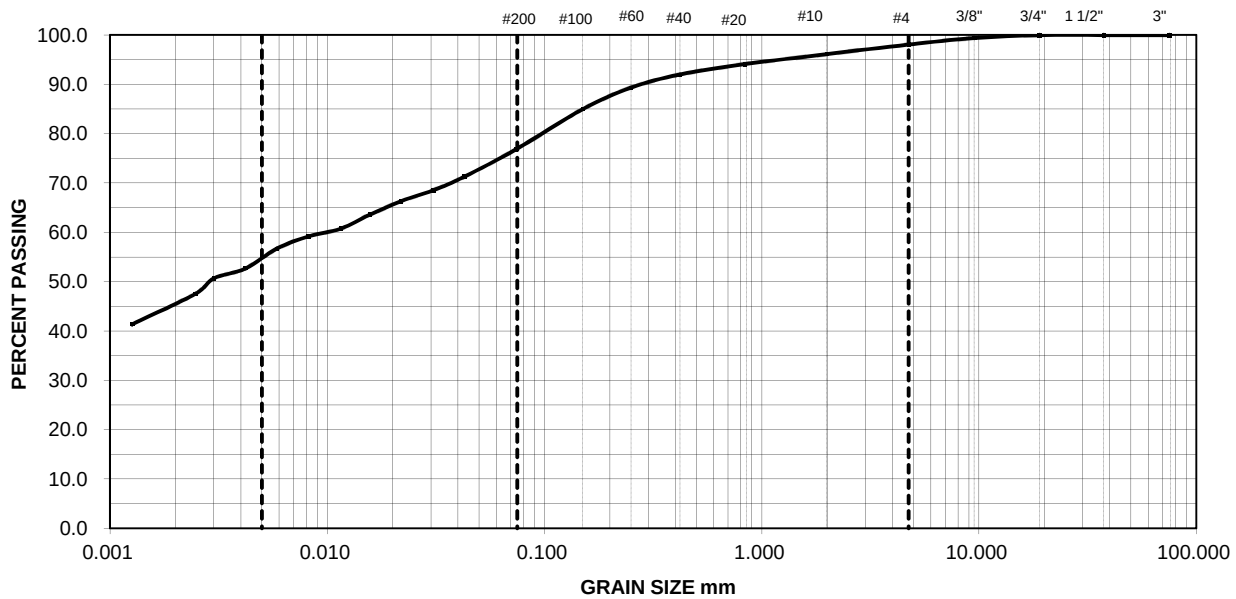
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141210 FIELD NO. S1 HOLE NO. TH15-05 DEPTH (m) 1.5-2.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	27.7	23.0	0.0429	71.3
1.50	37.5	100.0	2	26.8	22.1	0.0307	68.5
0.75	19.0	100.0	4	26.1	21.4	0.0219	66.4
0.375	9.5	99.4	8	25.2	20.5	0.0157	63.6
#4	4.75	98.1	15	24.3	19.6	0.0116	60.8
#10	2.00	96.1	30	23.8	19.1	0.0082	59.2
#20	0.850	94.1	60	23.0	18.3	0.0059	56.7
#40	0.425	92.0	120	21.7	17.0	0.0042	52.7
#60	0.250	89.3	240	21.0	16.3	0.0030	50.7
#100	0.150	85.0	360	20.0	15.3	0.0025	47.6
#200	0.075	76.9	1440	18.0	13.3	0.0013	41.3

% GRAVEL	% SAND	% SILT	% CLAY
2	21	22	55



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

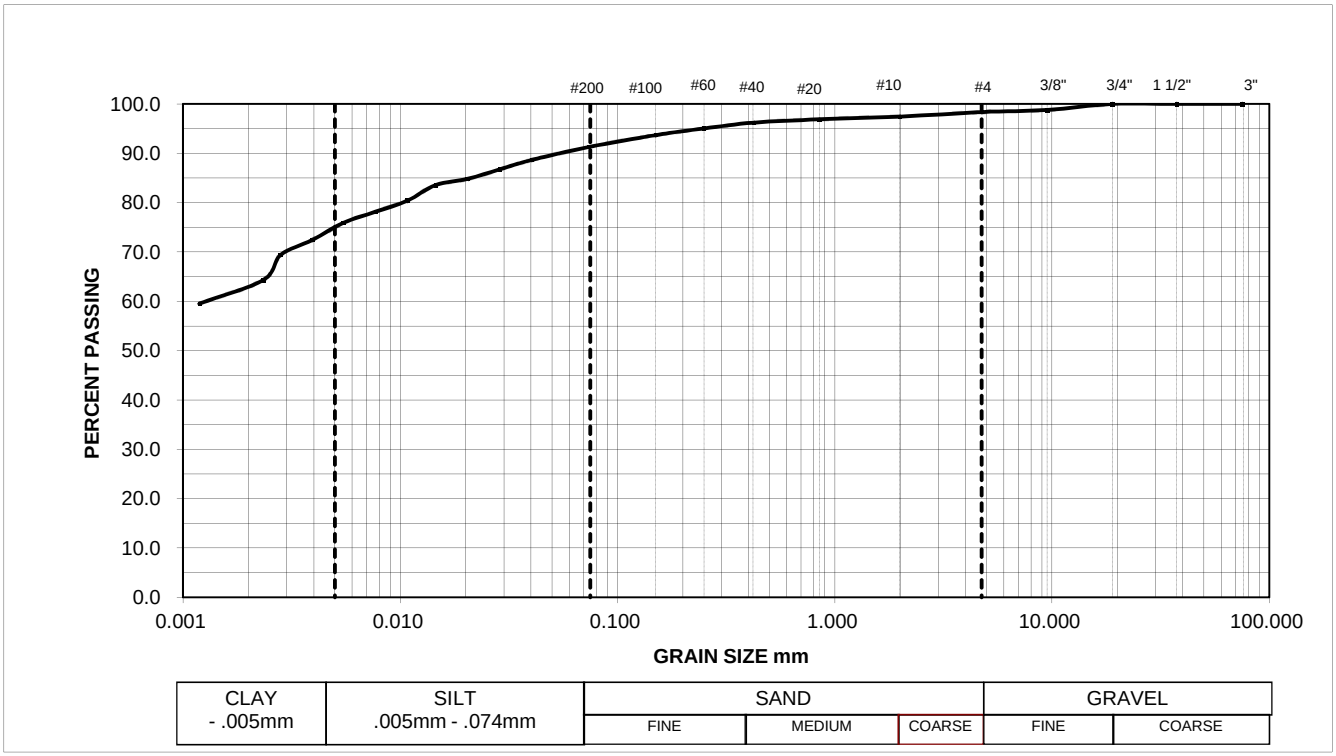
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141212 FIELD NO. S3 HOLE NO. TH15-05 DEPTH (m) 9.0-10.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	32.6	27.9	0.0402	88.6
1.50	37.50	100.0	2	32.0	27.3	0.0287	86.7
0.75	19.00	100.0	4	31.4	26.7	0.0204	84.8
0.375	9.50	98.8	8	31.0	26.3	0.0145	83.5
#4	4.75	98.3	15	30.0	25.3	0.0108	80.4
#10	2.00	97.4	30	29.3	24.6	0.0077	78.1
#20	0.850	96.9	60	28.6	23.9	0.0055	75.9
#40	0.425	96.2	120	27.5	22.8	0.0039	72.4
#60	0.250	95.0	240	26.5	21.8	0.0028	69.4
#100	0.150	93.7	360	24.9	20.2	0.0023	64.3
#200	0.075	91.3	1440	23.4	18.7	0.0012	59.5

% GRAVEL	% SAND	% SILT	% CLAY
2	7	16	75



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

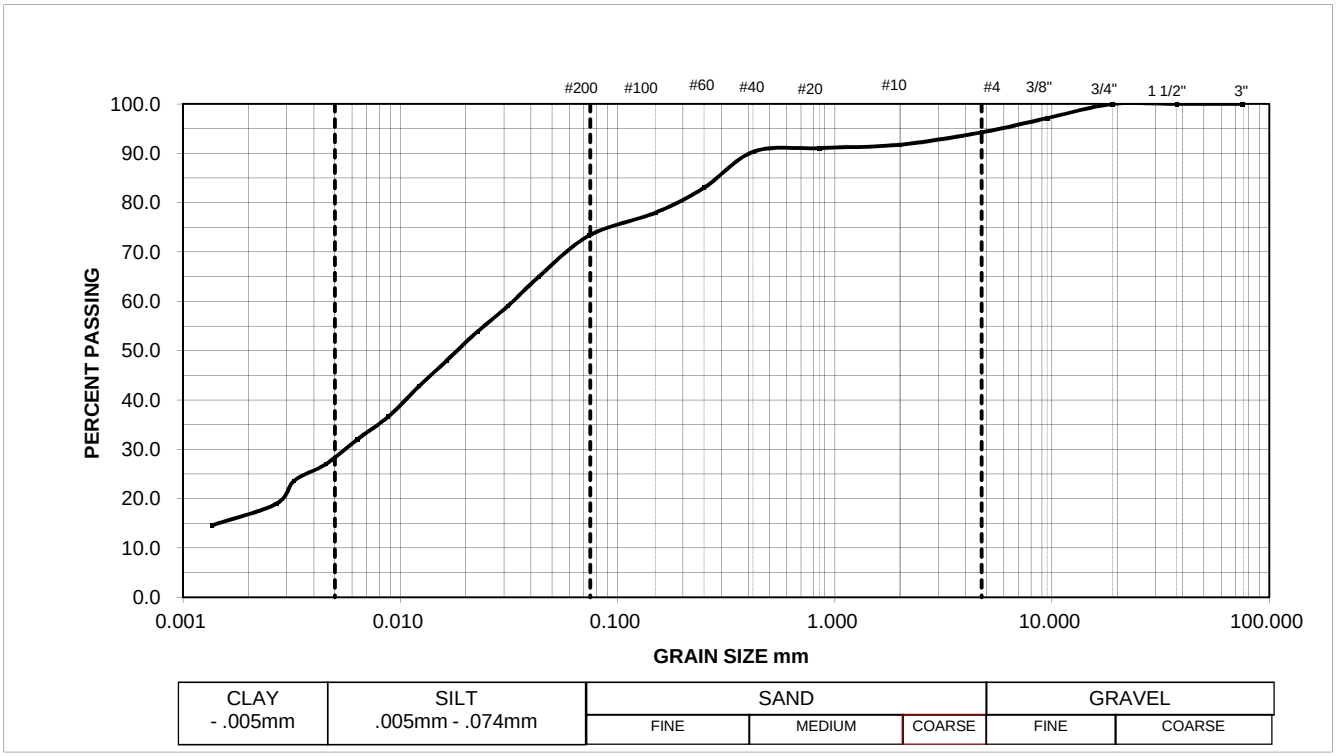
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141213 FIELD NO. S4 HOLE NO. TH15-05 DEPTH (m) 12.0-13.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	27.0	22.3	0.0433	64.9
1.50	37.50	100.0	2	25.0	20.3	0.0314	59.1
0.75	19.00	100.0	4	23.2	18.5	0.0227	53.9
0.375	9.50	97.1	8	21.2	16.5	0.0164	48.0
#4	4.75	94.3	15	19.4	14.7	0.0122	42.8
#10	2.00	91.7	30	17.3	12.6	0.0088	36.6
#20	0.850	91.1	60	15.7	11.0	0.0063	32.0
#40	0.425	90.4	120	14.0	9.3	0.0045	27.0
#60	0.250	83.0	240	12.8	8.1	0.0032	23.6
#100	0.150	78.0	360	11.2	6.5	0.0027	19.0
#200	0.075	73.3	1440	9.7	5.0	0.0014	14.6

% GRAVEL	% SAND	% SILT	% CLAY
6	21	45	28



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

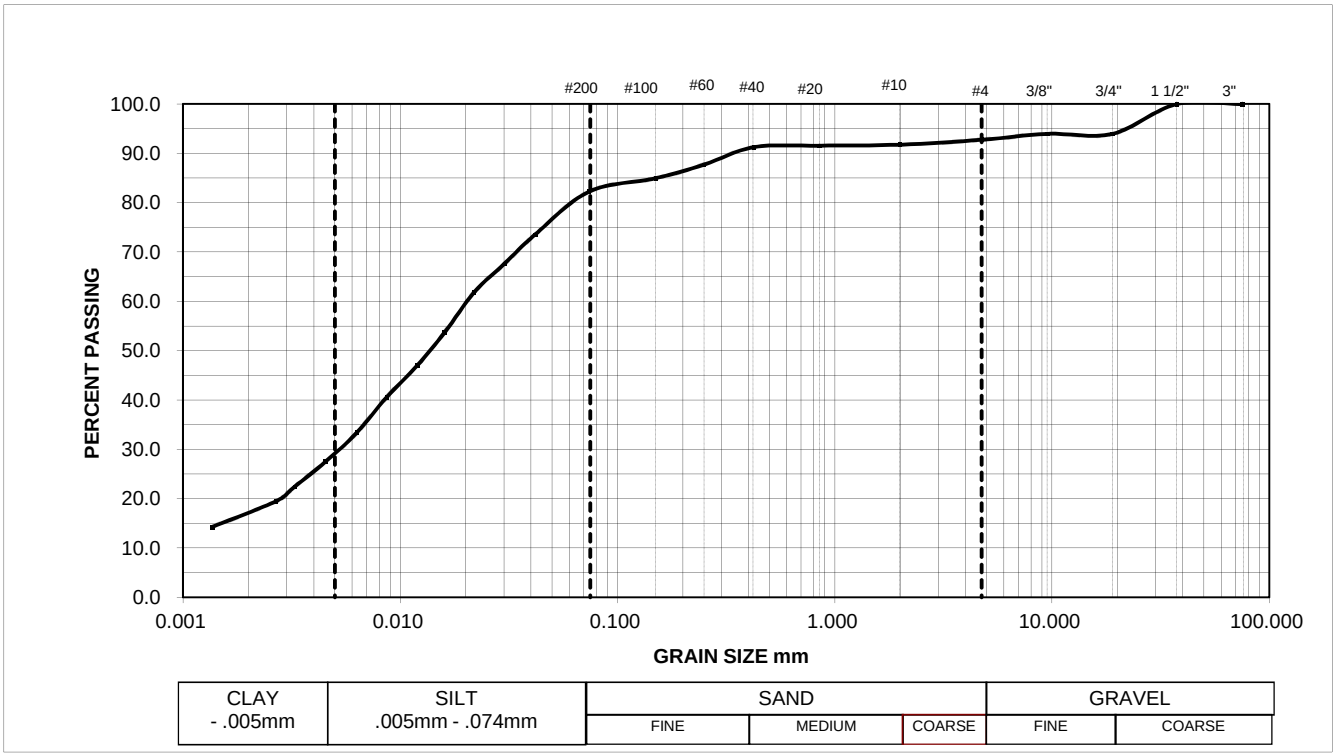
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141214 FIELD NO. S5 HOLE NO. TH15-05 DEPTH (m) 15.0-16.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	30.0	25.3	0.0417	73.5
1.50	37.5	100.0	2	28.0	23.3	0.0302	67.7
0.75	19.0	94.0	4	26.0	21.3	0.0219	61.9
0.375	9.5	94.0	8	23.2	18.5	0.0160	53.7
#4	4.75	92.7	15	20.9	16.2	0.0120	47.0
#10	2.00	91.8	30	18.7	14.0	0.0087	40.6
#20	0.850	91.6	60	16.2	11.5	0.0063	33.3
#40	0.425	91.3	120	14.2	9.5	0.0045	27.5
#60	0.250	87.7	240	12.4	7.7	0.0033	22.4
#100	0.150	85.0	360	11.4	6.7	0.0027	19.5
#200	0.075	82.2	1440	9.6	4.9	0.0014	14.3

% GRAVEL	% SAND	% SILT	% CLAY
7	11	54	28



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

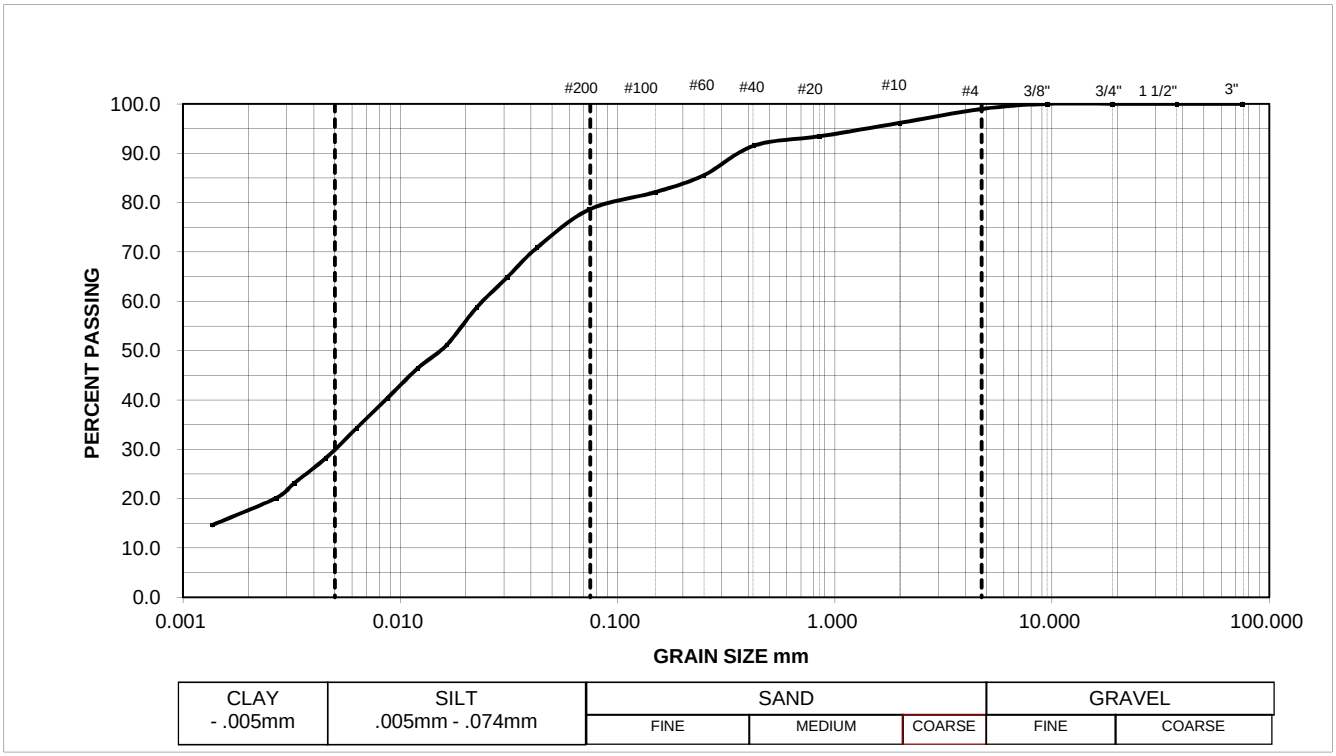
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141215 FIELD NO. S6 HOLE NO. TH15-05 DEPTH (m) 19.0-20.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	28.0	23.3	0.0428	70.9
1.50	37.50	100.0	2	26.0	21.3	0.0310	64.8
0.75	19.00	100.0	4	24.0	19.3	0.0224	58.7
0.375	9.50	100.0	8	21.5	16.8	0.0163	51.1
#4	4.75	98.9	15	20.0	15.3	0.0121	46.5
#10	2.00	96.1	30	18.0	13.3	0.0087	40.4
#20	0.850	93.4	60	16.0	11.3	0.0063	34.3
#40	0.425	91.5	120	14.0	9.3	0.0045	28.2
#60	0.250	85.5	240	12.3	7.6	0.0033	23.2
#100	0.150	82.1	360	11.3	6.6	0.0027	20.1
#200	0.075	78.5	1440	9.5	4.8	0.0014	14.6

% GRAVEL	% SAND	% SILT	% CLAY
1	20	49	30



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

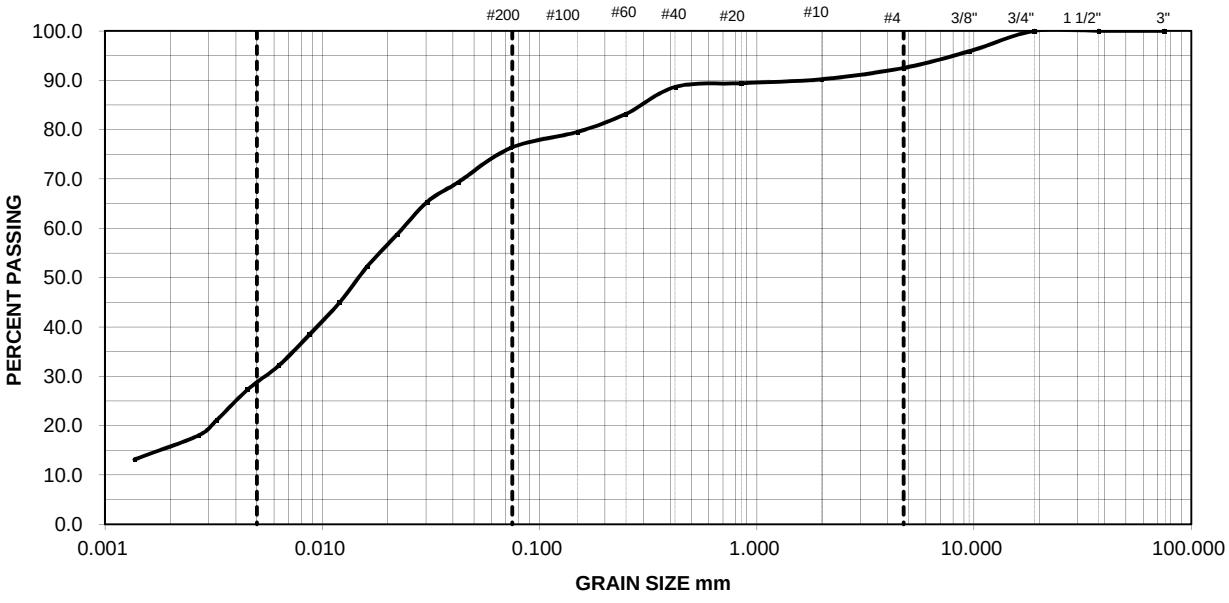
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Dike** **Checked By:** **GK**

LAB.NO. WGT141216 FIELD NO. S7 HOLE NO. TH15-05 DEPTH (m) 20.0-21.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	29.0	24.3	0.0422	69.3
1.50	37.50	100.0	2	27.6	22.9	0.0304	65.3
0.75	19.00	100.0	4	25.3	20.6	0.0221	58.7
0.375	9.50	95.8	8	23.0	18.3	0.0161	52.2
#4	4.75	92.5	15	20.5	15.8	0.0120	45.0
#10	2.00	90.2	30	18.2	13.5	0.0087	38.4
#20	0.850	89.4	60	16.0	11.3	0.0063	32.2
#40	0.425	88.7	120	14.3	9.6	0.0045	27.3
#60	0.250	83.2	240	12.1	7.4	0.0033	21.2
#100	0.150	79.5	360	11.0	6.3	0.0027	18.0
#200	0.075	76.3	1440	9.3	4.6	0.0014	13.1

% GRAVEL	% SAND	% SILT	% CLAY
8	16	47	29



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 Quarry** **Checked By:** **GK**

LAB.NO. WGT141274 FIELD NO. S1 HOLE NO. TH15-13 DEPTH (m) 3.5-4.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	24.5	20.0	0.0445	54.8
1.50	37.5	100.0	2	22.0	17.5	0.0324	48.0
0.75	19.0	97.3	4	20.0	15.5	0.0234	42.5
0.375	9.5	92.6	8	17.4	12.9	0.0170	35.4
#4	4.75	88.9	15	15.5	11.0	0.0126	30.1
#10	2.00	86.4	30	13.5	9.0	0.0091	24.7
#20	0.850	84.9	60	12.0	7.5	0.0065	20.6
#40	0.425	82.9	120	10.4	5.9	0.0047	16.2
#60	0.250	75.7	240	9.0	4.5	0.0034	12.3
#100	0.150	70.3	360	8.7	4.2	0.0027	11.5
#200	0.075	65.1	1440	8.0	3.7	0.0014	10.0

% GRAVEL	% SAND	% SILT	% CLAY
11	24	48	17



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

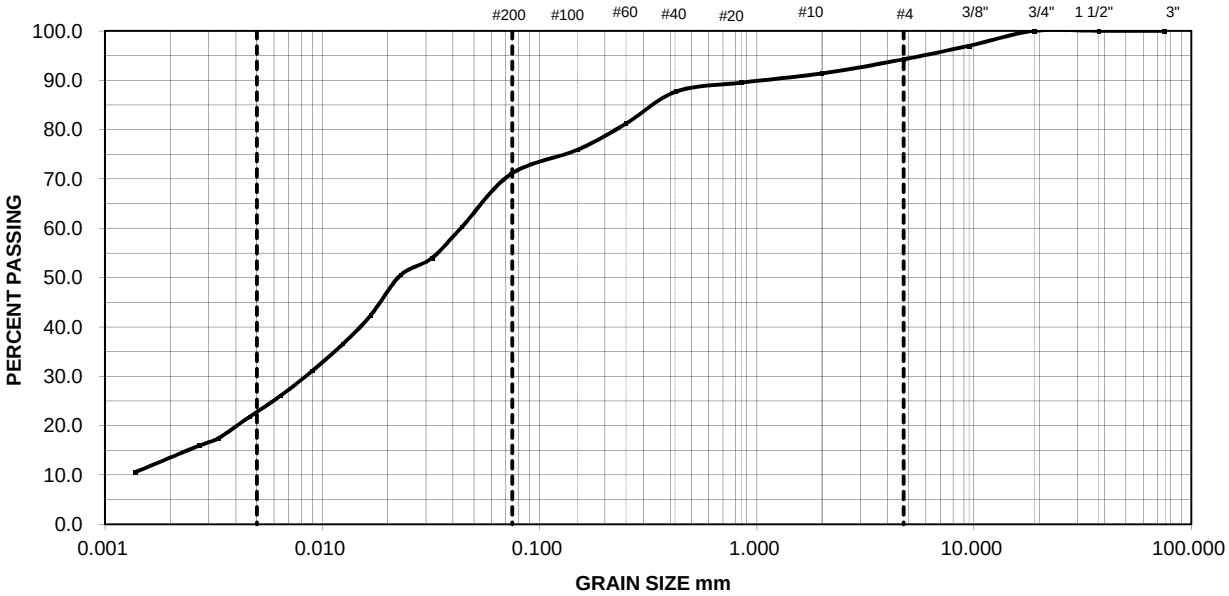
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 Quarry** **Checked By:** **GK**

LAB.NO. WGT141275 FIELD NO. S2 HOLE NO. TH15-13 DEPTH (m) 6.5-7.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	25.3	20.8	0.0441	60.3
1.50	37.50	100.0	2	23.1	18.6	0.0320	54.0
0.75	19.00	100.0	4	21.9	17.4	0.0229	50.5
0.375	9.50	97.0	8	19.1	14.6	0.0167	42.4
#4	4.75	94.2	15	17.1	12.6	0.0124	36.6
#10	2.00	91.4	30	15.2	10.7	0.0090	31.0
#20	0.850	89.5	60	13.5	9.0	0.0064	26.1
#40	0.425	87.7	120	12.0	7.5	0.0046	21.8
#60	0.250	81.2	240	10.5	6.0	0.0033	17.4
#100	0.150	75.9	360	10.0	5.5	0.0027	16.0
#200	0.075	71.0	1440	8.0	3.7	0.0014	10.6

% GRAVEL	% SAND	% SILT	% CLAY
6	23	49	22



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

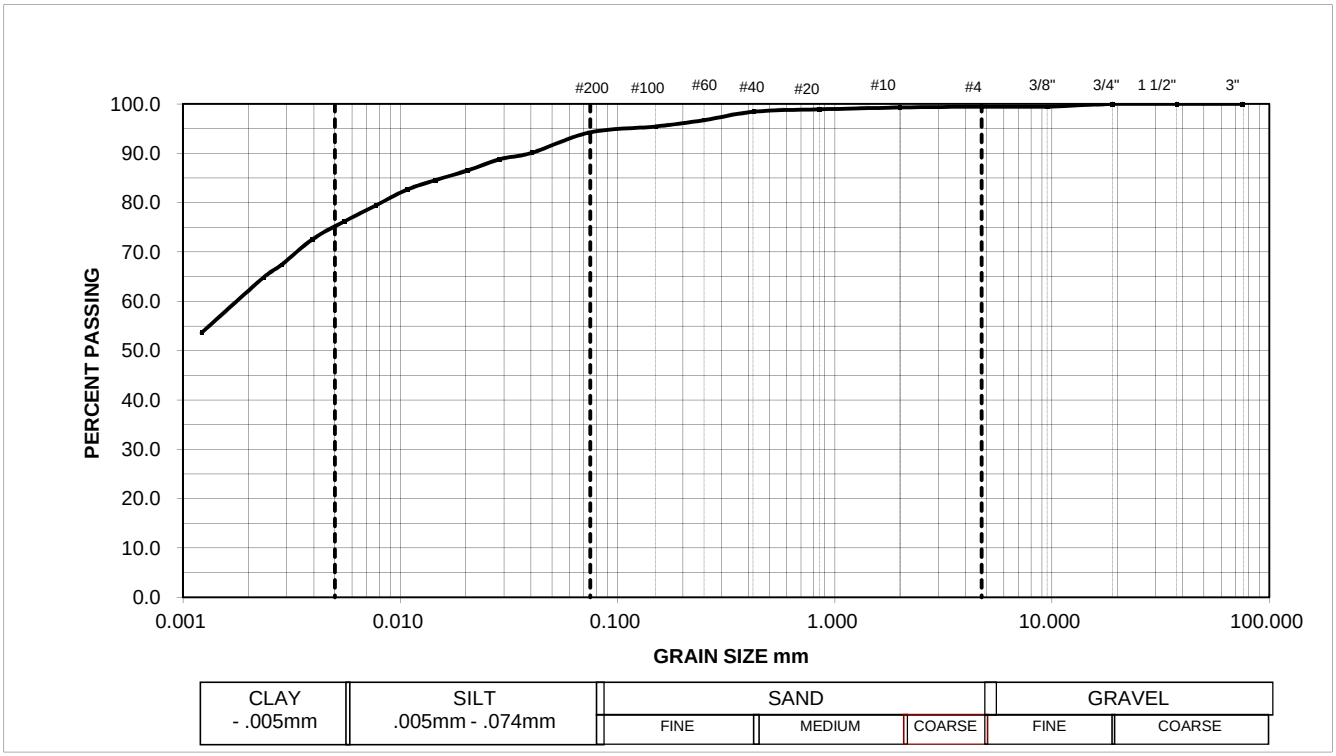
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141315 FIELD NO. S1 HOLE NO. TP15-01 DEPTH (m) 7-8

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	32.3	27.8	0.0402	90.1
1.50	37.5	100.0	2	31.9	27.4	0.0286	88.8
0.75	19.0	100.0	4	31.2	26.7	0.0204	86.5
0.375	9.5	99.5	8	30.6	26.1	0.0146	84.6
#4	4.75	99.5	15	30.0	25.5	0.0107	82.6
#10	2.00	99.3	30	29.0	24.5	0.0077	79.4
#20	0.850	98.9	60	28.0	23.5	0.0055	76.2
#40	0.425	98.4	120	26.9	22.4	0.0039	72.6
#60	0.250	96.7	240	25.3	20.8	0.0028	67.4
#100	0.150	95.4	360	24.5	20.0	0.0023	64.8
#200	0.075	94.2	1440	20.9	16.6	0.0012	53.6

% GRAVEL	% SAND	% SILT	% CLAY
1	5	19	75



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

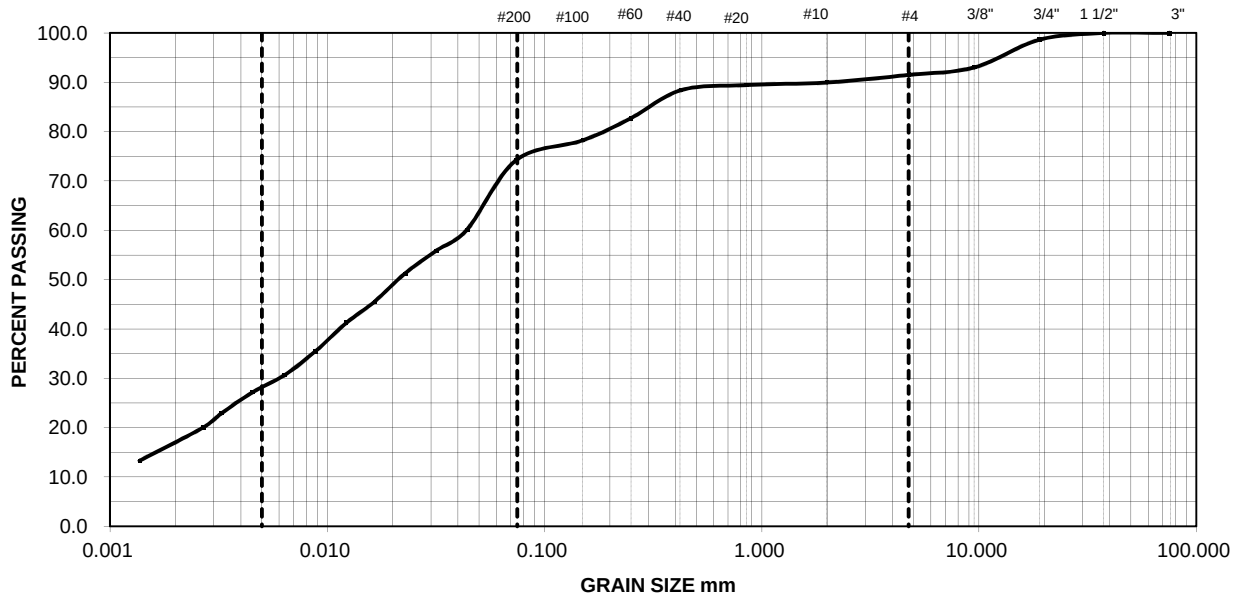
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141316 FIELD NO. S2 HOLE NO. TP15-01 DEPTH (m) 10-11

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	25.5	21.0	0.0440	60.2
1.50	37.50	100.0	2	24.0	19.5	0.0317	55.9
0.75	19.00	98.6	4	22.4	17.9	0.0228	51.3
0.375	9.50	93.0	8	20.4	15.9	0.0165	45.6
#4	4.75	91.5	15	18.9	14.4	0.0122	41.3
#10	2.00	90.0	30	16.9	12.4	0.0088	35.5
#20	0.850	89.5	60	15.2	10.7	0.0063	30.7
#40	0.425	88.4	120	14.0	9.5	0.0045	27.2
#60	0.250	82.8	240	12.5	8.0	0.0033	22.9
#100	0.150	78.3	360	11.5	7.0	0.0027	20.1
#200	0.075	74.2	1440	9.0	4.7	0.0014	13.3

% GRAVEL	% SAND	% SILT	% CLAY
8	17	46	28



CLAY	SILT	SAND			GRAVEL	
- .005mm	.005mm - .074mm	FINE	MEDIUM	COARSE	FINE	COARSE

MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

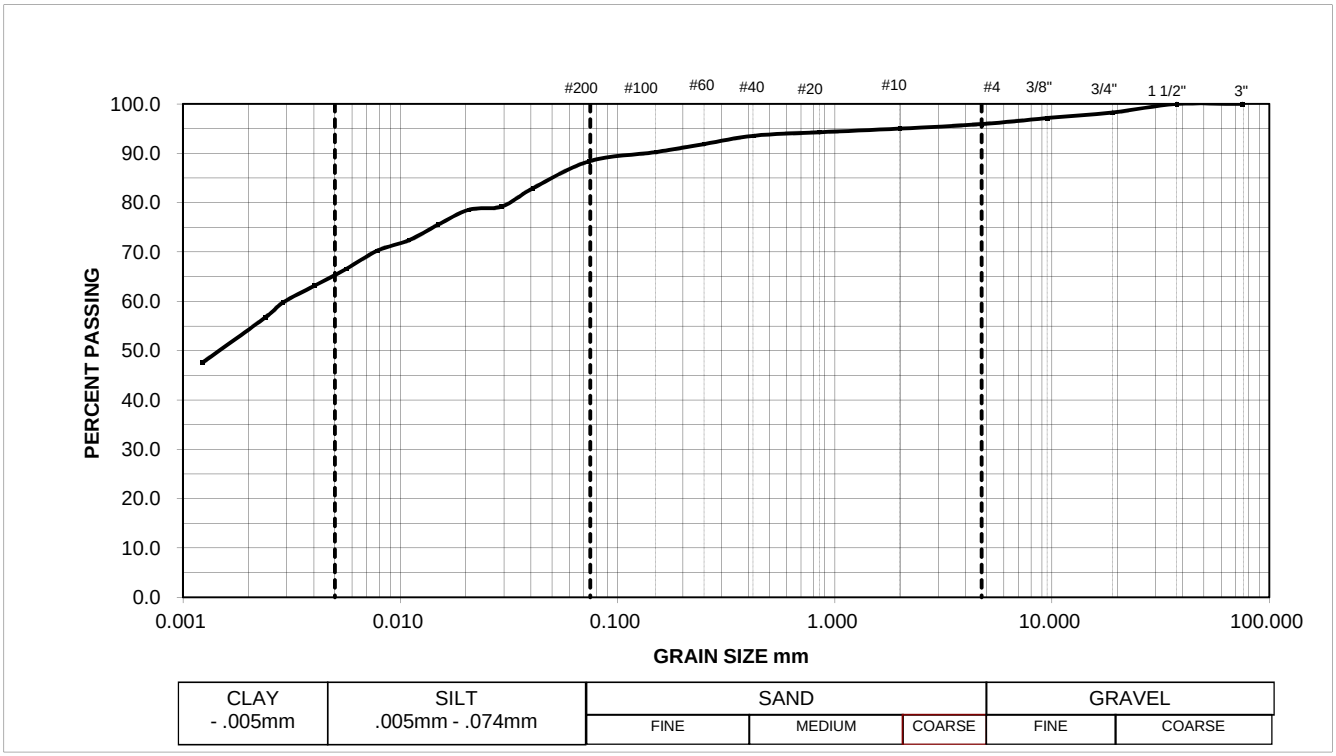
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141317 FIELD NO. S1 HOLE NO. TP15-02 DEPTH (m) 6-7

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	31.4	26.9	0.0407	82.9
1.50	37.50	100.0	2	30.2	25.7	0.0293	79.2
0.75	19.00	98.3	4	30.0	25.5	0.0208	78.6
0.375	9.50	97.1	8	29.0	24.5	0.0149	75.5
#4	4.75	95.9	15	28.0	23.5	0.0110	72.4
#10	2.00	95.0	30	27.3	22.8	0.0079	70.3
#20	0.850	94.3	60	26.1	21.6	0.0056	66.6
#40	0.425	93.6	120	25.0	20.5	0.0040	63.2
#60	0.250	91.9	240	23.9	19.4	0.0029	59.8
#100	0.150	90.3	360	22.9	18.4	0.0024	56.7
#200	0.075	88.4	1440	19.8	15.5	0.0012	47.6

% GRAVEL	% SAND	% SILT	% CLAY
4	8	23	65



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

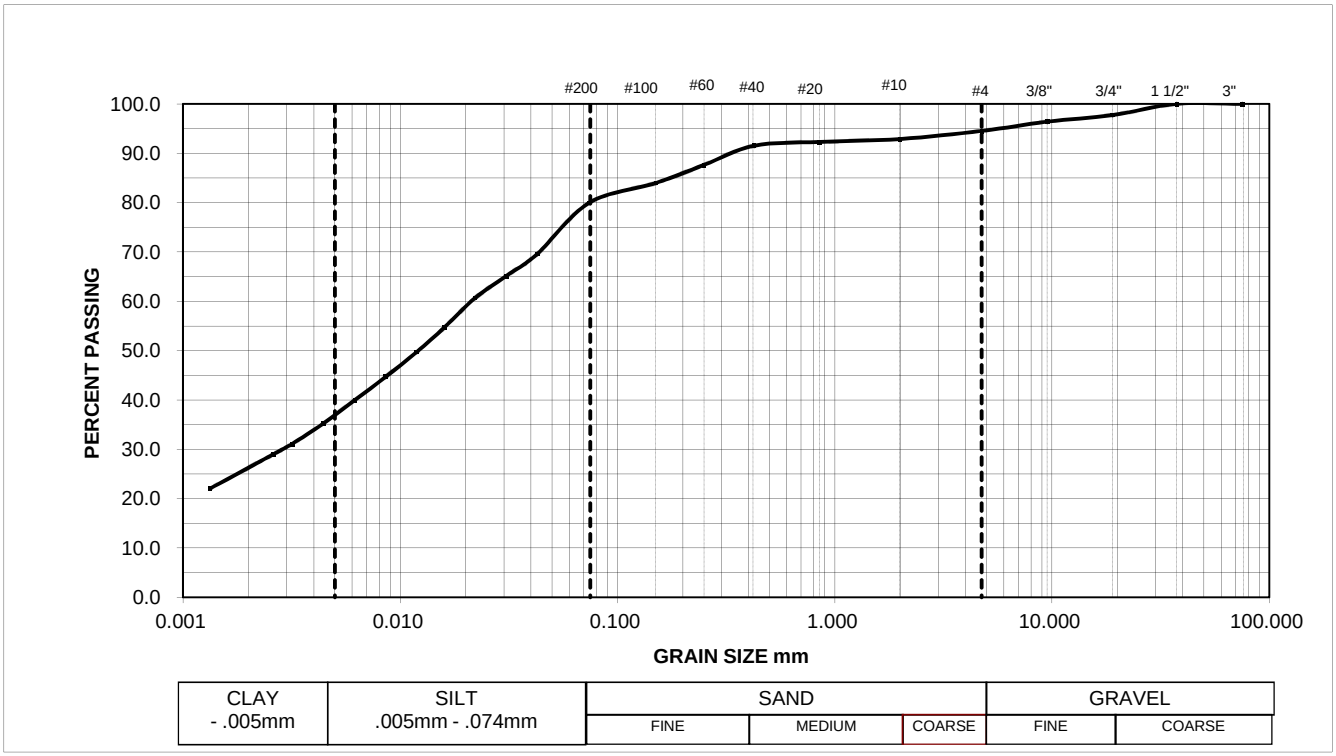
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141318 FIELD NO. S2 HOLE NO. TP15-02 DEPTH (m) 9-10

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	28.0	23.5	0.0426	69.5
1.50	37.5	100.0	2	26.5	22.0	0.0307	65.1
0.75	19.0	97.7	4	25.0	20.5	0.0221	60.7
0.375	9.5	96.4	8	23.0	18.5	0.0160	54.7
#4	4.75	94.5	15	21.3	16.8	0.0119	49.7
#10	2.00	92.9	30	19.6	15.1	0.0086	44.7
#20	0.850	92.3	60	18.0	13.5	0.0062	39.9
#40	0.425	91.5	120	16.4	11.9	0.0044	35.2
#60	0.250	87.6	240	15.0	10.5	0.0032	31.1
#100	0.150	83.9	360	14.3	9.8	0.0026	29.0
#200	0.075	79.9	1440	11.8	7.5	0.0013	22.0

% GRAVEL	% SAND	% SILT	% CLAY
5	15	43	37



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

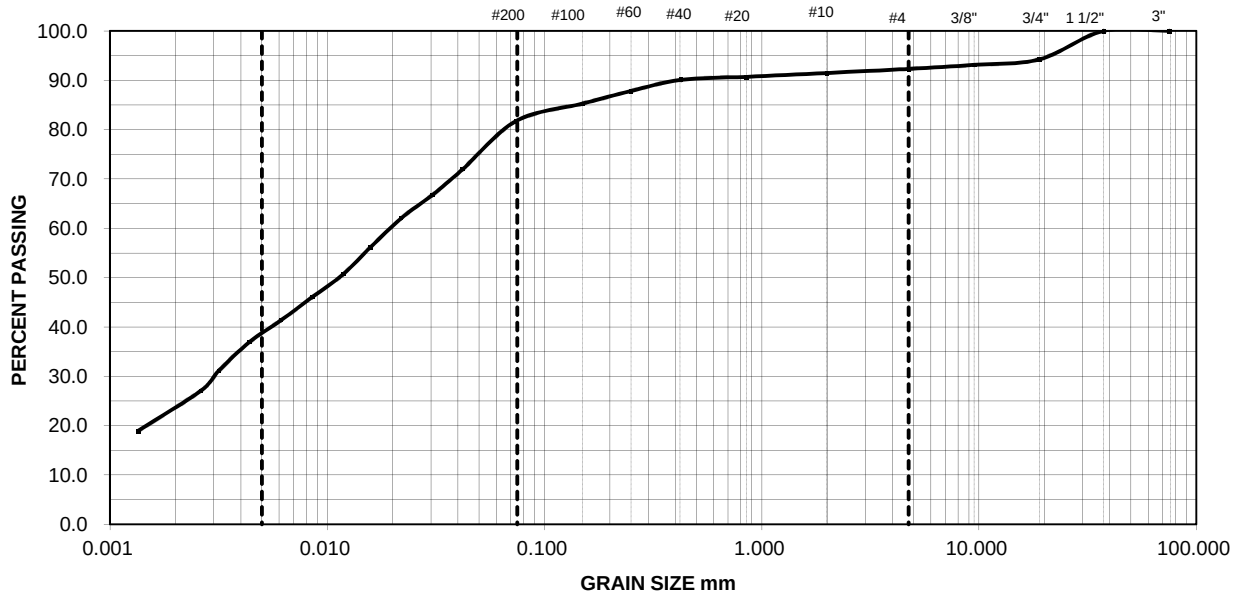
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141319 FIELD NO. S1 HOLE NO. TP15-03 DEPTH (m) 4-5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	29.4	24.7	0.0420	71.9
1.50	37.50	100.0	2	27.6	22.9	0.0304	66.7
0.75	19.00	94.2	4	26.0	21.3	0.0219	62.0
0.375	9.50	93.1	8	24.0	19.3	0.0159	56.2
#4	4.75	92.3	15	22.1	17.4	0.0118	50.7
#10	2.00	91.5	30	20.5	15.8	0.0085	46.0
#20	0.850	90.7	60	18.9	14.2	0.0061	41.4
#40	0.425	90.1	120	17.4	12.7	0.0044	37.0
#60	0.250	87.8	240	15.4	10.7	0.0032	31.2
#100	0.150	85.3	360	14.0	9.3	0.0026	27.1
#200	0.075	81.7	1440	11.2	6.5	0.0013	18.9

% GRAVEL	% SAND	% SILT	% CLAY
8	11	43	39



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

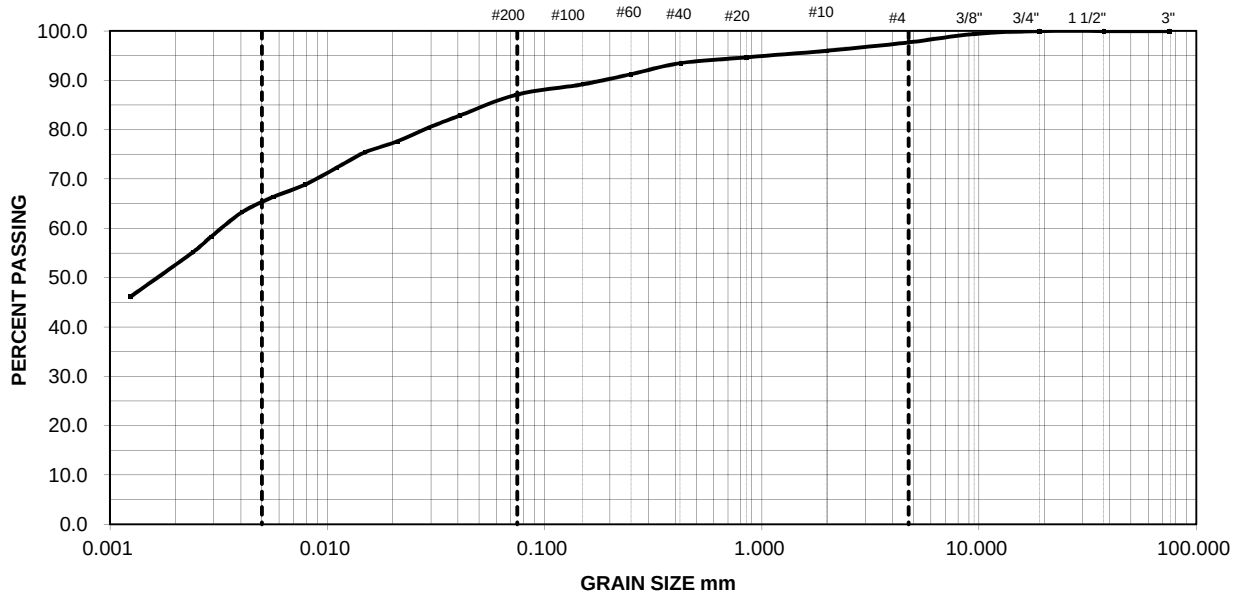
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141320 FIELD NO. S1 HOLE NO. TP15-04 DEPTH (m) 4-5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	31.3	26.6	0.0409	82.9
1.50	37.50	100.0	2	30.5	25.8	0.0293	80.4
0.75	19.00	100.0	4	29.6	24.9	0.0209	77.6
0.375	9.50	99.4	8	28.9	24.2	0.0149	75.4
#4	4.75	97.7	15	27.9	23.2	0.0111	72.3
#10	2.00	96.0	30	26.8	22.1	0.0079	68.9
#20	0.850	94.7	60	26.0	21.3	0.0057	66.4
#40	0.425	93.5	120	25.0	20.3	0.0040	63.3
#60	0.250	91.2	240	23.4	18.7	0.0029	58.3
#100	0.150	89.2	360	22.4	17.7	0.0024	55.2
#200	0.075	87.1	1440	19.5	14.8	0.0012	46.1

% GRAVEL	% SAND	% SILT	% CLAY
2	11	22	65



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

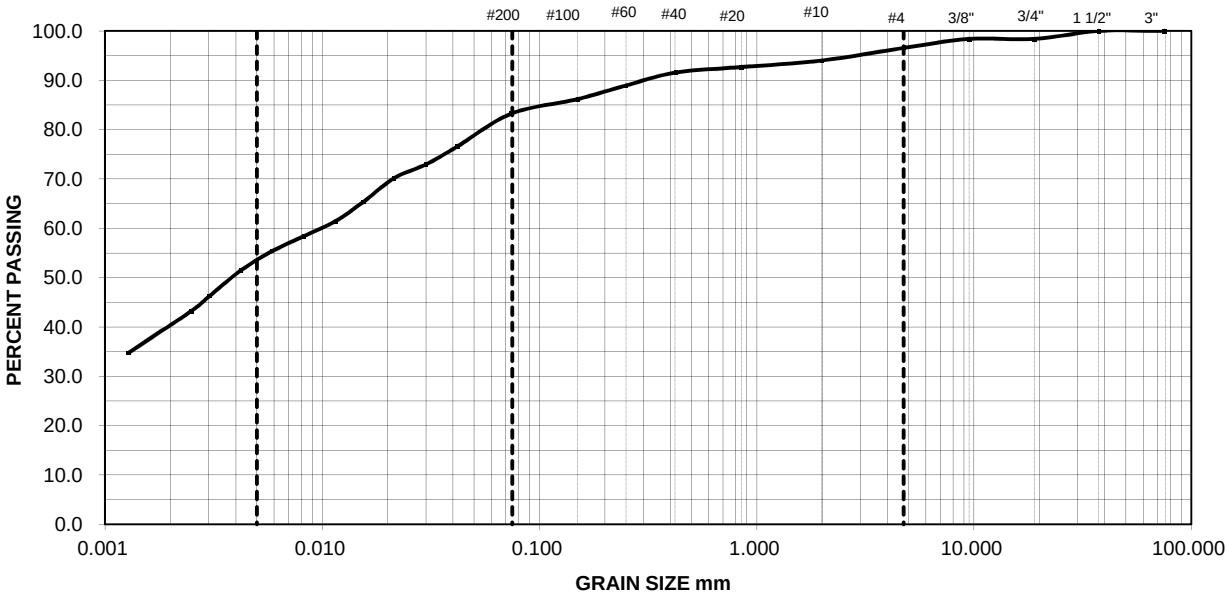
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141321 FIELD NO. S2 HOLE NO. TP15-04 DEPTH (m) 9-10

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	30.0	25.3	0.0416	76.5
1.50	37.50	100.0	2	28.8	24.1	0.0299	72.9
0.75	19.00	98.4	4	27.9	23.2	0.0214	70.2
0.375	9.50	98.4	8	26.3	21.6	0.0154	65.3
#4	4.75	96.6	15	25.0	20.3	0.0114	61.4
#10	2.00	94.0	30	24.0	19.3	0.0082	58.4
#20	0.850	92.7	60	23.0	18.3	0.0059	55.4
#40	0.425	91.6	120	21.7	17.0	0.0042	51.4
#60	0.250	88.9	240	20.0	15.3	0.0030	46.3
#100	0.150	86.2	360	19.0	14.3	0.0025	43.3
#200	0.075	83.2	1440	16.2	11.5	0.0013	34.8

% GRAVEL	% SAND	% SILT	% CLAY
3	13	30	53



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

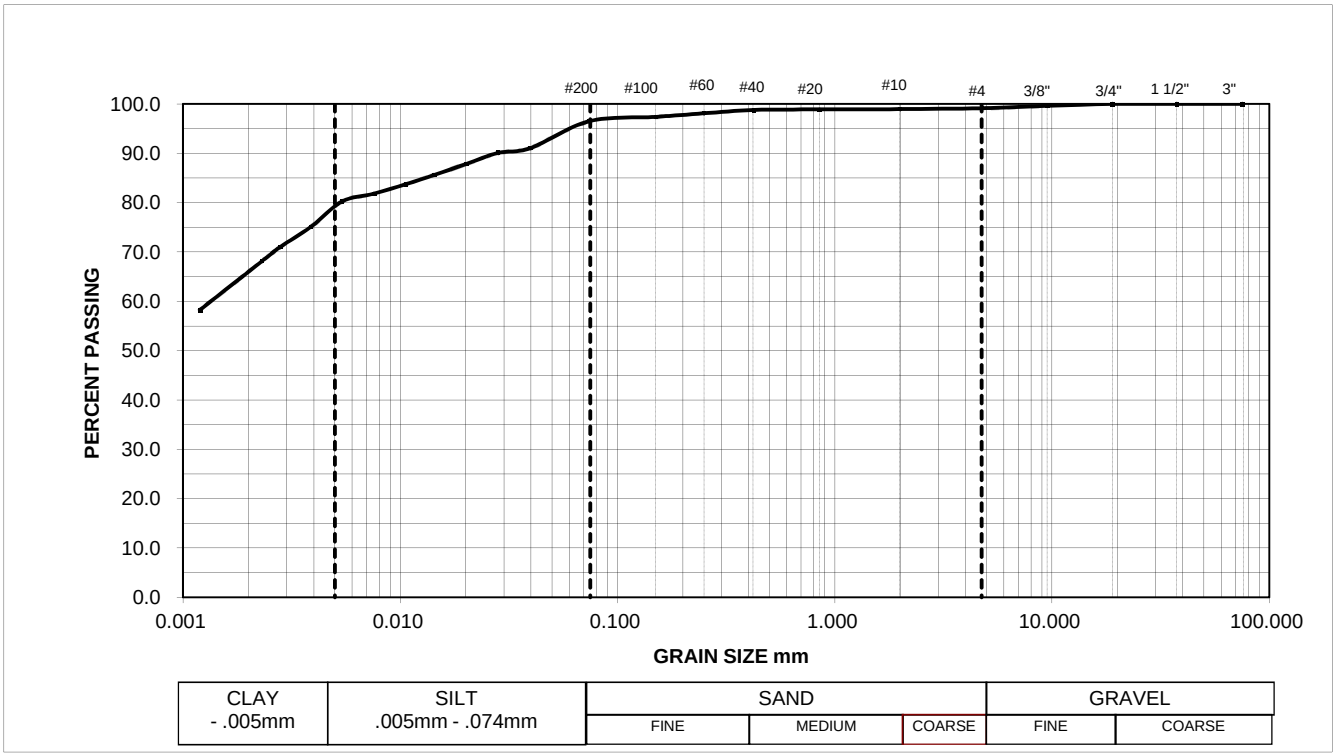
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141322 FIELD NO. S1 HOLE NO. TP15-05 DEPTH (m) 11-12

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	33.3	28.6	0.0398	91.0
1.50	37.50	100.0	2	33.0	28.3	0.0282	90.1
0.75	19.00	100.0	4	32.3	27.6	0.0202	87.9
0.375	9.50	99.6	8	31.6	26.9	0.0144	85.6
#4	4.75	99.1	15	31.0	26.3	0.0106	83.7
#10	2.00	98.9	30	30.4	25.7	0.0076	81.8
#20	0.850	98.9	60	29.9	25.2	0.0054	80.2
#40	0.425	98.8	120	28.3	23.6	0.0039	75.1
#60	0.250	98.1	240	27.0	22.3	0.0028	71.0
#100	0.150	97.4	360	26.1	21.4	0.0023	68.1
#200	0.075	96.5	1440	23.0	18.3	0.0012	58.3

% GRAVEL	% SAND	% SILT	% CLAY
1	3	17	79



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

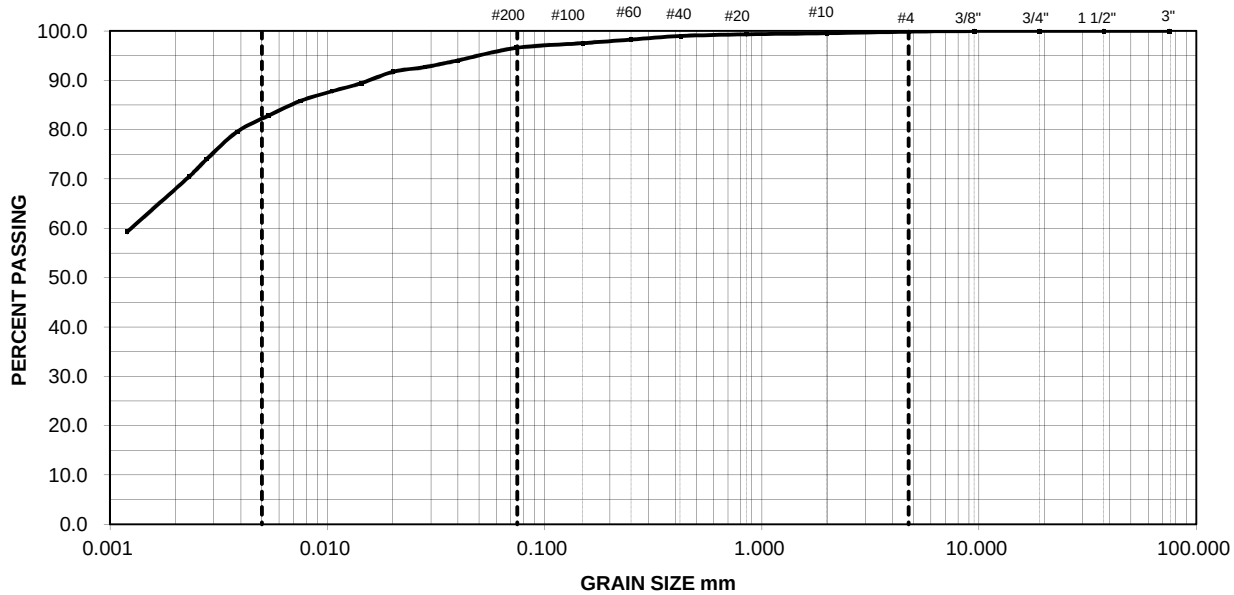
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141323 FIELD NO. S1 HOLE NO. TP15-06 DEPTH (m) 4-5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	33.4	28.7	0.0397	94.0
1.50	37.50	100.0	2	33.0	28.3	0.0282	92.7
0.75	19.00	100.0	4	32.7	28.0	0.0201	91.7
0.375	9.50	100.0	8	32.0	27.3	0.0143	89.4
#4	4.75	99.9	15	31.5	26.8	0.0105	87.8
#10	2.00	99.6	30	30.9	26.2	0.0075	85.8
#20	0.850	99.3	60	30.0	25.3	0.0054	82.9
#40	0.425	99.0	120	29.0	24.3	0.0039	79.6
#60	0.250	98.3	240	27.3	22.6	0.0028	74.0
#100	0.150	97.5	360	26.2	21.5	0.0023	70.4
#200	0.075	96.6	1440	22.8	18.1	0.0012	59.3

% GRAVEL	% SAND	% SILT	% CLAY
0	3	15	82



CLAY	SILT	SAND			GRAVEL	
- .005mm	.005mm - .074mm	FINE	MEDIUM	COARSE	FINE	COARSE

MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

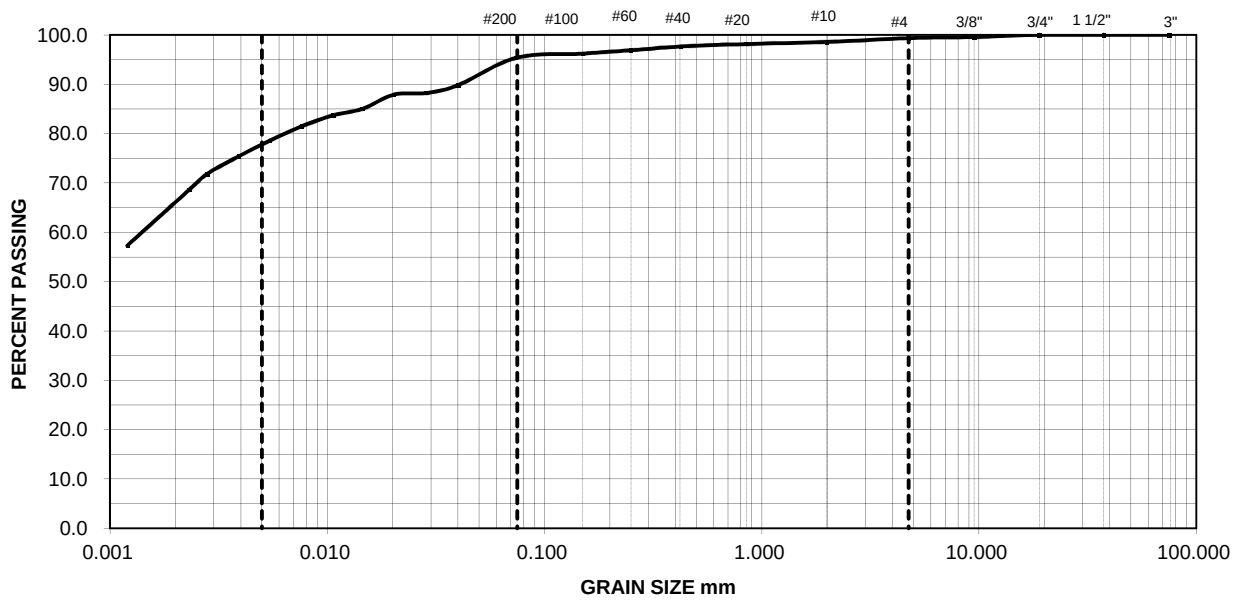
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141324 FIELD NO. S2 HOLE NO. TP15-06 DEPTH (m) 9-10

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	32.6	27.9	0.0402	89.8
1.50	37.50	100.0	2	32.1	27.4	0.0286	88.2
0.75	19.00	100.0	4	32.0	27.3	0.0203	87.9
0.375	9.50	99.6	8	31.1	26.4	0.0145	85.0
#4	4.75	99.3	15	30.7	26.0	0.0107	83.7
#10	2.00	98.6	30	30.0	25.3	0.0076	81.5
#20	0.850	98.1	60	29.1	24.4	0.0054	78.6
#40	0.425	97.7	120	28.1	23.4	0.0039	75.3
#60	0.250	96.9	240	27.0	22.3	0.0028	71.8
#100	0.150	96.2	360	26.0	21.3	0.0023	68.6
#200	0.075	95.4	1440	22.5	17.8	0.0012	57.3

% GRAVEL	% SAND	% SILT	% CLAY
1	4	17	78



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

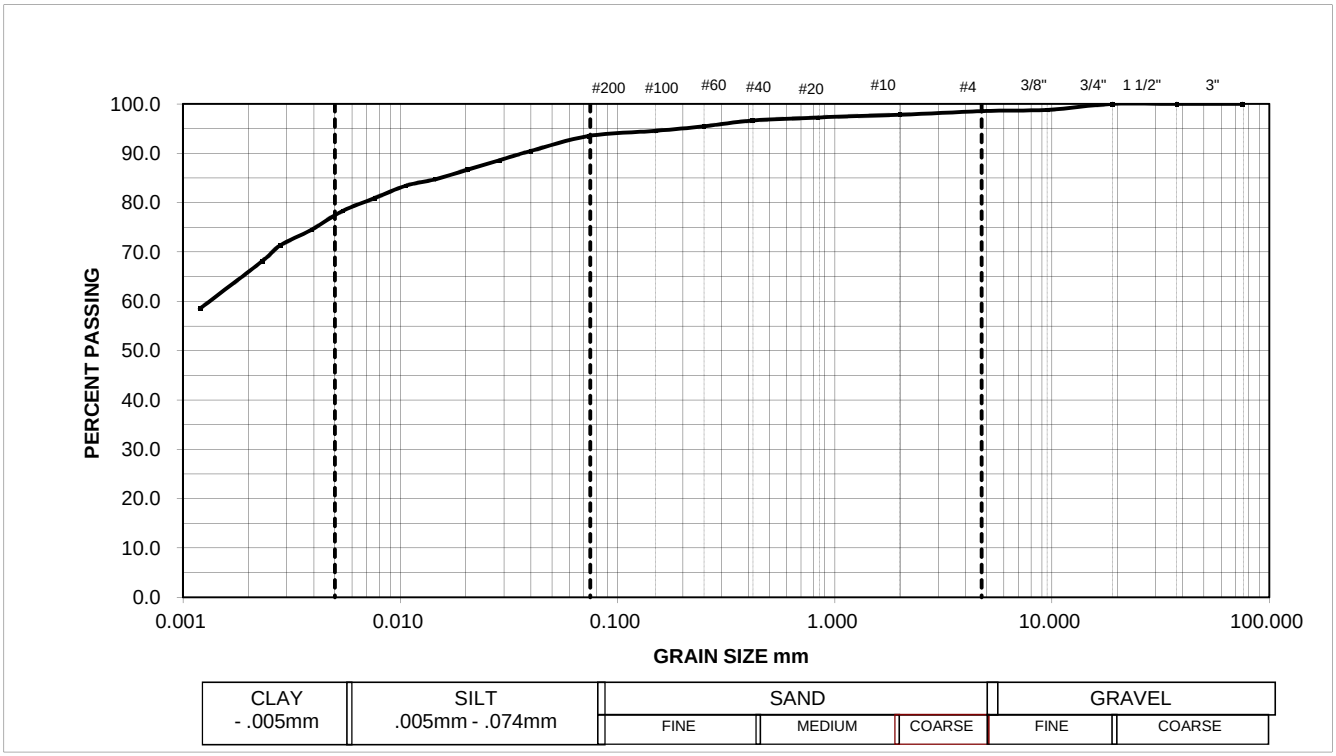
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141325 FIELD NO. S1 HOLE NO. TP15-07 DEPTH (m) 7-8

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	33.0	28.3	0.0399	90.5
1.50	37.5	100.0	2	32.4	27.7	0.0285	88.6
0.75	19.0	100.0	4	31.8	27.1	0.0203	86.6
0.375	9.5	98.8	8	31.2	26.5	0.0145	84.7
#4	4.75	98.5	15	30.8	26.1	0.0106	83.4
#10	2.00	97.8	30	30.0	25.3	0.0076	80.9
#20	0.850	97.2	60	29.2	24.5	0.0054	78.3
#40	0.425	96.6	120	28.0	23.3	0.0039	74.5
#60	0.250	95.5	240	27.0	22.3	0.0028	71.3
#100	0.150	94.5	360	26.0	21.3	0.0023	68.1
#200	0.075	93.5	1440	23.0	18.3	0.0012	58.5

% GRAVEL	% SAND	% SILT	% CLAY
1	5	16	78



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

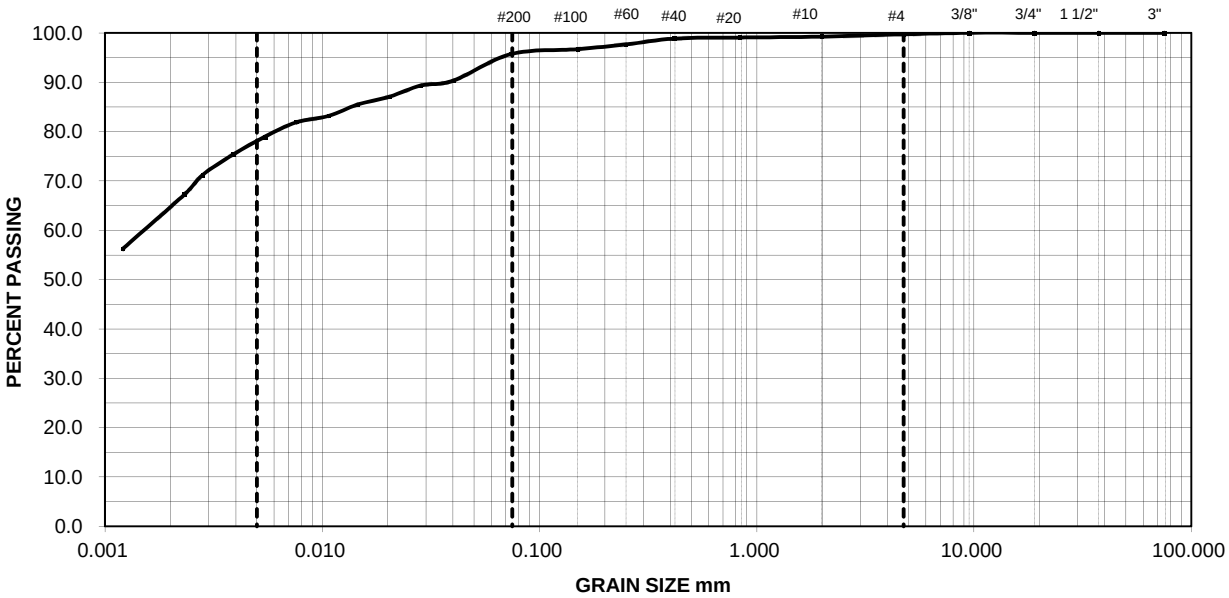
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141326 FIELD NO. S1 HOLE NO. TP15-08 DEPTH (m) 10-11

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	32.5	27.8	0.0402	90.3
1.50	37.5	100.0	2	32.2	27.5	0.0286	89.3
0.75	19.0	100.0	4	31.5	26.8	0.0204	87.1
0.375	9.5	100.0	8	31.0	26.3	0.0145	85.4
#4	4.75	99.7	15	30.3	25.6	0.0107	83.2
#10	2.00	99.2	30	29.9	25.2	0.0076	81.9
#20	0.850	99.0	60	29.0	24.3	0.0054	78.9
#40	0.425	98.8	120	27.9	23.2	0.0039	75.4
#60	0.250	97.6	240	26.6	21.9	0.0028	71.1
#100	0.150	96.7	360	25.4	20.7	0.0023	67.2
#200	0.075	95.7	1440	22.0	17.3	0.0012	56.2

% GRAVEL	% SAND	% SILT	% CLAY
0	4	18	78



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

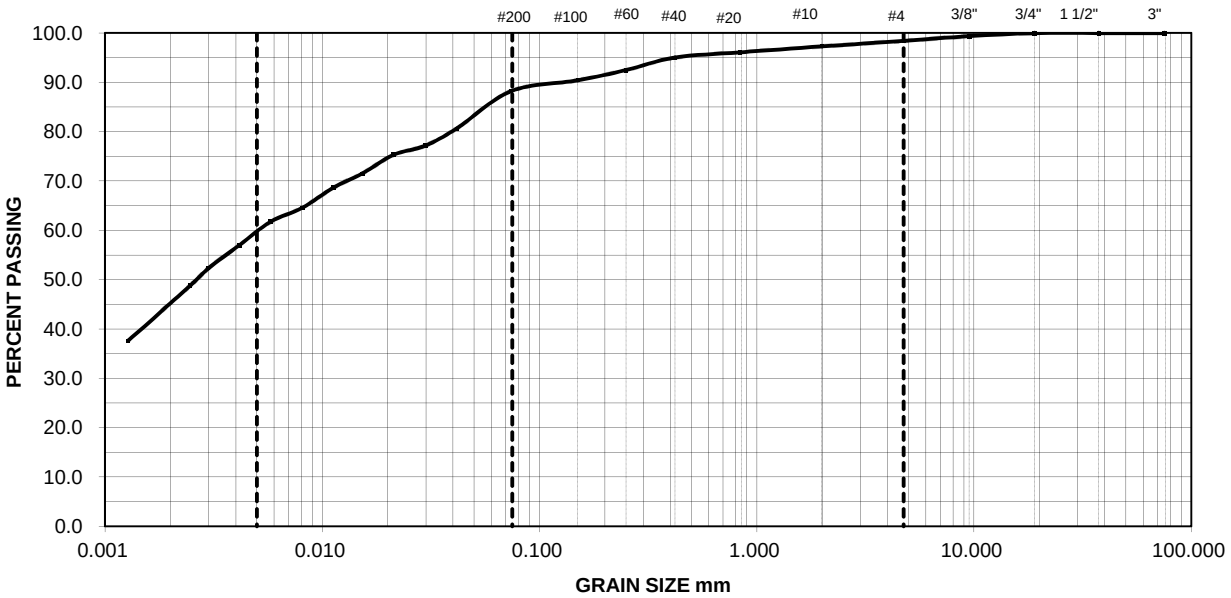
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141327 FIELD NO. S1 HOLE NO. TP15-09 DEPTH (m) 4.5-5.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	30.1	25.6	0.0415	80.6
1.50	37.5	100.0	2	29.0	24.5	0.0298	77.2
0.75	19.0	100.0	4	28.4	23.9	0.0212	75.3
0.375	9.5	99.4	8	27.2	22.7	0.0152	71.5
#4	4.75	98.4	15	26.3	21.8	0.0112	68.7
#10	2.00	97.3	30	25.0	20.5	0.0081	64.6
#20	0.850	96.1	60	24.1	19.6	0.0058	61.7
#40	0.425	95.0	120	22.6	18.1	0.0042	57.0
#60	0.250	92.5	240	21.1	16.6	0.0030	52.3
#100	0.150	90.4	360	20.0	15.5	0.0025	48.8
#200	0.075	88.2	1440	16.3	12.0	0.0013	37.6

% GRAVEL	% SAND	% SILT	% CLAY
2	10	28	60



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

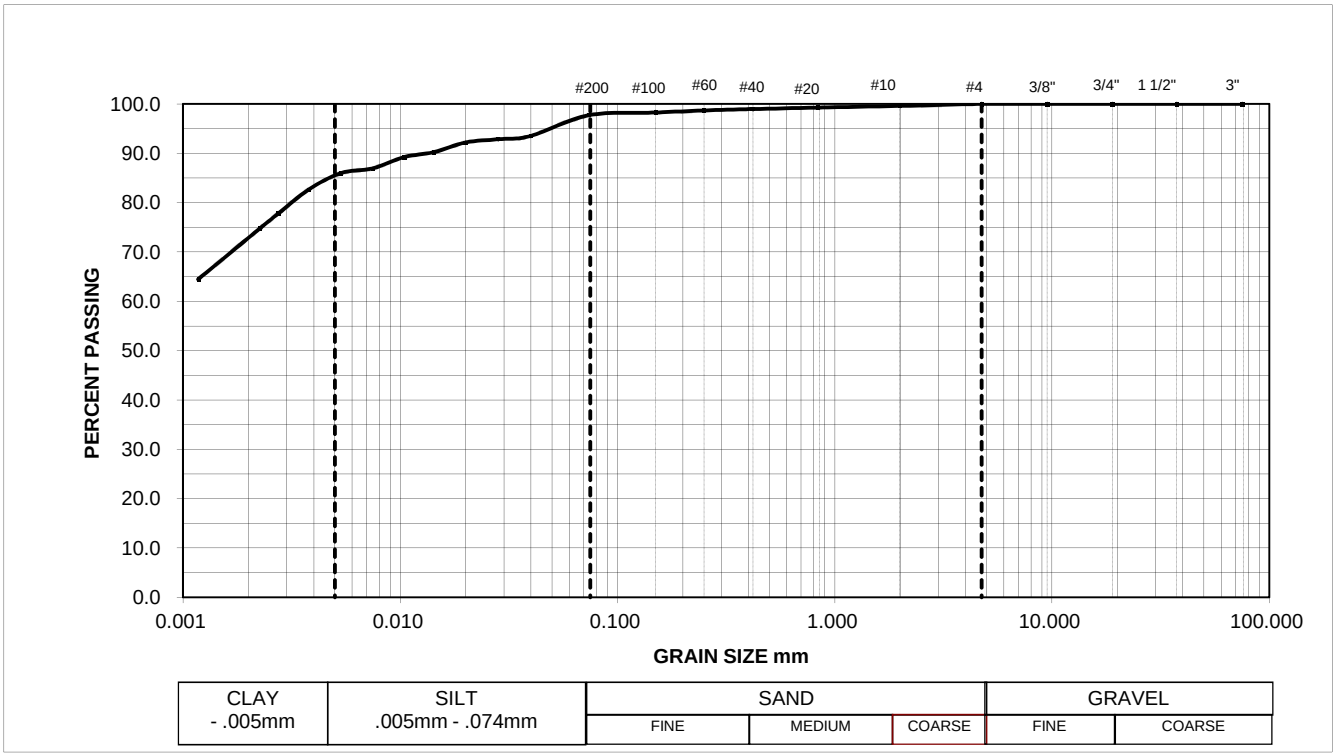
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141328 FIELD NO. S2 HOLE NO. TP15-09 DEPTH (m) 8-9

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	33.0	28.5	0.0398	93.5
1.50	37.5	100.0	2	32.8	28.3	0.0282	92.8
0.75	19.0	100.0	4	32.6	28.1	0.0200	92.2
0.375	9.5	100.0	8	32.0	27.5	0.0143	90.2
#4	4.75	100.0	15	31.7	27.2	0.0105	89.2
#10	2.00	99.6	30	31.0	26.5	0.0075	86.9
#20	0.850	99.2	60	30.7	26.2	0.0053	85.9
#40	0.425	99.0	120	29.7	25.2	0.0038	82.7
#60	0.250	98.7	240	28.2	23.7	0.0027	77.7
#100	0.150	98.2	360	27.3	22.8	0.0023	74.8
#200	0.075	97.7	1440	24.0	19.7	0.0012	64.5

% GRAVEL	% SAND	% SILT	% CLAY
	2	13	85



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

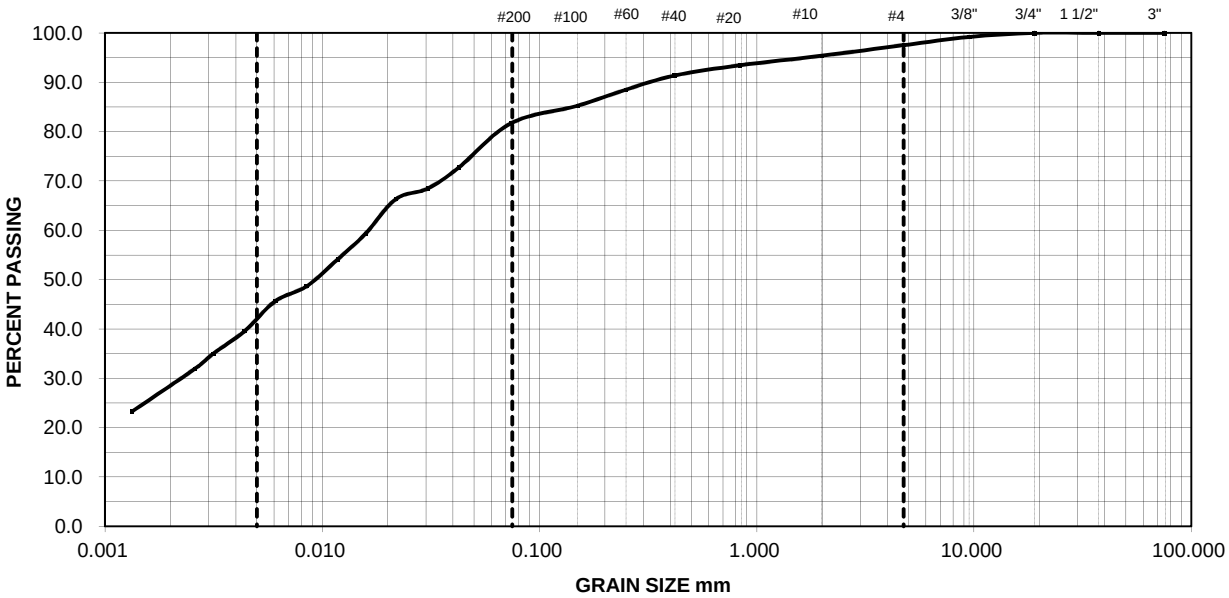
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141330 FIELD NO. S2 HOLE NO. TP15-10 DEPTH (m) 8-9

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	28.4	23.9	0.0424	72.7
1.50	37.5	100.0	2	27.0	22.5	0.0305	68.4
0.75	19.0	100.0	4	26.3	21.8	0.0218	66.3
0.375	9.5	99.2	8	24.0	19.5	0.0158	59.3
#4	4.75	97.5	15	22.3	17.8	0.0118	54.1
#10	2.00	95.4	30	20.5	16.0	0.0085	48.7
#20	0.850	93.4	60	19.5	15.0	0.0061	45.6
#40	0.425	91.4	120	17.5	13.0	0.0044	39.5
#60	0.250	88.5	240	16.0	11.5	0.0031	35.0
#100	0.150	85.3	360	15.0	10.5	0.0026	31.9
#200	0.075	81.7	1440	12.0	7.7	0.0013	23.3

% GRAVEL	% SAND	% SILT	% CLAY
2	16	40	42



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

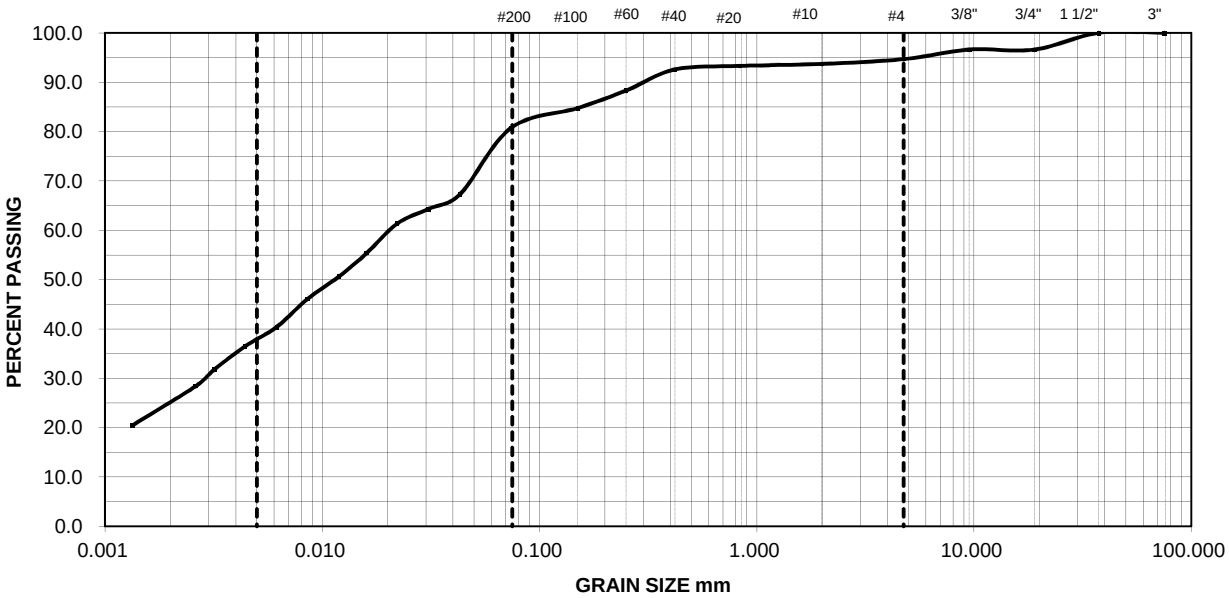
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141331 FIELD NO. S1 HOLE NO. TP15-11 DEPTH (m) 12-13

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	27.0	22.5	0.0432	67.3
1.50	37.5	100.0	2	26.0	21.5	0.0309	64.3
0.75	19.0	96.6	4	25.0	20.5	0.0221	61.3
0.375	9.5	96.6	8	23.0	18.5	0.0160	55.4
#4	4.75	94.7	15	21.4	16.9	0.0119	50.6
#10	2.00	93.7	30	19.9	15.4	0.0086	46.1
#20	0.850	93.3	60	18.0	13.5	0.0062	40.4
#40	0.425	92.6	120	16.7	12.2	0.0044	36.5
#60	0.250	88.3	240	15.1	10.6	0.0032	31.7
#100	0.150	84.8	360	14.0	9.5	0.0026	28.4
#200	0.075	80.7	1440	11.2	6.9	0.0013	20.5

% GRAVEL	% SAND	% SILT	% CLAY
5	14	43	38



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

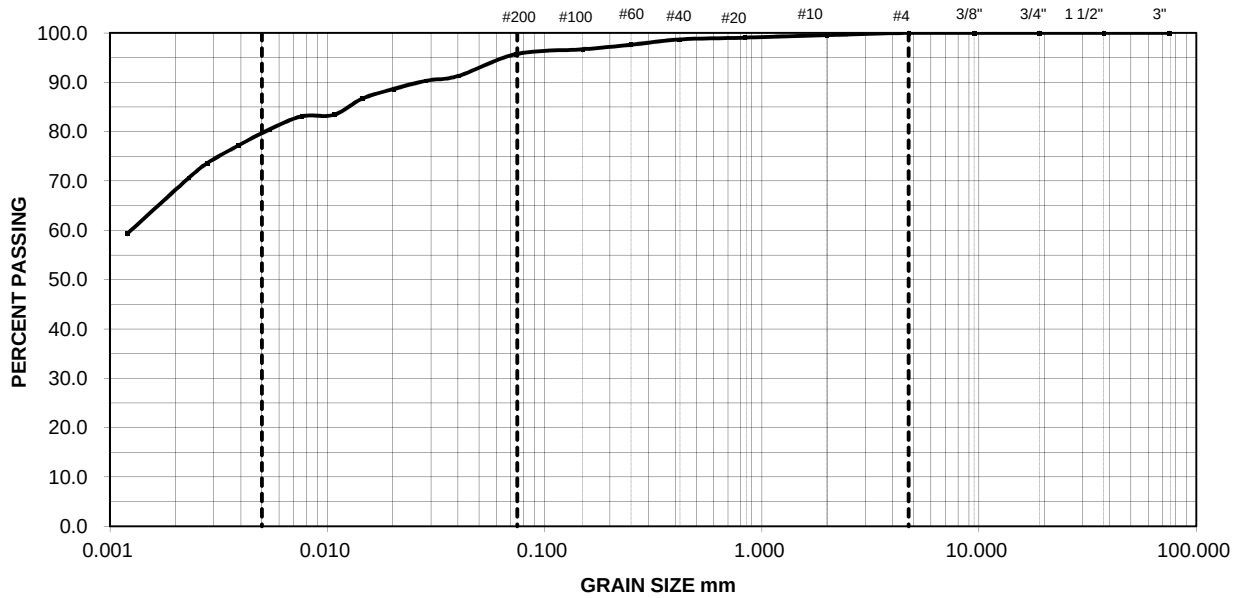
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141332 FIELD NO. S1 HOLE NO. TP15-12 DEPTH (m) 9-10

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	32.3	27.8	0.0402	91.3
1.50	37.5	100.0	2	32.0	27.5	0.0286	90.3
0.75	19.0	100.0	4	31.5	27.0	0.0203	88.7
0.375	9.5	100.0	8	30.9	26.4	0.0145	86.7
#4	4.75	100.0	15	29.9	25.4	0.0107	83.4
#10	2.00	99.5	30	29.8	25.3	0.0076	83.1
#20	0.850	99.0	60	29.0	24.5	0.0054	80.5
#40	0.425	98.7	120	28.0	23.5	0.0039	77.2
#60	0.250	97.6	240	26.9	22.4	0.0028	73.6
#100	0.150	96.7	360	26.0	21.5	0.0023	70.6
#200	0.075	95.7	1440	22.4	18.1	0.0012	59.3

% GRAVEL	% SAND	% SILT	% CLAY
	4	16	80



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

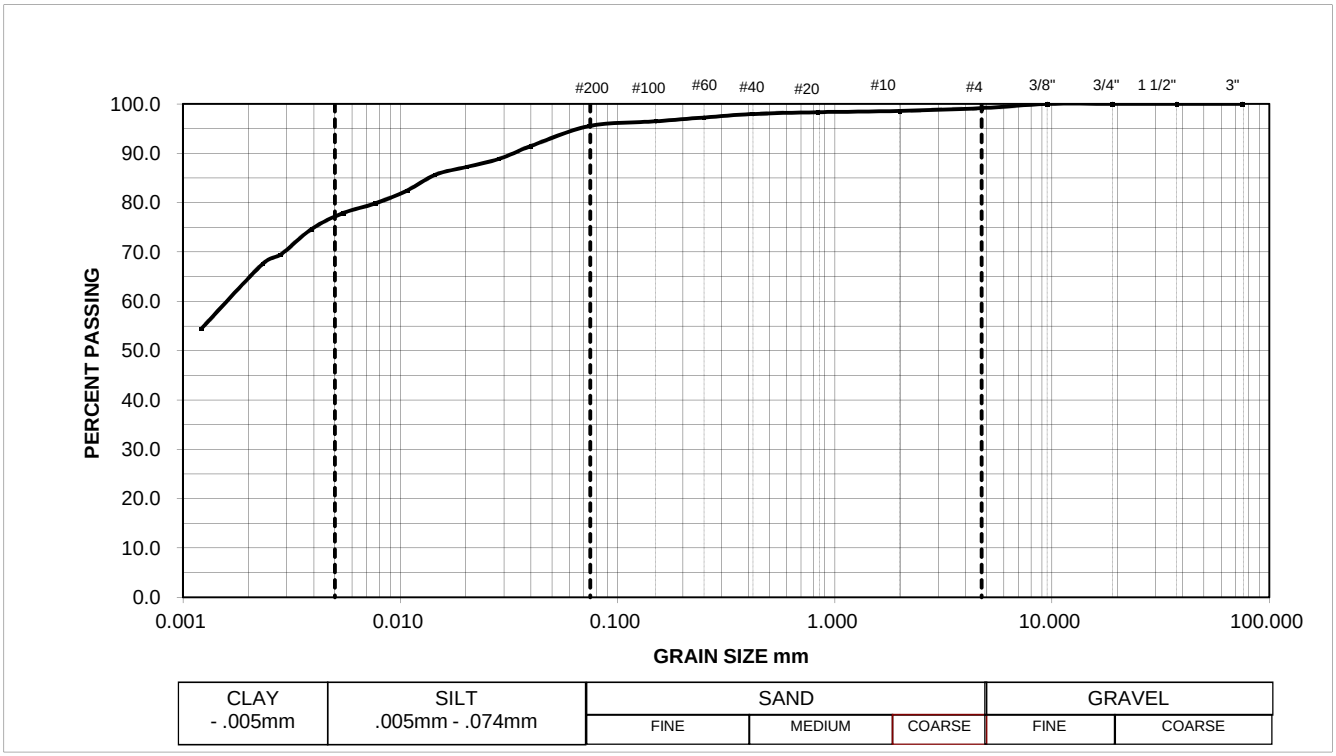
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141333 FIELD NO. S2 HOLE NO. TP15-12 DEPTH (m) 12-13

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	32.8	28.3	0.0399	91.5
1.50	37.5	100.0	2	32.0	27.5	0.0286	88.9
0.75	19.0	100.0	4	31.5	27.0	0.0203	87.3
0.375	9.5	100.0	8	31.0	26.5	0.0145	85.6
#4	4.75	99.2	15	30.0	25.5	0.0107	82.4
#10	2.00	98.6	30	29.2	24.7	0.0077	79.8
#20	0.850	98.3	60	28.6	24.1	0.0055	77.9
#40	0.425	98.0	120	27.6	23.1	0.0039	74.7
#60	0.250	97.2	240	26.0	21.5	0.0028	69.5
#100	0.150	96.5	360	25.4	20.9	0.0023	67.5
#200	0.075	95.5	1440	21.2	16.9	0.0012	54.5

% GRAVEL	% SAND	% SILT	% CLAY
1	4	19	77



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

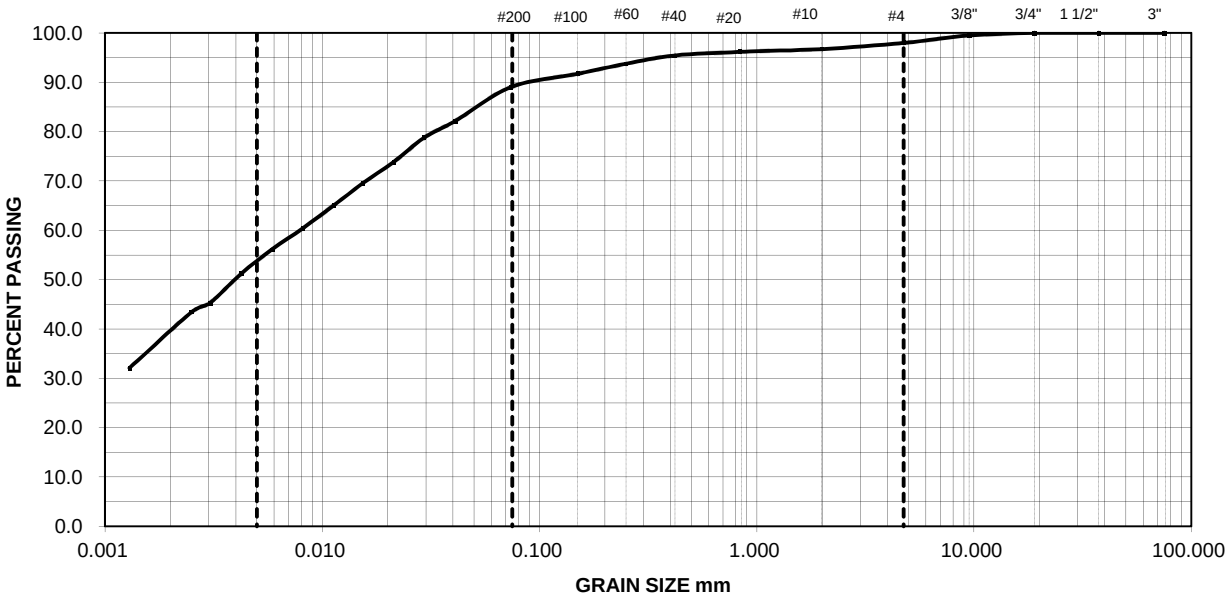
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141334 FIELD NO. S3 HOLE NO. TP15-12 DEPTH (m) 15.5-16.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	31.0	26.5	0.0410	82.2
1.50	37.5	100.0	2	29.9	25.4	0.0294	78.8
0.75	19.0	100.0	4	28.3	23.8	0.0212	73.8
0.375	9.5	99.5	8	26.9	22.4	0.0153	69.4
#4	4.75	98.0	15	25.5	21.0	0.0114	65.1
#10	2.00	96.7	30	24.0	19.5	0.0082	60.5
#20	0.850	96.2	60	22.6	18.1	0.0059	56.1
#40	0.425	95.4	120	21.0	16.5	0.0042	51.2
#60	0.250	93.8	240	19.1	14.6	0.0030	45.3
#100	0.150	91.7	360	18.5	14.0	0.0025	43.4
#200	0.075	89.0	1440	14.7	10.4	0.0013	32.1

% GRAVEL	% SAND	% SILT	% CLAY
2	9	36	53



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

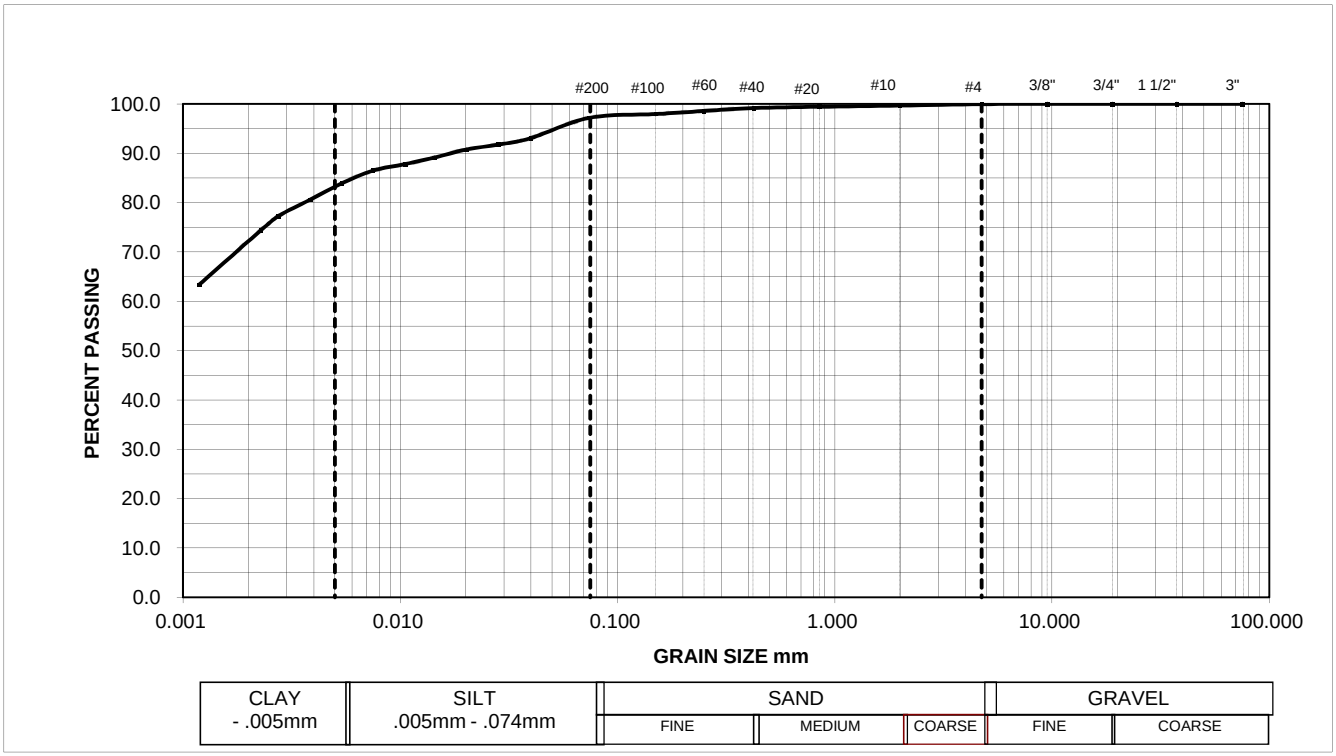
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141335 FIELD NO. S1 HOLE NO. TP15-13 DEPTH (m) 7-8

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	32.8	28.3	0.0399	93.1
1.50	37.5	100.0	2	32.4	27.9	0.0284	91.8
0.75	19.0	100.0	4	32.1	27.6	0.0202	90.8
0.375	9.5	100.0	8	31.6	27.1	0.0144	89.1
#4	4.75	100.0	15	31.2	26.7	0.0105	87.8
#10	2.00	99.7	30	30.8	26.3	0.0075	86.5
#20	0.850	99.4	60	30.0	25.5	0.0054	83.9
#40	0.425	99.2	120	29.0	24.5	0.0038	80.6
#60	0.250	98.6	240	28.0	23.5	0.0028	77.3
#100	0.150	97.9	360	27.1	22.6	0.0023	74.3
#200	0.075	97.2	1440	23.6	19.3	0.0012	63.3

% GRAVEL	% SAND	% SILT	% CLAY
0	3	14	83



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

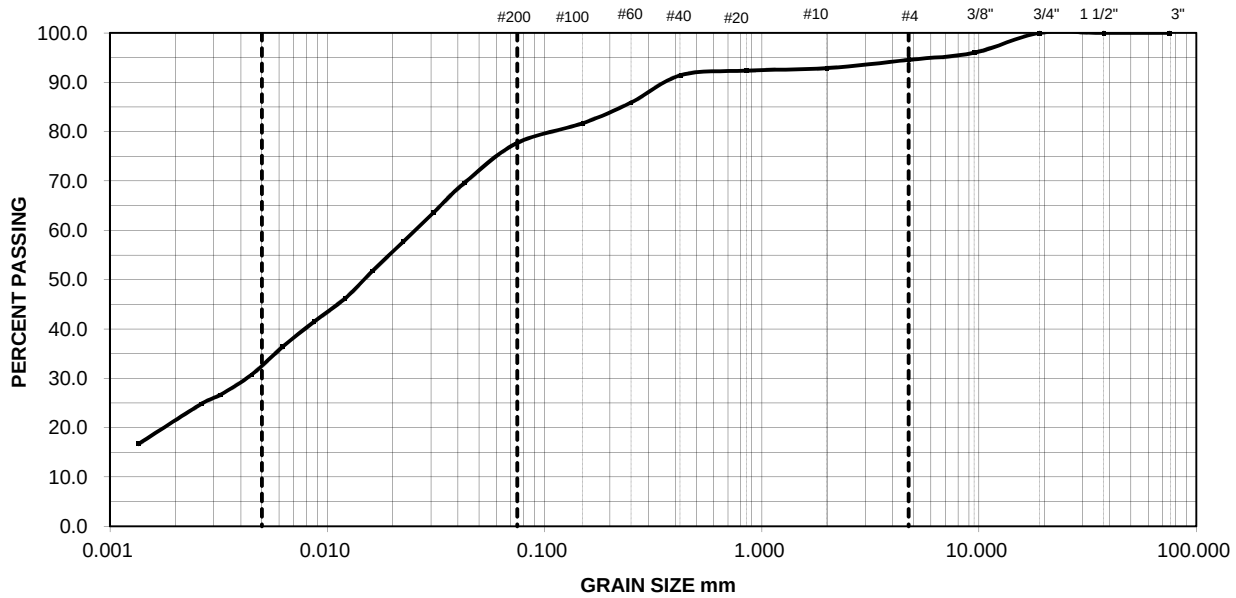
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141336 FIELD NO. S1 HOLE NO. TP15-14 DEPTH (m) 4-5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	28.0	23.5	0.0426	69.5
1.50	37.50	100.0	2	26.0	21.5	0.0309	63.6
0.75	19.00	100.0	4	24.0	19.5	0.0224	57.7
0.375	9.50	96.0	8	22.0	17.5	0.0162	51.8
#4	4.75	94.5	15	20.1	15.6	0.0121	46.2
#10	2.00	92.9	30	18.5	14.0	0.0087	41.4
#20	0.850	92.4	60	16.8	12.3	0.0062	36.4
#40	0.425	91.4	120	14.9	10.4	0.0045	30.8
#60	0.250	85.9	240	13.5	9.0	0.0032	26.6
#100	0.150	81.7	360	12.9	8.4	0.0026	24.9
#200	0.075	77.6	1440	10.0	5.7	0.0014	16.7

% GRAVEL	% SAND	% SILT	% CLAY
5	17	45	33



CLAY	SILT	SAND			GRAVEL	
- .005mm	.005mm - .074mm	FINE	MEDIUM	COARSE	FINE	COARSE

MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

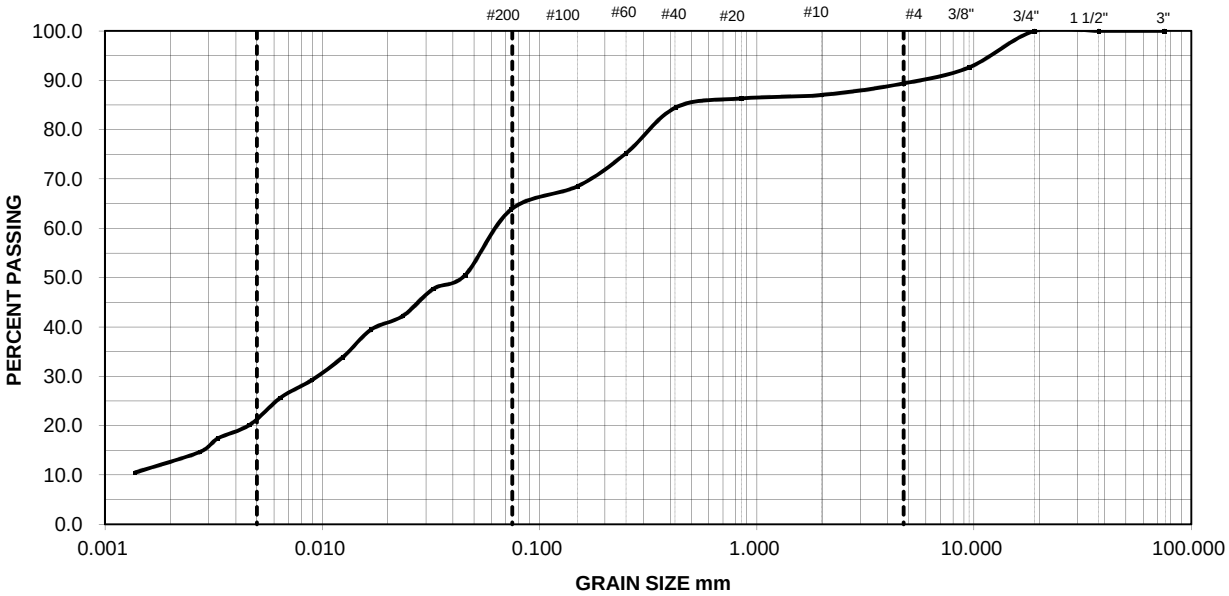
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141337 FIELD NO. S2 HOLE NO. TP15-14 DEPTH (m) 8-9

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	23.0	18.3	0.0454	50.5
1.50	37.50	100.0	2	22.0	17.3	0.0324	47.7
0.75	19.00	100.0	4	20.0	15.3	0.0234	42.2
0.375	9.50	92.6	8	19.0	14.3	0.0168	39.4
#4	4.75	89.4	15	17.0	12.3	0.0125	33.9
#10	2.00	87.0	30	15.3	10.6	0.0090	29.2
#20	0.850	86.3	60	14.0	9.3	0.0064	25.6
#40	0.425	84.5	120	12.0	7.3	0.0046	20.1
#60	0.250	75.2	240	11.0	6.3	0.0033	17.4
#100	0.150	68.5	360	10.0	5.3	0.0027	14.6
#200	0.075	63.8	1440	8.5	3.8	0.0014	10.5

% GRAVEL	% SAND	% SILT	% CLAY
11	26	43	21



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

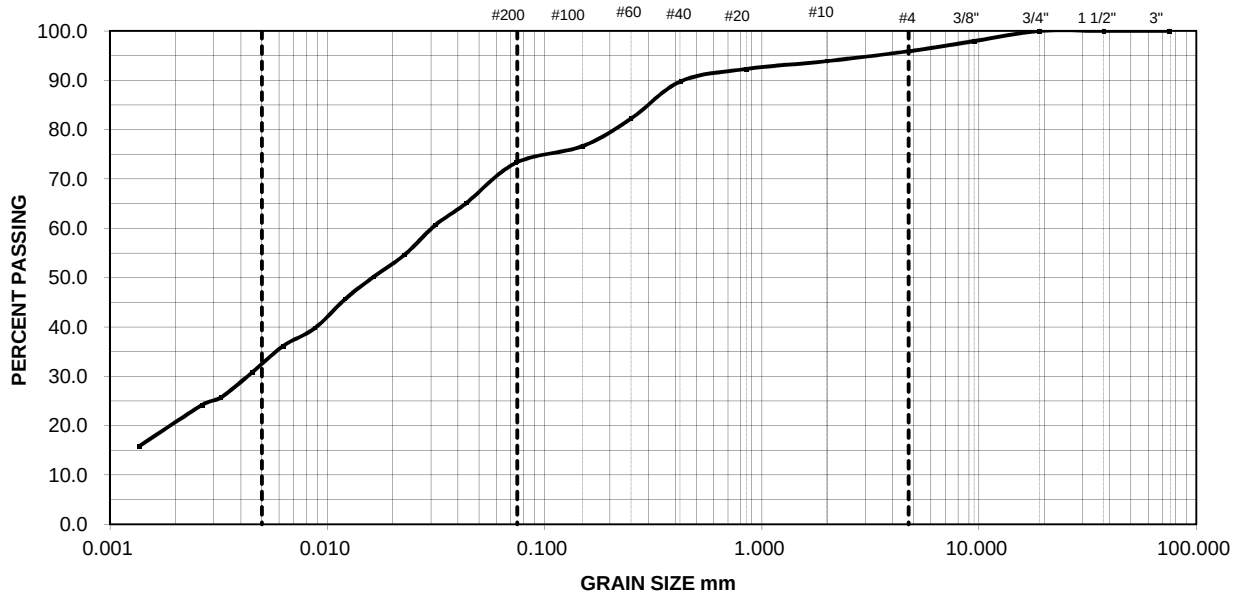
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141338 FIELD NO. S1 HOLE NO. TP15-15 DEPTH (m) 4-5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	26.5	21.8	0.0436	65.1
1.50	37.5	100.0	2	25.0	20.3	0.0314	60.6
0.75	19.0	100.0	4	23.0	18.3	0.0227	54.6
0.375	9.5	97.9	8	21.5	16.8	0.0163	50.2
#4	4.75	95.9	15	20.0	15.3	0.0121	45.7
#10	2.00	93.9	30	18.0	13.3	0.0087	39.7
#20	0.850	92.3	60	16.8	12.1	0.0063	36.1
#40	0.425	89.8	120	15.0	10.3	0.0045	30.8
#60	0.250	82.2	240	13.3	8.6	0.0032	25.7
#100	0.150	76.7	360	12.8	8.1	0.0027	24.2
#200	0.075	73.3	1440	10.0	5.3	0.0014	15.8

% GRAVEL	% SAND	% SILT	% CLAY
4	23	40	33



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

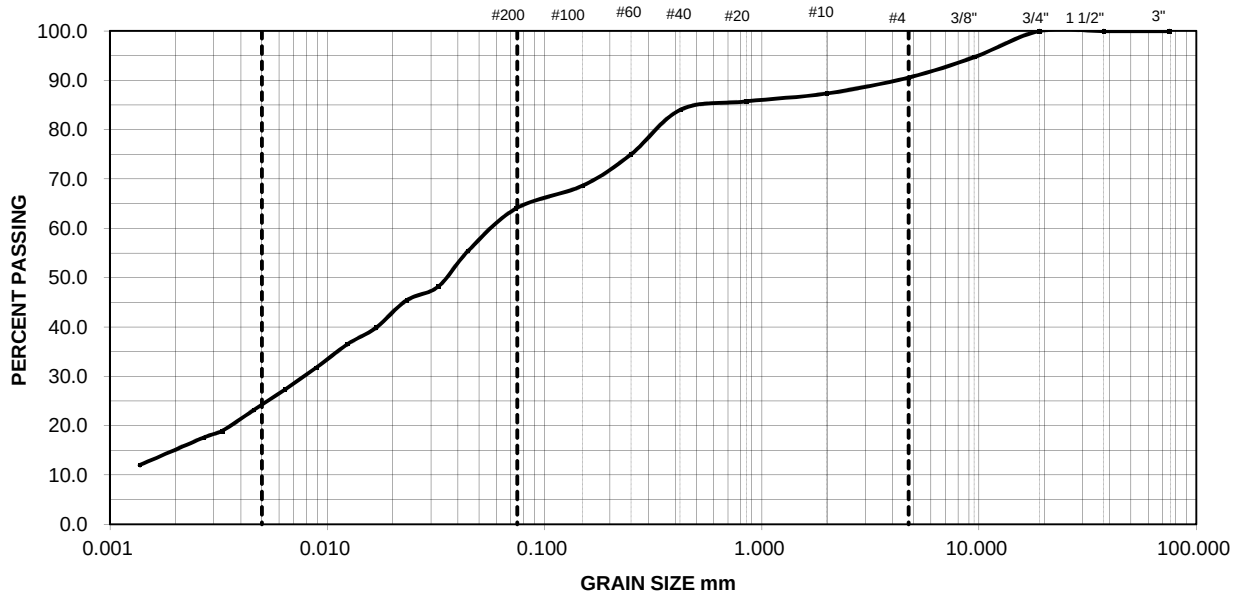
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141339 FIELD NO. S2 HOLE NO. TP15-15 DEPTH (m) 9-10

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	24.6	19.9	0.0446	55.4
1.50	37.50	100.0	2	22.0	17.3	0.0324	48.2
0.75	19.00	100.0	4	21.0	16.3	0.0232	45.4
0.375	9.50	94.7	8	19.0	14.3	0.0168	39.8
#4	4.75	90.6	15	17.8	13.1	0.0124	36.5
#10	2.00	87.3	30	16.1	11.4	0.0089	31.7
#20	0.850	85.7	60	14.5	9.8	0.0064	27.3
#40	0.425	84.1	120	13.0	8.3	0.0046	23.1
#60	0.250	75.0	240	11.5	6.8	0.0033	18.9
#100	0.150	68.6	360	11.0	6.3	0.0027	17.5
#200	0.075	64.0	1440	9.0	4.3	0.0014	12.0

% GRAVEL	% SAND	% SILT	% CLAY
9	27	40	24



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

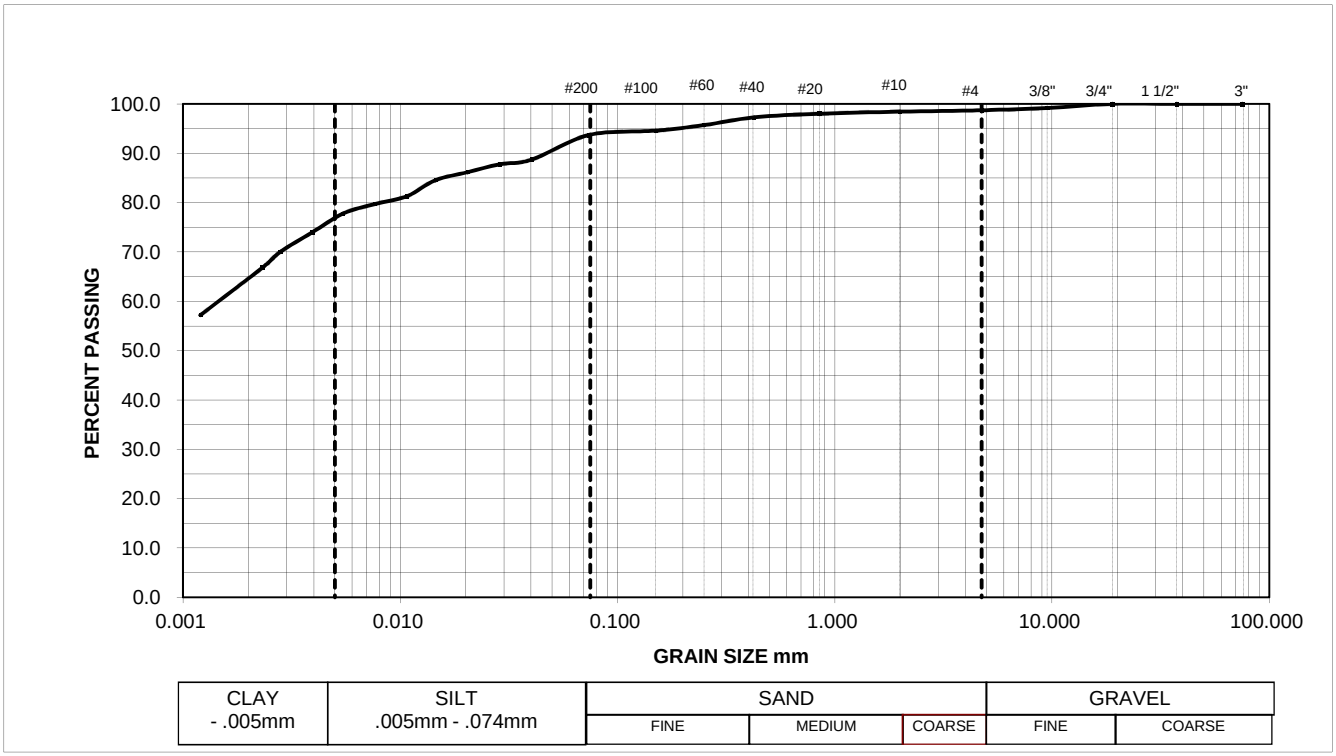
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141340 FIELD NO. S1 HOLE NO. TP15-16 DEPTH (m) 5-6

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	32.3	27.6	0.0403	88.7
1.50	37.50	100.0	2	32.0	27.3	0.0286	87.8
0.75	19.00	100.0	4	31.5	26.8	0.0204	86.2
0.375	9.50	99.2	8	31.0	26.3	0.0145	84.5
#4	4.75	98.7	15	30.0	25.3	0.0108	81.3
#10	2.00	98.4	30	29.5	24.8	0.0077	79.7
#20	0.850	98.0	60	28.9	24.2	0.0055	77.8
#40	0.425	97.3	120	27.7	23.0	0.0039	73.9
#60	0.250	95.7	240	26.5	21.8	0.0028	70.1
#100	0.150	94.6	360	25.5	20.8	0.0023	66.9
#200	0.075	93.7	1440	22.5	17.8	0.0012	57.2

% GRAVEL	% SAND	% SILT	% CLAY
1	5	17	77



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

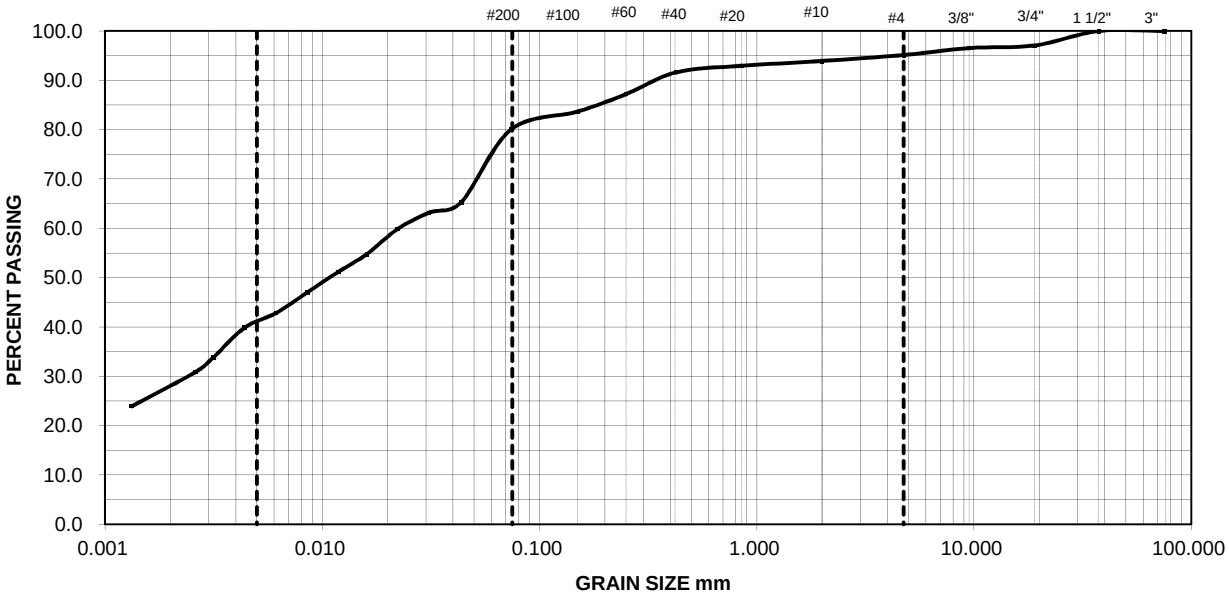
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141341 FIELD NO. S1 HOLE NO. TP15-17 DEPTH (m) 10-11

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	26.5	21.8	0.0436	65.3
1.50	37.50	100.0	2	25.8	21.1	0.0311	63.2
0.75	19.00	97.1	4	24.7	20.0	0.0223	59.9
0.375	9.50	96.5	8	23.0	18.3	0.0160	54.8
#4	4.75	95.1	15	21.8	17.1	0.0119	51.2
#10	2.00	93.9	30	20.4	15.7	0.0085	47.0
#20	0.850	93.0	60	19.0	14.3	0.0061	42.8
#40	0.425	91.6	120	18.0	13.3	0.0044	39.8
#60	0.250	87.2	240	16.0	11.3	0.0032	33.8
#100	0.150	83.7	360	15.0	10.3	0.0026	30.9
#200	0.075	80.1	1440	12.7	8.0	0.0013	24.0

% GRAVEL	% SAND	% SILT	% CLAY
5	15	39	41



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

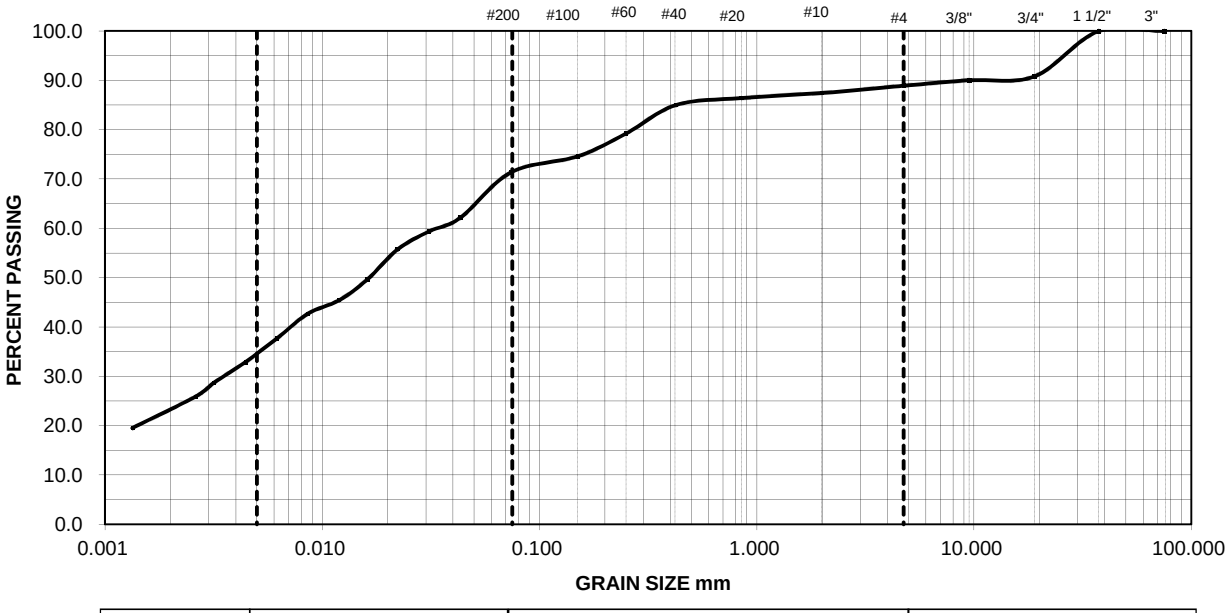
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141342 FIELD NO. S1 HOLE NO. TP15-18 DEPTH (m) 6-7

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	27.0	22.3	0.0433	62.1
1.50	37.50	100.0	2	26.0	21.3	0.0310	59.4
0.75	19.00	90.8	4	24.7	20.0	0.0223	55.7
0.375	9.50	90.0	8	22.5	17.8	0.0161	49.6
#4	4.75	88.9	15	21.0	16.3	0.0120	45.4
#10	2.00	87.4	30	20.0	15.3	0.0086	42.6
#20	0.850	86.4	60	18.2	13.5	0.0062	37.6
#40	0.425	85.0	120	16.5	11.8	0.0044	32.9
#60	0.250	79.2	240	15.0	10.3	0.0032	28.7
#100	0.150	74.6	360	14.0	9.3	0.0026	25.9
#200	0.075	71.4	1440	11.7	7.0	0.0013	19.5

% GRAVEL	% SAND	% SILT	% CLAY
11	18	36	35



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

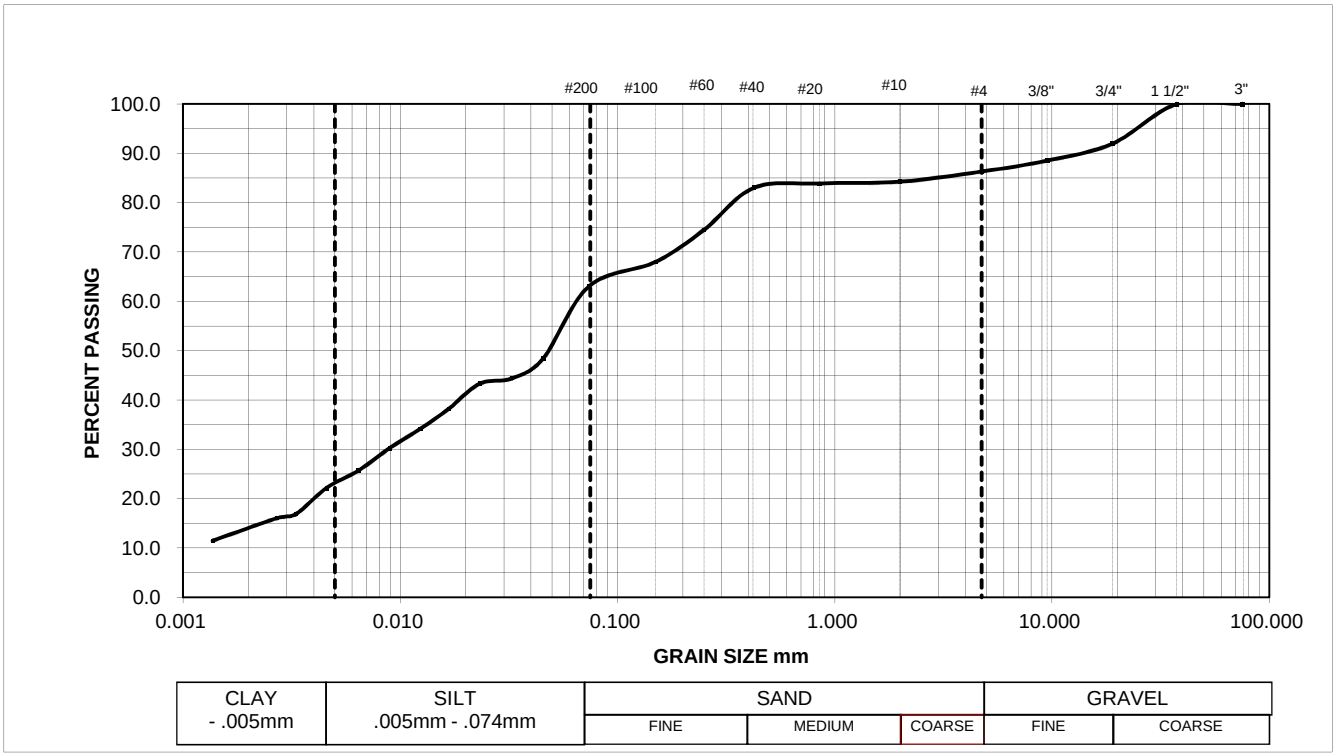
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141343 FIELD NO. S2 HOLE NO. TP15-18 DEPTH (m) 13-14

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	22.8	18.1	0.0455	48.4
1.50	37.50	100.0	2	21.3	16.6	0.0327	44.4
0.75	19.00	92.0	4	20.9	16.2	0.0232	43.3
0.375	9.50	88.5	8	19.0	14.3	0.0168	38.2
#4	4.75	86.3	15	17.5	12.8	0.0124	34.2
#10	2.00	84.3	30	16.0	11.3	0.0089	30.2
#20	0.850	83.9	60	14.3	9.6	0.0064	25.7
#40	0.425	83.0	120	13.0	8.3	0.0046	22.2
#60	0.250	74.5	240	11.0	6.3	0.0033	16.8
#100	0.150	68.0	360	10.7	6.0	0.0027	16.0
#200	0.075	63.1	1440	9.0	4.3	0.0014	11.5

% GRAVEL	% SAND	% SILT	% CLAY
14	23	40	23



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

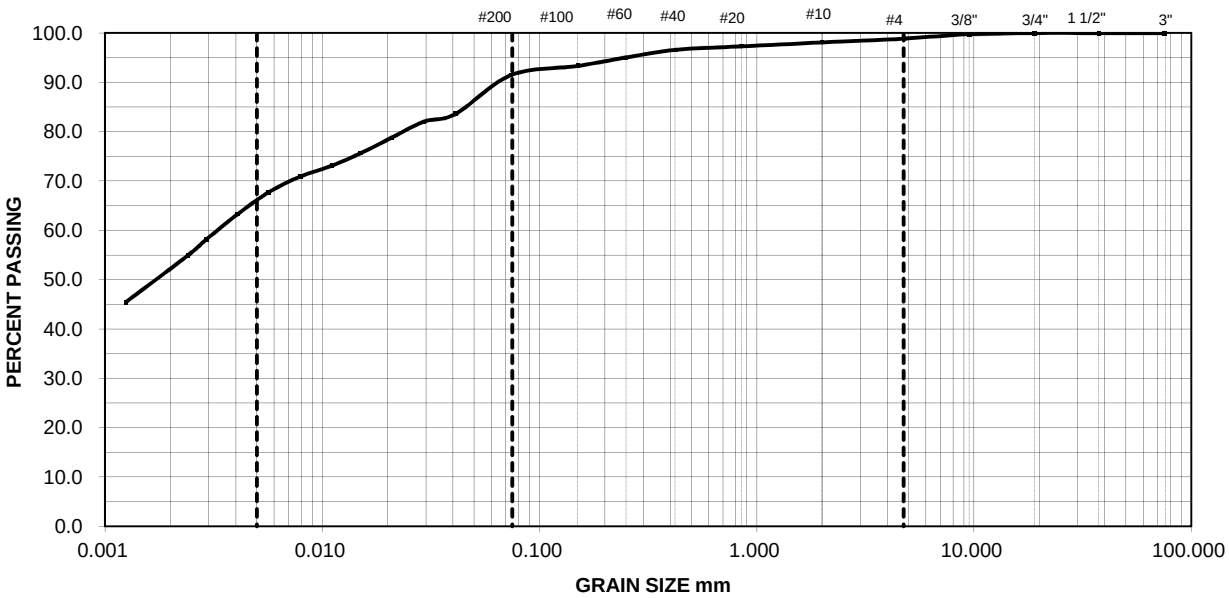
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141344 FIELD NO. S1 HOLE NO. TP15-19 DEPTH (m) 5-6

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	31.0	26.3	0.0411	83.6
1.50	37.50	100.0	2	30.5	25.8	0.0293	82.0
0.75	19.00	100.0	4	29.5	24.8	0.0210	78.8
0.375	9.50	99.8	8	28.5	23.8	0.0150	75.6
#4	4.75	98.9	15	27.7	23.0	0.0111	73.1
#10	2.00	98.1	30	27.0	22.3	0.0079	70.9
#20	0.850	97.3	60	26.0	21.3	0.0057	67.7
#40	0.425	96.6	120	24.6	19.9	0.0041	63.3
#60	0.250	95.0	240	23.0	18.3	0.0029	58.2
#100	0.150	93.3	360	22.0	17.3	0.0024	55.0
#200	0.075	91.5	1440	19.0	14.3	0.0012	45.5

% GRAVEL	% SAND	% SILT	% CLAY
1	7	25	66



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

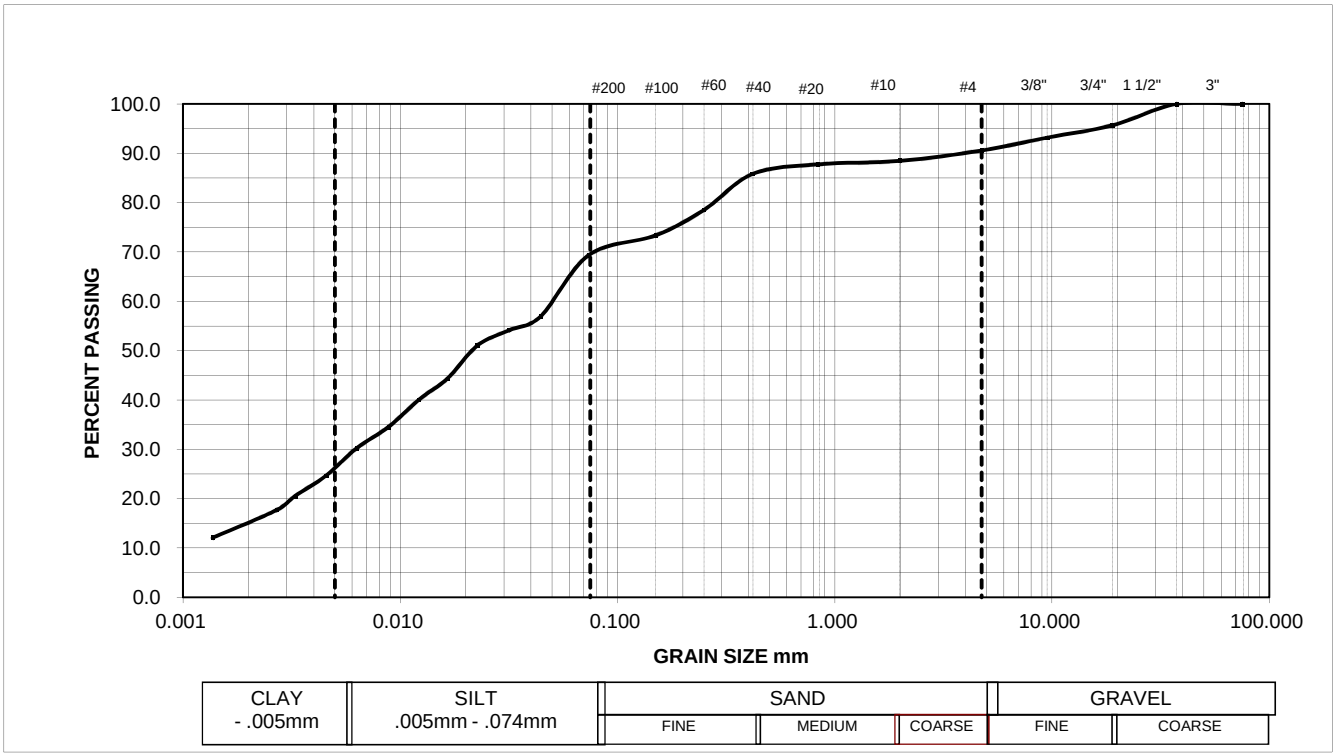
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141345 FIELD NO. S2 HOLE NO. TP15-19 DEPTH (m) 11-12

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	25.0	20.3	0.0443	56.9
1.50	37.5	100.0	2	24.0	19.3	0.0317	54.1
0.75	19.0	95.7	4	22.9	18.2	0.0227	51.1
0.375	9.5	93.2	8	20.5	15.8	0.0165	44.3
#4	4.75	90.5	15	19.0	14.3	0.0122	40.1
#10	2.00	88.5	30	17.0	12.3	0.0088	34.5
#20	0.850	87.8	60	15.5	10.8	0.0063	30.3
#40	0.425	85.8	120	13.5	8.8	0.0046	24.7
#60	0.250	78.5	240	12.0	7.3	0.0033	20.5
#100	0.150	73.4	360	11.0	6.3	0.0027	17.7
#200	0.075	69.4	1440	9.0	4.3	0.0014	12.1

% GRAVEL	% SAND	% SILT	% CLAY
9	21	42	27



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

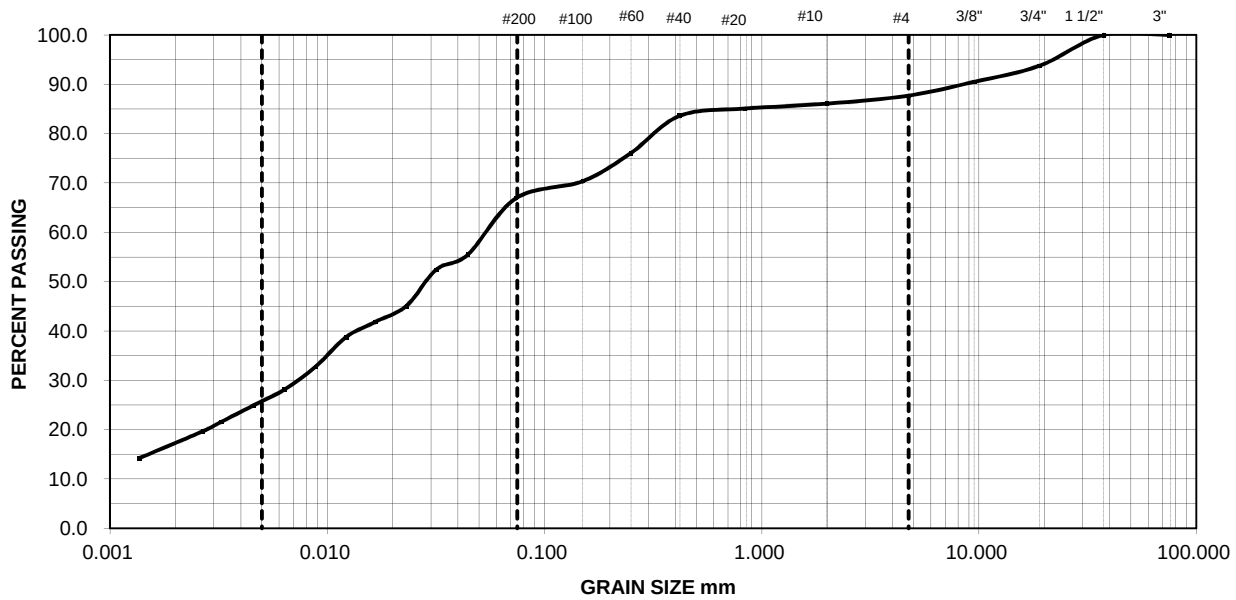
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141347 FIELD NO. S1 HOLE NO. TP15-21 DEPTH (m) 5-6

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	25.0	20.3	0.0443	55.5
1.50	37.5	100.0	2	23.9	19.2	0.0318	52.4
0.75	19.0	93.7	4	21.2	16.5	0.0231	45.1
0.375	9.5	90.5	8	20.0	15.3	0.0166	41.8
#4	4.75	87.7	15	18.9	14.2	0.0122	38.8
#10	2.00	86.1	30	16.7	12.0	0.0089	32.8
#20	0.850	85.1	60	15.0	10.3	0.0064	28.1
#40	0.425	83.6	120	13.8	9.1	0.0046	24.9
#60	0.250	76.1	240	12.6	7.9	0.0033	21.6
#100	0.150	70.3	360	11.9	7.2	0.0027	19.7
#200	0.075	66.9	1440	9.9	5.2	0.0014	14.2

% GRAVEL	% SAND	% SILT	% CLAY
12	21	42	25



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

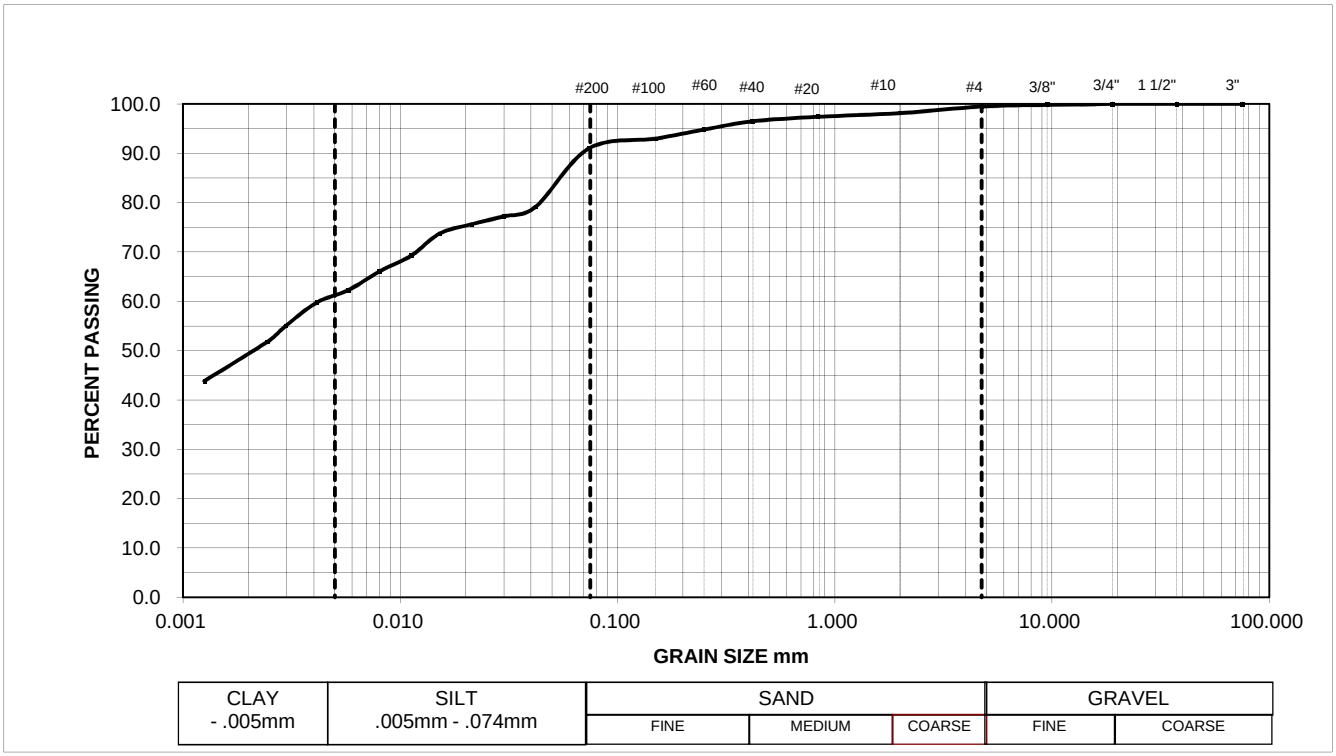
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141348 FIELD NO. S2 HOLE NO. TP15-21 DEPTH (m) 10-11

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	29.6	24.9	0.0419	79.1
1.50	37.5	100.0	2	29.0	24.3	0.0298	77.2
0.75	19.0	100.0	4	28.5	23.8	0.0212	75.6
0.375	9.5	99.8	8	27.9	23.2	0.0151	73.7
#4	4.75	99.5	15	26.5	21.8	0.0112	69.3
#10	2.00	98.1	30	25.5	20.8	0.0080	66.1
#20	0.850	97.4	60	24.3	19.6	0.0058	62.3
#40	0.425	96.5	120	23.5	18.8	0.0041	59.7
#60	0.250	94.8	240	22.0	17.3	0.0030	55.0
#100	0.150	93.0	360	21.0	16.3	0.0024	51.8
#200	0.075	91.0	1440	18.5	13.8	0.0013	43.8

% GRAVEL	% SAND	% SILT	% CLAY
1	8	30	61



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

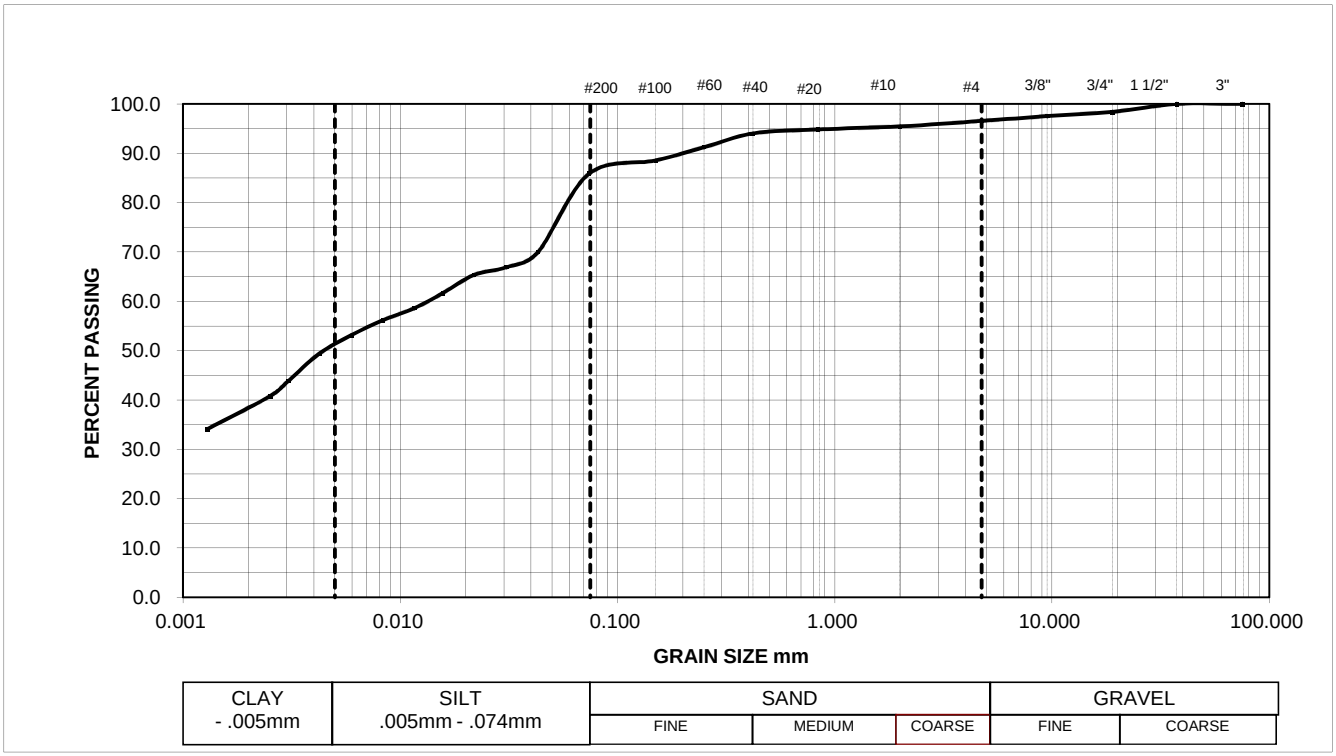
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141349 FIELD NO. S1 HOLE NO. TP15-22 DEPTH (m) 2-3

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	27.5	22.8	0.0430	70.0
1.50	37.5	100.0	2	26.5	21.8	0.0308	66.9
0.75	19.0	98.4	4	26.0	21.3	0.0219	65.4
0.375	9.5	97.5	8	24.8	20.1	0.0157	61.7
#4	4.75	96.5	15	23.8	19.1	0.0116	58.6
#10	2.00	95.4	30	23.0	18.3	0.0083	56.2
#20	0.850	94.8	60	22.0	17.3	0.0059	53.1
#40	0.425	94.0	120	20.8	16.1	0.0042	49.4
#60	0.250	91.2	240	19.0	14.3	0.0031	43.9
#100	0.150	88.6	360	18.0	13.3	0.0025	40.8
#200	0.075	85.9	1440	15.8	11.1	0.0013	34.1

% GRAVEL	% SAND	% SILT	% CLAY
3	11	34	52



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

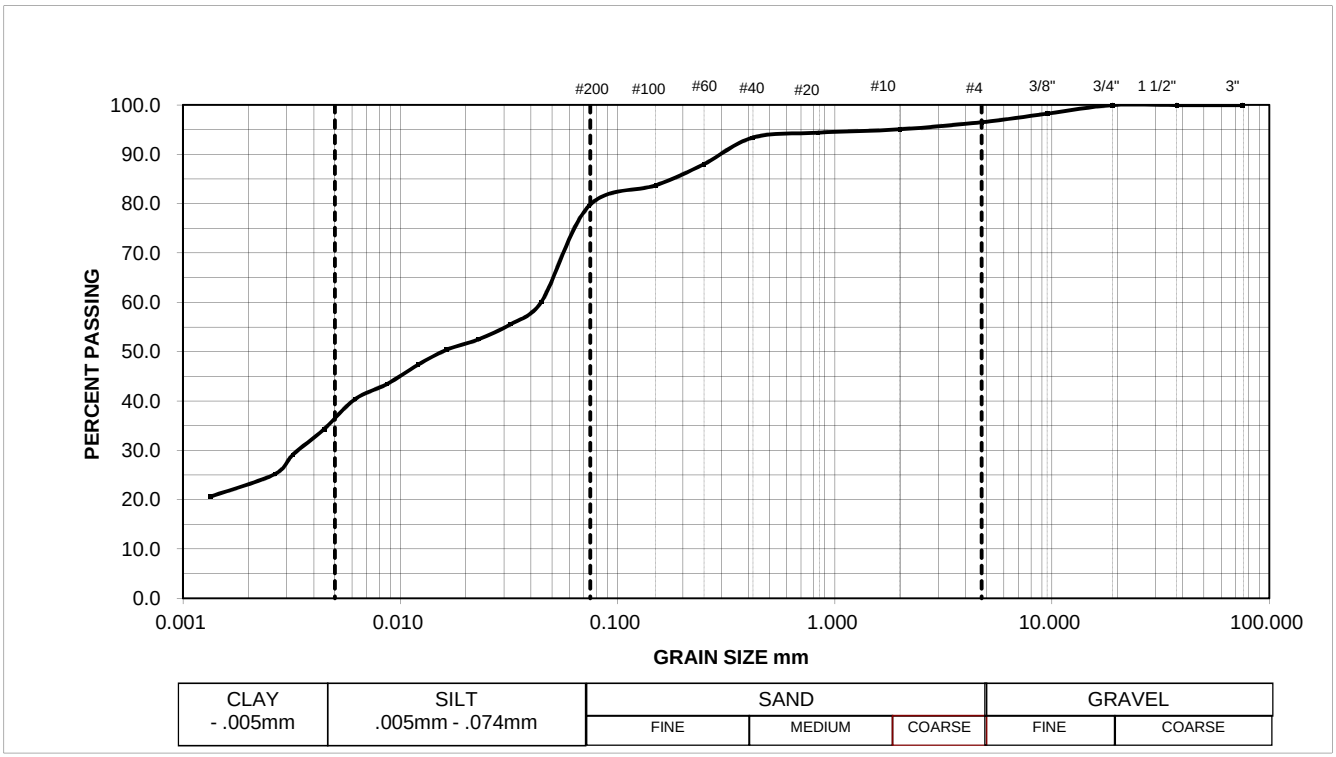
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141350 FIELD NO. S2 HOLE NO. TP15-22 DEPTH (m) 11-12

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	24.5	19.8	0.0446	60.1
1.50	37.5	100.0	2	23.0	18.3	0.0321	55.5
0.75	19.0	100.0	4	22.0	17.3	0.0229	52.5
0.375	9.5	98.2	8	21.3	16.6	0.0163	50.4
#4	4.75	96.5	15	20.3	15.6	0.0121	47.4
#10	2.00	95.1	30	19.0	14.3	0.0087	43.4
#20	0.850	94.4	60	18.0	13.3	0.0062	40.4
#40	0.425	93.4	120	16.0	11.3	0.0045	34.3
#60	0.250	88.0	240	14.3	9.6	0.0032	29.1
#100	0.150	83.7	360	13.0	8.3	0.0026	25.2
#200	0.075	79.6	1440	11.5	6.8	0.0013	20.6

% GRAVEL	% SAND	% SILT	% CLAY
3	17	44	36



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

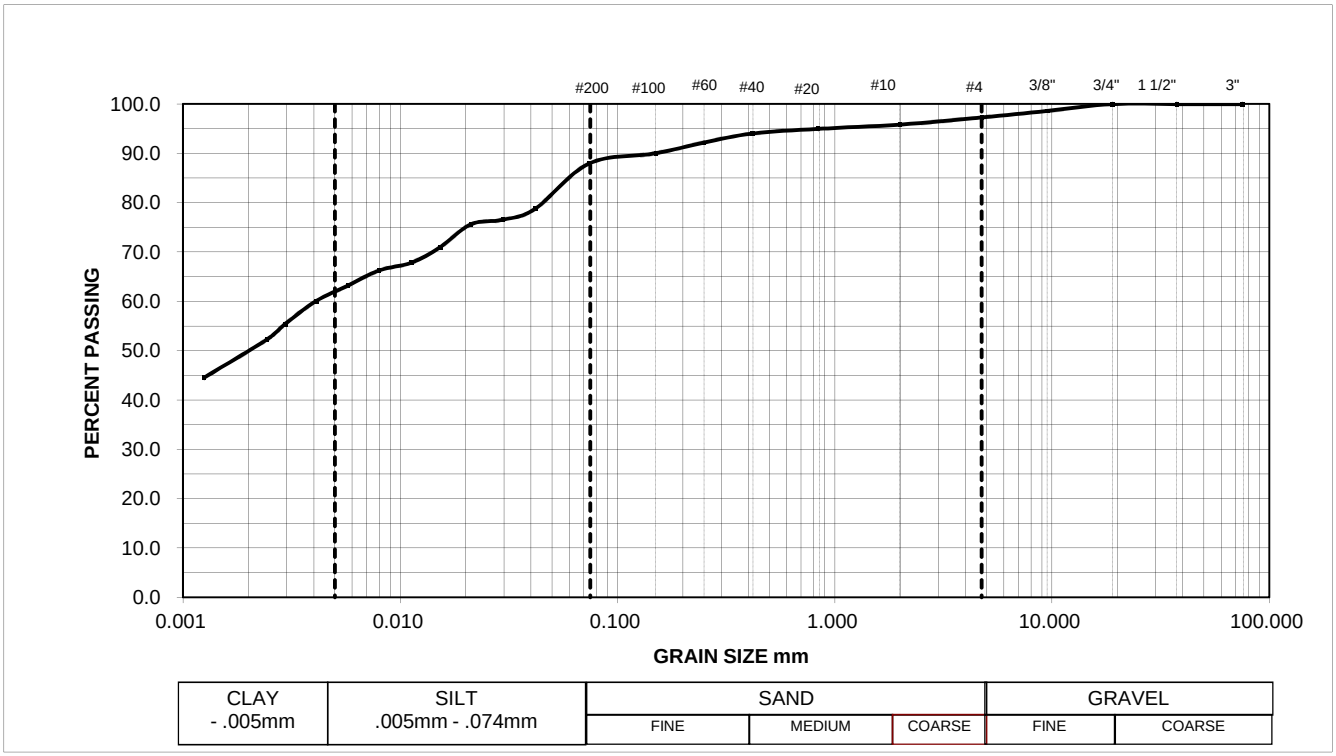
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141351 FIELD NO. S1 HOLE NO. TP15-23 DEPTH (m) 4.0-4.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	30.0	25.3	0.0416	78.7
1.50	37.5	100.0	2	29.3	24.6	0.0297	76.5
0.75	19.0	100.0	4	29.0	24.3	0.0211	75.6
0.375	9.5	98.6	8	27.5	22.8	0.0152	70.9
#4	4.75	97.3	15	26.5	21.8	0.0112	67.8
#10	2.00	95.8	30	26.0	21.3	0.0080	66.3
#20	0.850	95.0	60	25.0	20.3	0.0057	63.2
#40	0.425	94.0	120	24.0	19.3	0.0041	60.1
#60	0.250	92.2	240	22.5	17.8	0.0029	55.4
#100	0.150	90.0	360	21.5	16.8	0.0024	52.3
#200	0.075	88.0	1440	19.0	14.3	0.0012	44.5

% GRAVEL	% SAND	% SILT	% CLAY
3	9	26	62



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

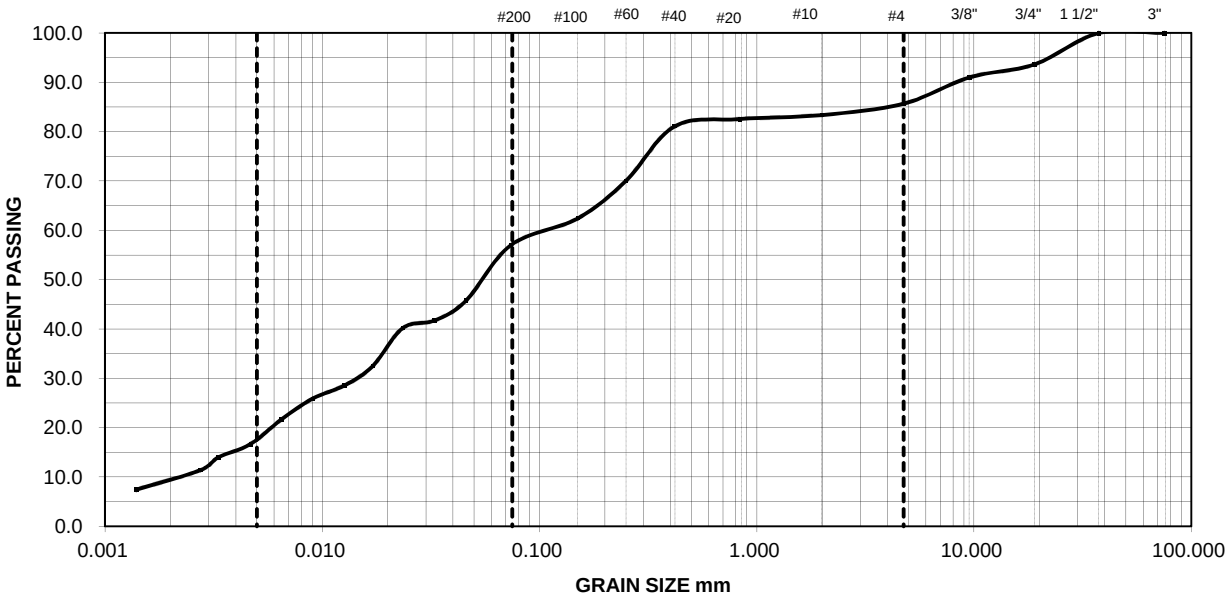
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141352 FIELD NO. S2 HOLE NO. TP15-23 DEPTH (m) 6-7

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	22.0	17.3	0.0459	45.7
1.50	37.5	100.0	2	20.5	15.8	0.0330	41.8
0.75	19.0	93.6	4	19.9	15.2	0.0235	40.2
0.375	9.5	91.0	8	17.0	12.3	0.0171	32.5
#4	4.75	85.7	15	15.5	10.8	0.0127	28.6
#10	2.00	83.4	30	14.5	9.8	0.0090	25.9
#20	0.850	82.6	60	12.9	8.2	0.0065	21.7
#40	0.425	81.1	120	11.0	6.3	0.0047	16.7
#60	0.250	70.0	240	10.0	5.3	0.0033	14.0
#100	0.150	62.4	360	9.0	4.3	0.0027	11.4
#200	0.075	57.0	1440	7.5	2.8	0.0014	7.4

% GRAVEL	% SAND	% SILT	% CLAY
14	29	40	17



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

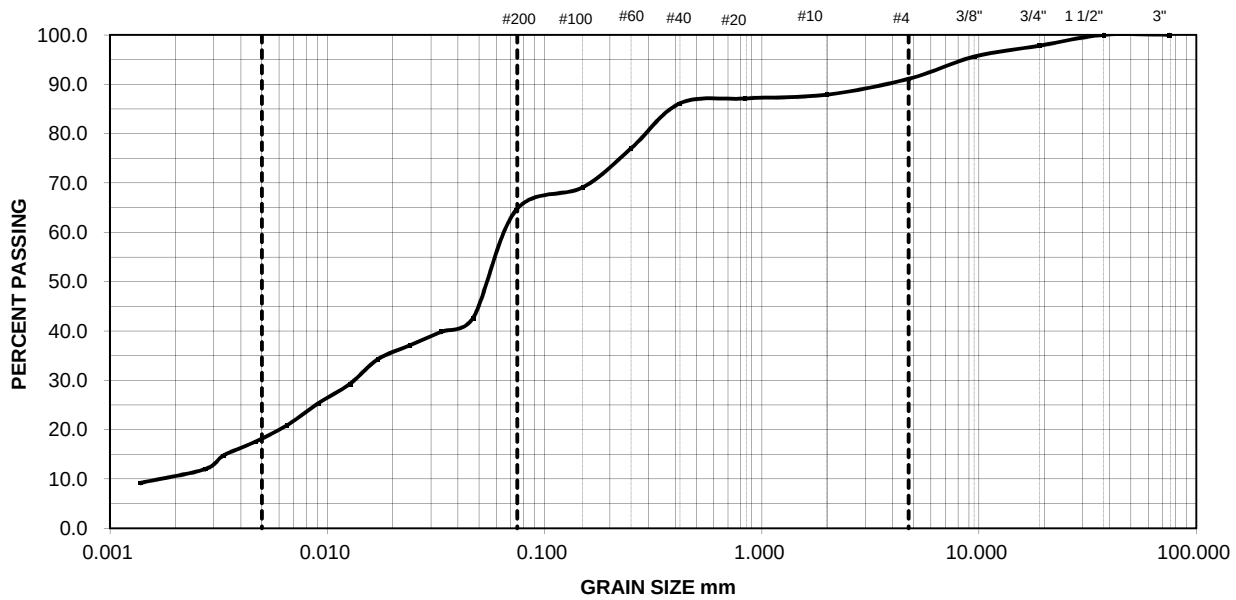
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141353 FIELD NO. S1 HOLE NO. TP15-24 DEPTH (m) 3-4

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	20.0	15.3	0.0469	42.6
1.50	37.5	100.0	2	19.0	14.3	0.0335	39.8
0.75	19.0	97.8	4	18.0	13.3	0.0239	37.0
0.375	9.5	95.6	8	17.0	12.3	0.0171	34.2
#4	4.75	91.1	15	15.2	10.5	0.0127	29.2
#10	2.00	87.9	30	13.8	9.1	0.0091	25.3
#20	0.850	87.1	60	12.2	7.5	0.0065	20.9
#40	0.425	86.1	120	11.0	6.3	0.0047	17.5
#60	0.250	77.0	240	10.0	5.3	0.0033	14.8
#100	0.150	69.1	360	9.0	4.3	0.0027	12.0
#200	0.075	64.5	1440	8.0	3.3	0.0014	9.2

% GRAVEL	% SAND	% SILT	% CLAY
9	27	46	18



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

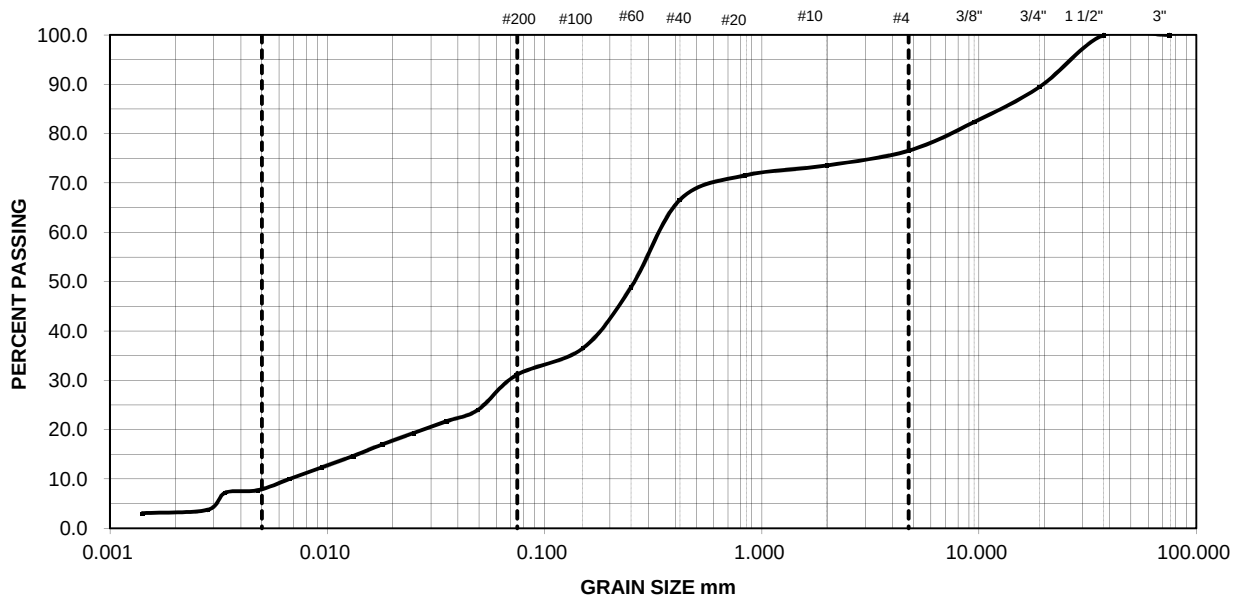
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141354 FIELD NO. S2 HOLE NO. TP15-24 DEPTH (m) 9-10

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	15.0	10.3	0.0493	24.0
1.50	37.5	100.0	2	14.0	9.3	0.0352	21.7
0.75	19.0	89.5	4	13.0	8.3	0.0251	19.3
0.375	9.5	82.3	8	12.0	7.3	0.0179	17.0
#4	4.75	76.5	15	11.0	6.3	0.0132	14.7
#10	2.00	73.5	30	10.0	5.3	0.0094	12.3
#20	0.850	71.5	60	9.0	4.3	0.0067	10.0
#40	0.425	66.6	120	8.0	3.3	0.0048	7.7
#60	0.250	48.8	240	7.8	3.1	0.0034	7.2
#100	0.150	36.5	360	6.3	1.6	0.0028	3.7
#200	0.075	31.0	1440	6.0	1.3	0.0014	3.0

% GRAVEL	% SAND	% SILT	% CLAY
23	46	23	8



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141355 FIELD NO. S1 HOLE NO. TP15-25 DEPTH (m) 4-5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	90.3	1	18.0	13.5	0.0478	26.8
1.50	37.5	82.9	2	17.0	12.5	0.0341	24.8
0.75	19.0	79.4	4	16.0	11.5	0.0244	22.8
0.375	9.5	71.9	8	14.3	9.8	0.0175	19.5
#4	4.75	66.6	15	13.0	8.5	0.0129	16.9
#10	2.00	62.6	30	11.1	6.6	0.0093	13.1
#20	0.850	59.4	60	9.6	5.1	0.0067	10.1
#40	0.425	55.0	120	8.4	3.9	0.0048	7.7
#60	0.250	40.0	240	7.4	2.9	0.0034	5.8
#100	0.150	32.0	360	6.5	2.0	0.0028	4.0
#200	0.075	27.5	1440	5.1	0.8	0.0014	1.5

% GRAVEL	% SAND	% SILT	% CLAY
33	39	19	8



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

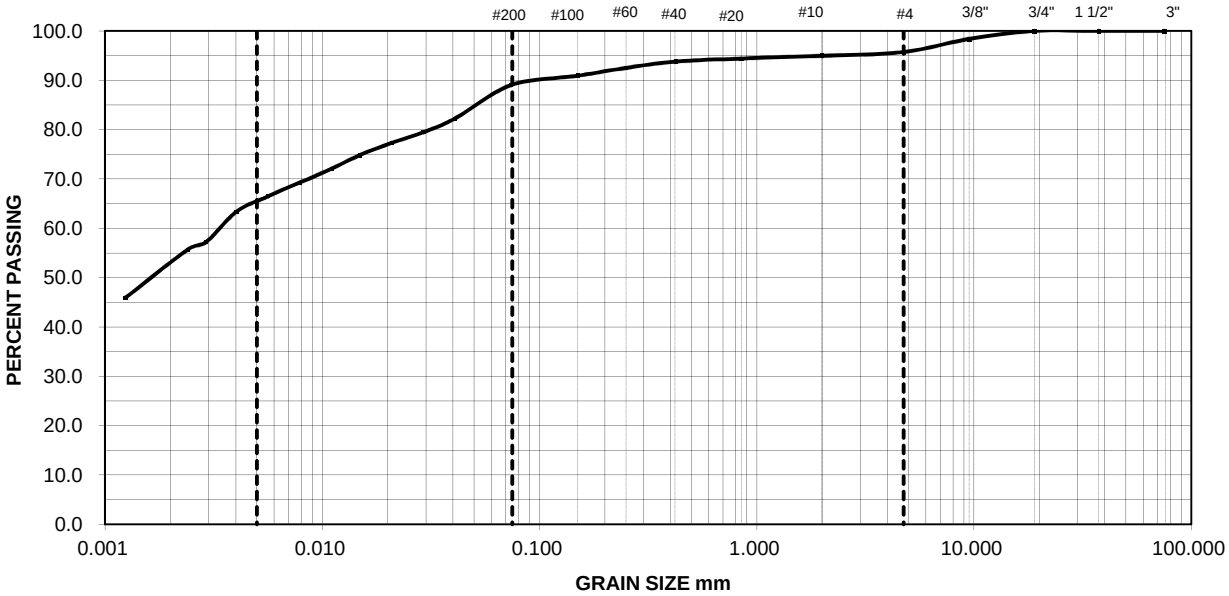
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141356 FIELD NO. S1 HOLE NO. TP15-26 DEPTH (m) 4-5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	31.1	26.6	0.0409	82.3
1.50	37.50	100.0	2	30.2	25.7	0.0293	79.5
0.75	19.00	100.0	4	29.5	25.0	0.0209	77.3
0.375	9.50	98.4	8	28.7	24.2	0.0149	74.9
#4	4.75	95.7	15	27.8	23.3	0.0110	72.1
#10	2.00	94.9	30	26.9	22.4	0.0079	69.3
#20	0.850	94.4	60	26.0	21.5	0.0056	66.5
#40	0.425	93.8	120	25.0	20.5	0.0040	63.4
#60	0.250	92.5	240	23.0	18.5	0.0029	57.2
#100	0.150	90.9	360	22.5	18.0	0.0024	55.7
#200	0.075	89.0	1440	19.2	14.9	0.0012	45.9

% GRAVEL	% SAND	% SILT	% CLAY
4	7	23	66



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

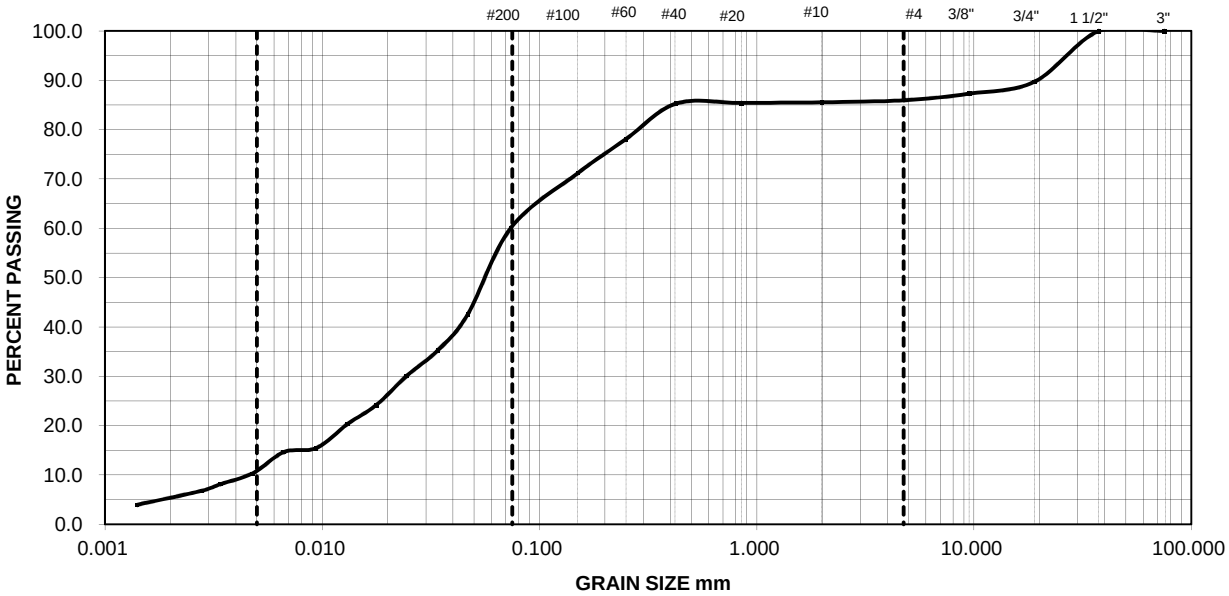
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 3 - Willow Point** **Checked By:** **GK**

LAB.NO. WGT141357 FIELD NO. S2 HOLE NO. TP15-26 DEPTH (m) 14-15

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	20.2	15.7	0.0467	42.5
1.50	37.50	100.0	2	17.5	13.0	0.0339	35.2
0.75	19.00	89.7	4	15.6	11.1	0.0245	30.1
0.375	9.50	87.3	8	13.4	8.9	0.0177	24.1
#4	4.75	86.0	15	12.0	7.5	0.0131	20.3
#10	2.00	85.5	30	10.2	5.7	0.0094	15.4
#20	0.850	85.4	60	9.9	5.4	0.0067	14.6
#40	0.425	85.3	120	8.3	3.8	0.0048	10.3
#60	0.250	78.1	240	7.5	3.0	0.0034	8.1
#100	0.150	71.2	360	7.0	2.5	0.0028	6.8
#200	0.075	60.1	1440	5.8	1.5	0.0014	3.9

% GRAVEL	% SAND	% SILT	% CLAY
14	26	49	11



Manitoba Infrastructure and Transportation
Materials Engineering Branch - Central Lab

SIEVE OR SCREEN ANALYSIS OF FINE AND COARSE AGGREGATES
ASTM C 117, C 136

PROJECT: Lake St. Martin Channel
LOCATION : Reach 3 - Willow Point

Technician: MJ
Checked By: GK

LAB. NO.: WGT141329 **FIELD NO:** S1 **HOLE NO.:** TP15-10 **DEPTH(m):** 4-5

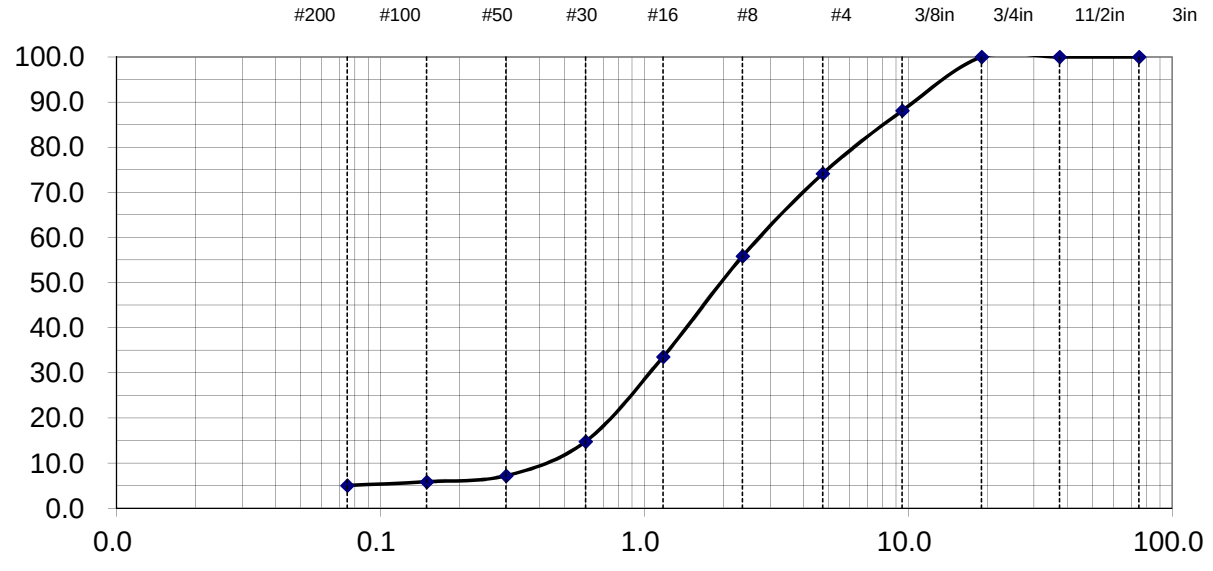
Sieve U.S standard	Size m.m.	Mass Retained Basis Total Sample	Retained (%)	Cumulative Retained (%)	Passing (%)
					100.0
3.00	75.0				100.0
1.50	37.5				100.0
.750	19.0				100.0
.375	9.5	64.3	11.9	11.9	88.1
#4	4.75	75.4	14.0	25.8	74.2
#8	2.36	98.9	18.3	44.1	55.9
#16	1.18	120.6	22.3	66.5	33.5
#30	0.600	101.5	18.8	85.2	14.8
#50	0.300	41.0	7.6	92.8	7.2
#100	0.150	7.2	1.3	94.2	5.8
#200	0.075	4.5	0.8	95.0	5.0
Pan		0.8	0.1	95.1	
Total		514.2	95.1		

Mass of Sample Before Washing	540.5
Mass of Sample After Washing	514.3
Mass Passing (wash) 75 µm	26.2
Mass Passing (sieve) 75 µm	0.8
Total Mass Passing 75 µm	27.0

D10= 0.43 D30= 1.20 D60= 2.80
Cu= 6.5 Cc= 1.2

% Pass 75 µm =	5.0	Unified
% Sand =	69.1	Classification
% Gravel =	25.8	
F.M. =	4.21	

U.S. Standard Sieve Series ASTM E 11



SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (ft)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m³	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L / D_{10}	W_P / C_C	I_P / C_U	GRAIN SIZE GRAVEL %	SAND %	P_{200} or SILT % / CLAY %	STRENGTH q_u K.S.F. / kPa	POCKET PENETROMETER T.S.F.
S1	WGT14 1178	CL-ML, Silty Clay, +wp, sandy, some gravel, very soft, very moist, light brown										
TH15-02	6.5-7.5											
S2	WGT14 1179	ML, Silt, sandy, some clay, some gravel, loose, moist, light brown										
TH15-02	9-10											
S3	WGT14 1180	ML, Silt, sandy, some clay, very soft, wet, light brown, trace gravel										
TH15-02	10-10.5											
S4	WGT14 1181	CL-ML, Silty Clay, sandy, loose, moist, light brown										
TH15-02	15-15.5											
S5	WGT14 1182	ML, Silt, sandy, some clay, some gravel, firm, moist, light brown										
TH15-02	20-20.5											
S6	WGT14 1183	ML, Silt, sandy, some clay, some gravel, hard/loose, moist, light brown										
TH15-02	25-26.5											
S7	WGT14 1184	SM, Sand, gravelly, silty, some clay, soft, very moist, light brown										
TH15-02	30-31.5											
S8	WGT14 1185	CL-ML, Silty Clay, -wp, sandy, clayey, some gravel, hard, moist, light brown										
TH15-02	35-36.5											
S9	WGT14 1186	No Classification										
TH15-02	39-40.7											
S10	WGT14 1187	CL-ML, Silty Clay, -wp, gravelly, some sand, firm-hard, moist, light brown										
TH15-02	40.75-45.75											
S11	WGT14 1188	No Classification										
TH15-02	45.75-50.75											
R1	WGT14 1189	No Classification										
TH15-02	50.75-55.75											
R2	WGT14 1190	No Classification										
TH15-02	55.75-60.75											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Lake St Martin Channel
LOCATION: Reach 3 Inlet - East Side
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-03-25

SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (ft)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m^3	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L / D_{10}	W_P / C_C	I_P / C_U	GRAIN SIZE GRAVEL %	SAND %	P_{200} or SILT % / % CLAY	STRENGTH q_u K.S.F. / kPa	POCKET PENETROMETER T.S.F.
S1	WGT14 1191	ML, Silt, sandy, some clay, soft, very moist, light brown, trace gravel										
TH15-03	3-5											
S2	WGT14 1192	OL, Organic Clay, +wp, some silt, organics, very soft, very moist, black, trace sand, trace gravel										
TH15-03	6-8											
S3	WGT14 1193	CL-ML, Silty Clay, +wp, sandy, some gravel, very soft, very moist, grey, trace organics										
TH15-03	8-10											
S4	WGT14 1194	ML, Silt, sandy, some clay, loose, moist, light brown, trace gravel										
TH15-03	15-16.5											
S5	WGT14 1195	No Classification										
TH15-03	15-20											
R1	WGT14 1196	No Classification										
TH15-03	20.5-25.5											
R2	WGT14 1197	No Classification										
TH15-03	25.5-30.5											
S1	WGT14 1198	CI, Clay, +wp, silty, some sand, soft, moist, grey, trace gravel, trace silt pockets										
TH15-04	1.5-2.5											
S2	WGT14 1199	CI, Clay, +wp, silty, some sand, firm-soft, moist, grey, trace gravel, trace silt pockets										
TH15-04	4-5											
S3	WGT14 1200	PT, Peat, highly organic, roots, moss, very soft, very moist, black, trace silt										
TH15-04	5-6.25											
S4	WGT14 1201	CI, Clay, +wp, silty, sandy, very soft, moist, grey, trace gravel, trace organics										
TH15-04	6.5-7.5											
S5	WGT14 1202	CH, Clay, +wp, silty, some sand, firm, moist, grey, trace gravel, trace organics										
TH15-04	9-10											
S6	WGT14 1203	ML, silt, sandy, some clay, loose, moist, light brown, trace gravel										
TH15-04	11-13											
S7	WGT14 1204	ML, Silt, sandy, some clay, loose, moist, light brown, trace gravel										
TH15-04	15-15.75											
S8	WGT14 1205	No Classification										
TH15-04	25.75-30.75											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Lake St Martin Channel
LOCATION: Reach 3 - Dike
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-03-25

SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (ft)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m^3	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L / D_{10}	W_P / C_C	I_P / C_U	GRAIN SIZE GRAVEL %	SAND %	P_{200} or SILT % / CLAY %	STRENGTH q_u K.S.F. / kPa	POCKET PENETROMETER T.S.F.
S9	WGT14 1206	No Classification										
TH15-04	30.75-35.75											
S10	WGT14 1207	No Classification										
TH15-04	35.75-40.75											
R1	WGT14 1208	No Classification										
TH15-04	40.75-45.75											
R2	WGT14 1209	No Classification										
TH15-04	45.75-50.75											
S1	WGT14 1210	CI, Clay, +wp, silty, sandy, loose/soft, moist, grey, trace gravel, trace silt pockets										
TH15-05	1.5-2.5											
S2	WGT14 1211	PT, Peat, highly organic, roots, moss, loose/soft, moist, black, trace silt, trace sand										
TH15-05	5-7											
S3	WGT14 1212	CH, Clay, +wp, some silt, some sand, hard, moist, grey, trace silt pockets, trace gravel, trace organics										
TH15-05	9-10											
S4	WGT14 1213	CL, Clay, +wp, silty, sandy, some gravel, loose/crumbly, moist, light brown,										
TH15-05	12-13											
S5	WGT14 1214	CL-ML, Silty Clay, -wp, some sand, some gravel, loose/crumbly, moist, light brown										
TH15-05	15-16.5											
S6	WGT14 1215	CL-ML, Silty Clay, sandy, loose, dry, light brown, trace gravel										
TH15-05	19-20											
S7	WGT14 1216	CL-ML, Silty Clay, -wp, some sand, some gravel, very hard, moist, light brown										
TH15-05	20-21.5											
R1	WGT14 1217	No Classification										
TH15-05	23.4-24.7											
R2	WGT14 1218	No Classification										
TH15-05	24.7-29.7											
R3	WGT14 1219	No Classification										
TH15-05	29.7-34.7											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Lake St Martin Channel
LOCATION: Reach 3 - Dike
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-03-25

SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
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FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (ft)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m³	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L / D_{10}	W_P / C_C	I_P / C_U	GRAIN SIZE GRAVEL %	SAND %	P_{200} or SILT % / % CLAY	STRENGTH q_u K.S.F. / kPa	POCKET PENETROMETER T.S.F.
S1	WGT14 1274	ML, Silt, sandy, some clay, some gravel, very soft, very moist, light grey, trace organics										
TH15-13	3.5-4.5											
S2	WGT14 1275	CL-ML, Silty Clay, +wp, sandy, some gravel, firm, moist, light grey, trace organics										
TH15-13	6.5-7.5											
R1	WGT14 1276	No Classification										
TH15-13	42292.0											
R2	WGT14 1277	No Classification										
TH15-13	15-20											
R3	WGT14 1278	No Classification										
TH15-13	20-25											
R4	WGT14 1279	No Classification										
TH15-13	25-30											

SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
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FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (ft)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m^3	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L / D_{10}	W_P / C_C	I_P / C_U	GRAIN SIZE GRAVEL %	SAND %	P_{200} or SILT % / % CLAY	STRENGTH q_u K.S.F. / kPa	POCKET PENETROMETER T.S.F.
S1	WGT14 1315	CH, Clay, +wp, some silt, firm, moist, brown/grey, trace sand, trace gravel, trace organics										
TP15-01	7-8											
S2	WGT14 1316	CL, Clay, -wp, silty, some sand, some gravel, hard, moist, light brown										
TP15-01	10-11											
S1	WGT14 1317	CH, clay, +wp, silty, some sand, firm, moist, grey, trace gravel, trace silt lenses										
TP15-02	6-7											
S2	WGT14 1318	CL, Clay, +wp, silty, some sand, some gravel, very soft, very moist, light grey										
TP15-02	9-10											
S1	WGT14 1319	CL, Clay, +wp, silty, some sand, some gravel, firm, moist, light grey, trace organics										
TP15-03	4-5											
S1	WGT14 1320	CH, Clay, -wp, silty, some sand, hard, moist, grey, trace gravel, trace silt pockets										
TP15-04	4-5											
S2	WGT14 1321	CI, Clay, -wp, silty, some sand, hard, moist, grey, trace gravel, trace silt layers										
TP15-04	9-10											
S1	WGT14 1322	CH, Clay, +wp, some silt, firm, moist, grey, trace sand, trace gravel, trace silt pockets										
TP15-05	11-12											
S1	WGT14 1323	CH, Clay, +wp, some silt, firm, moist, grey, trace sand, trace silt lenses										
TP15-06	4-5											
S2	WGT14 1324	CH, Clay, +wp, some silt, firm-hard, moist, grey, trace sand, trace gravel, trace silt pockets										
TP15-06	9-10											
S1	WGT14 1325	CH, Clay, +wp, some silt, firm, moist, grey, trace sand, trace gravel, trace silt pockets										
TP15-07	7-8											
S2	WGT14 1326	CH, Clay, -wp, some silt, hard, moist, grey, trace sand, trace silt pockets										
TP15-08	10-11											
S1	WGT14 1327	CI, Clay, +wp, silty, some sand, firm, moist, grey, trace gravels, trace silt layers, trace organics										
TP15-09	4.5-5.5											
S2	WGT14 1328	CH, Clay, -wp, some silt, hard, moist, grey, trace sand, trace silt pockets										
TP15-09	8-9											
S1	WGT14 1329	SW-SM, Sand, gravelly, loose, wet, light brown, trace silt, trace clay										
TP15-10	4-5											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Lake St Martin Channel
LOCATION: Reach 3 - Willow Point
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-04-29

SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (ft)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m^3	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L / D_{10}	W_P / C_C	I_P / C_U	GRAIN SIZE GRAVEL %	SAND %	P_{200} or SILT % / CLAY %	STRENGTH q_u K.S.F. / kPa	POCKET PENETROMETER T.S.F.
S2	WGT14 1330	CL, Clay, -wp, silty, some sand, hard, moist, grey, trace gravel										
TP15-10	8-9											
S1	WGT14 1331	CL, Clay, -wp, silty, some sand, hard, moist, light grey, trace gravel, trace silt pockets										
TP15-11	12-13											
S1	WGT14 1332	CH, Clay, +wp, some silt, firm/loose, moist, grey, trace sand, trace silt pockets										
TP15-12	9-10											
S2	WGT14 1333	CH, Clay, +wp, some silt, firm-hard, moist, grey, trace sand, trace gravel, trace silt pockets										
TP15-12	12-13											
S3	WGT14 1334	CI, Clay, -wp, silty, some sand, hard, moist, light grey, trace gravel										
TP15-12	15.5-16.5											
S1	WGT14 1335	CH, Clay, +wp, some silt, soft, very moist, grey, trace sand, trace silt pockets										
TP15-13	7-8											
S1	WGT14 1336	CL, Clay, -wp, silty, some sand, firm, very moist, light brown, trace gravel										
TP15-14	4-5											
S2	WGT14 1337	ML, Silt, sandy, some clay, some gravel, very hard, moist, light brown										
TP15-14	8-9											
S1	WGT14 1338	CL, Clay, +wp, silty, sandy, firm, moist, light brown, trace gravel										
TP15-15	4-5											
S2	WGT14 1339	CL-ML, Silty Clay, -wp, sandy, some gravel, hard/loose, moist, brown										
TP15-15	9-10											
S1	WGT14 1340	CH, Clay, +wp, some silt, hard, moist, grey, trace sand, trace gravel, trace silt pockets										
TP15-16	5-6											
S1	WGT14 1341	CL, Clay, -wp, silty, some sand, very hard, moist, grey, trace gravel										
TP15-17	10-11											
S1	WGT14 1342	CL, Clay, +wp, silty, some sand, some gravel, hard, moist, light grey										
TP15-18	6-7											
S2	WGT14 1343	CL, Clay, -wp, silty, sandy, some gravel, hard, moist, light grey										
TP15-18	13-14											
S1	WGT14 1344	CI, Clay, +wp, silty, some sand, firm, moist, grey, trace gravel, trace silt layers										
TP15-19	5-6											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Lake St Martin Channel
LOCATION: Reach 3 - Willow Point
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-04-29

SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (ft)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m^3	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L / D_{10}	W_P / C_C	I_P / C_U	GRAIN SIZE GRAVEL %	SAND %	P_{200} or SILT % / CLAY %	STRENGTH q_u K.S.F. / kPa	POCKET PENETROMETER T.S.F.
S2	WGT14 1345	CL-ML, Silty Clay, -wp, sandy, some gravel, very hard, dry, light grey										
TP15-19	11-12											
S1	WGT14 1346	No Sample										
TP15-20	10-11											
S1	WGT14 1347	CL-ML, Silty Clay, sandy, some gravel, hard, moist, light brown										
TP15-21	5-6											
S2	WGT14 1348	CH, Clay, +wp, silty, some sand, firm, moist, grey, trace gravel, trace silt pockets										
TP15-21	10-11											
S1	WGT14 1349	CI, Clay, +wp, silty, some sand, firm, moist, grey, trace gravel, trace silt pockets										
TP15-22	2-3											
S2	WGT14 1350	CL, Clay, -wp, silty, some sand, hard, moist, grey, trace gravel										
TP15-22	11-12											
S1	WGT14 1351	CI, Clay, +wp, silty, some sand, firm-soft, moist, grey, trace gravel, trace silt pockets										
TP15-23	4.0-4.5											
S2	WGT14 1352	ML, Silt, sandy, some clay, some gravel, firm/loose, moist, light brown										
TP15-23	6-7											
S1	WGT14 1353	ML, Silt, sandy, some clay, some gravel, soft/loose, moist, light brown										
TP15-24	3-4											
S2	WGT14 1354	SM, Sand, gravelly, silty, some clay, loose, very moist, light brown										
TP15-24	9-10											
S1	WGT14 1355	SM, Sand, gravelly, some silt, some clay, loose, wet, light brown										
TP15-25	4-5											
S1	WGT14 1356	CI, Clay, +wp, silty, some sand, hard, moist, grey, trace gravel, trace silt layers										
TP15-26	4-5											
S2	WGT14 1357	ML, Silt, sandy, some gravel, some clay, loose, moist, light brown										
TP15-26	14-15											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Lake St Martin Channel
LOCATION: Reach 3 - Willow Point
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-04-29

Manitoba

INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

Geotechnical Testing Report

Appended:

A) Summary Sheets
B) Grain Size Analysis
C) Sieve Analysis
D) Lab visual Classifications

Client:	Water Management and Structures
Project:	Lake St Martin Channel
Locations:	Reach 1 Inlet - South Side Reach 2 Camp Site Quarry Granular Borrow
Geotech No.	
Internal Order No.	200037101
Date Sampled:	February 2-10, 2015
Date Requisitioned:	March 6, 2015
Date Reported:	June 27, 2015

Manitoba Infrastructure and Transportation

Materials Engineering Branch

GEOTECHNICAL SOIL PROPERTY SUMMARY SHEET

Client:	Water Management and Structures	Site/File No. :		Date Requisitioned:	2015-03-06
Project:	Lake St. Martin Channel	Internal Order No. :	200037101	Date Reported:	2015-06-27
Location:	Reach 1 Inlet - South Side	Sampled By:	KGS Group	Report To:	Akinbola George
Municipality:		Date Sampled:	2015-02-04	Page:	1 of 1

Lab No.	SAMPLE DATA					Unified Classification	Moisture Content %	ATTERBERG LIMITS			GRAIN SIZE					Organic Content %	Reactivity with HCl *	STRENGTH								Visual Classification
	Test Hole No.	Sample No.	Station	Centerline	Depth (ft)			Liquid Limit % (-1 = NP)	Plastic Limit % (-1 = NP)	Plasticity Index % (-1 = NP)	Gravel % (pass 75mm)	Sand % (pass 4.75mm)	Silt % (pass 0.075mm)	Clay % (pass 0.005 mm)	Silt/Clay % (pass 0.075 mm)			Field SPT (N)	Field PP (kpa)	Field Torvane Value (kpa)	Unconfined qu (kpa)	Bulk Dry Density (kg/cu.m.)	Direct Shear Performed	Consolidation Performed	Permeability Performed	
WGT141159	TH15-01	S1			4.0-5.0	CL	9	25	13	12	9	24	40	27													
WGT141160	TH15-01	S2			7.5-8.5		41									10.3										CI/CH
WGT141161	TH15-01	S3			9.0-10.0	CH	31	54	23	31	2	14	23	61													
WGT141162	TH15-01	S4			10.0-11.5	CH	24	57	21	36	3	11	24	63				8									
WGT141163	TH15-01	S5			10.0-14.0	CH	26	61	22	39	3	6	19	71													
WGT141164	TH15-01	S6			15.0-16.5	CL-ML	10	18	13	5	12	22	44	21				15									
WGT141165	TH15-01	S7			20.0-21.5	CL-ML	8	16	11	5	10	23	46	21				32									
WGT141166	TH15-01	S8			25.0-26.5	CL-ML	9	16	12	4	14	23	44	20				17									
WGT141167	TH15-01	S9			30.0-31.5	ML	8	14	12	2	11	25	47	18				33									
WGT141168	TH15-01	S10			35.0-36.5	CL-ML	7	14	10	4	9	34	37	21				56									
WGT141169	TH15-01	S11			40.0-41.5	ML	7	15	12	3	10	28	43	19				42									
WGT141170	TH15-01	S12			45.0-46.5	CL-ML	6	16	11	5	11	29	43	18				44									
WGT141171	TH15-01	S13			50.0-51.5	CL-ML	8	16	10	6	7	28	44	21				26									
WGT141172	TH15-01	S14			55.0-56.5	CL-ML	8	17	11	6	10	24	44	23				36									
WGT141173	TH15-01	S15			60.0-61.5	CL-ML	8	16	12	4	11	24	41	24				26									
WGT141174	TH15-01	S16			65.0-66.5	ML	7	17	14	3	12	31	35	23				34									
WGT141175	TH15-01	S17			80.0-81.5	CL-ML	22	19	14	5	4	4	53	39				4									
WGT141176	TH15-01	R1			87.5-89.5																						
WGT141177	TH15-01	R2			89.5-94.0																						

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NT = Not Tested, US = Unsuitable sample, IS = Insufficient Sample

Manitoba Infrastructure and Transportation

Materials Engineering Branch

GEOTECHNICAL SOIL PROPERTY SUMMARY SHEET

Client:	Water Management and Structures	Site/File No. :		Date Requisitioned:	2015-03-06
Project:	Lake St. Martin Channel	Internal Order No. :	200037101	Date Reported:	2015-06-27
Location:	Reach 2	Sampled By:	KGS Group	Report To:	Akinbola George
Municipality:		Date Sampled:	2015-02-09	Page:	1 of 1

Lab No.	SAMPLE DATA					Unified Classification	Moisture Content %	ATTERBERG LIMITS			GRAIN SIZE					Organic Content %	Reactivity with HCl *	STRENGTH								Visual Classification
	Test Hole No.	Sample No.	Station	Centerline	Depth(ft)			Liquid Limit % (-1 = NP)	Plastic Limit % (-1 = NP)	Plasticity Index % (-1 = NP)	Gravel % (pass 75mm)	Sand % (pass 4.75mm)	Silt % (pass 0.075mm)	Clay % (pass 0.005 mm)	Silt/Clay % (pass 0.075 mm)			Field SPT (N)	Field PP (kpa)	Field Torvane Value (kpa)	Unconfined qu (kpa)	Bulk Dry Density (kg/cu.m.)	Direct Shear Performed	Consolidation Performed	Permeability Performed	
WGT141303	TP15-27	S1			2.5-3.5	CI	26	43	21	22	2	10	30	58													
WGT141304	TP15-27	S2			8.0-9.0	CL-ML	8	17	11	6	22	27	35	15													
WGT141305	TP15-27	S3			15.0-16.0	ML	5	15	13	2	16	28	42	14													
WGT141306	TP15-28	S1			2.0-3.0	ML	8	14	11	3	14	31	39	16													
WGT141307	TP15-28	S2			8.0-9.0	ML	8	16	13	3	15	26	41	18													
WGT141308	TP15-29	S1			5.0-6.0	CI	30	44	17	27	3	10	30	57													
WGT141309	TP15-29	S2			12.0-13.0	CL	10	21	13	8	16	20	40	24													
WGT141310	TP15-29	S3			15.0-16.0	CL-ML	6	14	10	4	12	26	45	17													
WGT141311	TP15-30	S1			2.0-3.0	CI	20	39	18	21	4	11	33	52													
WGT141312	TP15-30	S2			11.0-12.0	GC-GM	7	15	11	4	29	26	31	14													
WGT141313	TP15-31	S1			2.0-3.0	CI	12	32	16	16	11	32	25	33													
WGT141314	TP15-31	S2			6.0-7.0	ML	8	16	13	3	18	24	44	14													

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Manitoba Infrastructure and Transportation

Materials Engineering Branch

GEOTECHNICAL SOIL PROPERTY SUMMARY SHEET

Client:	Water Management and Structures	Site/File No. :		Date Requisitioned:	2015-03-06
Project:	Lake St. Martin Channel	Internal Order No. :	200037101	Date Reported:	2015-06-27
Location:	Campsite Quarry	Sampled By:	KGS Group	Report To:	Akinbola George
Municipality:		Date Sampled:	2015-02-04	Page:	1 of 1

	SAMPLE DATA							ATTERBERG LIMITS			GRAIN SIZE							STRENGTH								
Lab No.	Test Hole No.	Sample No.	Station	Centerline	Depth(ft)	Unified Classification	Moisture Content %	Liquid Limit % (-1 = NP)	Plastic Limit % (-1 = NP)	Plasticity Index % (-1 = NP)	Gravel % (pass 75mm)	Sand % (pass 4.75mm)	Silt % (pass 0.075mm)	Clay % (pass 0.005 mm)	Silt/Clay % (pass 0.075 mm)	Organic Content %	Reactivity with HCl *	Field SPT (N)	Field PP (kpa)	Field Torvane Value (kpa)	Unconfined qu (kpa)	Bulk Dry Density (kg/cu.m.)	Direct Shear Performed	Consolidation Performed	Permeability Performed	Visual Classification
WGT140280	TH15-14	S1			1.0-2.0		8																			CI
WGT140281	TH15-14	S2			4.0-5.0		9																			CI
WGT140282	TH15-14	S3			7.5-8.5		7																			CI
WGT140283	TH15-14	R1			10.0-15.0																					
WGT140284	TH15-14	R2			15.0-20.0																					
WGT140285	TH15-14	R3			20.0-25.0																					
WGT140286	TH15-14	R4			25.0-30.0																					
WGT140287	TH15-15	S1			1.0-2.0		8																			CL
WGT140288	TH15-15	S2			3.5-4.5		8																			CI
WGT140289	TH15-15	R1			7.5-10.0																					
WGT140290	TH15-15	R2			10.0-15.0																					
WGT140291	TH15-15	R3			15.0-20.0																					
WGT140292	TH15-15	R4			20.0-25.0																					
WGT140293	TH15-15	R5			25.0-30.0																					

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Manitoba Infrastructure and Transportation

Materials Engineering Branch

GEOTECHNICAL SOIL PROPERTY SUMMARY SHEET

Client:	Water Management and Structures	Site/File No. :		Date Requisitioned:	2015-03-06
Project:	Lake St. Martin Channel	Internal Order No. :	200037101	Date Reported:	2015-06-27
Location:	Granular Borrow	Sampled By:	KGS Group	Report To:	Akinbola George
Municipality:		Date Sampled:	2015-02-04	Page:	1 of 1

	SAMPLE DATA							ATTERBERG LIMITS			GRAIN SIZE							STRENGTH								
Lab No.	Test Hole No.	Sample No.	Station	Centerline	Depth(ft)	Unified Classification	Moisture Content %	Liquid Limit % (-1 = NP)	Plastic Limit % (-1 = NP)	Plasticity Index % (-1 = NP)	Gravel % (pass 75mm)	Sand % (pass 4.75mm)	Silt % (pass 0.075mm)	Clay % (pass 0.005 mm)	Silt/Clay % (pass 0.075 mm)	Organic Content %	Reactivity with HCl *	Field SPT (N)	Field PP (kpa)	Field Torvane Value (kpa)	Unconfined qu (kpa)	Bulk Dry Density (kg/cu.m.)	Direct Shear Performed	Consolidation Performed	Permeability Performed	Visual Classification
WGT141294	TH15-17	S1			3.5-5.0		3				31	50	17	2												SM
WGT141295	TH15-17	S2			5.0-5.5		3				14	50	26	10												SM
WGT141296	TH15-17	S3			6.0-8.0		3				21	45	28	7												SM
WGT141297	TH15-17	S4			8.0-10.0		3				12	53	28	8												SM
WGT141298	TH15-18	S1			1.0-4.0		10				11	67	20	2												SM
WGT141299	TH15-18	S2			5.0-7.0		3				13	53	27	7												SM
WGT141300	TH15-18	S3			7.0-10.0		5				28	51			21											SM
WGT141301	TH15-19	S1			3.5-5.0		5				10	66			24											SM
WGT141302	TH15-19	S2			5.0-7.0		4				1	76			23											SM

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NT = Not Tested, US = Unsuitable sample, IS = Insufficient Sample

MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

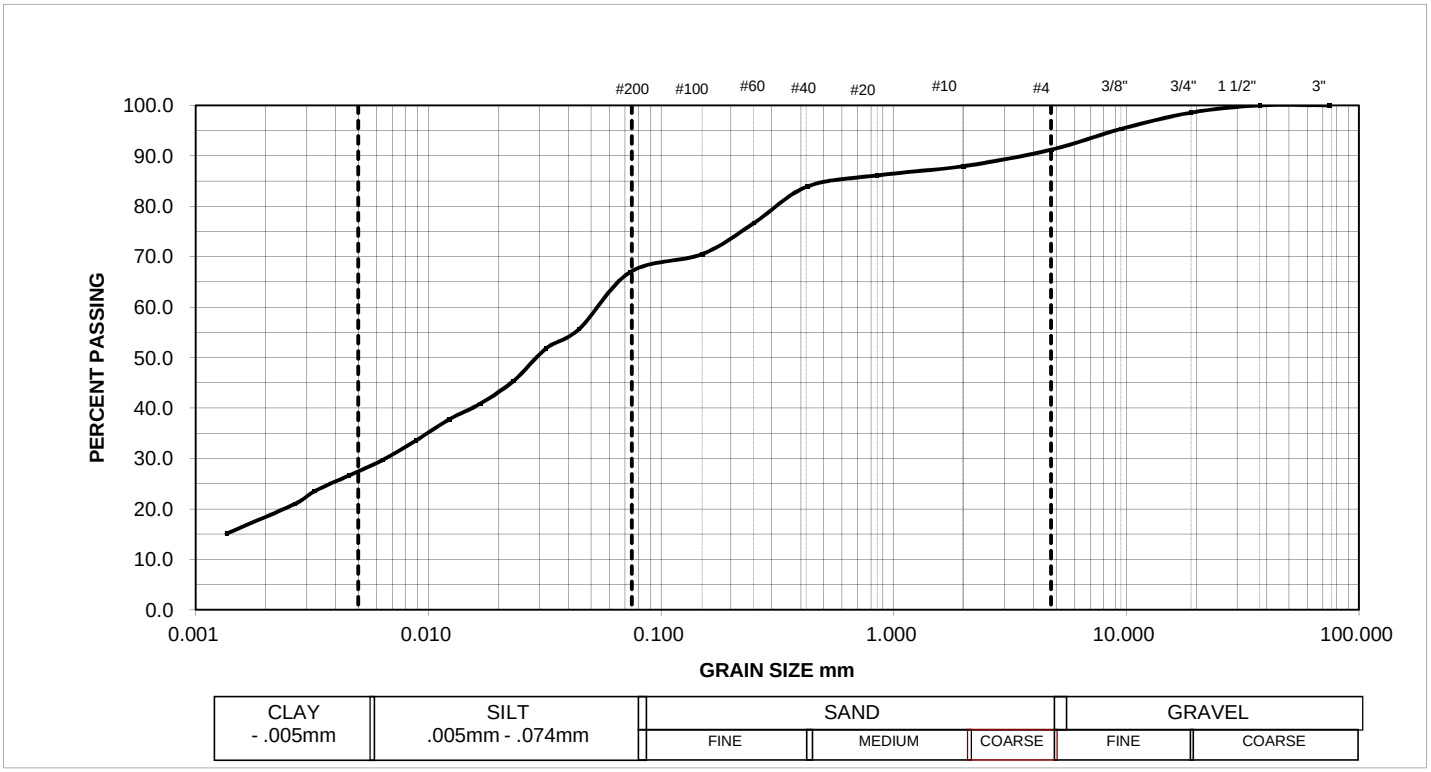
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MO
Checked By: GK

LAB.NO. WGT141159 FIELD NO. S1 HOLE NO. TH15-01 DEPTH (m) 4.0-5.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	24.4	19.9	0.0446	55.7
1.50	37.5	100.0	2	23.0	18.5	0.0320	51.8
0.75	19.0	98.5	4	20.7	16.2	0.0232	45.3
0.375	9.5	95.3	8	19.1	14.6	0.0167	40.9
#4	4.75	91.2	15	18.0	13.5	0.0123	37.8
#10	2.00	87.9	30	16.5	12.0	0.0089	33.6
#20	0.850	86.1	60	15.1	10.6	0.0063	29.7
#40	0.425	83.9	120	14.0	9.5	0.0045	26.6
#60	0.250	76.6	240	12.9	8.4	0.0032	23.5
#100	0.150	70.5	360	12.0	7.5	0.0027	21.0
#200	0.075	67.0	1440	10.0	5.4	0.0014	15.1

% GRAVEL	% SAND	% SILT	% CLAY
9	24	40	27



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

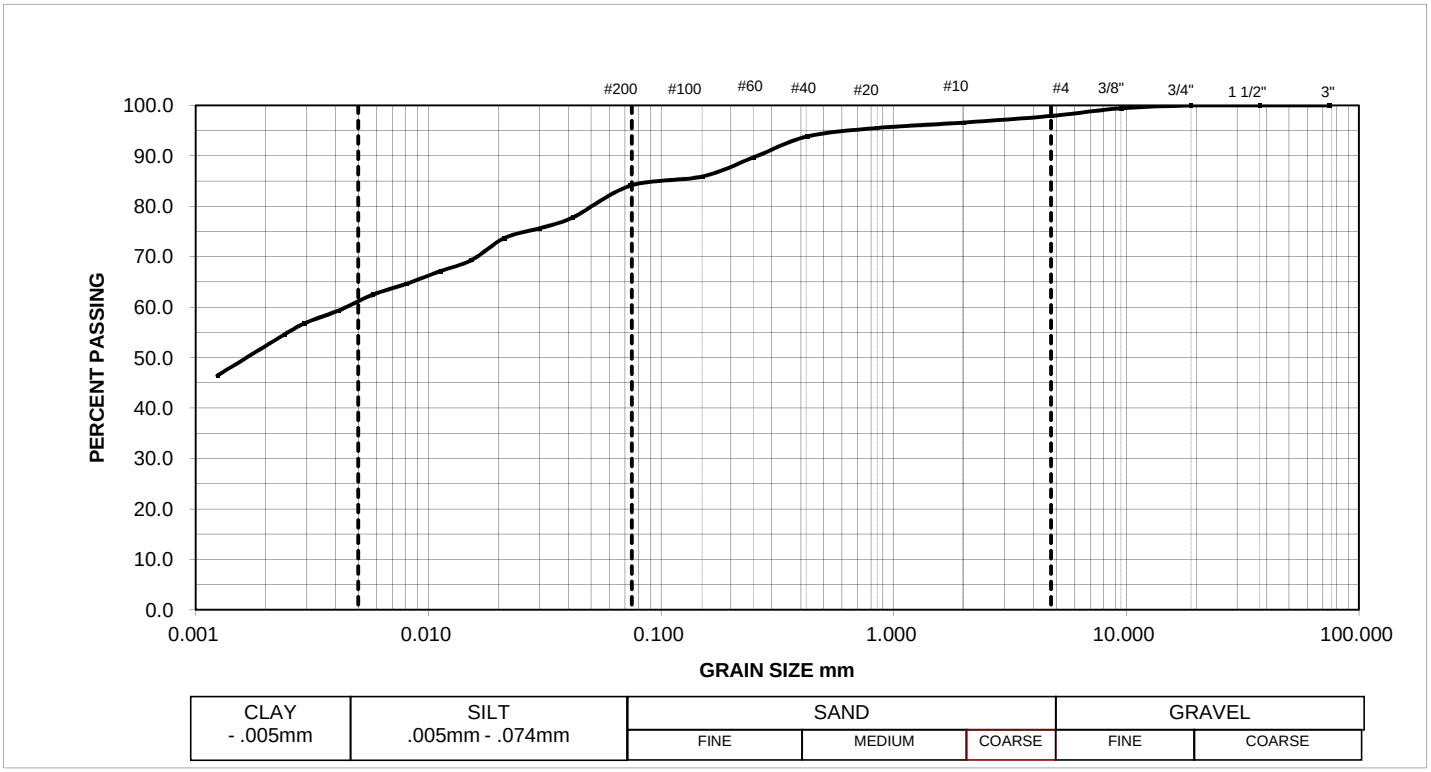
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MO
Checked By: GK

LAB.NO. WGT141161 FIELD NO. S3 HOLE NO. TH15-01 DEPTH (m) 9.0-10.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	29.3	24.8	0.0419	77.8
1.50	37.50	100.0	2	28.6	24.1	0.0299	75.6
0.75	19.00	100.0	4	28.0	23.5	0.0213	73.7
0.375	9.50	99.4	8	26.6	22.1	0.0153	69.3
#4	4.75	97.9	15	25.9	21.4	0.0113	67.1
#10	2.00	96.6	30	25.1	20.6	0.0081	64.6
#20	0.850	95.5	60	24.4	19.9	0.0058	62.4
#40	0.425	93.9	120	23.4	18.9	0.0041	59.3
#60	0.250	89.7	240	22.6	18.1	0.0029	56.8
#100	0.150	85.9	360	21.9	17.4	0.0024	54.6
#200	0.075	84.1	1440	19.4	14.8	0.0012	46.4

% GRAVEL	% SAND	% SILT	% CLAY
2	14	23	61



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MO
Checked By: GK

LAB.NO. WGT141162 FIELD NO. S4 HOLE NO. TH15-01 DEPTH (m) 10.0-11.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	30.0	25.5	0.0415	79.5
1.50	37.5	100.0	2	29.1	24.6	0.0297	76.7
0.75	19.0	100.0	4	28.1	23.6	0.0213	73.6
0.375	9.5	99.2	8	27.0	22.5	0.0153	70.2
#4	4.75	97.3	15	26.3	21.8	0.0112	68.0
#10	2.00	96.0	30	25.5	21.0	0.0080	65.5
#20	0.850	94.7	60	25.0	20.5	0.0057	63.9
#40	0.425	93.2	120	23.9	19.4	0.0041	60.5
#60	0.250	90.5	240	22.6	18.1	0.0029	56.5
#100	0.150	88.4	360	22.0	17.5	0.0024	54.6
#200	0.075	86.7	1440	19.7	15.1	0.0012	47.1

% GRAVEL	% SAND	% SILT	% CLAY
3	11	24	63



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

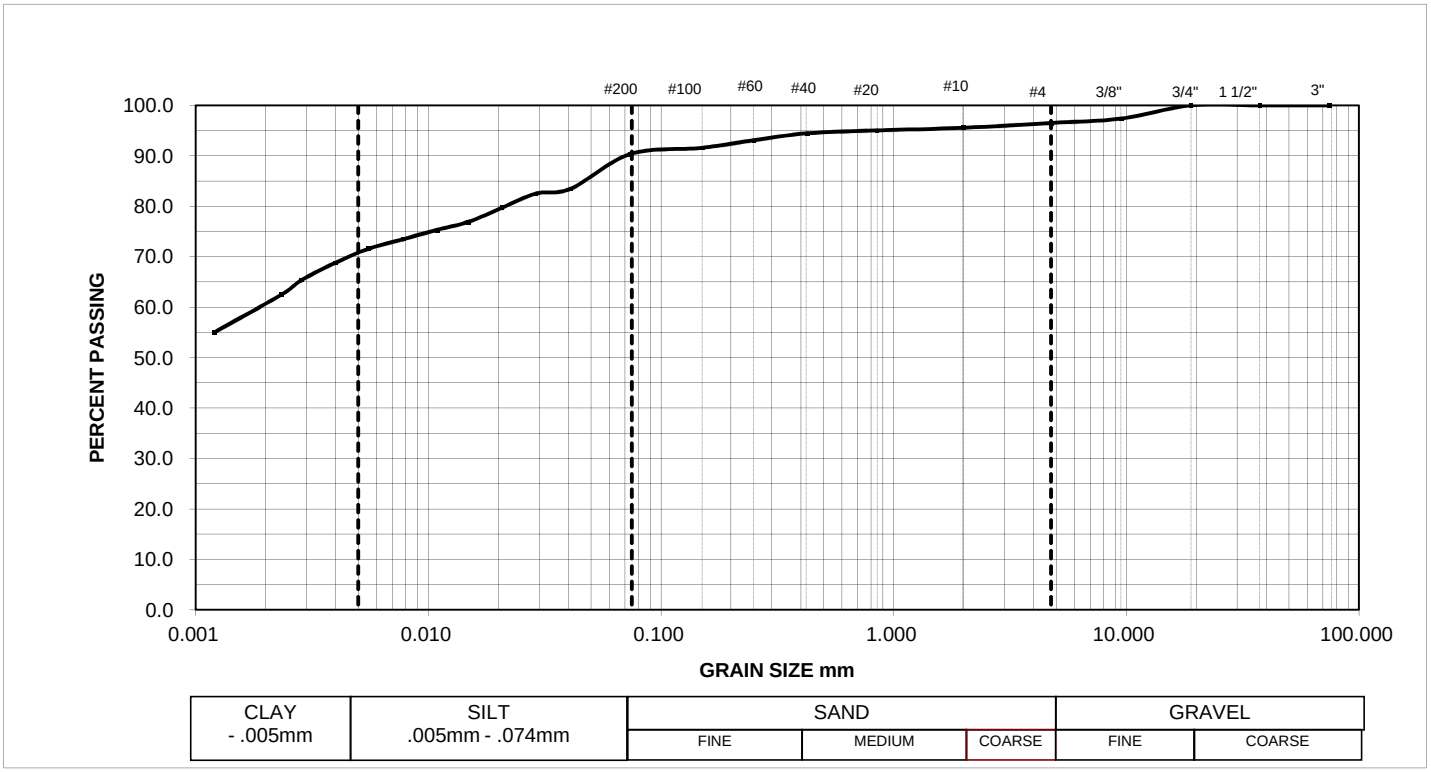
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MO
Checked By: GK

LAB.NO. WGT141163 FIELD NO. S5 HOLE NO. TH15-01 DEPTH (m) 10.0-14.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	31.2	26.7	0.0409	83.5
1.50	37.50	100.0	2	30.9	26.4	0.0290	82.5
0.75	19.00	100.0	4	30.0	25.5	0.0208	79.7
0.375	9.50	97.4	8	29.1	24.6	0.0149	76.9
#4	4.75	96.5	15	28.6	24.1	0.0109	75.3
#10	2.00	95.6	30	28.0	23.5	0.0078	73.5
#20	0.850	95.0	60	27.4	22.9	0.0055	71.6
#40	0.425	94.5	120	26.5	22.0	0.0040	68.8
#60	0.250	93.1	240	25.4	20.9	0.0028	65.3
#100	0.150	91.6	360	24.5	20.0	0.0023	62.5
#200	0.075	90.4	1440	22.2	17.6	0.0012	55.0

% GRAVEL	% SAND	% SILT	% CLAY
3	6	19	71



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MO
Checked By: GK

LAB.NO. WGT141164 FIELD NO. S6 HOLE NO. TH15-01 DEPTH (m) 15.0-16.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	24.3	19.8	0.0446	53.3
1.50	37.50	100.0	2	22.7	18.2	0.0321	49.0
0.75	19.00	98.4	4	20.8	16.3	0.0232	43.9
0.375	9.50	91.9	8	18.6	14.1	0.0168	37.9
#4	4.75	87.6	15	16.9	12.4	0.0125	33.4
#10	2.00	84.8	30	15.0	10.5	0.0090	28.3
#20	0.850	83.4	60	13.3	8.8	0.0065	23.7
#40	0.425	81.7	120	12.0	7.5	0.0046	20.2
#60	0.250	74.1	240	10.9	6.4	0.0033	17.2
#100	0.150	68.3	360	10.0	5.5	0.0027	14.8
#200	0.075	65.3	1440	9.0	4.4	0.0014	11.8

% GRAVEL	% SAND	% SILT	% CLAY
12	22	44	21



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MO
Checked By: GK

LAB.NO. WGT141165 FIELD NO. S7 HOLE NO. TH15-01 DEPTH (m) 20.0-21.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	25.0	20.5	0.0442	56.5
1.50	37.50	100.0	2	22.7	18.2	0.0321	50.2
0.75	19.00	96.0	4	20.8	16.3	0.0232	44.9
0.375	9.50	92.9	8	18.4	13.9	0.0168	38.3
#4	4.75	90.1	15	16.6	12.1	0.0125	33.4
#10	2.00	87.0	30	14.9	10.4	0.0090	28.7
#20	0.850	85.8	60	13.3	8.8	0.0065	24.3
#40	0.425	84.0	120	12.0	7.5	0.0046	20.7
#60	0.250	76.4	240	10.7	6.2	0.0033	17.1
#100	0.150	69.7	360	10.0	5.5	0.0027	15.2
#200	0.075	66.7	1440	9.0	4.4	0.0014	12.1

% GRAVEL	% SAND	% SILT	% CLAY
10	23	46	21



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

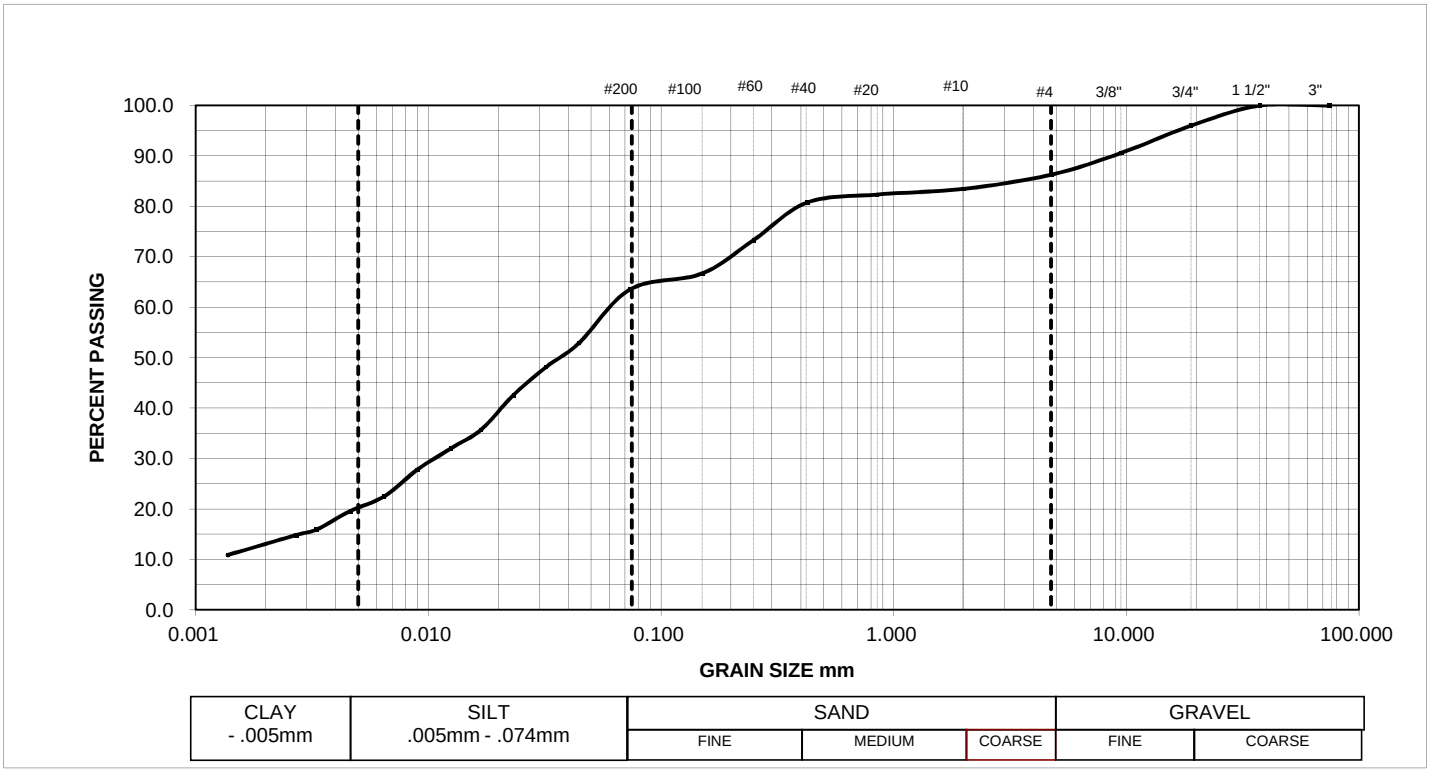
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MO
Checked By: GK

LAB.NO. WGT141166 FIELD NO. S8 HOLE NO. TH15-01 DEPTH (m) 25.0-26.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	24.5	20.0	0.0445	52.9
1.50	37.50	100.0	2	22.7	18.2	0.0321	48.1
0.75	19.00	96.0	4	20.6	16.1	0.0232	42.6
0.375	9.50	90.6	8	18.0	13.5	0.0169	35.7
#4	4.75	86.3	15	16.6	12.1	0.0125	32.0
#10	2.00	83.5	30	15.0	10.5	0.0090	27.8
#20	0.850	82.3	60	13.0	8.5	0.0065	22.5
#40	0.425	80.8	120	11.9	7.4	0.0046	19.6
#60	0.250	73.3	240	10.5	6.0	0.0033	15.9
#100	0.150	66.7	360	10.1	5.6	0.0027	14.8
#200	0.075	63.6	1440	8.7	4.1	0.0014	10.8

% GRAVEL	% SAND	% SILT	% CLAY
14	23	44	20



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MO
Checked By: GK

LAB.NO. WGT141167 FIELD NO. S9 HOLE NO. TH15-01 DEPTH (m) 30.0-31.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	24.0	19.5	0.0448	53.5
1.50	37.50	100.0	2	22.0	17.5	0.0324	48.0
0.75	19.00	97.2	4	19.8	15.3	0.0234	42.0
0.375	9.50	93.4	8	17.9	13.4	0.0169	36.8
#4	4.75	89.0	15	16.0	11.5	0.0126	31.6
#10	2.00	86.7	30	14.5	10.0	0.0090	27.5
#20	0.850	85.6	60	12.9	8.4	0.0065	23.1
#40	0.425	84.1	120	11.0	6.5	0.0047	17.8
#60	0.250	75.9	240	10.0	5.5	0.0033	15.1
#100	0.150	69.3	360	9.6	5.1	0.0027	14.0
#200	0.075	64.5	1440	8.5	3.9	0.0014	10.7

% GRAVEL	% SAND	% SILT	% CLAY
11	25	47	18



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

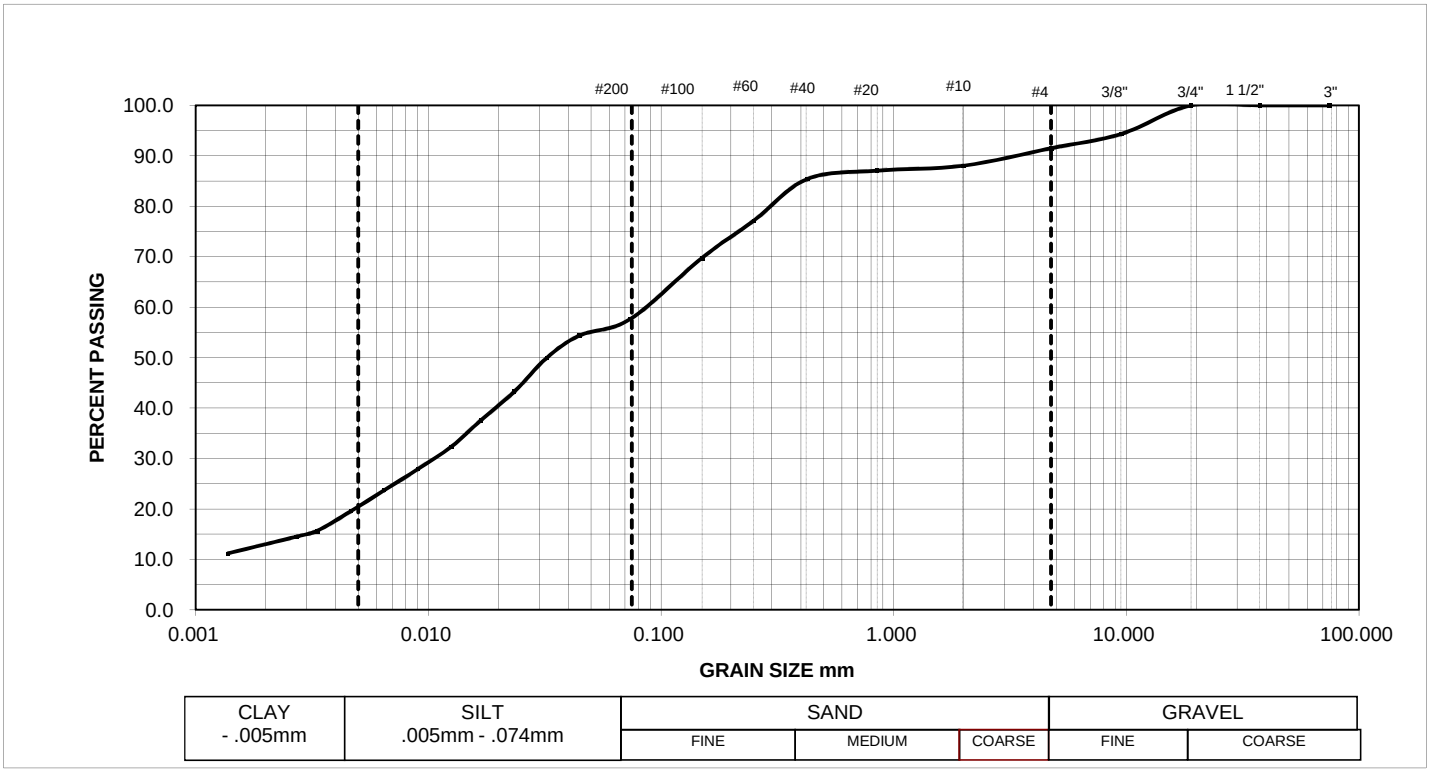
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MO
Checked By: GK

LAB.NO. WGT141168 FIELD NO. S10 HOLE NO. TH15-01 DEPTH (m) 35.0-36.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	24.0	19.5	0.0448	54.4
1.50	37.50	100.0	2	22.4	17.9	0.0322	49.9
0.75	19.00	100.0	4	20.0	15.5	0.0234	43.2
0.375	9.50	94.3	8	18.0	13.5	0.0169	37.7
#4	4.75	91.5	15	16.1	11.6	0.0126	32.4
#10	2.00	88.0	30	14.5	10.0	0.0090	27.9
#20	0.850	87.1	60	13.0	8.5	0.0065	23.7
#40	0.425	85.4	120	11.5	7.0	0.0046	19.5
#60	0.250	77.1	240	10.1	5.6	0.0033	15.6
#100	0.150	69.7	360	9.7	5.2	0.0027	14.5
#200	0.075	57.7	1440	8.6	4.0	0.0014	11.2

% GRAVEL	% SAND	% SILT	% CLAY
9	34	37	21



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

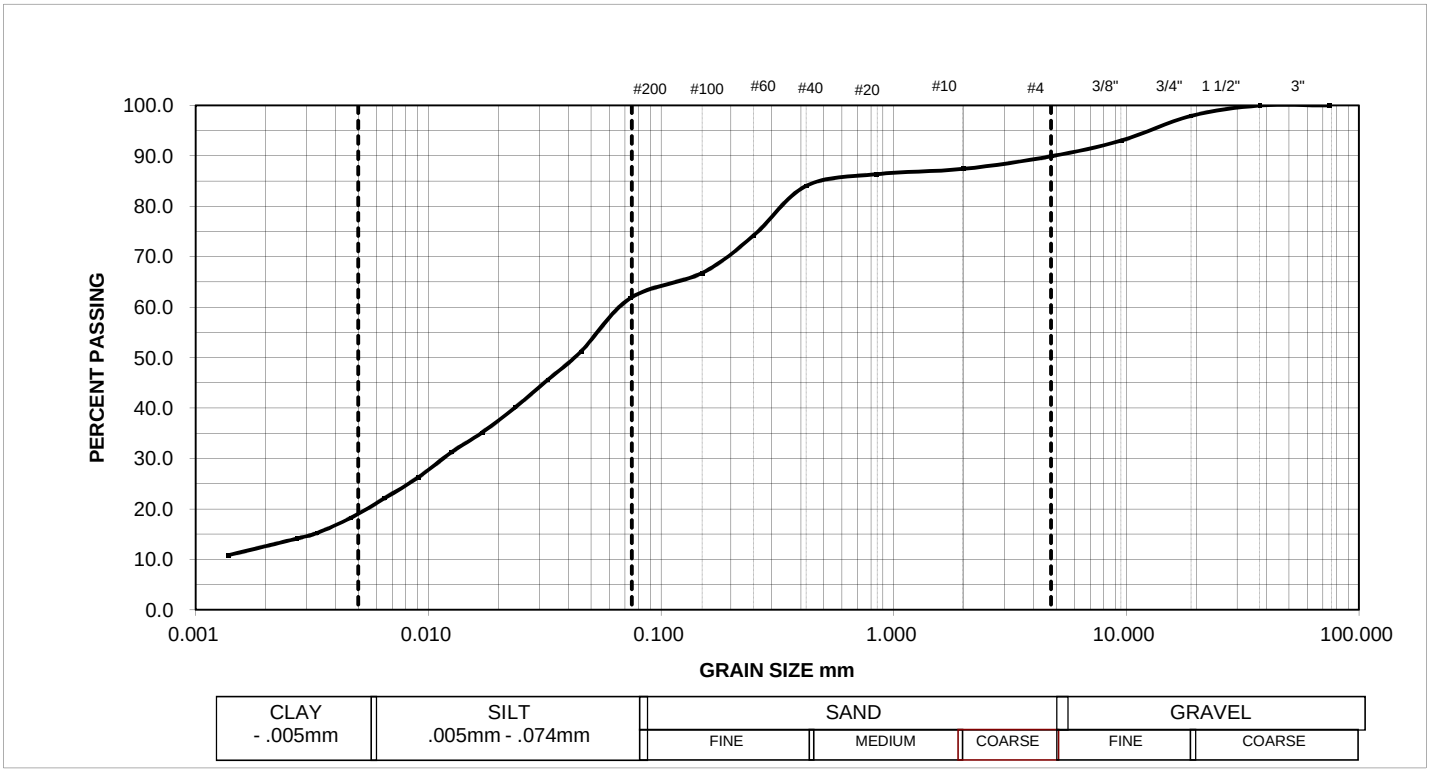
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MO
Checked By: GK

LAB.NO. WGT141169 FIELD NO. S11 HOLE NO. TH15-01 DEPTH (m) 40.0-41.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	23.0	18.5	0.0453	51.2
1.50	37.5	100.0	2	21.0	16.5	0.0327	45.7
0.75	19.0	97.9	4	19.0	14.5	0.0236	40.1
0.375	9.5	93.0	8	17.2	12.7	0.0170	35.1
#4	4.75	89.9	15	15.8	11.3	0.0126	31.3
#10	2.00	87.4	30	14.0	9.5	0.0091	26.3
#20	0.850	86.4	60	12.5	8.0	0.0065	22.1
#40	0.425	84.0	120	11.1	6.6	0.0047	18.3
#60	0.250	74.2	240	10.0	5.5	0.0033	15.2
#100	0.150	66.8	360	9.6	5.1	0.0027	14.1
#200	0.075	61.8	1440	8.5	3.9	0.0014	10.8

% GRAVEL	% SAND	% SILT	% CLAY
10	28	43	19



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

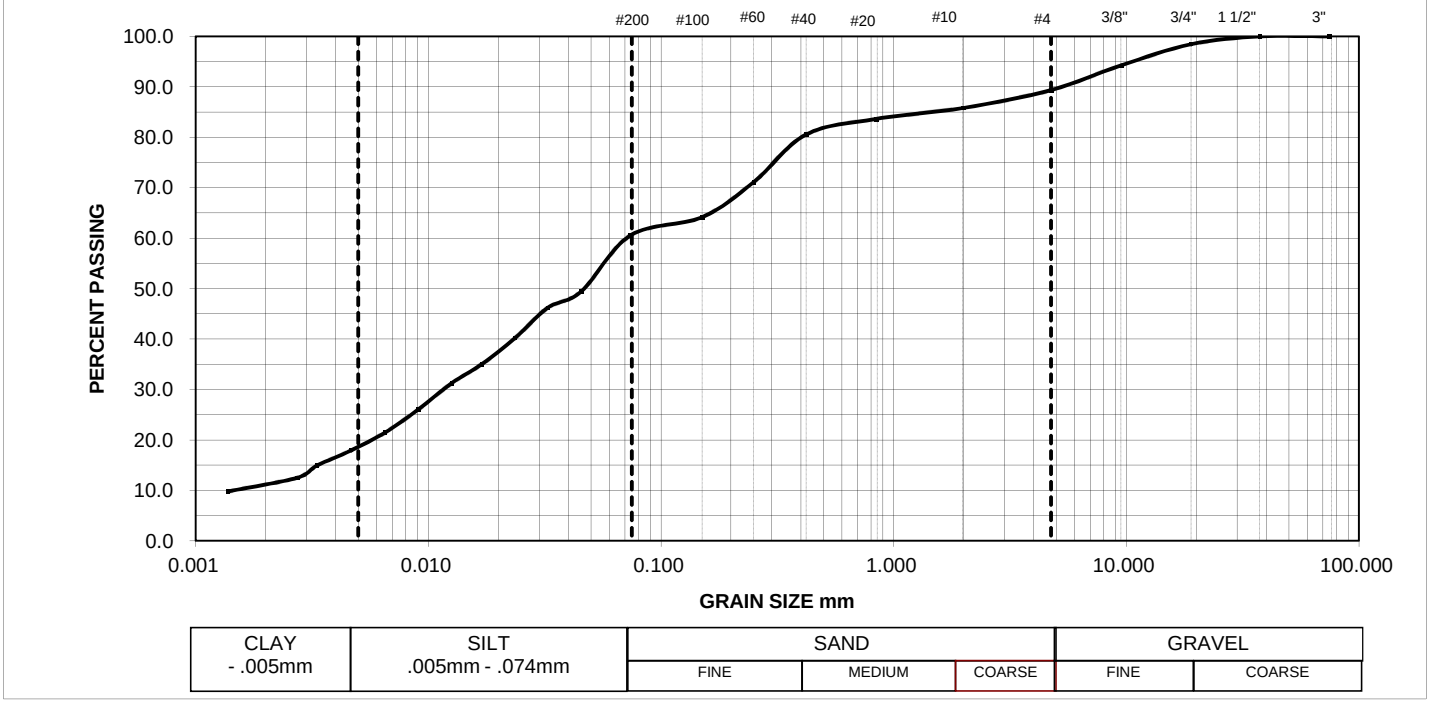
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MO
Checked By: GK

LAB.NO. WGT141170 FIELD NO. S12 HOLE NO. TH15-01 DEPTH (m) 45.0-46.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	22.7	18.2	0.0454	49.4
1.50	37.5	100.0	2	21.5	17.0	0.0326	46.2
0.75	19.0	98.5	4	19.3	14.8	0.0236	40.2
0.375	9.5	94.3	8	17.4	12.9	0.0170	35.0
#4	4.75	89.4	15	16.0	11.5	0.0126	31.2
#10	2.00	85.8	30	14.1	9.6	0.0091	26.1
#20	0.850	83.6	60	12.4	7.9	0.0065	21.5
#40	0.425	80.5	120	11.1	6.6	0.0047	17.9
#60	0.250	71.1	240	10.0	5.5	0.0033	14.9
#100	0.150	64.1	360	9.1	4.6	0.0027	12.5
#200	0.075	60.6	1440	8.2	3.6	0.0014	9.8

% GRAVEL	% SAND	% SILT	% CLAY
11	29	43	18



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

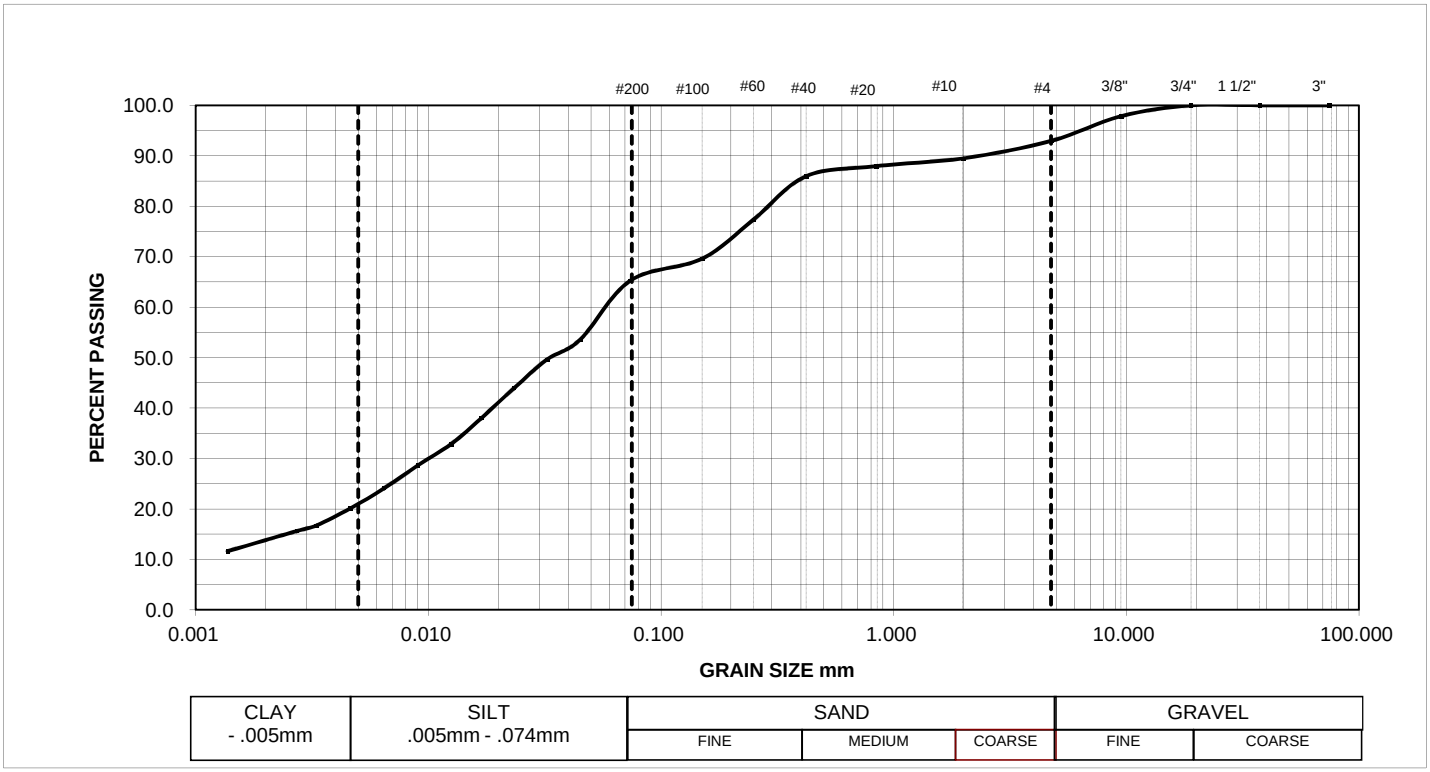
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MO
Checked By: GK

LAB.NO. WGT141171 FIELD NO. S13 HOLE NO. TH15-01 DEPTH (m) 50.0-51.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	23.4	18.9	0.0451	53.6
1.50	37.5	100.0	2	22.0	17.5	0.0324	49.6
0.75	19.0	100.0	4	20.0	15.5	0.0234	43.9
0.375	9.5	97.8	8	17.9	13.4	0.0169	38.0
#4	4.75	92.9	15	16.1	11.6	0.0126	32.9
#10	2.00	89.5	30	14.6	10.1	0.0090	28.6
#20	0.850	87.9	60	13.0	8.5	0.0065	24.1
#40	0.425	85.9	120	11.6	7.1	0.0046	20.1
#60	0.250	77.3	240	10.4	5.9	0.0033	16.7
#100	0.150	69.6	360	10.0	5.5	0.0027	15.6
#200	0.075	65.3	1440	8.7	4.1	0.0014	11.6

% GRAVEL	% SAND	% SILT	% CLAY
7	28	44	21



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MJ
Checked By: GK

LAB.NO. WGT141172 FIELD NO. S14 HOLE NO. TH15-01 DEPTH (m) 55.0-56.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	24.0	19.3	0.0449	52.7
1.50	37.5	100.0	2	22.5	17.8	0.0323	48.6
0.75	19.0	95.7	4	21.0	16.3	0.0232	44.5
0.375	9.5	93.7	8	19.2	14.5	0.0167	39.5
#4	4.75	90.3	15	18.0	13.3	0.0124	36.3
#10	2.00	85.9	30	16.0	11.3	0.0089	30.8
#20	0.850	84.9	60	14.0	9.3	0.0064	25.3
#40	0.425	83.6	120	13.0	8.3	0.0046	22.7
#60	0.250	77.9	240	11.9	7.2	0.0033	19.7
#100	0.150	71.5	360	11.0	6.3	0.0027	17.2
#200	0.075	66.7	1440	9.2	4.5	0.0014	12.3

% GRAVEL	% SAND	% SILT	% CLAY
10	24	44	23



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

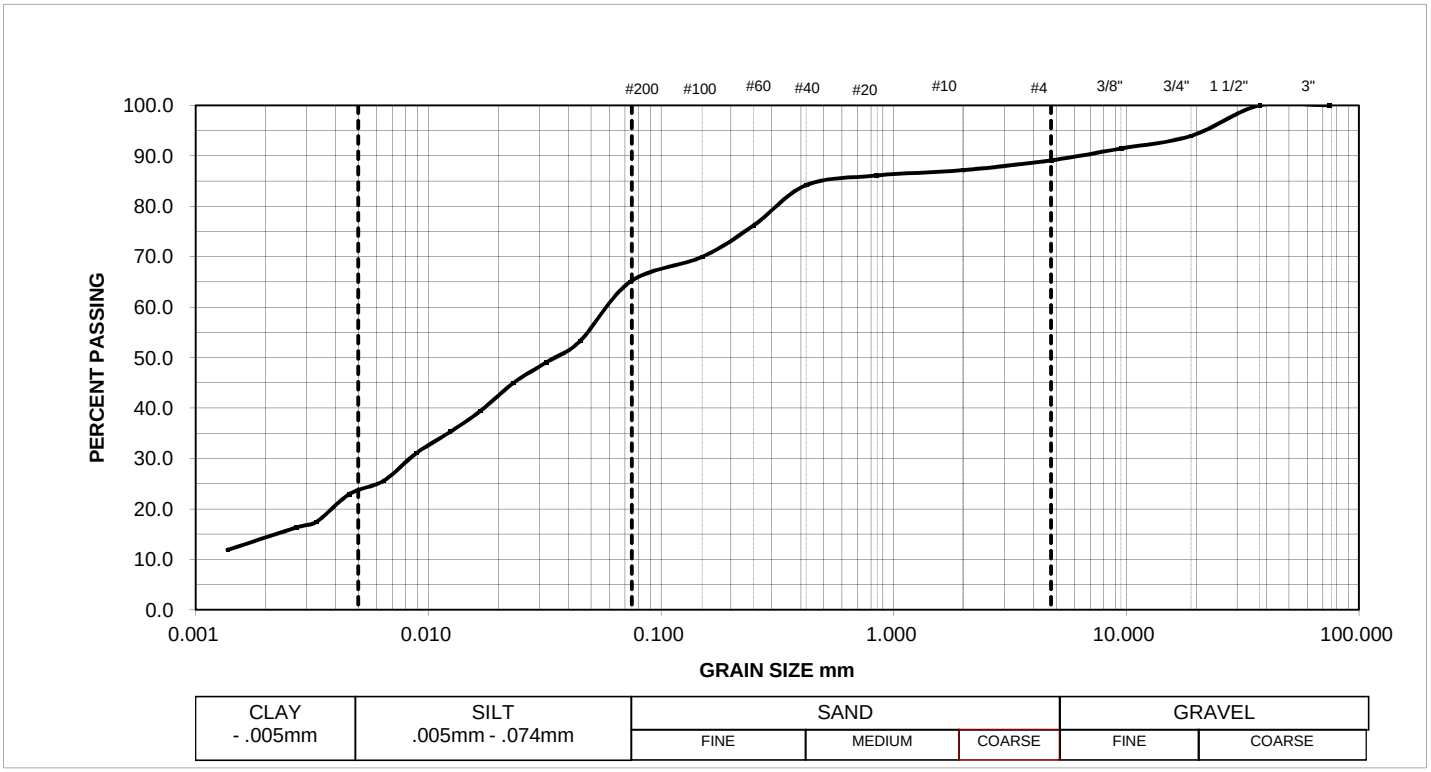
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MJ
Checked By: GK

LAB.NO. WGT141173 FIELD NO. S15 HOLE NO. TH15-01 DEPTH (m) 60.0-61.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	24.0	19.3	0.0449	53.3
1.50	37.5	100.0	2	22.5	17.8	0.0323	49.1
0.75	19.0	93.9	4	21.0	16.3	0.0232	45.0
0.375	9.5	91.5	8	19.0	14.3	0.0168	39.4
#4	4.75	89.1	15	17.5	12.8	0.0124	35.3
#10	2.00	87.2	30	16.0	11.3	0.0089	31.1
#20	0.850	86.1	60	14.0	9.3	0.0064	25.6
#40	0.425	84.2	120	13.0	8.3	0.0046	23.0
#60	0.250	76.2	240	11.0	6.3	0.0033	17.4
#100	0.150	70.0	360	10.6	5.9	0.0027	16.3
#200	0.075	65.1	1440	9.0	4.3	0.0014	11.9

% GRAVEL	% SAND	% SILT	% CLAY
11	24	41	24



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Reach 1 Inlet - South Side** **Checked By:** **GK**

LAB.NO. WGT141174 FIELD NO. S16 HOLE NO. TH15-01 DEPTH (m) 65.0-66.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	22.3	17.6	0.0458	46.9
1.50	37.5	100.0	2	21.0	16.3	0.0328	43.4
0.75	19.0	100.0	4	20.5	15.8	0.0233	42.1
0.375	9.5	93.0	8	18.9	14.2	0.0168	37.8
#4	4.75	88.1	15	17.0	12.3	0.0125	32.7
#10	2.00	84.1	30	16.0	11.3	0.0089	30.0
#20	0.850	82.2	60	14.0	9.3	0.0064	24.7
#40	0.425	77.1	120	13.0	8.3	0.0046	22.2
#60	0.250	67.2	240	12.0	7.3	0.0033	19.5
#100	0.150	60.6	360	11.0	6.3	0.0027	16.8
#200	0.075	57.6	1440	9.2	4.5	0.0014	12.0

% GRAVEL	% SAND	% SILT	% CLAY
12	31	35	23



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

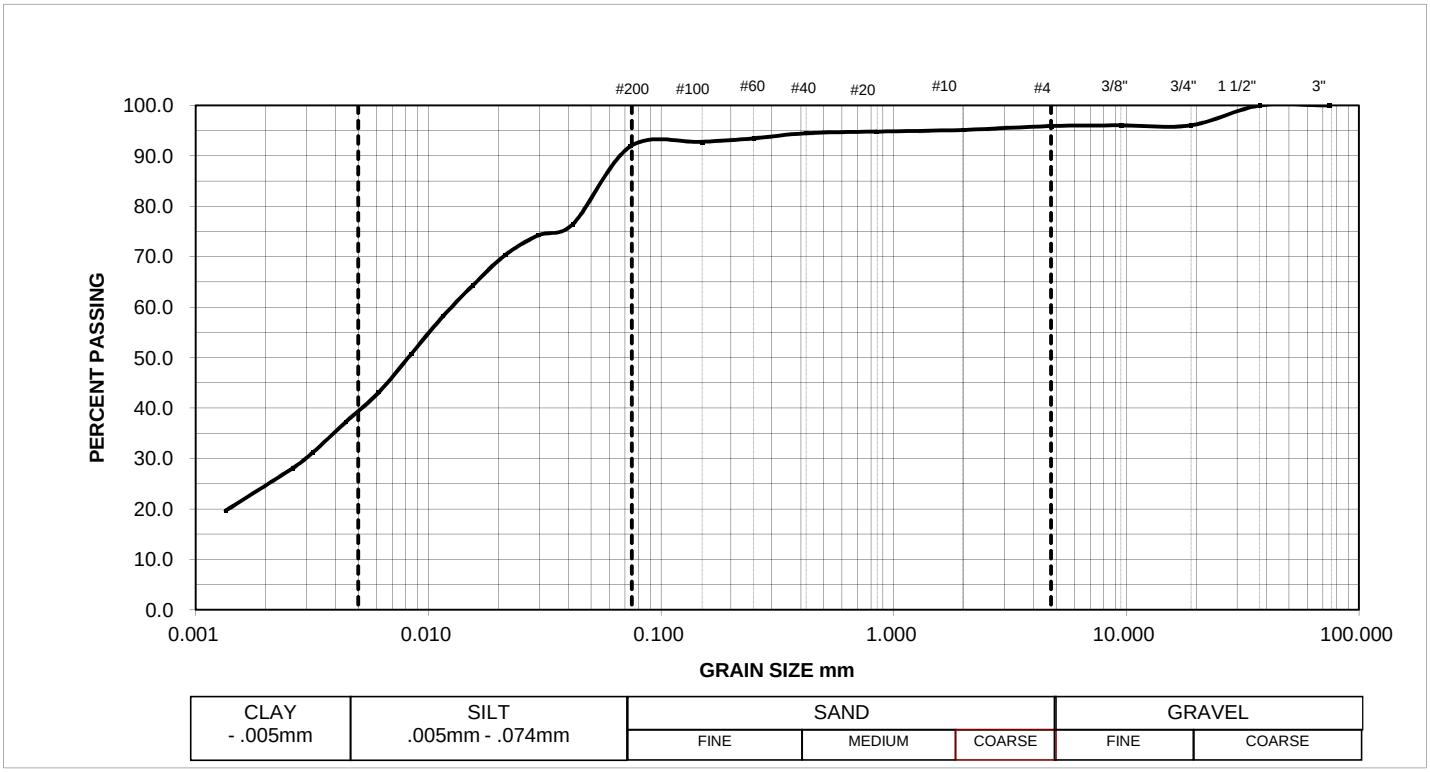
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel
LOCATION: Reach 1 Inlet - South Side
Technician: MJ
Checked By: GK

LAB.NO. WGT141175 FIELD NO. S17 HOLE NO. TH15-01 DEPTH (m) 80.0-81.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	30.0	25.3	0.0417	76.4
1.50	37.5	100.0	2	29.3	24.6	0.0297	74.3
0.75	19.0	96.1	4	28.0	23.3	0.0214	70.3
0.375	9.5	96.1	8	26.0	21.3	0.0155	64.3
#4	4.75	95.9	15	24.0	19.3	0.0116	58.2
#10	2.00	95.2	30	21.5	16.8	0.0084	50.7
#20	0.850	94.8	60	19.0	14.3	0.0061	43.1
#40	0.425	94.5	120	17.0	12.3	0.0044	37.2
#60	0.250	93.5	240	15.0	10.3	0.0032	31.2
#100	0.150	92.8	360	14.0	9.3	0.0026	28.1
#200	0.075	91.9	1440	11.2	6.5	0.0013	19.7

% GRAVEL	% SAND	% SILT	% CLAY
4	4	53	39



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

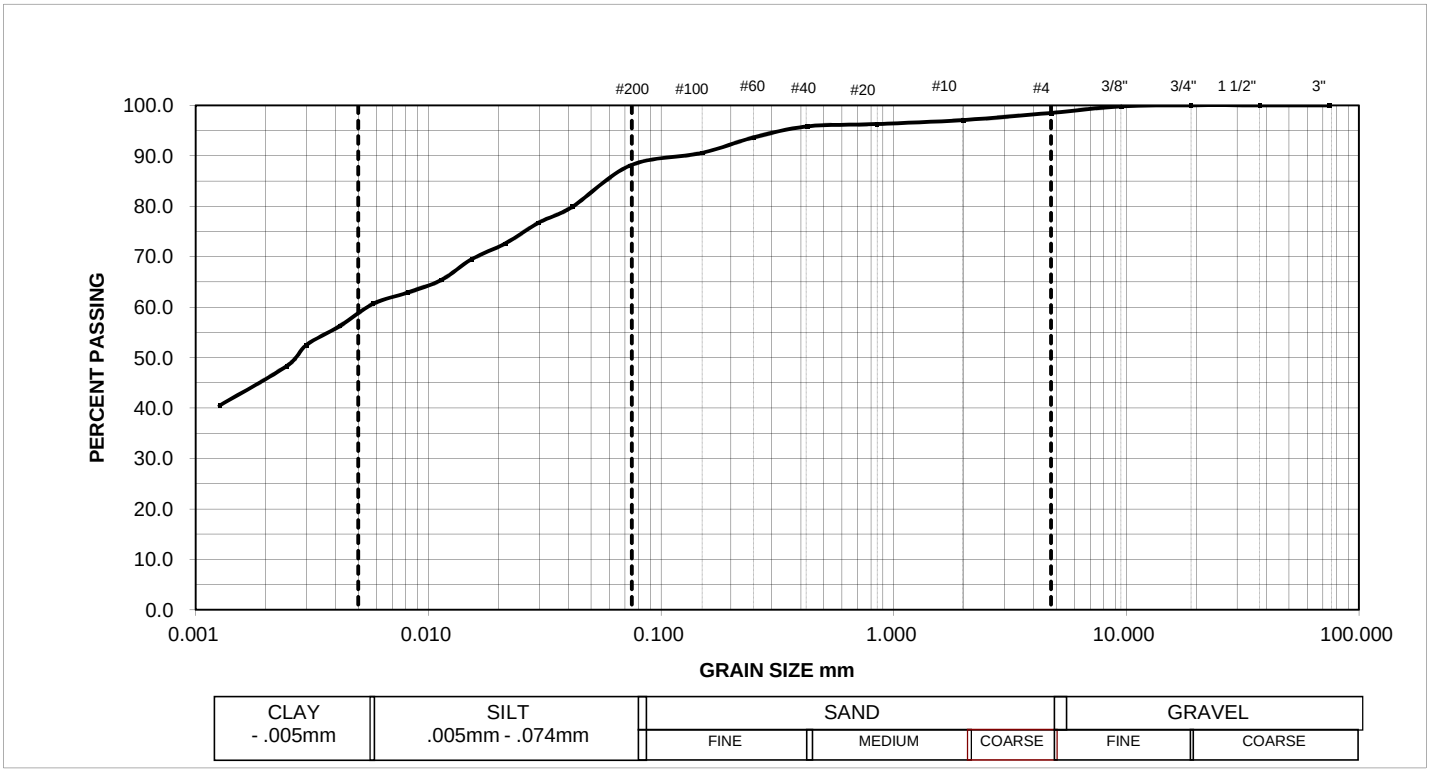
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 2** **Checked By:** **GK**

LAB.NO. WGT141303 FIELD NO. S1 HOLE NO. TP15-27 DEPTH (m) 2.5-3.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	30.0	25.4	0.0416	79.9
1.50	37.5	100.0	2	29.0	24.4	0.0298	76.7
0.75	19.0	100.0	4	27.7	23.1	0.0214	72.6
0.375	9.5	99.8	8	26.7	22.1	0.0154	69.5
#4	4.75	98.5	15	25.4	20.8	0.0114	65.4
#10	2.00	97.1	30	24.6	20.0	0.0081	62.9
#20	0.850	96.3	60	23.9	19.3	0.0058	60.7
#40	0.425	95.8	120	22.5	17.9	0.0042	56.3
#60	0.250	93.6	240	21.3	16.7	0.0030	52.5
#100	0.150	90.6	360	20.0	15.4	0.0025	48.4
#200	0.075	88.1	1440	17.5	12.9	0.0013	40.5

% GRAVEL	% SAND	% SILT	% CLAY
2	10	30	58



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel **Technician:** MO
LOCATION: Reach 2 **Checked By:** GK

LAB.NO. WGT141304 FIELD NO. S2 HOLE NO. TP15-27 DEPTH (m) 8.0-9.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	21.9	17.3	0.0459	41.8
1.50	37.50	100.0	2	19.6	15.0	0.0333	36.2
0.75	19.00	85.9	4	18.0	13.4	0.0239	32.3
0.375	9.50	80.2	8	15.9	11.3	0.0173	27.2
#4	4.75	77.7	15	14.2	9.6	0.0128	23.1
#10	2.00	76.2	30	14.0	9.4	0.0091	22.6
#20	0.850	75.5	60	11.6	7.0	0.0066	16.8
#40	0.425	72.7	120	10.7	6.1	0.0047	14.7
#60	0.250	61.0	240	9.8	5.2	0.0033	12.5
#100	0.150	54.2	360	9.0	4.4	0.0027	10.5
#200	0.075	50.4	1440	7.5	2.9	0.0014	6.9

% GRAVEL	% SAND	% SILT	% CLAY
22	27	35	15



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel **Technician:** MO
LOCATION: Reach 2 **Checked By:** GK

LAB.NO. WGT141305 FIELD NO. S3 HOLE NO. TP15-27 DEPTH (m) 15.0-16.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	21.6	17.0	0.0461	43.8
1.50	37.50	100.0	2	19.5	14.9	0.0333	38.3
0.75	19.00	92.0	4	17.5	12.9	0.0240	33.2
0.375	9.50	87.2	8	15.3	10.7	0.0174	27.5
#4	4.75	83.5	15	14.0	9.4	0.0128	24.1
#10	2.00	81.4	30	12.4	7.8	0.0092	20.0
#20	0.850	79.7	60	11.2	6.6	0.0066	16.9
#40	0.425	76.9	120	10.0	5.4	0.0047	13.8
#60	0.250	67.0	240	9.0	4.4	0.0034	11.2
#100	0.150	60.7	360	8.7	4.1	0.0027	10.5
#200	0.075	55.5	1440	7.0	2.4	0.0014	6.1

% GRAVEL	% SAND	% SILT	% CLAY
16	28	42	14



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 2** **Checked By:** **GK**

LAB.NO. WGT141306 FIELD NO. S1 HOLE NO. TP15-28 DEPTH (m) 2.0-3.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	21.5	16.9	0.0461	44.5
1.50	37.5	100.0	2	19.8	15.2	0.0332	40.0
0.75	19.0	96.6	4	17.7	13.1	0.0240	34.5
0.375	9.5	90.5	8	16.0	11.4	0.0173	30.0
#4	4.75	86.4	15	14.1	9.5	0.0128	25.0
#10	2.00	83.2	30	12.7	8.1	0.0092	21.3
#20	0.850	80.3	60	11.7	7.1	0.0066	18.6
#40	0.425	76.7	120	10.6	6.0	0.0047	15.7
#60	0.250	68.3	240	9.8	5.2	0.0033	13.6
#100	0.150	60.6	360	9.0	4.4	0.0027	11.5
#200	0.075	55.3	1440	7.6	3.0	0.0014	7.8

% GRAVEL	% SAND	% SILT	% CLAY
14	31	39	16



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel **Technician:** MO
LOCATION: Reach 2 **Checked By:** GK

LAB.NO. WGT141307 FIELD NO. S2 HOLE NO. TP15-28 DEPTH (m) 8.0-9.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	23.3	18.7	0.0452	49.0
1.50	37.50	100.0	2	21.2	16.6	0.0327	43.5
0.75	19.00	96.7	4	19.6	15.0	0.0235	39.3
0.375	9.50	88.8	8	17.1	12.5	0.0171	32.7
#4	4.75	84.9	15	15.6	11.0	0.0126	28.8
#10	2.00	82.7	30	14.1	9.5	0.0091	24.8
#20	0.850	81.5	60	12.8	8.2	0.0065	21.4
#40	0.425	79.4	120	11.6	7.0	0.0046	18.3
#60	0.250	70.3	240	10.0	5.4	0.0033	14.0
#100	0.150	63.7	360	9.0	4.4	0.0027	11.4
#200	0.075	59.3	1440	8.0	3.4	0.0014	8.8

% GRAVEL	% SAND	% SILT	% CLAY
15	26	41	18



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

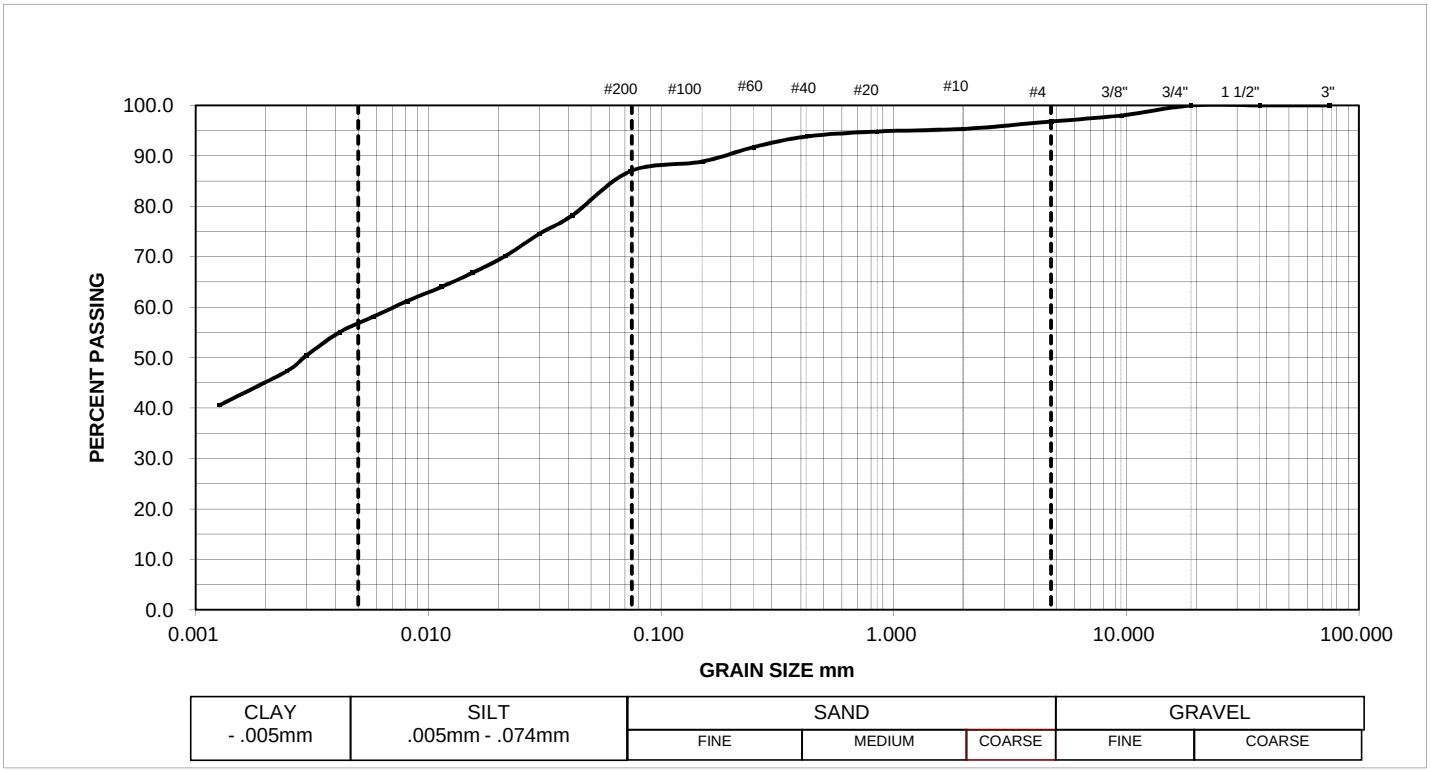
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel **Technician:** MO
LOCATION: Reach 2 **Checked By:** GK

LAB.NO. WGT141308 FIELD NO. S1 HOLE NO. TP15-29 DEPTH (m) 5.0-6.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	30.0	25.4	0.0416	78.2
1.50	37.50	100.0	2	28.8	24.2	0.0299	74.5
0.75	19.00	100.0	4	27.4	22.8	0.0215	70.2
0.375	9.50	98.0	8	26.3	21.7	0.0154	66.8
#4	4.75	96.8	15	25.4	20.8	0.0114	64.0
#10	2.00	95.4	30	24.5	19.9	0.0081	61.3
#20	0.850	94.8	60	23.5	18.9	0.0058	58.2
#40	0.425	93.9	120	22.5	17.9	0.0042	55.1
#60	0.250	91.7	240	21.0	16.4	0.0030	50.5
#100	0.150	88.9	360	20.0	15.4	0.0025	47.4
#200	0.075	87.0	1440	17.8	13.2	0.0013	40.6

% GRAVEL	% SAND	% SILT	% CLAY
3	10	30	57



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

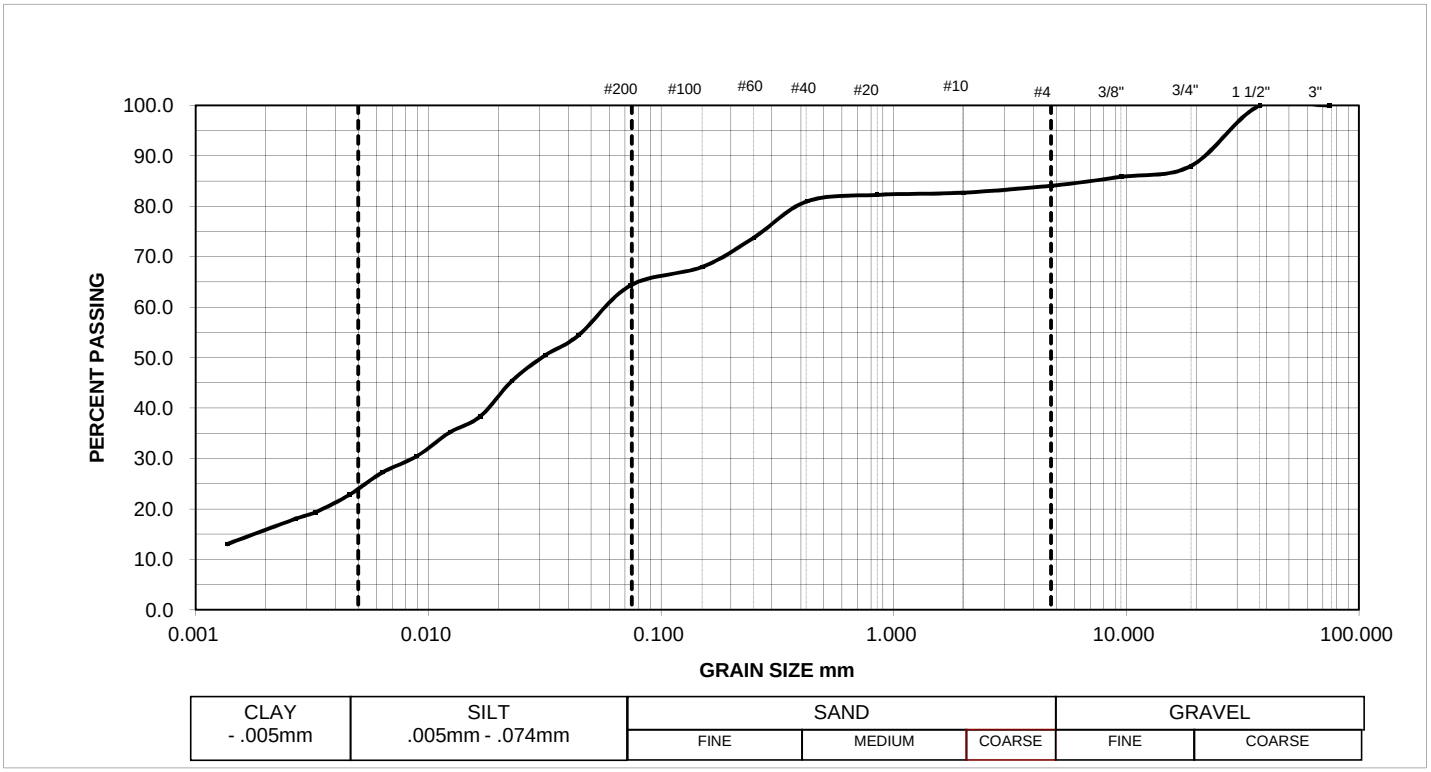
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 2** **Checked By:** **GK**

LAB.NO. WGT141309 FIELD NO. S2 HOLE NO. TP15-29 DEPTH (m) 12.0-13.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	25.3	20.7	0.0442	54.4
1.50	37.50	100.0	2	23.8	19.2	0.0318	50.5
0.75	19.00	88.0	4	21.9	17.3	0.0230	45.5
0.375	9.50	85.9	8	19.2	14.6	0.0167	38.3
#4	4.75	84.1	15	18.0	13.4	0.0124	35.2
#10	2.00	82.7	30	16.2	11.6	0.0089	30.4
#20	0.850	82.3	60	15.0	10.4	0.0064	27.3
#40	0.425	81.0	120	13.3	8.7	0.0046	22.8
#60	0.250	73.8	240	12.0	7.4	0.0033	19.4
#100	0.150	68.0	360	11.5	6.9	0.0027	18.1
#200	0.075	64.3	1440	9.6	5.0	0.0014	13.0

% GRAVEL	% SAND	% SILT	% CLAY
16	20	40	24



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 2** **Checked By:** **GK**

LAB.NO. WGT141310 FIELD NO. S3 HOLE NO. TP15-29 DEPTH (m) 15.0-16.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	24.0	19.4	0.0448	52.7
1.50	37.50	100.0	2	21.3	16.7	0.0327	45.4
0.75	19.00	98.3	4	19.3	14.7	0.0236	39.9
0.375	9.50	91.3	8	17.0	12.4	0.0171	33.7
#4	4.75	88.2	15	15.0	10.4	0.0127	28.2
#10	2.00	85.9	30	13.9	9.3	0.0091	25.2
#20	0.850	85.2	60	12.2	7.6	0.0065	20.6
#40	0.425	83.3	120	11.0	6.4	0.0047	17.3
#60	0.250	74.1	240	10.0	5.4	0.0033	14.6
#100	0.150	66.4	360	9.0	4.4	0.0027	11.9
#200	0.075	62.2	1440	8.0	3.4	0.0014	9.1

% GRAVEL	% SAND	% SILT	% CLAY
12	26	45	17



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

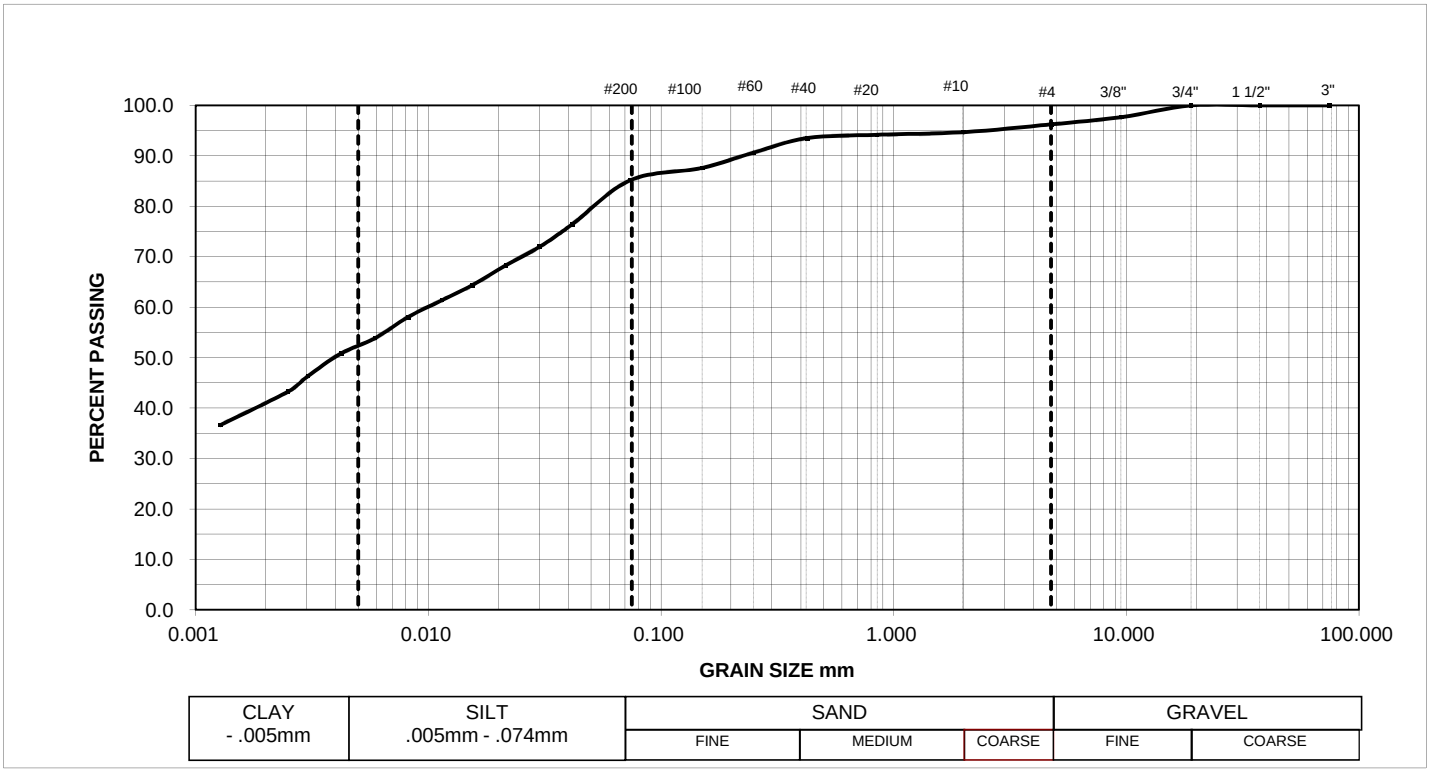
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 2** **Checked By:** **GK**

LAB.NO. WGT141311 FIELD NO. S1 HOLE NO. TP15-30 DEPTH (m) 2.0-3.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	30.0	25.4	0.0416	76.5
1.50	37.50	100.0	2	28.5	23.9	0.0300	71.9
0.75	19.00	100.0	4	27.3	22.7	0.0215	68.3
0.375	9.50	97.7	8	26.0	21.4	0.0155	64.4
#4	4.75	96.2	15	25.0	20.4	0.0114	61.4
#10	2.00	94.7	30	23.9	19.3	0.0082	58.1
#20	0.850	94.2	60	22.5	17.9	0.0059	53.8
#40	0.425	93.5	120	21.5	16.9	0.0042	50.8
#60	0.250	90.7	240	20.0	15.4	0.0030	46.3
#100	0.150	87.6	360	19.0	14.4	0.0025	43.3
#200	0.075	85.2	1440	16.8	12.2	0.0013	36.7

% GRAVEL	% SAND	% SILT	% CLAY
4	11	33	52



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: Lake St. Martin Channel **Technician:** MO
LOCATION: Reach 2 **Checked By:** GK

LAB.NO. WGT141312 FIELD NO. S2 HOLE NO. TP15-30 DEPTH (m) 11.0-12.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	24.0	19.4	0.0448	42.7
1.50	37.50	100.0	2	22.0	17.4	0.0324	38.3
0.75	19.00	80.1	4	19.7	15.1	0.0235	33.2
0.375	9.50	74.4	8	17.3	12.7	0.0170	27.9
#4	4.75	71.1	15	15.5	10.9	0.0127	23.9
#10	2.00	69.6	30	14.0	9.4	0.0091	20.6
#20	0.850	69.4	60	12.2	7.6	0.0065	16.7
#40	0.425	68.3	120	11.0	6.4	0.0047	14.0
#60	0.250	61.6	240	9.9	5.3	0.0033	11.6
#100	0.150	48.7	360	9.0	4.4	0.0027	9.6
#200	0.075	44.7	1440	8.0	3.4	0.0014	7.4

% GRAVEL	% SAND	% SILT	% CLAY
29	26	31	14



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

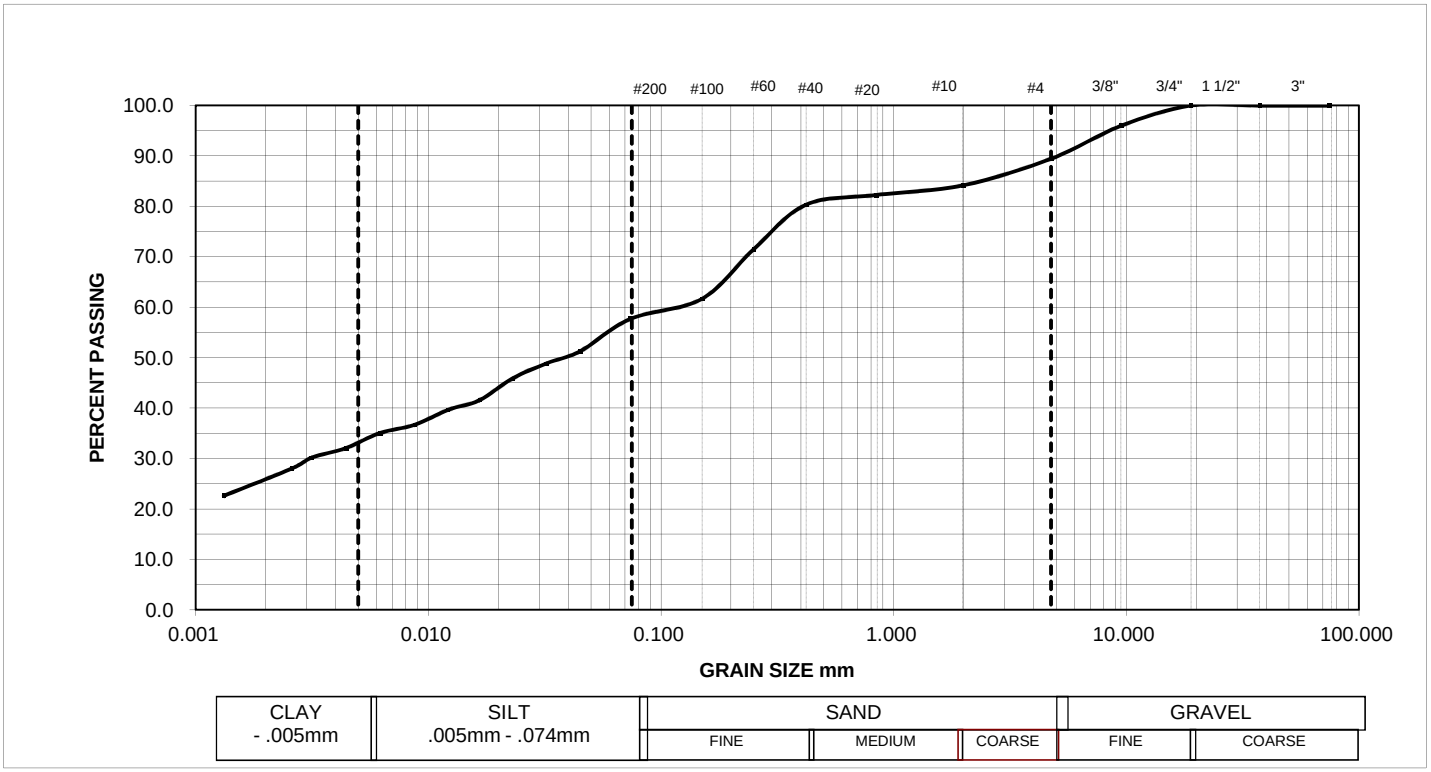
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 2** **Checked By:** **GK**

LAB.NO. WGT141313 FIELD NO. S1 HOLE NO. TP15-31 DEPTH (m) 2.0-3.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	23.6	19.0	0.0450	51.3
1.50	37.5	100.0	2	22.7	18.1	0.0322	48.8
0.75	19.0	100.0	4	21.6	17.0	0.0230	45.9
0.375	9.5	96.0	8	20.0	15.4	0.0166	41.5
#4	4.75	89.4	15	19.3	14.7	0.0122	39.6
#10	2.00	84.2	30	18.2	13.6	0.0087	36.7
#20	0.850	82.3	60	17.6	13.0	0.0062	35.0
#40	0.425	80.3	120	16.5	11.9	0.0044	32.1
#60	0.250	71.5	240	15.8	11.2	0.0032	30.2
#100	0.150	61.6	360	15.0	10.4	0.0026	28.0
#200	0.075	57.7	1440	13.0	8.4	0.0013	22.6

% GRAVEL	% SAND	% SILT	% CLAY
11	32	25	33



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

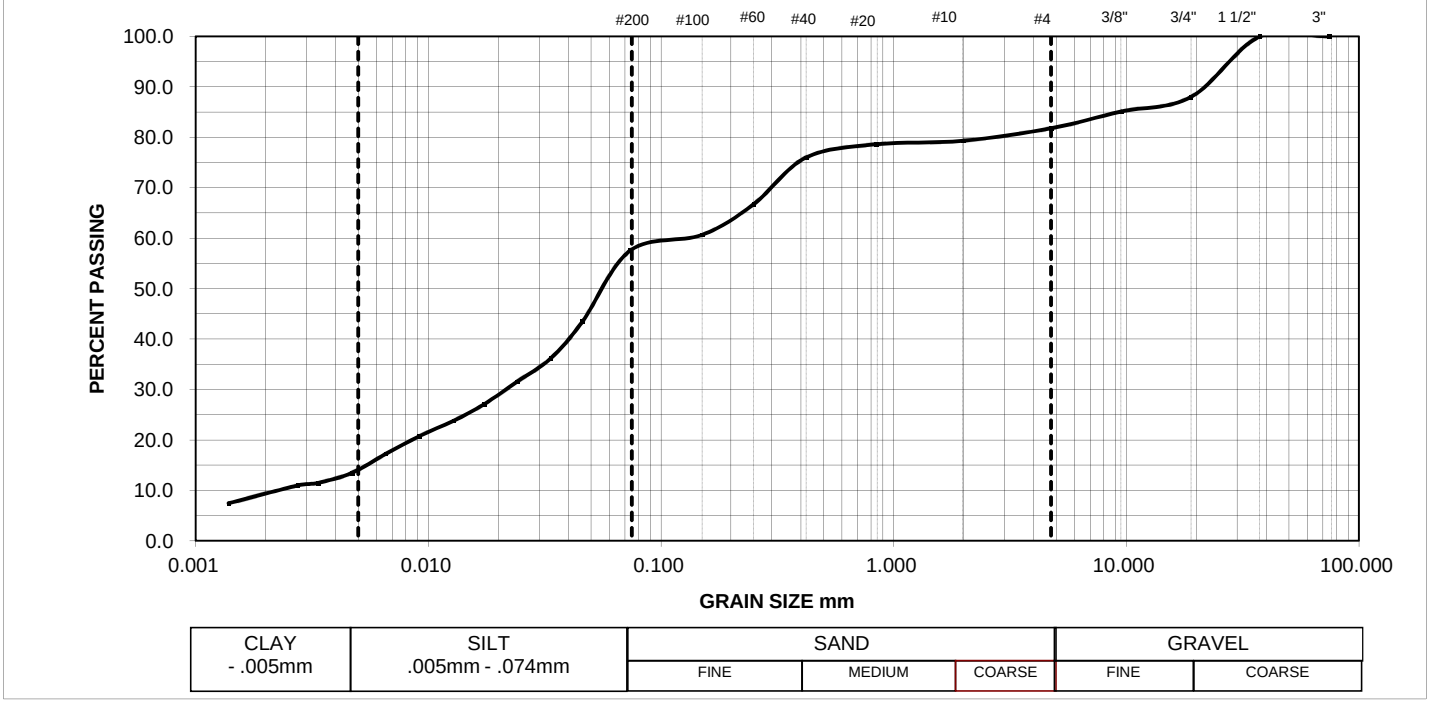
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MO**
LOCATION: **Reach 2** **Checked By:** **GK**

LAB.NO. WGT141314 FIELD NO. S2 HOLE NO. TP15-31 DEPTH (m) 6.0-7.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	21.9	17.3	0.0459	43.4
1.50	37.5	100.0	2	19.0	14.4	0.0335	36.1
0.75	19.0	88.0	4	17.2	12.6	0.0241	31.6
0.375	9.5	85.1	8	15.4	10.8	0.0174	27.0
#4	4.75	81.8	15	14.1	9.5	0.0128	23.8
#10	2.00	79.3	30	12.9	8.3	0.0092	20.8
#20	0.850	78.6	60	11.5	6.9	0.0066	17.2
#40	0.425	76.0	120	10.0	5.4	0.0047	13.5
#60	0.250	66.7	240	9.2	4.6	0.0034	11.4
#100	0.150	60.6	360	9.0	4.4	0.0027	10.9
#200	0.075	57.6	1440	7.6	3.0	0.0014	7.4

% GRAVEL	% SAND	% SILT	% CLAY
18	24	44	14



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

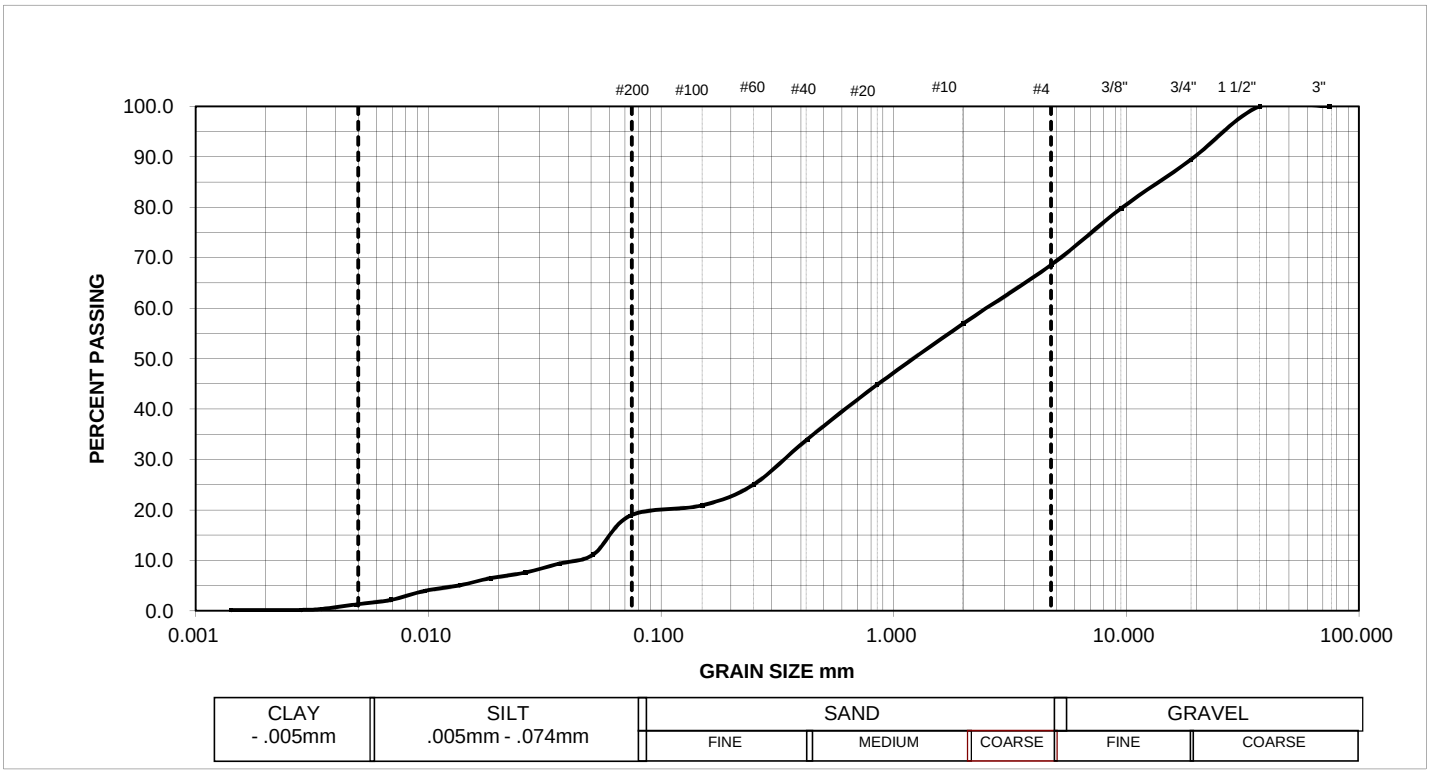
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Granular Borrow** **Checked By:** **GK**

LAB.NO. WGT141294 FIELD NO. S1 HOLE NO. TH15-17 DEPTH (m) 3.5-5.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	11.0	6.2	0.0512	11.2
1.50	37.5	100.0	2	10.0	5.2	0.0365	9.4
0.75	19.0	89.5	4	9.0	4.2	0.0260	7.6
0.375	9.5	79.8	8	8.4	3.6	0.0185	6.5
#4	4.75	68.6	15	7.6	2.8	0.0136	5.0
#10	2.00	57.0	30	7.0	2.2	0.0097	4.0
#20	0.850	44.8	60	6.0	1.2	0.0069	2.2
#40	0.425	34.0	120	5.5	0.7	0.0049	1.3
#60	0.250	25.0	240	5.0	0.2	0.0035	0.4
#100	0.150	20.9	360	4.9	0.1	0.0028	0.2
#200	0.075	18.9	1440	4.9	0.1	0.0014	0.2

% GRAVEL	% SAND	% SILT	% CLAY
31	50	17	2



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

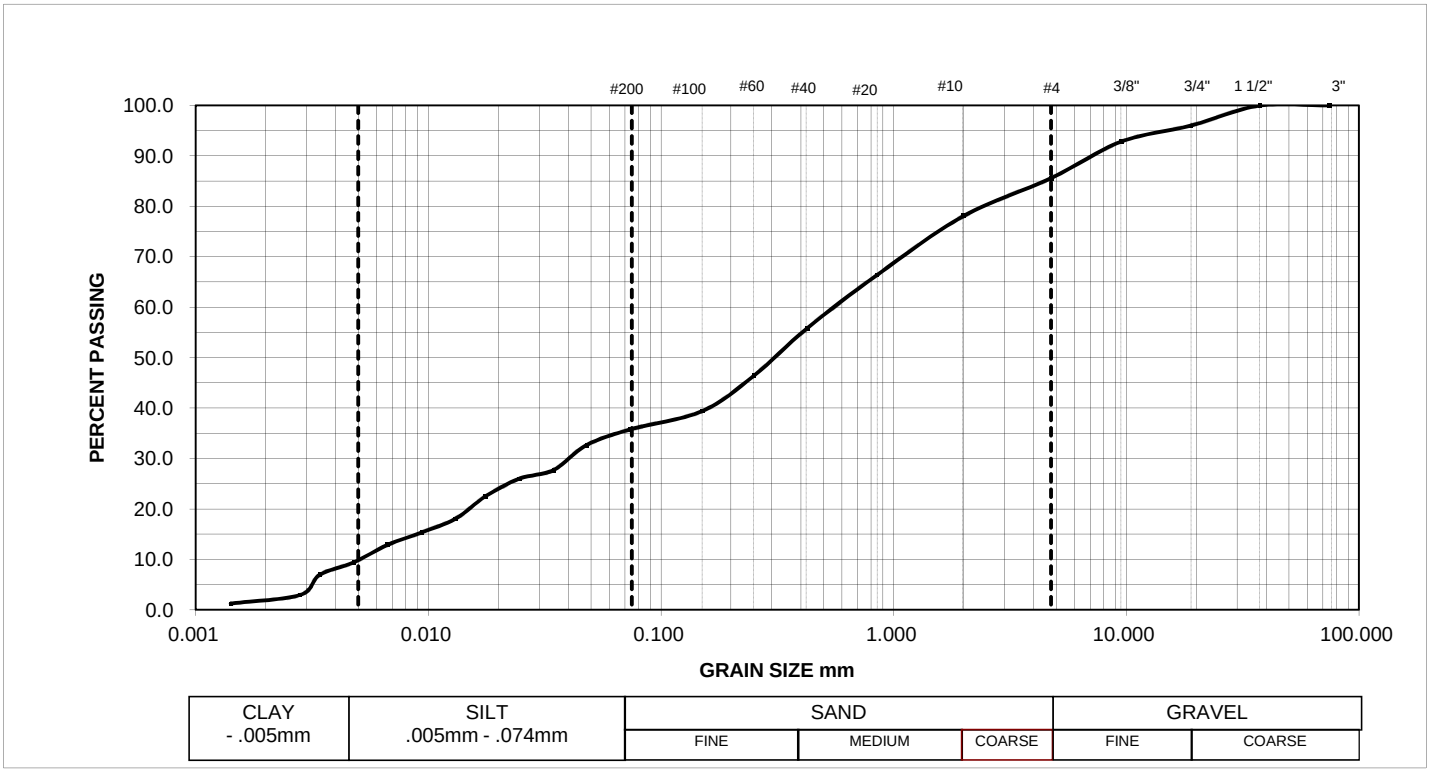
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Granular Borrow** **Checked By:** **GK**

LAB.NO. WGT141295 FIELD NO. S2 HOLE NO. TH15-17 DEPTH (m) 5.0-5.5

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	18.0	13.2	0.0479	32.7
1.50	37.50	100.0	2	16.0	11.2	0.0346	27.7
0.75	19.00	96.0	4	15.3	10.5	0.0246	26.0
0.375	9.50	92.8	8	13.9	9.1	0.0176	22.5
#4	4.75	85.6	15	12.1	7.3	0.0131	18.1
#10	2.00	78.1	30	11.0	6.2	0.0093	15.4
#20	0.850	66.4	60	10.0	5.2	0.0067	12.9
#40	0.425	55.9	120	8.6	3.8	0.0048	9.4
#60	0.250	46.4	240	7.6	2.8	0.0034	6.9
#100	0.150	39.4	360	6.0	1.2	0.0028	3.0
#200	0.075	35.8	1440	5.3	0.5	0.0014	1.2

% GRAVEL	% SAND	% SILT	% CLAY
14	50	26	10



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

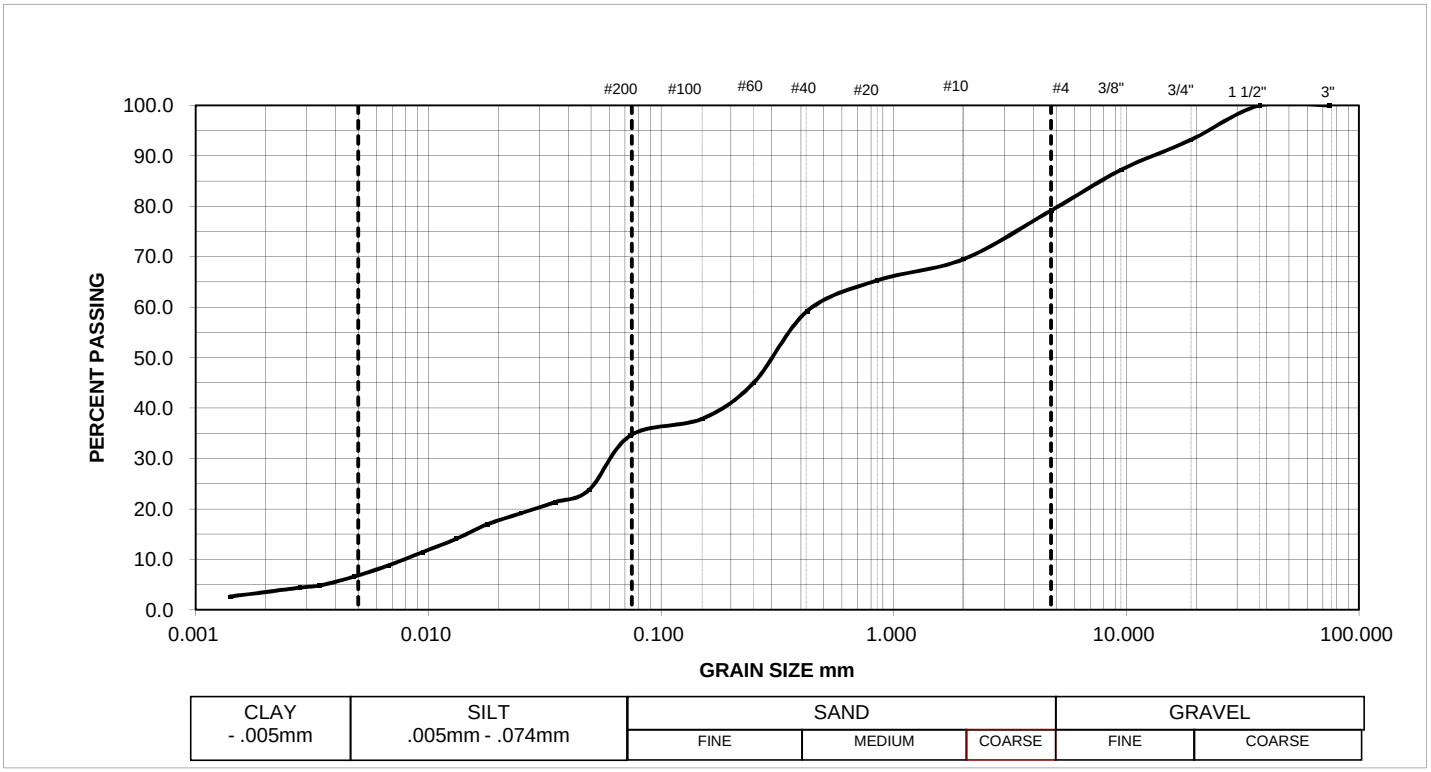
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Granular Borrow** **Checked By:** **GK**

LAB.NO. WGT141296 FIELD NO. S3 HOLE NO. TH15-17 DEPTH (m) 6.0-8.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	15.6	10.8	0.0491	23.8
1.50	37.50	100.0	2	14.5	9.7	0.0351	21.3
0.75	19.00	93.2	4	13.5	8.7	0.0250	19.1
0.375	9.50	87.2	8	12.5	7.7	0.0179	16.9
#4	4.75	79.1	15	11.2	6.4	0.0132	14.1
#10	2.00	69.5	30	10.0	5.2	0.0094	11.4
#20	0.850	65.3	60	8.8	4.0	0.0067	8.8
#40	0.425	59.2	120	7.8	3.0	0.0048	6.6
#60	0.250	45.0	240	7.0	2.2	0.0034	4.8
#100	0.150	37.9	360	6.8	2.0	0.0028	4.4
#200	0.075	34.6	1440	6.0	1.2	0.0014	2.6

% GRAVEL	% SAND	% SILT	% CLAY
21	45	28	7



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

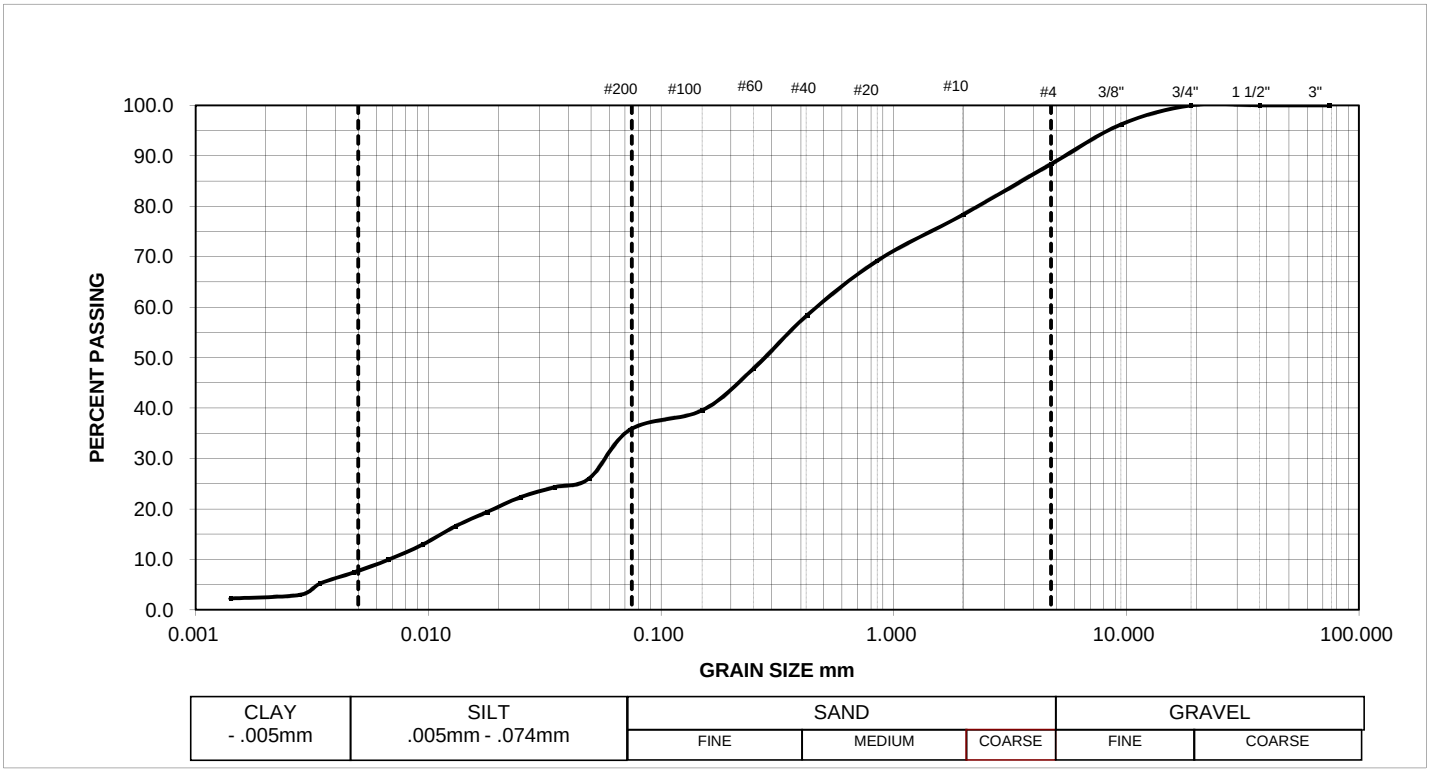
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **Mj**
LOCATION: **Granular Borrow** **Checked By:** **GK**

LAB.NO. WGT141297 FIELD NO. S4 HOLE NO. TH15-17 DEPTH (m) 8.0-10.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.0	100.0	1	15.3	10.5	0.0492	26.1
1.50	37.5	100.0	2	14.6	9.8	0.0350	24.3
0.75	19.0	100.0	4	13.8	9.0	0.0250	22.3
0.375	9.5	96.2	8	12.6	7.8	0.0178	19.4
#4	4.75	88.4	15	11.5	6.7	0.0132	16.6
#10	2.00	78.4	30	10.0	5.2	0.0094	12.9
#20	0.850	69.2	60	8.8	4.0	0.0067	9.9
#40	0.425	58.4	120	7.8	3.0	0.0048	7.4
#60	0.250	47.8	240	6.9	2.1	0.0034	5.2
#100	0.150	39.5	360	6.0	1.2	0.0028	3.0
#200	0.075	35.8	1440	5.7	0.9	0.0014	2.2

% GRAVEL	% SAND	% SILT	% CLAY
12	53	28	8



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

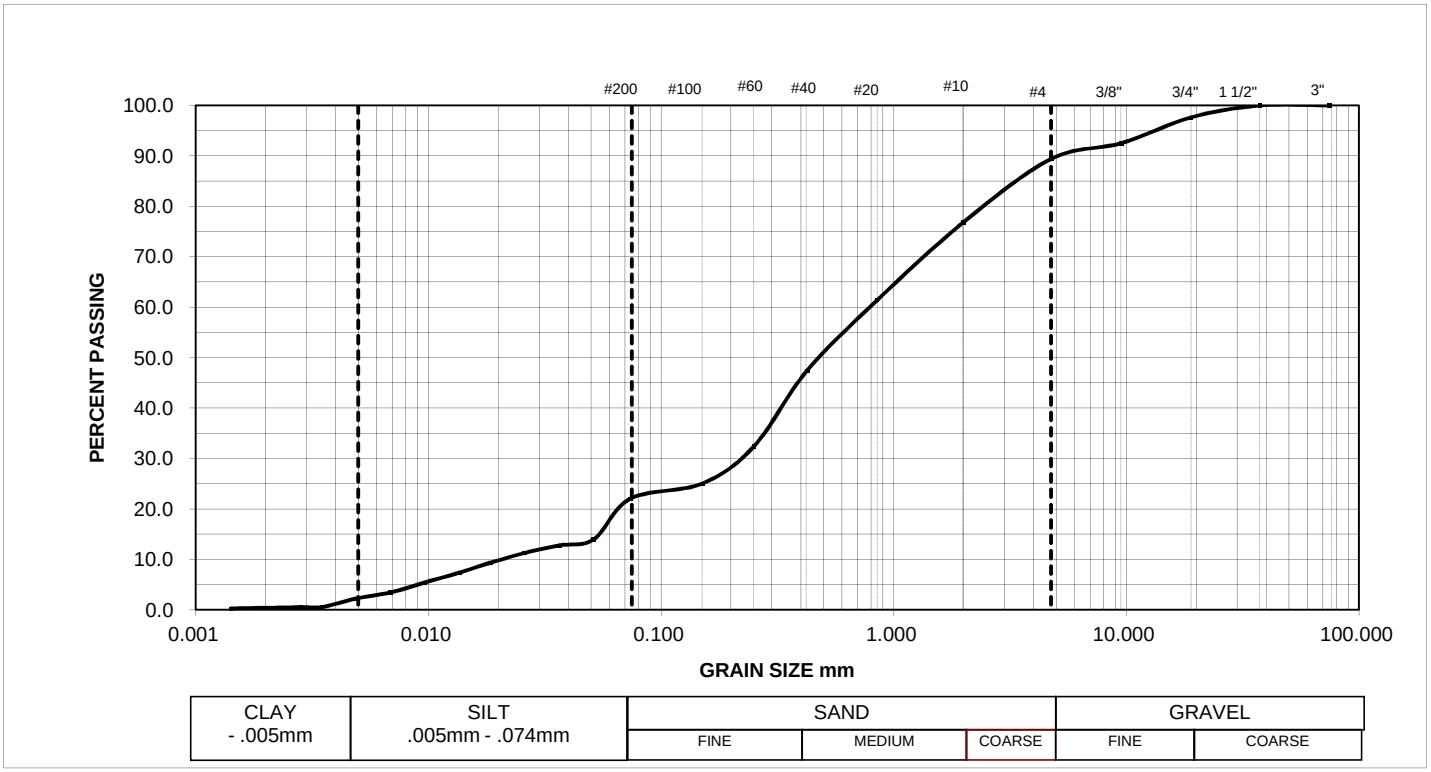
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Granular Borrow** **Checked By:** **GK**

LAB.NO. WGT141298 FIELD NO. S1 HOLE NO. TH15-18 DEPTH (m) 1.0-4.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	10.5	5.7	0.0514	14.0
1.50	37.50	100.0	2	10.0	5.2	0.0365	12.7
0.75	19.00	97.6	4	9.4	4.6	0.0260	11.3
0.375	9.50	92.5	8	8.6	3.8	0.0185	9.3
#4	4.75	89.4	15	7.8	3.0	0.0136	7.3
#10	2.00	76.9	30	7.0	2.2	0.0097	5.4
#20	0.850	61.4	60	6.2	1.4	0.0069	3.4
#40	0.425	47.4	120	5.7	0.9	0.0049	2.2
#60	0.250	32.3	240	5.0	0.2	0.0035	0.5
#100	0.150	25.0	360	5.0	0.2	0.0028	0.5
#200	0.075	22.1	1440	4.9	0.1	0.0014	0.2

% GRAVEL	% SAND	% SILT	% CLAY
11	67	20	2



MANITOBA INFRASTRUCTURE and TRANSPORTATION
MATERIALS ENGINEERING BRANCH - CENTRAL LAB

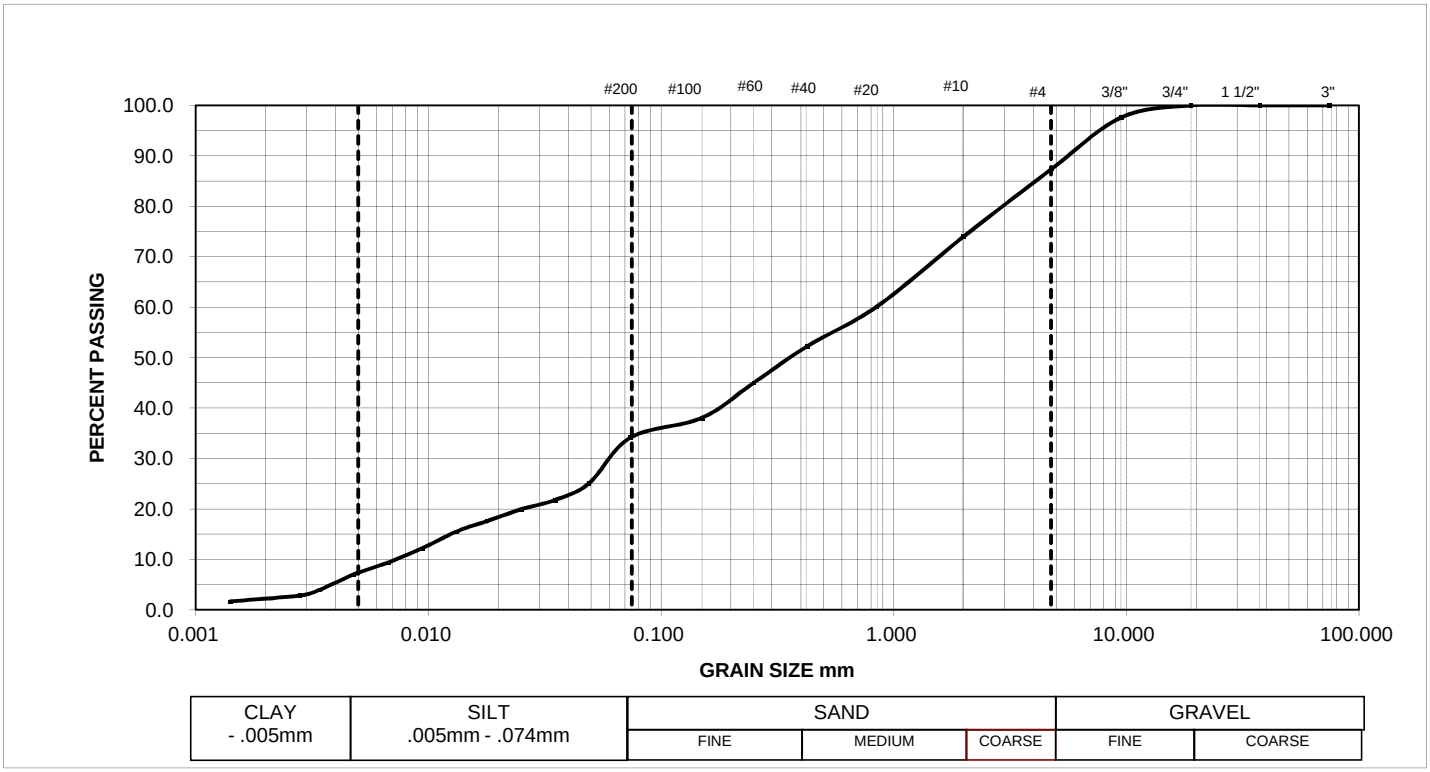
PARTICLE SIZE ANALYSIS of SOILS - ASTM D 422

PROJECT: **Lake St. Martin Channel** **Technician:** **MJ**
LOCATION: **Granular Borrow** **Checked By:** **GK**

LAB.NO. WGT141299 FIELD NO. S2 HOLE NO. TH15-18 DEPTH (m) 5.0-7.0

SIEVE ANALYSIS			HYDROMETER ANALYSIS				
SIEVE U.S. STANDARD	DIAMETER (mm)	% PASSING	TIME MINUTES	HYDROMETER READING R_O	HYDROMETER READING R_C	DIAMETER (mm)	% PASSING
3.00	75.00	100.0	1	15.5	10.7	0.0491	25.1
1.50	37.50	100.0	2	14.1	9.3	0.0352	21.8
0.75	19.00	100.0	4	13.3	8.5	0.0251	19.9
0.375	9.50	97.6	8	12.3	7.5	0.0179	17.6
#4	4.75	87.3	15	11.4	6.6	0.0132	15.5
#10	2.00	74.0	30	10.0	5.2	0.0094	12.2
#20	0.850	60.1	60	8.8	4.0	0.0067	9.4
#40	0.425	52.2	120	7.8	3.0	0.0048	7.0
#60	0.250	45.0	240	6.5	1.7	0.0034	4.0
#100	0.150	38.0	360	6.0	1.2	0.0028	2.8
#200	0.075	34.1	1440	5.5	0.7	0.0014	1.6

% GRAVEL	% SAND	% SILT	% CLAY
13	53	27	7



Manitoba Infrastructure and Transportation
Materials Engineering Branch - Central Lab

SIEVE OR SCREEN ANALYSIS OF FINE AND COARSE AGGREGATES
ASTM C 117, C 136

PROJECT: Lake St. Martin Channel
LOCATION : Granular Borrow

Technician: MO
Checked By: GK

LAB. NO.: WGT141300 **FIELD NO:** S3 **HOLE NO.:** TH15-18
DEPTH(m): 7.0-10.0

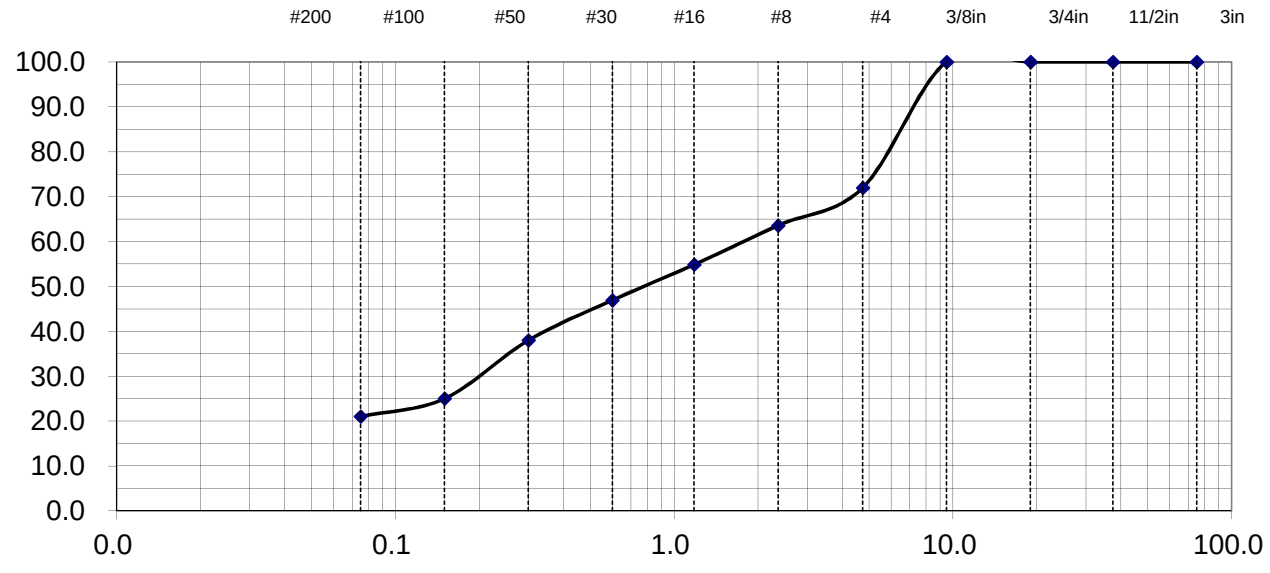
Sieve U.S standard	Size m.m.	Mass Retained Basis Total Sample	Retained (%)	Cumulative Retained (%)	Passing (%)
					100.0
3.00	75.0				100.0
1.50	37.5				100.0
.750	19.0				100.0
.375	9.5				100.0
#4	4.75	124.3	28.0	28.0	72.0
#8	2.36	37.2	8.4	36.4	63.6
#16	1.18	38.6	8.7	45.1	54.9
#30	0.600	35.2	7.9	53.1	46.9
#50	0.300	39.5	8.9	62.0	38.0
#100	0.150	57.6	13.0	75.0	25.0
#200	0.075	17.6	4.0	79.0	21.0
Pan		2.1	0.5	79.4	
Total		352.1	79.4		

Mass of Sample Before Washing	443.3
Mass of Sample After Washing	352.1
Mass Passing (wash) 75 µm	91.2
Mass Passing (sieve) 75 µm	2.1
Total Mass Passing 75 µm	93.3

D10= D30= D60=
Cu= Cc=

% Pass 75 µm =	21.0	Unified
% Sand =	50.9	Classification
% Gravel =	28.0	
F.M. =	3.00	

U.S. Standard Sieve Series ASTM E 11



Manitoba Infrastructure and Transportation
Materials Engineering Branch - Central Lab

SIEVE OR SCREEN ANALYSIS OF FINE AND COARSE AGGREGATES
ASTM C 117, C 136

PROJECT: Lake St. Martin Channel
LOCATION : Granular Borrow

Technician: MO
Checked By: GK

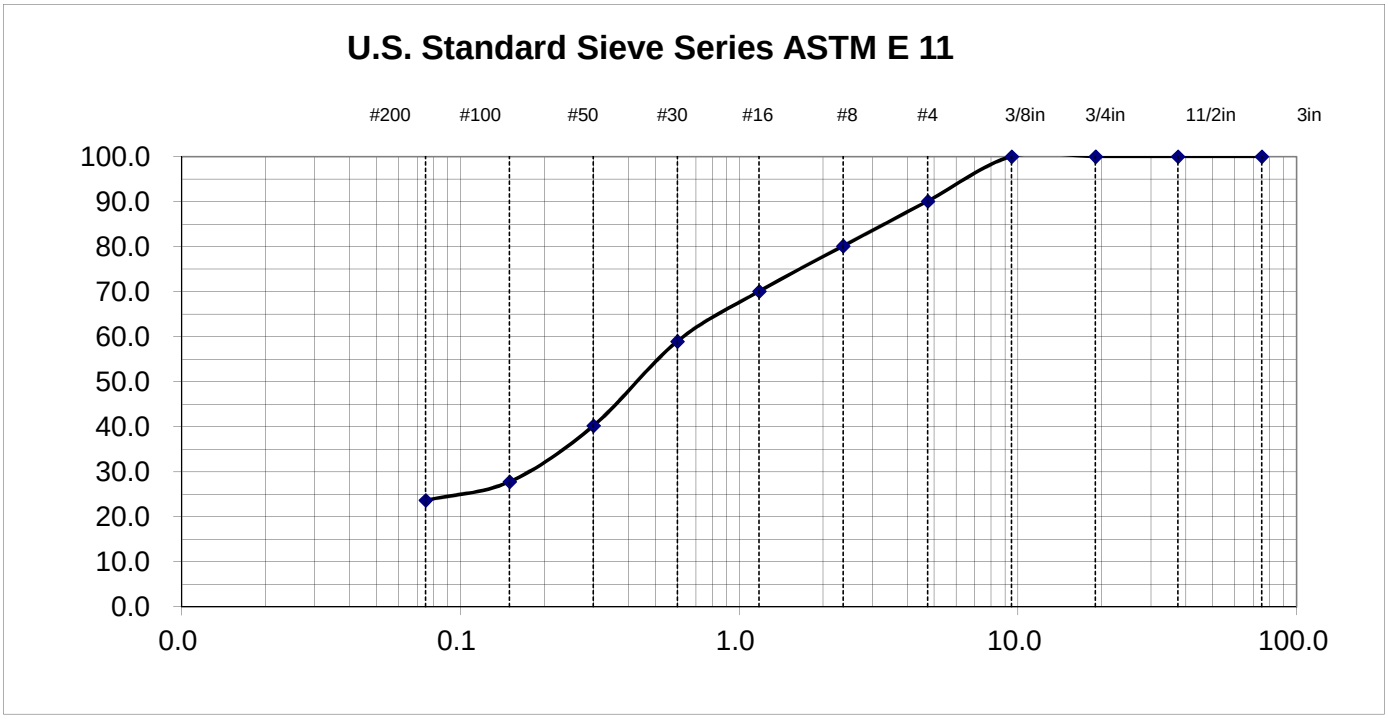
LAB. NO.: WGT141301 **FIELD NO:** S1 **HOLE NO.:** TH15-19
DEPTH(m): 3.5-5.0

Sieve U.S standard	Size m.m.	Mass Retained Basis Total Sample	Retained (%)	Cumulative Retained (%)	Passing (%)
					100.0
3.00	75.0				100.0
1.50	37.5				100.0
.750	19.0				100.0
.375	9.5				100.0
#4	4.75	35.4	9.9	9.9	90.1
#8	2.36	35.6	10.0	19.9	80.1
#16	1.18	35.9	10.1	29.9	70.1
#30	0.600	39.7	11.1	41.0	59.0
#50	0.300	66.9	18.7	59.8	40.2
#100	0.150	44.4	12.4	72.2	27.8
#200	0.075	14.7	4.1	76.3	23.7
Pan		0.9	0.3	76.6	
Total		273.5	76.6		

Mass of Sample Before Washing	357.2
Mass of Sample After Washing	273.5
Mass Passing (wash) 75 µm	83.7
Mass Passing (sieve) 75 µm	0.9
Total Mass Passing 75 µm	84.6

D10= D30= D60=
Cu= Cc=

% Pass 75 µm =	23.7	Unified
% Sand =	66.4	Classification
% Gravel =	9.9	
F.M. =	2.33	



Manitoba Infrastructure and Transportation
Materials Engineering Branch - Central Lab

SIEVE OR SCREEN ANALYSIS OF FINE AND COARSE AGGREGATES
ASTM C 117, C 136

PROJECT: Lake St. Martin Channel
LOCATION : Granular Borrow

Technician: MO
Checked By: GK

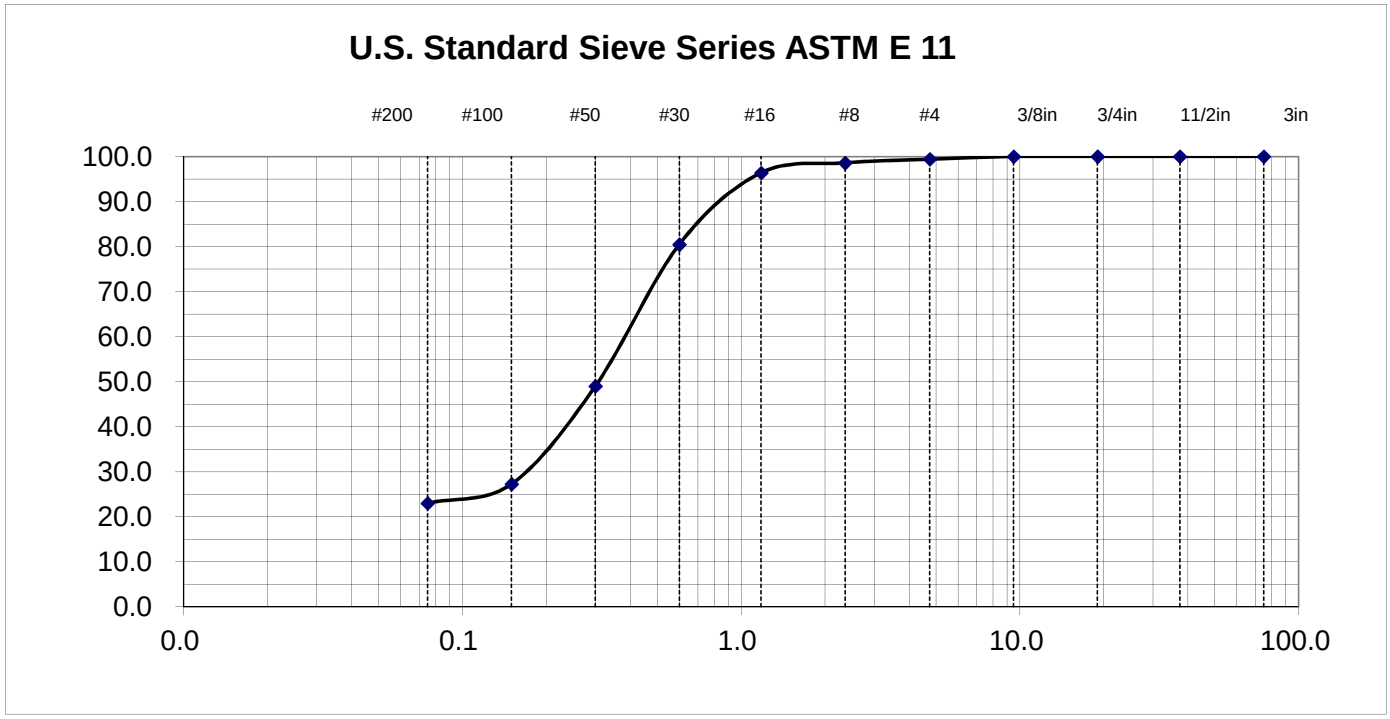
LAB. NO.: WGT141302 **FIELD NO:** S2 **HOLE NO.:** TH15-19
DEPTH(m): 5.0-7.0

Sieve U.S standard	Size m.m.	Mass Retained Basis Total Sample	Retained (%)	Cumulative Retained (%)	Passing (%)
					100.0
3.00	75.0				100.0
1.50	37.5				100.0
.750	19.0				100.0
.375	9.5				100.0
#4	4.75	1.2	0.6	0.6	99.4
#8	2.36	1.7	0.8	1.4	98.6
#16	1.18	4.5	2.2	3.6	96.4
#30	0.600	32.6	15.9	19.5	80.5
#50	0.300	64.4	31.5	51.0	49.0
#100	0.150	44.5	21.7	72.7	27.3
#200	0.075	8.7	4.3	77.0	23.0
Pan		0.6	0.3	77.3	
Total		158.2	77.3		

Mass of Sample Before Washing	204.7
Mass of Sample After Washing	158.2
Mass Passing (wash) 75 µm	46.5
Mass Passing (sieve) 75 µm	0.6
Total Mass Passing 75 µm	47.1

D10= D30= D60=
Cu= Cc=

% Pass 75 µm =	23.0	Unified
% Sand =	76.4	Classification
% Gravel =	0.6	
F.M. =	1.49	



SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (ft)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m³	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L D_{10}	W_P C_C	I_P C_U	GRAIN SIZE GRAVEL %	SAND %	P_{200} or SILT % % CLAY	STRENGTH q_u K.S.F. kPa	POCKET PENETROMETER T.S.F.
S1	WGT14 1159	CL, Clay, -wp, sandy, some gravel, loose/firm, moist, grey										
TH15-01	4.0-5.0											
S2	WGT14 1160	CI/CH, Clay, +wp, some silt, some sand, some organics, soft, moist, black/grey, trace gravel										
TH15-01	7.5-8.5											
S3	WGT14 1161	CH, Clay, +wp, silty, some sand, firm, moist, grey, trace gravel, trace silt pockets										
TH15-01	9.0-10.0											
S4	WGT14 1162	CH, Clay, +wp, silty, some sand, firm, moist, grey, trace gravel, trace silt pockets										
TH15-01	10.0-11.5											
S5	WGT14 1163	CH, Clay, +wp, some silt, some sand, hard, moist, brown, trace gravel, trace silt pockets										
TH15-01	10.0-14.0											
S6	WGT14 1164	CL-ML, Silty Clay, -wp, sandy, some gravel, hard, moist, grey										
TH15-01	15.0-16.5											
S7	WGT14 1165	CL-ML, Silty Clay, -wp, sandy, some gravel, hard, moist, grey										
TH15-01	20.0-21.5											
S8	WGT14 1166	CL-ML, Silty Clay, -wp, sandy, some gravel, hard/firm, moist, grey										
TH15-01	25.0-26.5											
S9	WGT14 1167	ML, Silt, sandy, some clay, some gravel, hard, moist, grey										
TH15-01	30.0-31.5											
S10	WGT14 1168	CL-ML, Silty Clay, -wp, sandy, some gravel, hard, moist, grey										
TH15-01	35.0-36.5											
S11	WGT14 1169	ML, Silt, sandy, some clay, some gravel, hard, moist, grey										
TH15-01	40.0-41.5											
S12	WGT14 1170	CL-ML, Silty Clay, -wp, sandy, some gravel, hard, moist, grey										
TH15-01	45.0-46.5											
S13	WGT14 1171	CL-ML, Silty Clay, -wp, sandy, some gravel, hard, moist, grey										
TH15-01	50.0-51.5											
S14	WGT14 1172	CL-ML, Silty Clay, -wp, sandy, some gravel, hard, moist, grey										
TH15-01	55.0-56.5											
S15	WGT14 1173	CL-ML, Silty Clay, -wp, sandy, some gravel, hard, moist, grey										
TH15-01	60.0-61.5											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Lake St Martin Channel
LOCATION: Reach 1 Inlet - South Side
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-03-25

SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (ft)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m³	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS: W_L / D_{10}	W_P / C_C	I_P / C_U	GRAIN SIZE: GRAVEL %	SAND %	P_{200} or SILT % / CLAY %	STRENGTH: q_u K.S.F. / kPa	POCKET PENETROMETER T.S.F.
S16	WGT14 1174	ML, Silt, sandy, clayey, some gravel, hard, moist, grey										
TH15-01	65.0-66.5											
S17	WGT14 1175	CL-ML, silty Clay, +wp, very soft, very moist, grey, trace gravel, trace sand										
TH15-01	80.0-81.5											
R1	WGT14 1176	No Classification										
TH15-01	87.5-89.5											
R2	WGT14 1177	No Classification										
TH15-01	89.5-94.0											

SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (ft)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m³	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L / D_{10}	W_P / C_C	I_P / C_U	GRAIN SIZE GRAVEL %	SAND %	P_{200} or SILT % / CLAY %	STRENGTH q_u K.S.F. / kPa	POCKET PENETROMETER T.S.F.
S1	WGT14 1303	CI, Clay, +wp, silty, some sand, firm, moist, brown, trace gravel, trace silt pockets, trace organics										
TP15-27	2.5-3.5											
S2	WGT14 1304	CL-ML, Silty Clay, -wp, sandy, gravelly, hard/loose, moist, light brown										
TP15-27	8.0-9.0											
S3	WGT14 1305	ML, Silt , sandy, some gravel, some clay, hard/loose, light brown										
TP15-27	15.0-16.0											
S1	WGT14 1306	ML, silt, sandy, some clay, some gravel, hard-firm, moist, light brown										
TP15-28	2.0-3.0											
S2	WGT14 1307	ML, Silt, sandy, some clay, some gravel, hard/loose, moist, light brown										
TP15-28	8.0-9.0											
S1	WGT14 1308	CI, clay, +wp, silty, some sand, firm-soft, moist, grey, trace gravel, trace organics, trace silt pockets										
TP15-29	5.0-6.0											
S2	WGT14 1309	CL, Clay, -wp, silty, some sand, some gravel, hard/loose, moist, light brown										
TP15-29	12.0-13.0											
S3	WGT14 1310	CL-ML, Silty Clay, sandy, some gravel, hard, moist, light brown										
TP15-29	15.0-16.0											
S1	WGT14 1311	CI, Clay, +wp, silty, some sand, soft, moist, grey, trace gravel, trace silt pockets										
TP15-30	2.0-3.0											
S2	WGT14 1312	GC-GM, Gravel, silty, sandy, some clay, hard, moist, light brown										
TP15-30	11.0-12.0											
S1	WGT14 1313	CI, Clay, +wp, sandy, silty, some gravel, firm/loose, grey, trace organics										
TP15-31	2.0-3.0											
S2	WGT14 1314	ML, Silt, sandy, some gravel, some clay, hard/loose, moist, light brown										
TP15-31	6.0-7.0											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Lake St Martin Channel
LOCATION: Reach 2
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-05-06

SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (ft)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m³	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L / D_{10}	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_P / C_C	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS I_P / C_U	GRAIN SIZE GRAVEL %	GRAIN SIZE SAND %	GRAIN SIZE P_{200} or SILT % / CLAY %	STRENGTH q_u K.S.F. / kPa	STRENGTH POCKET PENETROMETER T.S.F.
S1	WGT14 0280	CI, Clay, -wp, some silt, some sand, some gravel, loose, moist, light grey										
TH15-14	1.0-2.0											
S2	WGT14 0281	CI, Clay, -wp, some silt, some sand, loose, moist, light grey, trace gravel										
TH15-14	4.0-5.0											
S3	WGT14 0282	CI, Clay, -wp, some silt, some sand, loose, moist, light grey, trace gravel										
TH15-14	7.5-8.5											
R1	WGT14 0283	No Classification										
TH15-14	10.0-15.0											
R2	WGT14 0284	No Classification										
TH15-14	15.0-20.0											
R3	WGT14 0285	No Classification										
TH15-14	20.0-25.0											
R4	WGT14 0286	No Classification										
TH15-14	25.0-30.0											
S1	WGT14 0287	CL, Clay, -wp, some silt, some sand, loose, moist, brown, trace gravel										
TH15-15	1.0-2.0											
S2	WGT14 0288	CI, Clay, -wp, some silt, some sand, loose, moist, light grey, trace gravel										
TH15-15	3.5-4.5											
R1	WGT14 0289	No Classification										
TH15-15	7.5-10.0											
R2	WGT14 0290	No Classification										
TH15-15	10.0-15.0											
R3	WGT14 0291	No Classification										
TH15-15	15.0-20.0											
R4	WGT14 0292	No Classification										
TH15-15	20.0-25.0											
R5	WGT14 0293	No Classification										
TH15-15	25.0-30.0											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Lake St Martin Channel
LOCATION: Camp Site Quarry
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-04-10

SUMMARY OF LABORATORY TESTS

SOIL CLASSIFICATION CHECK LIST

COARSE GRAINED
1. SYMBOL or GROUP NAME
2. IF SAND-% GRAVEL, MAX. DIA.
3.IF GRAVEL-% SAND,GRADING
4. % passing 75um Sieve
5. FINES COMPOSITON, ODOUR
5. MOISTURE
7. CEMENTATION
8. COLOUR

FINE GRAINED
1. SYMBOL or GROUP NAME
2. MOISTURE - RELATE TO W_P, W_L (B&S only)
3. SOIL COMPOSITION, ODOUR
4. % SAND and GRADING
5. % GRAVEL and MAX. DIA.
6. SOIL STRENGTH
7. SOIL MOISTURE
8. COLOUR

LEGEND

W_N = WATER CONTENT
W_L = LIQUID LIMIT
W_P = PLASTIC LIMIT
I_P = PLASTICITY INDEX
C_C = COEFFICIENT OF CURVATURE
$C_C = (D_{30})^2/(D_{10}xD_{60})$

C_U = COEFFICIENT OF UNIFORMITY
$C_U = D_{60}/D_{10}$
D_{10} = 10% SIZE IN mm
D_{30} = 30% SIZE IN mm
D_{60} = 60% SIZE IN mm
P200 = % PASSING NO.200 SIEVE
P.P. = POCKET PENETROMETER
q_u = UNCONFINED COMPRESSIVE STRENGTH

FIELD SAMPLE and HOLE NO.	LAB. NO. and DEPTH RANGE (ft)	ASTM CLASSIFICATION SYMBOL or GROUP NAME and SAMPLE DESCRIPTION	W_N %	WET DENSITY kg/m³	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_L / D_{10}	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS W_P / C_C	ATTERBERG LIMITS / GRAIN SIZE CHARACTERISTICS I_P / C_U	GRAIN SIZE GRAVEL %	GRAIN SIZE SAND %	GRAIN SIZE P_{200} or SILT % / % CLAY	STRENGTH q_u K.S.F. / kPa	STRENGTH POCKET PENETROMETER T.S.F.
S1	WGT14 1294	SM, Sand, gravelly, some silt, loose, moist, light browm, trace clay										
TH15-17	3.5-5.0											
S2	WGT14 1295	SM, Sand, silty, some gravel, some clay, loose, moist, light brown										
TH15-17	5.0-6.0											
S3	WGT14 1296	SM, Sand, silty, gravelly, some clay, loose, moist, light brown										
TH15-17	6.0-8.0											
S4	WGT14 1297	SM, Sand, silty, some gravel, some clay, loose, moist, light brown										
TH15-17	8.0-10.0											
S1	WGT14 1298	SM, Sand, silty, some gravel, loose, moist, brown, trace clay, trace organics										
TH15-18	1.0-4.0											
S2	WGT14 1299	SM, Sand, silty, some gravel, some clay, loose, moist, light brown										
TH15-18	5.0-7.0											
S3	WGT14 1300	SM, Sand, gravelly, some silt, some clay, loose, moist, brown										
TH15-18	7.0-10.0											
S1	WGT14 1301	SM, Sand, some silt, some gravel, some clay, loose, moist, brown										
TH15-19	3.5-5.0											
S2	WGT14 1302	SM, Sand, some silt, some clay, loose, moist, brown, trace gravel										
TH15-19	5.0-7.0											

MANITOBA INFRASTRUCTURE AND TRANSPORTATION
MATERIALS ENGINEERING
CENTRAL LABS
GEOTECHNICAL LABORATORY

PROJECT: Lake St Martin Channel
LOCATION: Granular Borrow
SITE NO./GEOTECH. NO.:
CLASSIFIED BY: MO DATE: 2015-04-15

LSM Core Logging 12-0300-11

Testhole	Run	Depth (m)	Recovery	RQD
TH15-01	1		98%	84%
	2		94%	72%
TH15-02	1		100%	80%
	2		100%	84%
TH15-03	1		100%	97%
	2		100%	100%
TH15-04	1		91%	43%
	2		100%	90%
TH15-05	1		80%	37%
	2		100%	76%
	3		100%	68%
TH15-13	1		95%	
	2		50%	
	3		40%	0%
	4		95%	53%
TH15-14	1		50%	0%
	2		100%	69%
	3		98%	81%
	4		100%	75%
TH15-15	1	2.29 - 3.05		16%
	2	3.05 - 4.57	70%	8%
	3	4.57 - 6.10	100%	39%
	4	6.10 - 7.52	100%	98%
	5	7.52 - 9.14	90%	43%

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	TH15-01
		Sheet	1 of 1
Site / Location	Lake St. Martin Reach 1 – South Side of Inlet	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	Marooka MS1 300 VD	Logged By	T. Packulak
		Date	2015-02-23
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface			

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
26.75	TOR	38				X															
26.87	Joint	84		X		X															
26.92	Joint	86			X		X														
27.08	Joint	90		X			X														
27.20	Joint	86		X			X														
27.32	Joint						X														
27.20 – 27.32	BLCZ	Loss of 0.09 m																			
27.53	Joint	80					X														
27.69	Joint	77		X		X															
27.76	Joint	88		X		X															
27.91	Joint	23		X			X				X										
28.19	Joint	79		X		X															
28.52	Joint	88				X															
28.52 – 28.60	BCZ					X															

APPROVED:	SHIFT:	DATE:

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	TH15-02
		Sheet	1 of 2
Site / Location	Lake St. Martin Reach 3 Inlet (Past North Dike)	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	DR150 Bombardier	Logged By	T. Packulak
		Date	2015-02-23
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface	15.47		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
15.47	TOR	82					X														
15.54	Joint	70		X			X														
15.65	Joint	62			X		X														
15.67	Joint	80		X		X															X
15.82	Joint	85			X	X					X		X								X
15.85	Joint	40			X		X						X								X
15.93	Joint	88			X	X															X
16.21	Joint / GBD	89			X	X															
16.47	Joint / GBD	85			X	X															
16.50	Joint	87			X	X							X								
16.79	Joint	87		X			X														
16.90	Joint	80		X			X														
16.99	MB	83		X			X														
16.99	Joint	79			X	X															X
17.37	Joint	90		X		X															
17.48	Joint	84		X									X								X
17.83	Joint	85		X			X														
18.00	Joint	74		X									X								X
APPROVED:				SHIFT:									DATE:								

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	GEOLOGICAL DETAIL FRACTURE LOG	Hole No.	TH15-02
		Sheet	2 of 2
Site / Location	Lake St. Martin Reach 3 Inlet (Past North Dike)	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	DR150 Bombardier	Logged By	T. Packulak
		Date	2015-02-23
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface	15.47		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
18.01	Joint	85		X			X						X								X
18.02	Joint	58		X			X						X								X
18.11	Joint	86		X			X														
18.28	Joint	86		X			X														
18.45	Joint	84		X			X														
18.52	EOH	86					X														
APPROVED:			SHIFT:										DATE:								

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	TH15-03
		Sheet	1 of 1
Site / Location	Lake St. Martin Reach 3: Station 17+400	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	DR150 Bombardier	Logged By	T. Packulak
		Date	2015-02-23
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface	6.25 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION																			
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		JOINT FILLING									
													CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT	
6.25	TOR	-									X											
6.27	Joint	84		X			X															
6.45	Joint	79		X		X																
6.71	Joint	85		X			X				X											
6.83	Joint	62		X			X															
6.86	Joint	75		X			X															
6.99	Joint	79		X			X				X											
7.32	Joint	84			X	X				X	X											
7.61	Joint	85		X			X															
7.72	MB	83		X			X															
7.87	Joint	70		X			X															
8.41	Joint	65		X			X															
8.80	Joint	67		X			X															
9.16	EOH	-				X																
APPROVED:			SHIFT:										DATE:									

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	TH15-04
		Sheet	1 of 2
Site / Location	Lake St. Martin Reach 3: Station 18+500	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	DR150 Bombardier	Logged By	T. Packulak
		Date	2015-02-23
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface			

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
12.42	TOR	83					X														
12.55	Joint	79		X			X														
12.60	Joint	80			X		X				X										
12.76	Joint	83		X			X				X				X						
12.93	Joint	81		X			X				X				X						
13.04	Joint	73		X			X														
13.08	Joint	75		X			X														
13.08 - 13.32	BCZ										X										
13.32 - 13.79	BLCZ	Loss of 0.13 m								X	X		X		X						
13.84	Joint	80		X						X	X				X						
13.94	Joint	85		X			X														
14.07	Joint	81		X			X														
14.25	Joint	85		X			X														
14.47	Joint	73		X			X														
14.77	Joint	83			X		X						X								
14.96	Joint	54		X			X														
15.01	Joint	82		X		X															
15.24	Joint	88		X			X														
APPROVED:				SHIFT:									DATE:								

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	TH15-04
		Sheet	2 of 2
Site / Location	Lake St. Martin Reach 3: Station 18+500	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	DR150 Bombardier	Logged By	T. Packulak
		Date	2015-02-23
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface			

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
15.33	Joint	77		X			X														
15.35	Joint	83			X	X															
15.47	EOH	76					X														

APPROVED:	SHIFT:	DATE:

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	TH15-05
		Sheet	1 of 2
Site / Location	Lake St. Martin Reach 3: Station 19+500	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	Marooka MS1 300VD	Logged By	T. Packulak
		Date	2015-02-23
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface	7.14 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
7.14 – 7.26	BLCZ	-	Loss of 0.08 m																		
7.26	Joint	74			X		X														
7.39	Joint	88		X		X															
7.49	Joint	72		X		X															
7.52	Joint	85			X	X															
7.57	Joint	78		X			X														
7.66	Joint	77		X		X															
7.80	Joint	75		X		X															
7.86	Joint	90		X																	
7.90	Joint	55			X	X															
7.90	Joint	23			X	X															
7.94	Joint	66			X		X														
8.06	Joint	83		X		X															
8.60	Joint	82		X			X														
8.74	Joint	37			X	X					X										
8.76	Joint	39		X		X					X										
8.79	Joint	51		X		X					X										
8.88	Joint	89		X			X														
APPROVED:				SHIFT:									DATE:								

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	**GEOLOGICAL DETAIL FRACTURE LOG**	Hole No.	TH15-05
		Sheet	2 of 2
Site / Location	Lake St. Martin Reach 3: Station 19+500	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	Marooka MS1 300 VD	Logged By	T. Packulak
		Date	2015-02-23
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface	7.14 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
9.04	MB	79		X			X														
9.22	Joint	80			X		X														
9.25	Joint	41			X		X														
9.55	Joint	90			X		X														
9.66	Joint	84		X		X															
9.72	Joint	86		X		X															
9.83	Joint	88		X		X															
10.02	Joint	90		X			X														
10.21	Joint	83		X		X															
10.21	Joint	33		X		X															
10.24	Joint	56			X	X				X	X		X		X						
10.29	Joint	32			X		X														
10.36	Joint	36			X	X				X											
10.44	Joint	40		X			X														
10.46	Joint	90		X			X														
10.52	Joint	83			X	X															
10.57	EOH	62					X														

APPROVED: SHIFT: DATE:

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	GEOLOGICAL DETAIL FRACTURE LOG	Hole No.	TH15-13
		Sheet	1 of 3
Site / Location	Lake St. Martin Reach 3: Station 18+500	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	DR150 Bombardier	Logged By	T. Packulak
		Date	2015-03-02
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface	3.24 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
3.05 – 3.24	BCZ / Till	-																			
3.24	TOR	81					X														
3.30	Joint	83		X		X															
3.40	Joint	75			X		X			X											
3.45	Joint	86			X	X				X											
3.53	Joint	85		X			X														
3.62	Joint	89			X		X			X											
3.63	Joint	80			X		X			X											
3.84	Joint	83			X		X			X											
4.03	Joint	74			X		X			X											
4.27	Joint	78			X		X			X											
4.41	Joint	90			X		X			X											
4.46	Joint	89		X			X				X										
4.55	Joint	88		X			X								X						
4.57	MB	83		X			X														
4.70	Joint	74		X			X														
4.80	Joint / GBD	90			X	X				X											
4.83	Joint	89			X		X			X											

APPROVED:	SHIFT:	DATE:

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	GEOLOGICAL DETAIL FRACTURE LOG	Hole No.	TH15-13
		Sheet	2 of 3
Site / Location	Lake St. Martin Reach 3: Station 18+500	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	DR150 Bombardier	Logged By	T. Packulak
		Date	2015-03-02
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface	3.24 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
4.88	Joint	74			X	X				X											
4.91	Joint	87			X	X				X											
5.00	Joint	85				X															
5.00 – 5.05	BLCZ	Loss of 0.3 m																			
5.05	Joint	82				X															
5.08	Joint	86			X		X														
5.16	Joint	85		X			X														
5.23	Joint	90		X			X														
5.33	Joint	90		X			X														
5.33 – 5.49	Joint	00 – 10		X			X														
5.74	Joint	79		X			X														
6.10	MB	86		X			X														
6.15 – 7.70	BLCZ	Loss of 0.76 m								X			X								X
7.70	Joint	51					X														
7.94	Joint	89			X																
8.06	Joint	63			X																
8.13	Joint	85			X		X			X											
8.14	Joint	85			X		X			X											
APPROVED:				SHIFT:									DATE:								

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	GEOLOGICAL DETAIL FRACTURE LOG	Hole No.	TH15-13
		Sheet	3 of 3
Site / Location	Lake St. Martin Reach 3: Station 18+500	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	DR150 Bombardier	Logged By	T. Packulak
		Date	2015-03-02
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface	3.24 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
8.29	Joint	65		X			X														
8.34	Joint	64		X			X														
8.51	Joint	89		X			X														
8.55	Joint	81		X			X						X								
8.69	Joint	80		X			X														X
8.76 – 8.84	Joint	30		X		X							X								
8.84	Joint	42		X		X							X								
8.90	Joint	19	X																		
8.90	Joint	89		X																	
9.07	Joint	89			X								X								
9.09	Joint	87			X																
9.14	EOH	86				X															

APPROVED:	SHIFT:	DATE:

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	GEOLOGICAL DETAIL FRACTURE LOG	Hole No.	TH15-14
		Sheet	1 of 3
Site / Location	Lake St. Martin Reach 3: Station 18+500	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	DR150 Bombardier	Logged By	T. Packulak
		Date	2015-02-27
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface			

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
3.05 - 4.57	Till & Cobbles																				
4.57	TOR	82				X				X											
4.83	Joint	87		X		X															
5.11	Joint	84		X			X			X	X										
5.13	Joint	71		X			X								X						X
5.17	Joint	74		X			X														
5.31	Joint	51		X			X			X											
5.33	Joint	86			X		X														
5.44	Joint	75					X			X											
5.44 – 5.72	BCZ									X											
5.85	Joint	74		X			X			X	X				X						
5.94 – 6.10	Joint	02	X	X			X														
6.10	Joint	72			X		X														
6.34	Joint	71		X			X														
6.35	Joint	63		X			X														
6.60	Joint	90			X		X			X											
6.68	Joint	23		X			X			X											
6.71	Joint	51		X			X			X											

APPROVED: SHIFT: DATE:

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	GEOLOGICAL DETAIL FRACTURE LOG	Hole No.	TH15-14
		Sheet	2 of 3
Site / Location	Lake St. Martin Reach 3: Station 18+500	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	DR150 Bombardier	Logged By	T. Packulak
		Date	2015-02-27
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface			

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
6.96	Joint	90				X				X	X										
6.96 – 7.02	BLCZ	Loss of 0.04 m				X				X	X										X
7.02	Joint	90				X				X	X										
7.24	Joint	84		X																	
7.29	Joint	87			X	X				X	X										
7.57	Joint	80		X			X								X						
7.62	Joint	87			X		X														
7.70	MB	86		X		X															
7.77	Joint	73			X		X														
7.90	Joint	72		X			X														
8.04	Joint	80		X		X					X				X						
8.37	Joint	85		X		X					X										
8.53	Joint	82		X			X								X						
8.62	Joint	87		X			X								X						
8.69	Joint	84		X			X								X						
8.71	Joint	83		X		X									X						
8.75	Joint	83		X		X									X						
8.90	Joint	86		X			X								X						

APPROVED: SHIFT: DATE:

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	GEOLOGICAL DETAIL FRACTURE LOG	Hole No.	TH15-14
		Sheet	3 of 3
Site / Location	Lake St. Martin Reach 3: Station 18+500	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	DR150 Bombardier	Logged By	T. Packulak
		Date	2015-02-27
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface			

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION																		
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)	JOINT FILLING									
												CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT	
8.92	Joint	83		X			X							X							
9.12	Joint	86		X		X								X							
9.14	EOH	80					X														
APPROVED:			SHIFT:									DATE:									

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	GEOLOGICAL DETAIL FRACTURE LOG	Hole No.	TH15-15
		Sheet	1 of 3
Site / Location	Lake St. Martin Reach 3: Station 18+500	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	DR150 Bombardier	Logged By	T. Packulak
		Date	2015-03-02
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface	2.44 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
2.26 – 2.44	Washed Till																				
2.44	TOR	43								X											
2.49	Joint	86		X			X			X											
2.59	Joint	63		X			X			X											
2.64	Joint	79		X			X			X											
2.74	Joint	90			X		X														
2.74 – 2.82	Joint	06		X		X															
2.82	Joint	80		X		X															
2.84	Joint	22		X		X															
2.95	Joint	88		X			X			X											
3.05	Joint	72			X	X															
3.06	Joint	90			X	X															
3.10	Joint	80			X	X				X											
3.10 – 3.30	Joint	05		X		X				X											
3.19	Joint	84		X		X				X											
3.30	Joint	82					X														
3.30 – 4.34	BLCZ	Loss of 0.46 m																			
4.47	Joint	88		X			X														

APPROVED: SHIFT: DATE:

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	GEOLOGICAL DETAIL FRACTURE LOG	Hole No.	TH15-15
		Sheet	2 of 3
Site / Location	Lake St. Martin Reach 3: Station 18+500	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	DR150 Bombardier	Logged By	T. Packulak
		Date	2015-03-02
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface	2.44 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
4.57	MB	89		X			X														
4.72	Joint	88					X														
4.72 – 5.05	BLCZ	Loss of 0.15 m					X			X	X										
5.05	Joint	38					X			X	X										
5.11 – 5.28	Joint	00 – 10		X			X			X	X										
5.17	Joint	50		X			X			X	X										
5.36	Joint	89					X														
5.36 – 5.46	BCZ	-								X											
5.46 – 5.74	Joint	02		X			X			X											
5.46	Joint	63		X		X				X											
5.49	Joint	86		X			X			X											
5.58	Joint	70		X		X				X											
5.69	Joint	73			X																
5.72	Joint	78			X	X				X	X										
5.80	MB	81		X			X			X											
5.96	Joint	84		X			X			X	X										
6.10	MB	86			X		X														
6.21	Joint	80		X			X														

APPROVED: SHIFT: DATE:

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

KGS GROUP	GEOLOGICAL DETAIL FRACTURE LOG	Hole No.	TH15-15
		Sheet	3 of 3
Site / Location	Lake St. Martin Reach 3: Station 18+500	Client	Manitoba Infrastructure and Transportation
Contractor	Maple Leaf Enterprises	Project	Assiniboine River & Lake MB Flood Study
Core Diameter	NQ	Project No.	12-0300-011
Method	DR150 Bombardier	Logged By	T. Packulak
		Date	2015-03-02
Bearing of Hole	N/A	Depth to Water Table	
Angle From Horizontal	90°	Date	
Depth to Rock Surface	2.44 m		

DEPTH (m)	DISCONT-INUITY JOINT FOLIATION BEDDING PLANE FAULT. SHEARING ZONE ETC.	ANGLE WITH CORE AXIS	DESCRIPTION										JOINT FILLING								
			HAIRLINE	TIGHT	OPEN (IN)	SMOOTH	ROUGH	SLICKENSIDED	PLANOR	WEATHERED	STAINED (IRON)		CLAY	CHLORITE	RUST	GYPSUM	TALC	QUARTZ	SERPENTINE	CARBONATE	SILT
6.34	Joint	79			X		X			X	X										
6.68	MB	90		X			X			X											
7.09 – 7.52	Joint	00 – 10	X							X	X				X						
7.09	Joint	74		X			X														
7.24	Joint	67		X			X			X	X				X						
7.52	Joint	71		X			X								X						
7.75	Joint	86		X			X			X	X										
7.82	Joint	77		X			X			X	X										
7.98	Joint	67		X			X			X	X										
7.89 – 8.46	Joint	00 – 10	X							X											
8.08	Joint	73		X		X															
8.18	Joint	80		X			X			X	X										
8.46	Joint	50		X		X				X	X				X						
8.51	Joint	86		X		X				X	X										
8.56	MB	33		X		X					X										
8.56	MB	58		X		X					X										
8.62	Joint	87																			
8.62 – 9.14	BLCZ	Loss of 0.16 m																			
9.14	EOH																				

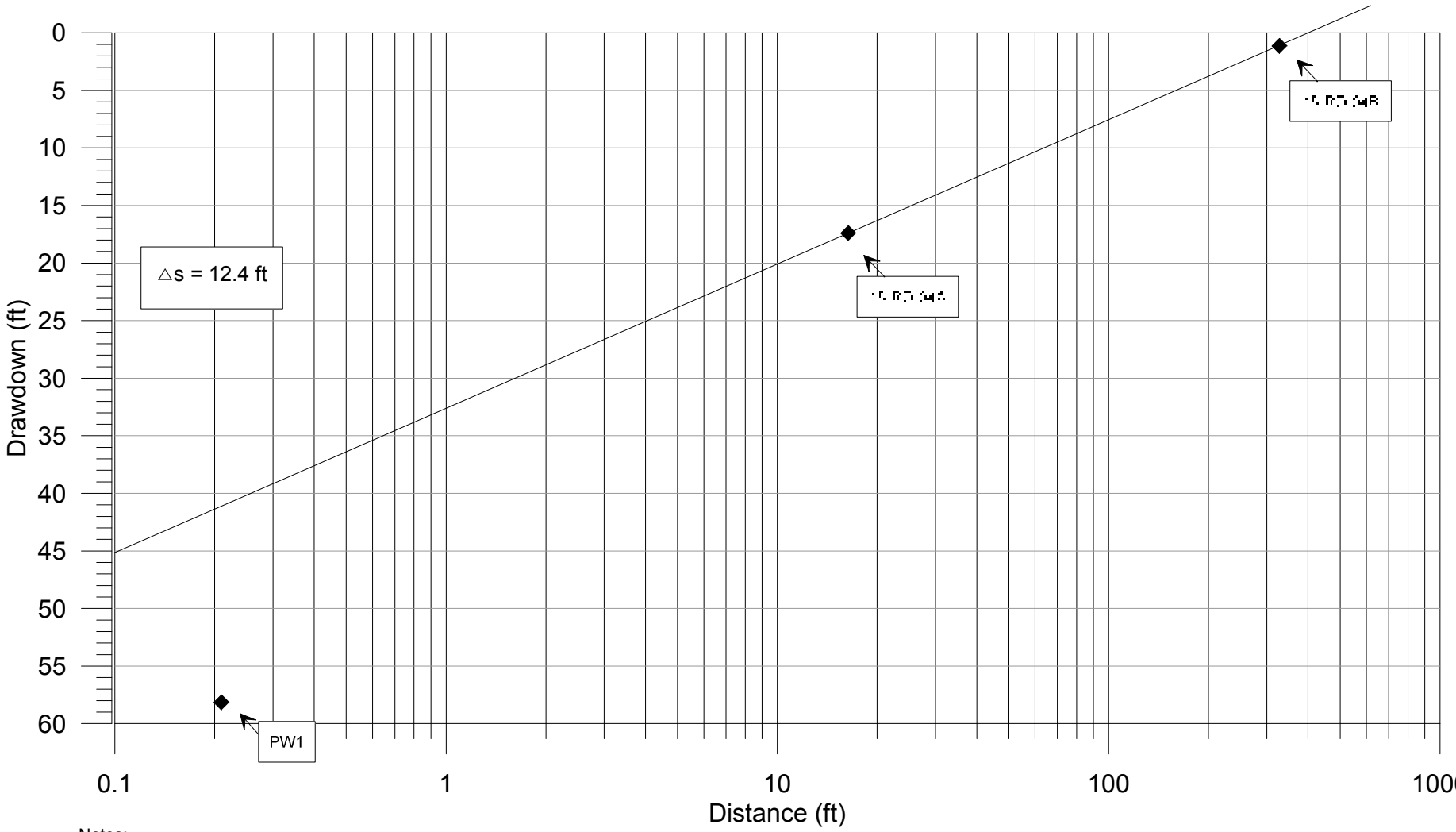
APPROVED:	SHIFT:	DATE:

LEGEND:	BZ – Broken Zone	BLCZ – Broken Lost Core Zone	H – Horizontal	V – Vertical	TOR – Top of Rock
	MB – Machine Break	GBD – Ground by Drill	SH- Sub-Horizontal	SV - Sub-Vertical	EOH – End of Hole

APPENDIX G

PUMPING TEST ANALYSIS AT 15-RD-04 LOCATION

DRAFT



Notes:
Date: August 4, 2015
Pumping Well: PW1
Distance Drawdown
Pump Rate (Q) = 7 USgpm

T =(528)(Q)/△s **T= 298 USgpd/ft**

△s= 12.4 ft Q = 7 USgpm

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/05	ISSUED WITH DRAFT REPORT	KDT

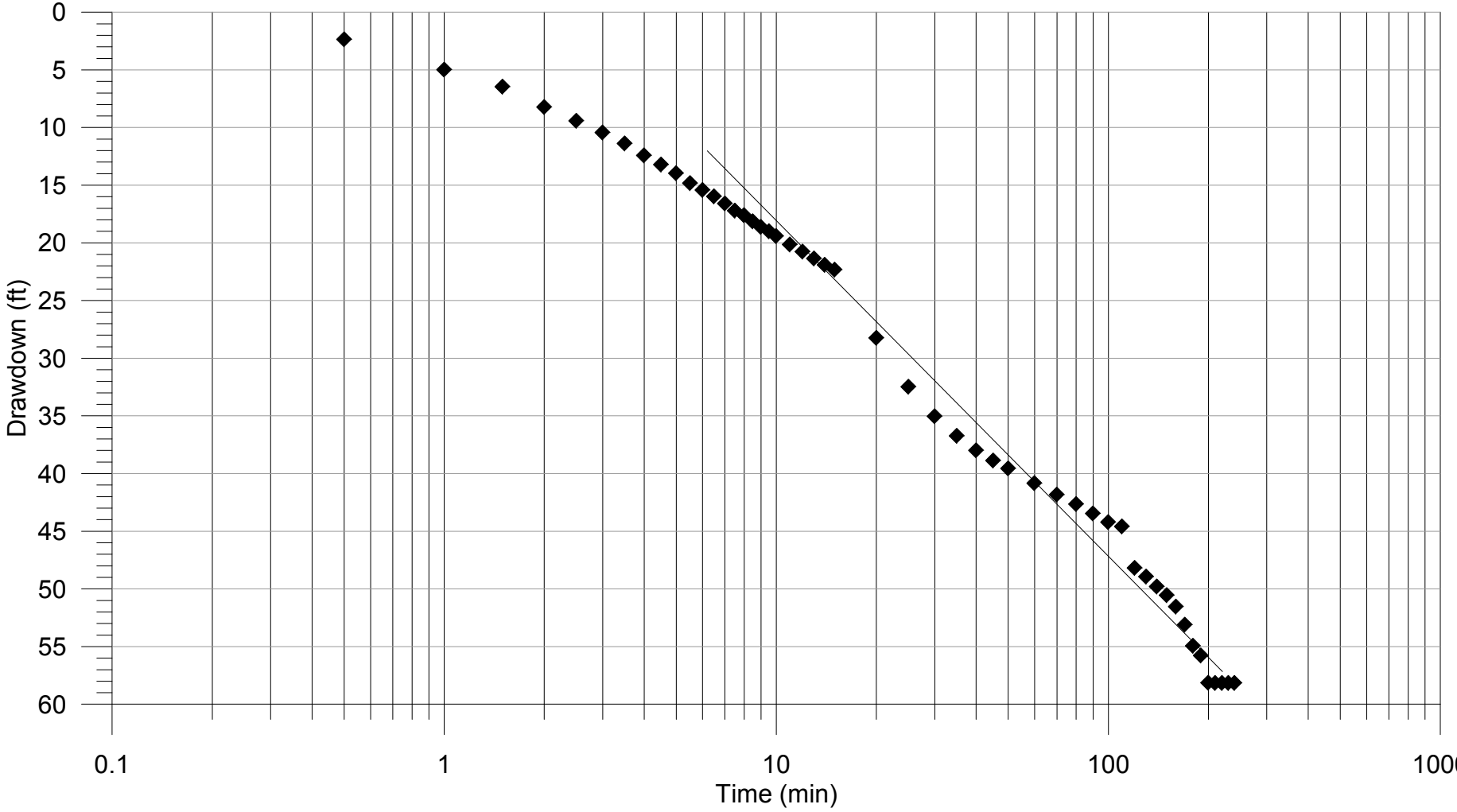
KGS GROUP CONSULTING ENGINEERS

Manitoba

ROUTE D

REV: A

P:\Projects\2012\12-0300-11\General\Docs\



Notes:
Date: August 4, 2015
Pumping Well: PW1
Observation: PW1
Drawdown
Pump Rate (Q) = 7 USgpm

T =(264)(Q)/△s **T= 63 USgpd/ft**

△s= 29.2 ft Q = 7 USgpm

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/05	ISSUED WITH DRAFT REPORT	KDT

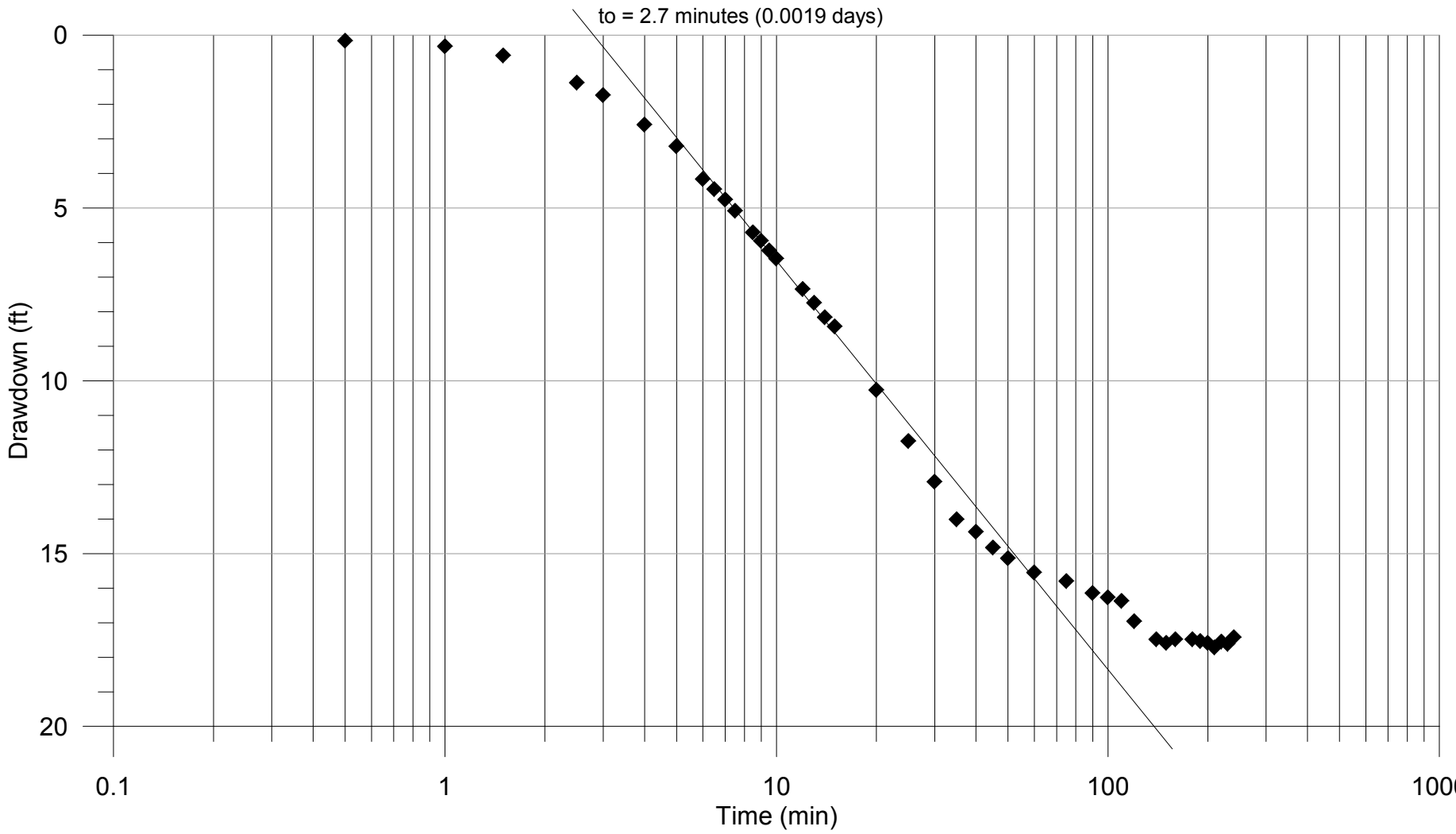
KGS GROUP CONSULTING ENGINEERS

Manitoba

ROUTE D

AUG 2015

REV: A



Notes:
Date: August 4, 2015
Pumping Well: PW1
Observation: 15-RD-04A
Drawdown
Pump Rate (Q) = 7 USgpm

$T = (264)(Q)/\triangle s$	**T= 157 USgpd/ft**
$\triangle s$= 11.8 ft	Q = 7 USgpm

$S = 0.3(T)(t_o)/r^2$	**S = 0.00033**	
r = 16.4 ft	to = 0.0019 days	T = 157 USgpd/ft

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/05	ISSUED WITH DRAFT REPORT	KDT

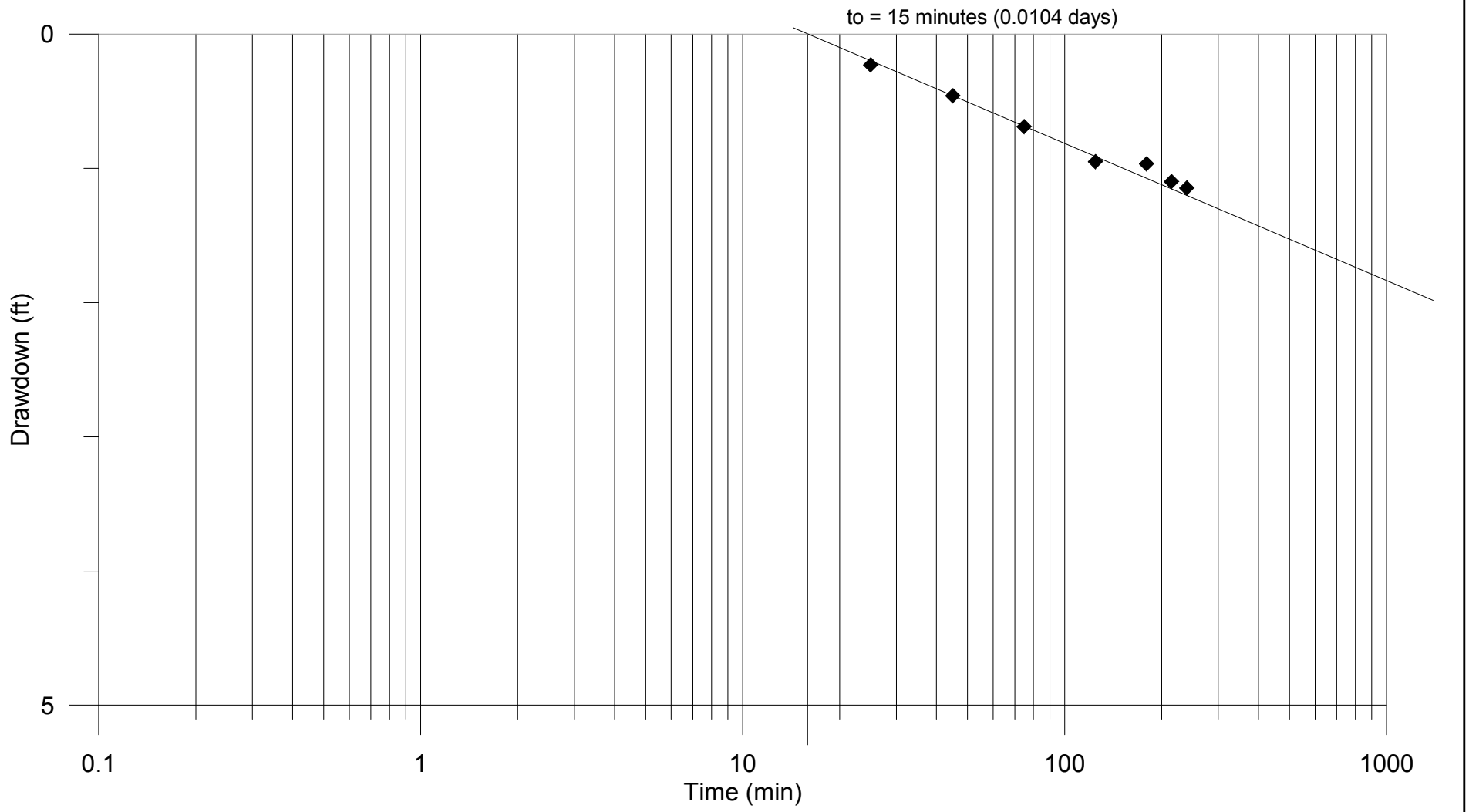
KGS GROUP CONSULTING ENGINEERS

Manitoba

ROUTE D

AUG 2015

REV: A



Notes:
Date: August 4, 2015
Pumping Well: PW1
Observation: 15-RD-04B
Drawdown
Pump Rate (Q) = 7 USgpm

$T = (264)(Q)/\triangle s$	**T= 1680 USgpd/ft**
$\triangle s$= 1.1 ft	Q = 7 USgpm

$S = 0.3(T)(t_o)/r^2$	**S = 0.00005**	
r = 328 ft	to = 0.0104 days	T = 1680 USgpd/ft

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/05	ISSUED WITH DRAFT REPORT	KDT

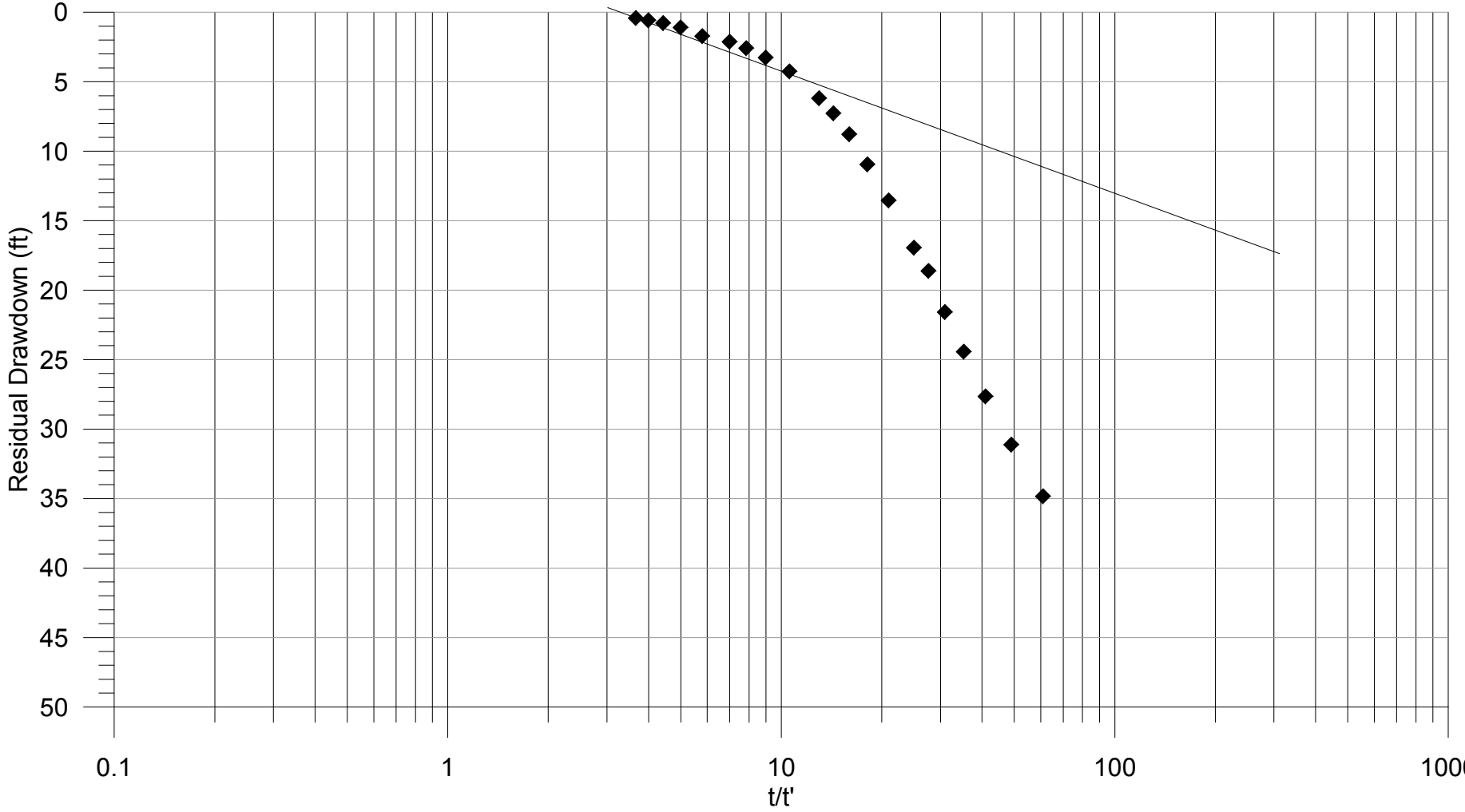
KGS GROUP CONSULTING ENGINEERS

Manitoba

ROUTE D

AUG 2015

REV: A



Notes:
Date: August 4, 2015
Pumping Well: PW1
Observation: PW1
Recovery
Pump Rate (Q) = 7 USgpm

T =(264)(Q)/△s **T= 203 USgpd/ft**

△s= 9.1 ft Q = 7 USgpm

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/05	ISSUED WITH DRAFT REPORT	KDT

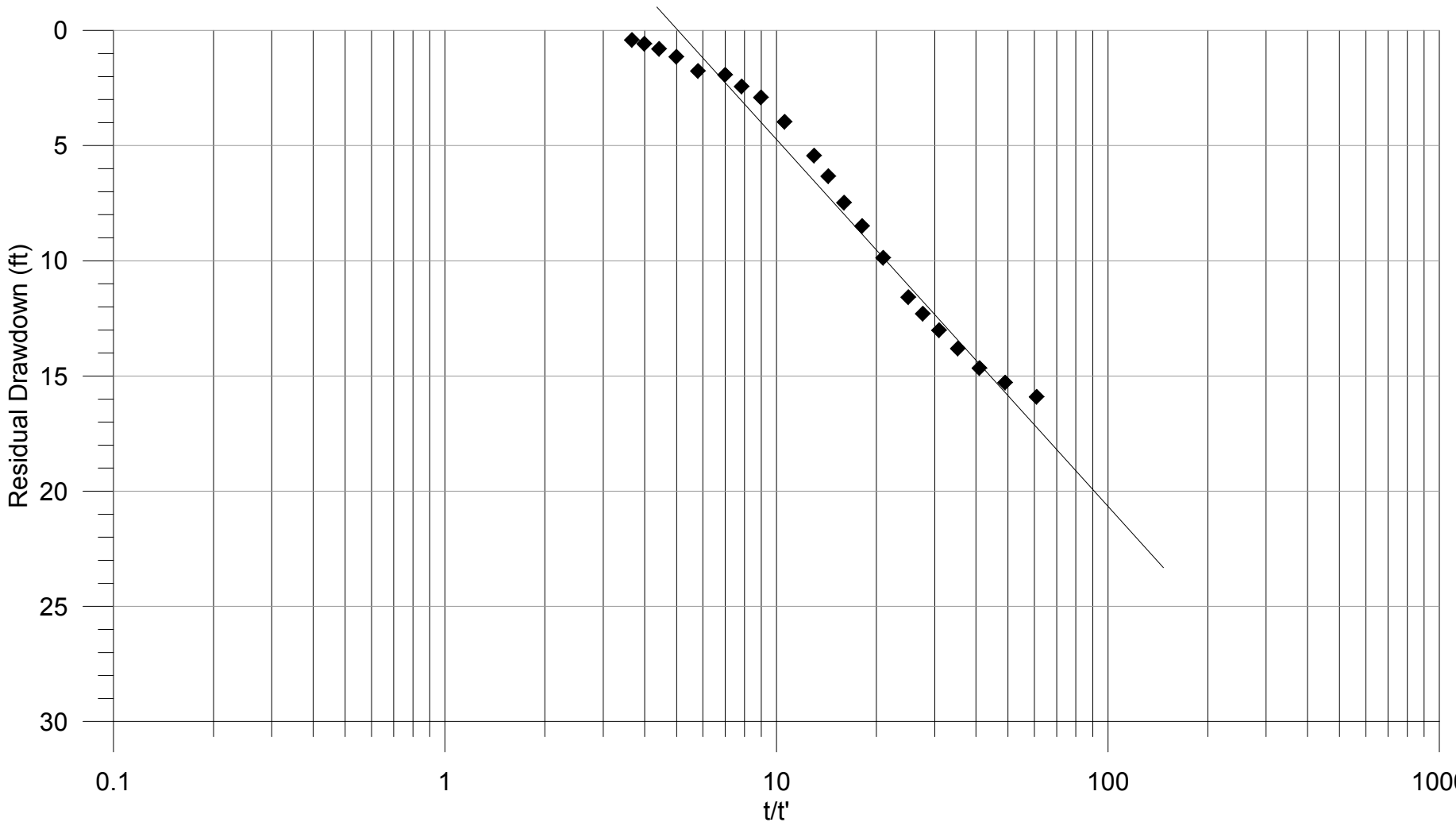
KGS GROUP CONSULTING ENGINEERS

Manitoba

ROUTE D

AUG 2015

REV: A



Notes:
Date: August 4, 2015
Pumping Well: PW1
Observation: 15-RD-04A
Recovery
Pump Rate (Q) = 7 USgpm

T =(264)(Q)/△s **T= 116 USgpd/ft**

△s= 15.9 ft Q = 7 USgpm

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/05	ISSUED WITH DRAFT REPORT	KDT

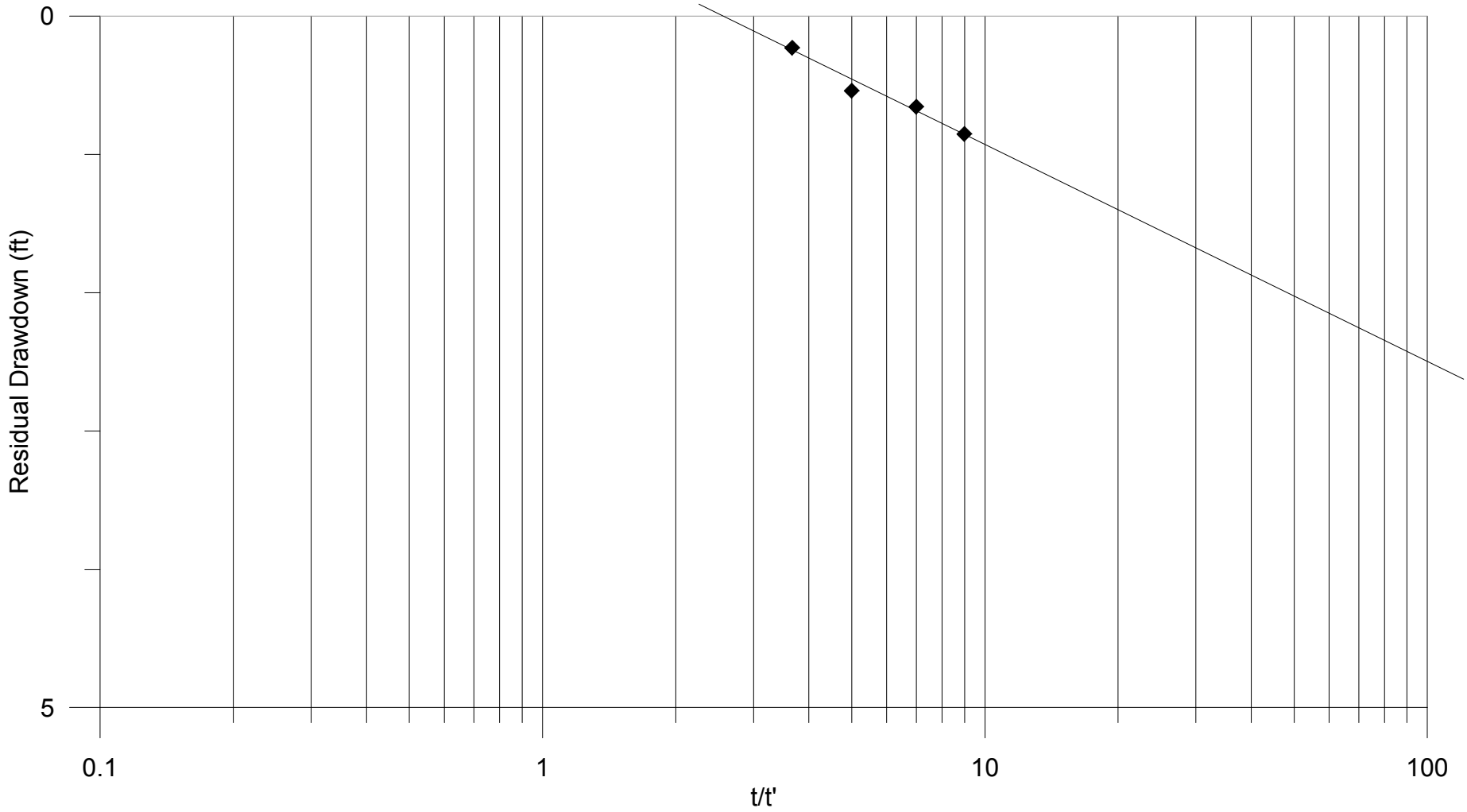
KGS GROUP CONSULTING ENGINEERS

Manitoba

ROUTE D

AUG 2015

REV: A



Notes:
Date: August 4, 2015
Pumping Well: PW1
Observation: 15-RD-04B
Recovery
Pump Rate (Q) = 7 USgpm

T =(264)(Q)/△s **T= 1155 USgpd/ft**

△s= 1.6 ft Q = 7 USgpm

NO.	YY/MM/DD	DESCRIPTION	BY
A	15/08/05	ISSUED WITH DRAFT REPORT	KDT

KGS GROUP CONSULTING ENGINEERS

Manitoba

ROUTE D

AUG 2015

REV: A

APPENDIX H

MEMORANDUM – DIESEL GENERATED ELECTRICITY FOR CONSTRUCTION – 6-BAY SPILLWAY

DRAFT

KGS GROUP CONSULTING ENGINEERS

MEMORANDUM

TO: **File**

FROM: **Eric Willms**

DATE: **April 10, 2015**

FILE NO: **12-0300-011**

RE: **Diesel Generated Electricity for Construction - 6-Bay Spillway**

1.0 BACKGROUND

Inquiries were made to Toromont for providing construction power for the 6-bay Spillway at the outlet of Lake St Martin. The criteria given to Toromont by KGS Group were:

- Assume Installed capacity 3 MVA; made up by two 1.5 MVA diesel units
- Assume rental period is 12 contiguous months
- Assume a base load of 1,000 kW 24 hrs/day seven days a week for one year

Refer to the attached e-mail response from Toromont c/w attachments.

2.0 COST ESTIMATE

2.1 GENERATOR SET RENTAL RATES

Toromont advised the following rate structure for rental units. The rates vary with the duration the unit is run each month.

XQ2000	Single 8-hr shift monthly rate	$33,271	160 Hrs. / Month
XQ2000	Double shift monthly rate	$49,906	320 Hrs. / Month
XQ2000	Triple shift monthly rate	$66,542	672 Hrs. / Month
XQ2000	Standby shift monthly rate	$24,953	40 Hrs. / Month

This estimate uses the following allocation:

1 Unit Triple shift	$66,542 x 12	$ 798,504
1 Unit Standby shift	$24,953 x 12	$ 299,436
Total Estimate for diesel generator rental		**$1,098,000** (rounded)

2.2 MOBILIZATION AND DEMOBILIZATION COSTS

The Toromont Units are located in Brampton Ontario. Freight from Brampton to Customer site at Lake St. Martin is $ 25,000.00 per unit per trip. Toromont indicated that freight carrier had some concerns on weight and road condition into site. This equipment may have to be moved in on frozen roads if road conditions are not good, given weight of 92,000 lbs.

Four trips (2 units x 2 ways each)	$ 100,000

Site work to set up the units is estimated at one week.
Tear down is the same length of time.

Labour

5 days (8 hour days) at $150.00 (set up)	$6,000
5 days (8 hour days) at $150.00 (tear down)	$6,000

Disbursements

Distance:	325 km x $1.60/km = $520 x 4trips	$2,080
Hotel:	$200.00 x 4 people = $800 x 2 trips	$1,600
Meals:	150 x 5 = 750.00 x 2	$1,500
Travel time:	5.5 hrs x $97.50= $536.25 x 4 trips	$2,145

Total Estimate for Mobilization / Demobilization **$119,000** (rounded)

2.3 MAINTENANCE COSTS

Maintenance costs over the one year period were arrived at as follows:

One unit running 24 x7 for 28 days per month = 672 hrs. /month
Toromont uses a pro-rated maintenance charge of $10.75 /hour

672 hrs. x $10.75/hr. =$ 7,224 x12 months $86,688

The service interval on the XQ2000 product is 500hrs,
thus requiring (672 x 12 / 500) 17 trips to perform the service work above.

Labour

17 trips x 5.5hrs./trip x $97.50/hr. = $9,116 x 2	$ 18,232

Disbursements

17 trips x 325km./trip x $1.60/km. = $8,840 x 2	$17,680

If we assume the second “Standby” unit has only 40 hrs. per month, the pro-rated maintenance cost is less.

40 hrs/month x 12 months = 480 hrs. at $10.75 per hour $ 4,160

Test/ Check and Adjust Valves: This has to be done every 3,000 hrs.
Over one year, this requires the work to be done twice.
(672 x 12 = 8064 hrs. per year)

4 hours x 150.00 = $600 x 2/year	$1,200	
Miscellaneous Expenses		
Allowance	$10,000	
Subtotal		$52,273
Total Maintenance Cost		**$138,000** (rounded)

2.4 OVERALL RENTAL/MOB-DEMOB AND MAINTENANCE COSTS

The costs to rent, mobilize, and demobilize the generators for a 12-month contiguous period is $1,222,625.

Rental	$1,098,000
Mob-Demob	$119,000
Maintenance	$138,000
Overall Equipment Cost	**$1,355,000**

2.5 OPERATING COSTS

The operating costs are essentially fuel costs.

Consumption
XQ2000 burn rate at 50% load (1000kw) = 205.5 L per hour
8,760 hr per year x 205.5L/hr = 1,800,180 L per year

Fuel Oil Cost
The closest bulk fuel delivery appears to be in Winnipeg (Husky Bulk Sales). Based on a minimum fuel order of 5,000 L, and diesel fuel oil is estimated at $1.21 / L. There is currently considerable variability in the cost of fuel oil.

Using $1.21/L at an annual cost of 1,800,180 L x $1.21/L = $2,178,000

A dedicated run to deliver fuel oil is estimated at $700 per trip from Winnipeg. Assuming there will be a 20,000 Liter tank with double wall storage on site dedicated to fuel for the diesels this would require (1,800,000 / 20,000 L truck)= 90 trips.

90 trips at $700	$63,000
20,000 Litre tank	$40,000
Total Operating Cost	**$2,281,000**

3.0 SUMMARY

The costs to operate on rental generating sets for one year with an average load of 1000 kW/hr 24 hrs. a day, 7 days a week, and a peak load capability of 3 MVA is estimated at:

Rental Cost	$1,098,000
Mob/Demob Cost	$119,000
Maintenance Cost	$138,000
Operating Cost	$2,281,000
Total:	**$3,636,000,** plus taxes

Note that this equates to $ 0.42 /kW-hr. ($3,636,000/8,760,000 kW-hrs).

Should the duration or average load of the diesel generation change, the estimate could be reworked for the new duration and new average load. A rougher but quick approximation could be made by assuming 30% of the costs are fixed, and 70% change with the increase/decrease in duration / and average load.

For example, an increase in duration to 18 months from 12 months, and an average load of 900 kW from 1000 kW, would result in the following estimate:

New cost:
(0.3 x 3,636,000) + (0.7 x 18 months/12 months x 900 kW/1000kW x 3,636,000) = **$4,506,900,** plus taxes.

Prepared By:
<original signed by>

R. Eric Willms, P.Eng.
Senior Electrical engineer

REW/gr

Approved By:
<original signed by>

Dave B. MacMillan, P.Eng.
Project Manager

TOROMONT EMAIL TO KGS GROUP
MARCH 30, 2015
GENERATOR RENTAL WORKSHEET FOR LAKE ST. MARTIN PROJECT

Eric Willms

From: Darin Sparrow [DSparrow@toromont.com]
Sent: Monday, March 30, 2015 10:20 AM
To: {ewillms@kgsgroup.com} Eric Willms
Subject: RE: Lake St Martin Outlet Structure - Construction Power project 150649
Attachments: GENERATOR RENTAL WORKSHEET FOR LAKE ST .MARTIN PROJECT .docx; XQ2000 Spec Sheet pdf.pdf

Good morning Eric thanks for talking with me this morning regarding this project. I have included a copy of my worksheet for you and my budget pricing . I have also included a copy of the cut sheet on our XQ2000 product for you to review as well.

Thanks again and have a great day.

Darin Sparrow
Account Manager
Toromont CAT Power Systems
Phone: 204-478-6547
Cell: 204-782-1203
Fax: 204-475-7964

Please consider your environmental responsibility before printing this email.

From: {ewillms@kgsgroup.com} Eric Willms [mailto:ewillms@kgsgroup.com]
Sent: March 23, 2015 1:41 PM
To: Darin Sparrow
Cc: Dave MacMillan; 'Patrice Leclercq'; 'Scott Murison'
Subject: Lake St Martin Outlet Structure - Construction Power project 150649

Hi Darin,

As discussed I am back at KGS Group helping out a bit with some projects. One involves building a new Spillway structure on Lake St Martin. The Structure is fairly significant and is effectively being built in the wilderness. The attached two marked up drawings show the Spillway location and the likely access road for both construction and permanent access purposes.

I am making inquiries with Manitoba Hydro with respect to power off the grid and we'll see where that leads. I suspect however that MH may not be able to accommodate 3 MVA of construction power at reasonable cost or schedule.

Accordingly could you please provide an estimate to mobilize, demobilize and operate 3 MVA of diesel generation for prime power purposes for one full year. Two 1.5 MVA units in parallel seems reasonable at this stage of our knowledge. It would provide peak power of 3 MVA but leave room for one unit to be out for maintenance, or when loads are low. The loads are a construction camp for 50 to 100 men, a concrete batch plant and general construction power and temporary heat. Assume the generation would run at an average of 1, 000 kW every day. Allow for required maintenance to be done by Toromont however fuel would be over and above.

Estimated rental cost for one year at an average of 1000 KW 24 hrs day seven days a week including mobilization and demobilization and maintenance.
$_____

Could you give me an estimate for the fuel consumption as well to run 1000 kW 24 seven for one year. $_____

Lastly what would fuel cost shipped o this location? Per Gallon or litre or whatever

Attached are two sketches. One marked up with the location of the site The second with the logging road which will be improved to handle heavy construction loads and the likely route to get fuel to the gensets.

Don't waste too much time as this is at a very preliminary stage.

Thanks Darin

Eric

R E (Eric) Willms
Project Manager / Snr Electrical Engineer
KGS Group
3rd Floor 865 Waverley Street
Winnipeg Manitoba
R3T 5P4
Phone Direct: 204-478-3213
Phone Switchboard: 204-896-1209
Fax 204-896-0754
E-mail ewillms@kgsgroup.com

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Toromont Industries Ltd., 3131 Highway 7 West, Concord, ON, L4K 1B7 www.toromont.com (416)667-5511.

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Toromont Industries Ltd., 3131 Highway 7 West, Concord, ON, L4K 1B7 www.toromont.com (416)667-5511.

GENERATOR RENTAL RATES

XQ2000 single shift monthly rate 33,271.00 160 hrs per month
XQ2000 double shift monthly rate 49,906.00 320 hrs per month
XQ2000 triple shift monthly rate 66,542.00 672 hrs per month
XQ2000 standby shift monthly rate 24,953 40 hrs per month

If we used 1 unit triple shift monthly $66,542.00 x 12 = 798,504.00
If we used 1 unit standby shift monthly $ 24,953 x 12 = 299,436.00

MOBILIZATION AND DEMOBILIZATION

Freight from Brampton to Customer site Lake St. Martin $ 25,000.00 per unit
(some concerns from carrier on weight and road condition into site. This may have to be moved in on frozen roads if road conditions are not good given weight of 92,000lbs)

So four trip or return Freight $ 100,000.00

Site work I would stay one week set up and tear down the same .

5 8hours day at $150.00 (set up) Estimated	$6000.00
5 8hours day at $150.00 (tear down) Estimated	$6000.00
325km x $1.60 = 520 x4 Estimated	$2080.00
Travel time 5.5 hrs x $97.50= 536.25 x4 Estimated	$2145.00
Hotel $200.00 x 4 = 800 x 2 Estimated	$1,600.00
Meals etc 150 x 5 = 750.00 x 2 Estimate	$ 1500.00

MAINTENANCE

If we look at one unit running 24 x7 or 28 days month = 672 hrs our pro-rated maintenance charge of $10.75 per hour 672 x 10.72 = 7,224.00 x12 months = $86,688.00

- **Service intervals are 500hrs on the XQ2000 product.**

17 trips would be required to perform the service work above:

17 x 325km x 1.60= 520.00 x 2 = 1040.00
17 x 5.5hrs. . x 97.50 = 536.25 x 2 = 1072.50

If we looked at the Standby unit have 40hrs per x 12 = 480/500 hrs.
$10.75 per hour 500hrs x 10.72 – 5,360.00

Test/ Check & Adjust valves 4 hour x 150.00 = 600.00 x 2 = $ 1200

- This has to be done every 3000 hrs
- 672 x 12 = 8064 hrs per year

Misc : $10,000.00

FUEL CONSUMPTION

XQ2000 burn rate at 50% load (1000kw) 205.5 L per hour
8064 hr per year x 205.5L = 1,657,152.00 L per year
5/3 8,760

FUEL DELIVERY TO SITE:

I found a bulk dealer that goes to Lake St. Martin here in the City. Husky Bulk sale as of today based on 5000l min order the price for diesel was 1.04 (Toromont price 1.60 but that is subject to change every day.

Estimate dedicated run would be $650.00 / Toromont 850.00

XQ2000 RENTAL

CATERPILLAR®



Image shown may not reflect actual package

STANDBY 2000 kW
PRIME 1825 kW
POWER MODULE
50/60 Hz

Frequency	Voltage	Standby kW (kVA)	Prime kW (kVA)
60	480/277V	2000 (2500)	1825 (2281)
50	400V	1440 (1800)	1310 (1638)

FEATURES

EPA TIER 2 and CARB certified for non-road mobile applications. Factory designed, certified prototype tested with torsional analysis. Production tested and delivered in a package that is ready to be connected to your fuel and power lines. Supported 100% by your Caterpillar® dealer with warranty on parts and labor. Extended warranty available in some areas. The generator set is designed and manufactured in an ISO 9001:2000 compliant facility. Generator set and components meet or exceed the following specifications: AS1359, AS2789, ABGSM TM3, BS4999, DIN6271, DIN6280, EGSA101P, JEM1359, IEC 34/1, ISO3046/1, ISO8528, NEMA MG1-22

CATERPILLAR SR4B GENERATOR

Single bearing, wye-connected, static regulated, brushless permanent magnet excited generator designed to match the performance and output characteristics of the Caterpillar diesel engine driving it.

RELIABLE, FUEL EFFICIENT DIESEL ENGINE

The compact, four-stroke-cycle diesel engine combines durability with minimum weight while providing dependability and economy. The fuel system operates on a variety of fuels.

CATERPILLAR COOLING SYSTEM

Sized compatible to rating with energy efficient fan and core.

CATERPILLAR SWITCHGEAR

Provides single unit and/or multi-unit/utility paralleling components. Standby, load sense/load demand, import, export, and base load modes. Comes standard with Basler Utility Multi-function Relay IPS-100.

EXCLUSIVE CATERPILLAR DIGITAL VOLTAGE REGULATOR (CDVR)

Three-phase sensing and adjustable Volts-per-Hertz regulation give precise control, excellent block loading, and constant voltage in the normal operating range.

ENVIRONMENTALLY FRIENDLY

110% spill containment of onboard engine fluids.

SOUND ATTENUATED CONTAINER

For ease of transportation and protection. Meets 75 dB(A) at 50 ft or below per SAE J1074 measurement procedure at 110% prime load.

FACTORY INSTALLED STANDARD EQUIPMENT

SYSTEM	STANDARD EQUIPMENT
Engine	EPA approved Tier 2 3516C Caterpillar engine Heavy duty air cleaner with service indicator 60-Amp charging alternator Fuel filters – primary and duplex secondary with integral water separator and change-over valve Lubricating oil system with spin-on, full flow oil filters and water cooled oil cooler Oil drain lines routed to engine rail Jacket water heater Fuel cooler and priming pump Electronic ADEM™ A3 controls 24V electric starting motors with battery rack and cables
Generator	SR-4B brushless, permanent magnet excited, three-phase with Caterpillar digital voltage regulator (CDVR), space heater, 6-lead design, Class H insulation operating at Class F temperature for extended life, winding temperature detectors and anti-condensation space heaters (120/240V 1.2 kW)
Containerized Module	40' ISO high cube container, CSC certified 3-axle, 40' ISO container chassis Seven (7) sound attenuated air intake louvers and 4 lockable personnel doors with panic release Side bus bar access door, external access load connection bus bars Shore power connection via distribution block connections for jacket water heater, battery charger, space heaters, and generator condensate heaters Standard lighting 3 AC/4 DC, one (1) single duplex service receptacle, 2 external break-glass emergency stop push buttons 1,250 gal fuel tank, UL listed, double wall, 9 hr runtime @ prime rating Sound attenuated 75 dB(A) @ 50 ft Spill containment 110% of all engine fluids Four (4) oversized maintenance-free batteries, battery rack and 20-Amp battery charger Hospital grade, internally insulated, rectangular exhaust silencer with vertical discharge Vibration isolators, corrosion resistant hardware and hinges External drain access to standard fluids Fire extinguishers (Qty 2) Standard Cat rental decals and painted standard Cat power module white Interior walls and ceilings insulated with 100 mm of acoustic paneling Floor of container insulated with acoustic glass and covered with galvanized steel
Cooling	Standard cooling provides 43° C ambient capability (60 Hz) at prime +10% rating Vertically mounted, separate ATAAC and JW cores with vertical air discharge
Generator Paralleling Control	Custom switchgear control with EMCP 3.3 genset mounted controller and wall mounted paralleling controls Automatic start/stop with cool down timer Protections: 25, 27/59, 40, 32, 81 O/U Utility multi-function relay protections: 25,27/59, 32, 47, 50/51, 62, 67, 81 O/U UMR is IEEE1547-2003 compliant in most applications Reverse compatibility module provided for interface to legacy power modules Touch screen controls with event log Multi-mode operation (island, multi-island and utility parallel), load sharing (multi-unit only) Import & export control (utility parallel only), manual and automatic paralleling capability Touch screen display (status and alarms) Metering display: voltage, current, frequency, power factor, kW, WHM, kVAR, and synchroscope
Quality	Standard genset and package factory tested UL, NEMA, ISO and IEEE standards O&M manuals

SPECIFICATIONS

CAT SR4B GENERATOR

Frame Size 825
Pitch 0.6667
No. of poles 4
Excitation ..... Static regulated brushless PM excited
Constructions ..... Single bearing, close coupled
Insulation ..... Class H
Enclosure ..... Drip proof IP22
Alignment ..... Pilot shaft
Overspeed capability – % of rated ..... 125% of rated
Voltage regulator ..... 3 phase sensing with Volts-per-Hertz
Voltage regulation ..... Less than ± ½% voltage gain
Adjustable to compensate for engine speed droop and line loss
Wave form deviation ..... Less than 5% deviation
Telephone Influence Factor (TIF) ..... Less than 50
Harmonic Distortion (THD) ..... Less than 5%

CAT 3516C DIESEL ENGINE

3516C, 4-Stroke diesel
Bore – mm (in) 170 (6.7)
Stroke – mm (in) 190 (7.5)
Displacement – L (cu in) 69 (4,210)
Compression ratio 15:1
Aspiration ..... ATAAC
Fuel system ..... EUI
Governor type ..... Caterpillar ADEM™ A3 Control System

TECHNICAL DATA

Materials and specifications are subject to change without notice.

Generator Set Technical Data		50 Hz		60 Hz	
	Units	Prime	Standby	Prime	Standby
Performance Specification		DM8754		DM8264	
Power Rating	kW (kVA)	1310 (1637)	1440 (1800)	1825 (2281)	2000 (2500)
Lubricating System					
Oil pan capacity	L (gal)	401.3 (106)		401.3 (106)	
Fuel System					
Fuel Consumption					
100% load	L (gal)	350.1 (92.5)	372.9 (98.5)	483.2 (127.6)	525.7 (138.9)
75% load	L (gal)	281.9 (74.5)	302.8 (80)	380 (100.4)	408.2 (107.8)
50% load	L (gal)	205.5 (54.3)	350.1 (92.4)	270.5 (71.5)	294.2 (77.7)
Fuel tank capacity	L (gal)	4731 (1,250)		4731 (1,250)	
Running time @ 75% rating	Hours	16.7	15.6	12.5	11.5
Cooling System					
Radiator coolant capacity including engine	L (gal)	630 (166)		630 (166)	
Air Requirements					
Combustion air flow	m³/min (cfm)	114.8 (4052)	118.1 (4173)	174.7 (6169)	180.3 (6367)
Maximum air cleaner restriction	kPa (in H_2O)	6.2 (24.9)		6.2 (24.9)	
Generator cooling air	m³/min (cfm)	140 (5,933)		168 (4,995)	
Exhaust System					
Exhaust flow at rated kW	m³/min (cfm)	311.3 (10,993)	320.8 (11,335)	404 (14,260)	428.6 (15,137)
Exhaust stack temperature at rated kW – dry exhaust	°C (°F)	502.1 (935.8)	513.1 (955.6)	387 (728)	405 (762)
Noise Rating (with enclosure)					
@ 7 meters (23 feet)	dB(A)	77	78	78	79
@15 meters (50 feet)	dB(A)	73	74	74	75

Model	Length mm (in)	Width mm (in)	Height mm (in)	Weight	
				With Lube Oil and Coolant kg (lb)	With Fuel, Lube Oil and Coolant kg (lb)
XQ2000 w/o Chassis	12 192 (480)	2438 (96)	2896 (114)	34 019 (75,000)	38 102 (84,000)
XQ2000 w/Chassis	12 192 (480)	2438 (96)	4267 (168)	38 102 (84,000)	42 184 (93,000)

RATING DEFINITIONS

Standby – Applicable for supplying continuous electrical power (at variable load) in the event of a utility power failure. No overload is permitted on these ratings. The generator on the generator set is peak prime rated (as defined in ISO8528-3) at 30° C (86° F).

Prime – Applicable for supplying continuous electrical power (at variable load) in lieu of commercially purchased power. There is no limitation to the annual hours of operation and the generator set can supply 10% overload power for 1 hour in 12 hours.

STANDARD FEATURES

GENERATOR SET EMCP 3.3 LOCAL CONTROL PANEL

- Generator mounted EMCP 3.3 provides power metering, protective relaying and engine and generator control and monitoring.
- Provides MODBUS datalink to paralleling control for monitoring of engine parameters.
- Convenient service access for Caterpillar service tools (not included).
- Integration with the CDVR provides enhanced system monitoring.
- Ability to view and reset diagnostics of all controls networked on J1939 datalink.
- Network modules via the control panel removes the need for a separate service tool for troubleshooting.
- Real-time clock allows for date and time stamping of diagnostics and events.

EMCP 3.3 ENGINE OPERATOR INTERFACE

- Graphical display with positive image, transflective LCD, adjustable white backlight/ contrast.
- Two LED status indicators (1 red, 1 amber).
- Three engine control keys and status indicators (Run/Auto/Stop).
- Lamp test key.
- Alarm acknowledgement key.
- Display navigation keys.
- Two shortcut keys: Engine Operating Parameters and Generator Operating Parameters.
- Fuel level monitoring and control.

CIRCUIT BREAKER

- 3000A fixed type, 3 poles, genset mounted, electrically operated, insulated case circuit breaker.
- Solid state trip unit for overload (time overcurrent) and fault (instantaneous) overcurrent protection.
- Includes DC shunt trip coil activated on any monitored engine or electrical fault, 100 KA-interrupting capacity at 480 VAC.

VOLTAGE REGULATION AND POWER FACTOR CONTROL CIRCUITRY

- Generator mounted automatic voltage regulator, microprocessor based.
- Manual raise/lower voltage adjust capability and VAR/power factor control circuitry for maintaining constant generator power factor while paralleled with the utility.
- Includes RFI suppression, exciter limiter and exciter diode monitoring.
- Voltage and power factor adjustments are performed on the setting screen of the HMI touch screen.

FUEL TANK

- UL Listed 1250 gallon double walled.
- Fuel transfer system

CURRENT TRANSFORMERS

- CT's rated 3000:5 with secondaries wired to shorting terminal strips.

POTENTIAL TRANSFORMERS

- 4:1 ratio with primary and secondary fuse protection.

BUS BARS

- Three phase, plus full rated neutral, bus bars are tin-plated copper with NEMA standard hole pattern for connection of customer load cables and generator cables.
- Bus bars are sized for full load capacity of the generator set at 0.8 power factor.
- Includes ground bus, tin-plated copper, for connection to the generator frame ground and field ground cable.

AC DISTRIBUTION

- Provides 240 VAC for all module accessories.
- Includes controls to de-energize jacket water heaters and generator space heater when the engine is running.

SHORE POWER TWO (2)

- One (1) shore power connection distribution block for jacket water heaters.
- One (1) for generator space, battery charger, and fuel pump.

INTERNAL LIGHTING

- Four (4) internal DC lights with one (1) timer and two switches installed at each side of the container door.
- Three (3) internal AC lights.
- One (1) single duplex service receptacle.

BATTERY CHARGER AND BATTERIES

- 24 VDC/20A battery charger with float/equalize modes and charging ammeter.
- Maintenance free batteries.

EMERGENCY STOP PUSHBUTTON

- Two external ESPs located near each access door.

MODES OF OPERATION

Caterpillar utility paralleling controls are intended for automatic or manual paralleling with a utility power source as a load management system, with provisions for standby operation feeding an isolated load network. Load management operation involves microprocessor-based automatic loading controls with soft loading, base load, Import/Export control and soft unloading. For Standby operation, the generator operates as an isochronous machine isolated from the utility supply. The controls allow for automatic operation, initiated locally or remotely by the customer's SCADA system. Detailed modes of operation are listed below:

SINGLE UNIT ISLAND AND MULTI-UNIT ISLAND OPERATION

1. Utility Standby Mode (Normal)
   a. The utility is providing power for the plant loads.
   b. The Power Module Generator breaker is open.
   c. The pm is in automatic standby mode to respond to a utility failure.
2. Emergency Mode (Emergency)
   a. Utility Failure
      1) The customer protective relaying senses a utility abnormal condition.
      2) A run request is sent to the Power Module Generator plant.
      3) The first Power Module Generator reach rated to voltage and frequency is closed to the bus.
      4) In Multi-Unit Island Mode, the remaining Power Module Generators are paralleled to the bus as they reach rated voltage and frequency. This function is performed via the ModBus Plus data link connected between the Power Modules.
      5) Plant load is transferred to the Power Modules, which share load equally via ModBus Plus data link.
      6) The system is now in Emergency Mode.

GENERATOR DEMAND PRIORITY CONTROL

The System Controls include a Generator Demand Priority Control function to automatically match the on-line Power Module Generator capacity to the loads in order to avoid unnecessary operation of all the Power Module Generators when the plant loads are low.

The following controls are provided for each Power Module Generator:

a. User-settable Generator Priority Selector
b. Status indicator for the Generator Priority selected
c. Status indicator for Power Module Generator on-line or off-line
d. Generator Demand Priority Control Switch (On/Off)
e. User-settable Generator Remove Level (% as a function of single generator capacity)
f. User-settable Generator Remove Time Delay
g. User-settable Generator Add Level (% as a function of single generator capacity)
h. User-settable Generator Add Time Delay

Upon entrance into Emergency Mode, all generators will be started and paralleled to the bus. After the Remove Time Delay, Power Module Generators will be removed from the bus as a function of the generator percentage loading. Generators will be removed from the bus in descending priority order.

Should the generator percentage loading increase to the user-selected Generator Add Level after the user-selected Generator Add Time Delay, the next priority generator will be started, synchronized and paralleled to the bus. Should the Power Module Generator plant ever reach 100% loading, the next priority generator will be started and added to the bus, bypassing the Generator Add Time Delay.

MODES OF OPERATION (continued)

SINGLE UNIT IMPORT, EXPORT OR BASE LOAD OPERATION

During periods of peak demand the system may be placed in operation using the operator interface panel on the front of the switchgear.

1. Entry – Local
   a. The operator places the System Control Switch into Load Management.
   b. The operator selects Import, Export or Base Load Operation.
   c. The Load Management Setpoint is the amount of power Imported, Exported or Base-Loaded. A 4-12-20mA signal is provided by the customer and is linearly proportional to the utility load, with 12mA equaling 0 kW. The 4-12-20mA utility load signal is wired to one and only one Power Module. If the Power Module selected for Load Management is not available, the 4-12-20mA signal will be routed to a different Power Module.
   d. The operator sets the Load Management Setpoint and Power Factor Setpoint.
   e. A Run request signal is received by the Single Unit Power Module.
   f. The Power Module Generator is started and will run for a predetermined warm-up time before it is synchronized and paralleled to the utility.
   g. When the generator is on the bus, it is soft-ramp-loaded until the generator output reaches the Load Management Setpoint.
   h. The generator output is dynamically adjusted to maintain the Load Management Setpoint.
   i. Should the utility fail during Load Management Operation, the Protective Relay will cause the Paralleling Circuit Breaker 52G to open and be locked out until the Lockout Relay is manually reset by an operator on site. The generator is allowed to run for the duration of the cooldown time.
2. Exit – Local
   a. The Run Request signal is removed from the power module.
   b. The generator is soft-ramp-unloaded until the plant load is fully supported by the utility.
   c. The Paralleling Circuit Breaker 52G is opened.
   d. The generator is allowed to run for the duration of the cooldown time.

STANDARD PARALLELING CONTROL

GENERATOR PARALLELING CONTROLS

The switchgear includes:

- Single unit island mode.
- Multiple unit island mode.
  - Includes Load Sense/Load Demand control.
  - Load sharing capability is provided via network communication.
- Single unit utility parallel mode.
  Selectable for Import/Export control.
  If import or export control is selected a 4-12-20mA signal is required (provided by others) scalable to the utility contribution.
- 6 inch black and white HMI touch screen.
- Reverse compatibility module provided for interface to legacy designed Power Module Switchgear. Includes PLC, load share and voltage droop.

Incoming Utility Breaker Status Circuit – Circuit to accept customers contact from remote utility disconnect device. Customer to provide a normally open form 'a' contact to indicate when the local load network is connected to the utility grid.

Utility Transfer Trip Circuit – Circuit accepts input (normally open dry contact) from customer's system protective relay(s) or other controlling device. Operation of contacts causes tripping of the generator circuit breaker via the generator (software) 86 lock-out function and places the engine in cooldown mode. Circuit is disabled when operating in single unit or multiple unit island.

GENERATOR PARALLELING CONTROLS OPERATOR INTERFACE

Graphical mimic one line diagram that shows generator with its respective circuit breaker in a one-line representation of the system. The graphics utilize black and white indicators and bar graphs while actively displaying the following information:

- Utility CB Open/Closed. Input contacts provided by others.
- Utility kW 4-12-20mA signal required and provided by customer that is scalable to the utility contribution.
- Generator CB Open/Closed/Tripped.
- Generator Volts/Amps/kW/Frequency.
- Engine Stopped/Running/Cooldown/Pre-Alarm/Shutdown.
- Engine ECS Position Stop/Auto/Run.
- Utility Output kW.
- System Summary Alarm.

Event logging is also included with up to 500 stored events.

GENERATOR METERING AND PROTECTION

Generator metering that will graphically display 3Ø Voltage, 3Ø Current, Frequency, Power Factor, kW, kVAR and a Synchroscope Display of EMCP 3.3 faults, CDVR or ADEM 3 will be provided via Modbus RTU interface to EMCP 3.3.

Generator/Intertie Protective Relaying including:

- Device 27/59 – Under/Over Voltage.
- Device 81O/U – Under/Over Frequency.
- Device 40 – Loss of Excitation.
- Device 32 – Reverse Power.
- Device 25 – Synchronizing Check.
- Device 15 – Auto Synchronizer.
- Device 65 – Governor Load Sharing, Soft Loading Control.
- Device 90 – VAR/PF and Cross Current Compensation Controller.

PROGRAMMING AND DIAGNOSTICS

Includes field programmable set points for engine control and monitoring variables and self-diagnosis of the EMCP 3.3 system component and wiring failures.

ENGINE CONTROL SWITCH

Keypad selectable, four (4) positions – Off, Auto, Man, Cool:

- Off for engine shutdown and resetting faults.
- Auto for local or remote automatic operation when initiated by switch operation or contact closure.
- Man for local starting and manual paralleling.
- Cool for normal engine shutdown with timed cool-down cycle.

CIRCUIT BREAKER CONTROL SWITCH

Heavy duty, three- (3) position spring return to center with momentary trip and close position and slip contacts for automatic closing. Includes circuit breaker position indicating lamps.

EMERGENCY STOP PUSHBUTTON

- Mushroom head, twist to reset, causes engine shutdown and tripping of the generator circuit breaker. Prevents engine starting when depressed.

STANDARD PARALLELING CONTROL (continued)

ELECTRONIC LOAD SHARING GOVERNOR

- Includes speed adjustment, and auto load share capability when in parallel with legacy power modules.

ALARM MODULE

- Dedicates annunciator screens for warning and shutdown faults. Includes external mounted horn and acknowledge push-button.

AUTOMATIC/MANUAL PARALLELING

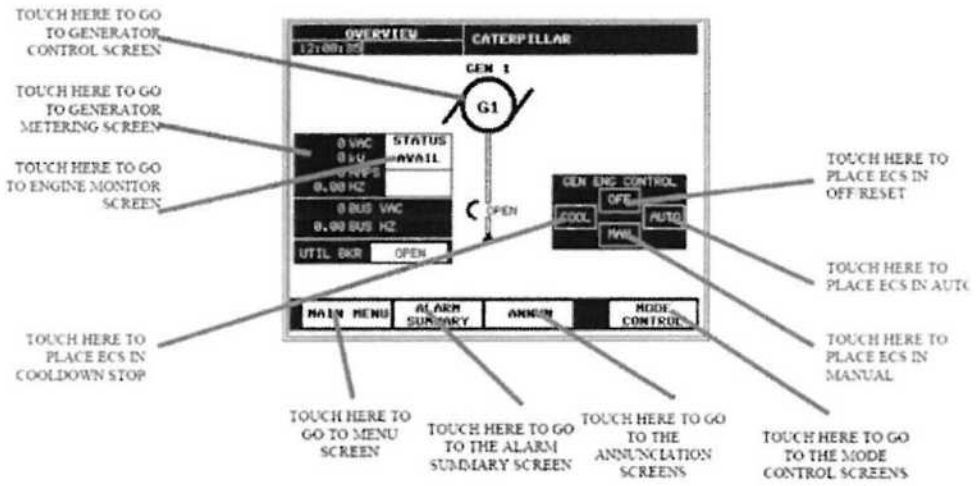
- Automatically synchronizes and parallels the generator with another power source.
- Includes provisions for manual permissive paralleling.

HUMAN MACHINE INTERFACE (HMI) HIGHLIGHTS

- Engine/Generator function is performed thru the 6" HMI touch screen interface.

Overview Screen (Typical)

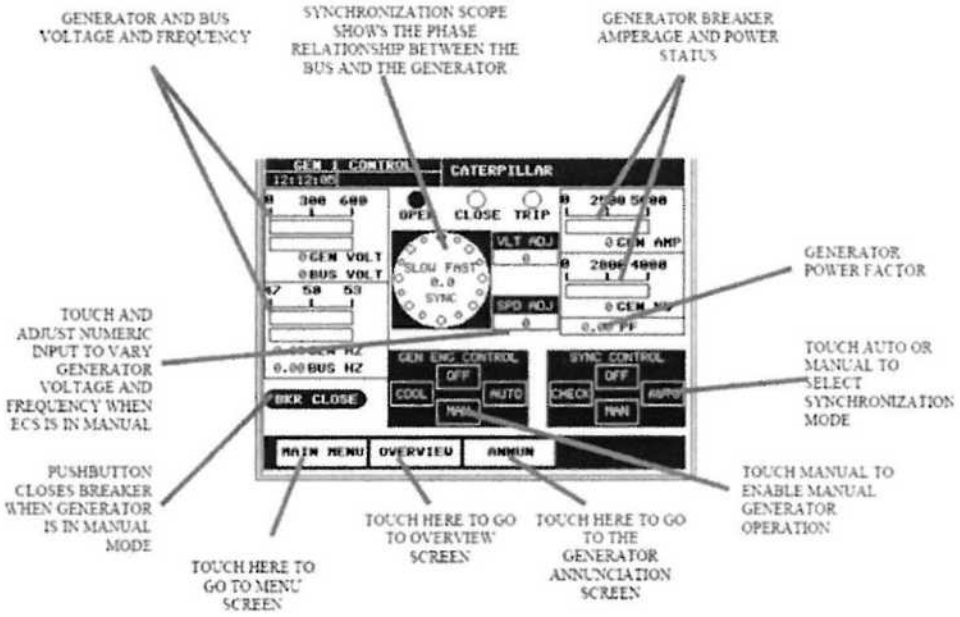
Shows the generator status, generator metering data, bus metering data, ECS position, and generator/utility breaker status.



STANDARD PARALLELING CONTROL (continued)

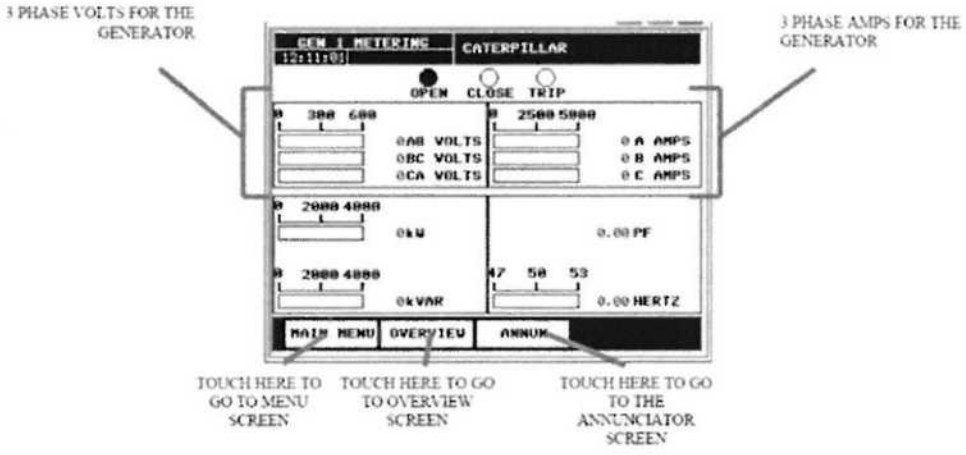
Generator Control Screen (Typical)

It allows the operator to observe the automatic synchronization and transfer of the load to and from the generator. Engine control allows the operator to run the engine in manual, or switch to automatic modes. Voltage and frequency offset adjustment allows the operator to control generator frequency and voltage.



Generator Metering Screen (Typical)

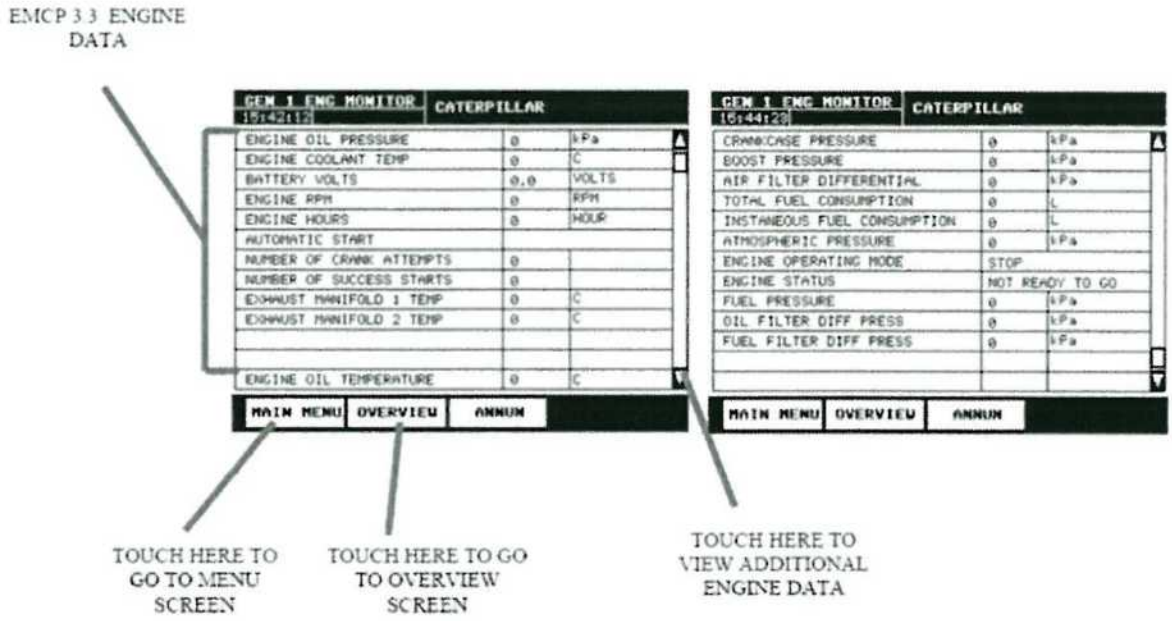
Allows the operator to view three phases of voltage and amperage for the bus and the generator.



STANDARD PARALLELING CONTROL (continued)

Engine Monitoring Screen (Typical)

Engine status is obtained directly from the EMCP 3. Engine starts and total hours can be used by the operator to determine when regular preventive maintenance is required. Other metering includes engine battery and oil filter health.



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GENERATOR RENTAL RATES

XQ2000 single shift monthly rate 33,271.00 160 hrs per month
XQ2000 double shift monthly rate 49,906.00 320 hrs per month
XQ2000 triple shift monthly rate 66,542.00 672 hrs per month
XQ2000 standby shift monthly rate 24,953 40 hrs per month

If we used 1 unit triple shift monthly $66,542.00 x 12 = 798,504.00
If we used 1 unit standby shift monthly $ 24,953 x 12 = 299,436.00

1,098,940 (1)

MOBILIZATION AND DEMOBILIZATION

Freight from Brampton to Customer site Lake St. Martin $ 25,000.00 per unit
(some concerns from carrier on weight and road condition into site. This may have to be moved in on frozen roads if road conditions are not good given weight of 92,000lbs)

So four trip or return Freight $ 100,000.00 (2)

Site work I would stay one week set up and tear down the same .

5 8hours day at $150.00 (set up) Estimated	$6000.00
5 8hours day at $150.00 (tear down) Estimated	$6000.00
325km x $1.60 = 520 x4 Estimated	$2080.00
Travel time 5.5 hrs x $97.50= 536.25 x4 Estimated	$2145.00
Hotel $200.00 x 4 = 800 x 2 Estimated	$1,600.00
Meals etc 150 x 5 = 750.00 x 2 Estimate	$ 1500.00

19,325 (3)

MAINTENANCE

If we look at one unit running 24 x7 or 28 days month = 672 hrs our pro-rated maintenance charge of $10.75 per hour 672 x 10.72 = 7,224.00 x12 months = $86,688.00

- **Service intervals are 500hrs on the XQ2000 product.**

17 trips would be required to perform the service work above:

17 x 325km x 1.60= 520.00 x 2 = 1040.00
17 x 5.5hrs. . x 97.50 = 536.25 x 2 = 1072.50

2112

If we looked at the Standby unit have 40hrs per x 12 = 480/500 hrs.
$10.75 per hour 500hrs x 10.72 – 5,360.00

Test/ Check & Adjust valves 4 hour x 150.00 = 600.00 x 2 = $ 1200

- This has to be done every 3000 hrs
- 672 x 12 = 8064 hrs per year

Misc : $10,000.00

FUEL CONSUMPTION

XQ2000 burn rate at 50% load (1000kw) 205.5 L per hour
8064 hr per year x 205.5L = 1,657,152.00 L per year

1657,152 L x $1.60 = $2651,443 (5)

$760

FUEL DELIVERY TO SITE:

I found a bulk dealer that goes to Lake St. Martin here in the City. Husky Bulk sale as of today based on 5000l min order the price for diesel was 1.04 (Toromont price 1.60 but that is subject to change every day.

Estimate dedicated run would be $650.00 / Toromont 850.00

(1) 1,048,040
(2) 100,000
(3) 19,325
(4) 105360 + plus
(5) 2,651,443

3,868,808

kw-hrs = 1000kw x 24 hr/day x 365 day

= 8,760,000

3868808 / 8760000 = $0.44/kw-hr

APPENDIX I

COST ESTIMATE DETAILS

DRAFT

LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

TOTAL COST SUMMARY - LMB OUTLET CHANNEL ROUTE C

Construction Component	**Estimated Cost**
Earth Works	$ 107,295,000
Control Structure	
Spillway	$ 14,678,000
Gates, Guides and Hoists	$ 9,500,000
Bridges	$ 5,556,000
Electrical Power Supply	
Permanent Power	$ 190,000
Construction Power	$ 2,000,000
Land Acquisition	$ 2,455,000
Fish Passage	$ 1,081,000
Sub-total	**$ 142,755,000**
Mitigation Cost (5%)	$ 7,138,000
Engineering, Contract Admin., Approvals (20%)	$ 28,551,000
Sub-total	**$ 178,444,000**
Contingency Cost (20%)	$ 35,689,000
TOTAL	**$ 214,133,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LMB OUTLET CHANNEL ROUTE C

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
EARTHWORKS				
Mobilization/Demobilization	LS	1	$500,000	$500,000
Channel Excavation				
Earth Excavation	m^3	3,890,000	$10	$38,900,000
Rock Excavation	m^3	1,940,000	$25	$48,500,000
Construction Dewatering	LS	1	$2,000,000	$2,000,000
Inlet Works				
Sediment Control Groins / Cofferdams				
Earthfill (Placement)	m^3	20,000	$20	$400,000
Riprap (Placement)	m^3	20,000	$90	$1,800,000
Cofferdam Closure Section				
Earthfill (Placement)	m^3	85,000	$20	$1,700,000
Riprap (Placement)	m^3	15,000	$90	$1,350,000
Removal (80% of volume)	m^3	80,000	$20	$1,600,000
Inlet Excavation (includes dewatering)	m^3	70,000	$20	$1,400,000
Outlet Works				
Cofferdam Closure Section				
Placement (Earthfill)	m^3	10,000	$20	$200,000
Placement (riprap)	m^3	5,000	$90	$450,000
Removal (80%)	m^3	12,000	$20	$240,000
Outlet Excavation (includes dewatering)	m^3	10,000	$20	$200,000
Other				
Revegetation (75% of footprint area)	ha	368	$8,000	$2,946,000
Construction Camp (5% of Total Costs)				$5,109,300
TOTAL				**$107,295,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LMB OUTLET CHANNEL ROUTE C

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
CONTROL STRUCTURE				
SITEWORK & STRUCTURE				
Foundation Preparation				
- Spillway Structure	sq metre	677	$20	$14,000
Approaches and Traffic Control	LS	1	$3,000,000	$3,000,000
Reinforced Concrete				
Main Spillway	cubic metre	2,500	$1,700	$4,250,000
D/S Wing Walls	cubic metre	120	$2,300	$276,000
U/S Wing Walls	cubic metre	40	$2,300	$92,000
Genset Pad	cubic metre	20	$1,000	$20,000
Precast Concrete Bridge	sq metre	350	$2,500	$875,000
Miscellaneous Steel Items				
U/S Walkway and Bridge	kg	7,500	$15	$113,000
Stair Towers	kg	8,500	$15	$128,000
Guardrails	kg	7,500	$15	$113,000
Downstream Walkway and Bridge	kg	7,500	$15	$113,000
Gate, Guide, and Hoist Installation	LS	1	$1,020,000	$1,020,000
Miscellaneous Embedded and Non-Embedded Items	LS	1	$300,000	$300,000
Backfill / Slope Protection				
Rip Rap	cubic metre	960	$90	$87,000
TOTAL DIRECT COSTS				**$10,401,000**
Indirect Costs			20%	$2,080,000
General Contractor Travel & Camp			5%	$624,000
TOTAL CONTROL STRUCTURE CONSTRUCTION COSTS				**$13,105,000**
General Contractor Bonding			1%	$131,050
General Contractor Insurance			1%	$131,050
General Contractor Overhead and Profit			10%	$1,310,500
TOTAL				**$14,678,000**

GATES GUIDES AND HOISTS (Design and Supply Only)				
Main Spillway Gates	kg	66,000	$18	$1,188,000
U/S Stoplogs	kg	12,000	$12	$144,000
D/S Stoplogs	kg	6,000	$12	$72,000
Main Gate Guides	kg	12,000	$23	$270,000
U/S Stoplog Guides	kg	9,600	$19	$180,000
D/S Stoplog Guides	kg	9,600	$19	$180,000
Steel Gate Hoist Superstructure	kg	31,000	$12	$372,000
Pre Fabricated Hoist Housing	sq metre	125	$1,900	$238,000
Main Gate Hoists & Controls	LS	3	$900,000	$2,700,000
U/S Stoplog Monorail Crane c/w Follower	LS	1	$1,200,000	$1,200,000
Maintenance Hoist	LS	1	$400,000	$400,000
D/S Stoplog Hoist	LS	1	$1,000,000	$1,000,000
Downstream stoplog hoist superstructure	kg	16,000	$12	$192,000
Supporting M&E Equipment	LS	1	$500,000	$500,000
TOTAL GATES, GUIDES AND HOISTS CONSTRUCTION COST				**$8,636,000**
General Contractor Overhead and Profit			10%	$863,600
TOTAL				**$9,500,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LMB OUTLET CHANNEL ROUTE C

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
BRIDGES				
Municipal Road at Stn. 0+450				
Bridge Construction Cost	m^2	826	$2,500	$2,565,500
Approaches and Traffic Control	LS	1	$500,000	$500,000
Municipal Road at Stn. 4+600				
Bridge Construction Cost	m^2	596	$2,500	$1,990,400
Approaches and Traffic Control	LS	1	$500,000	$500,000
TOTAL				**$5,556,000**

ELECTRICAL POWER SUPPLY				
Permanent Power				
Integration to Existing Manitoba Hydro Line	km	1	$150,000	$150,000
750 kVA Pad Mount	LS	1	$40,000	$40,000
Construction Power				
Diesel Generated	LS	1	$2,000,000	$2,000,000
TOTAL				**$2,190,000**

LAND ACQUISITION				
Purchase	ha	491	$5,000	$2,455,000
TOTAL				**$2,455,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LMB OUTLET CHANNEL ROUTE C

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
FISHWAY				
Mobilization/Demobilization	LS	1	$200,000	$200,000
Fishway Entrance and Lower Fishway Channel				
Excavation	m^3	400	$10	$4,000
Fill Placement	m^3	100	$20	$2,000
Channel Rockfill/Boulders	m^3	120	$90	$10,800
Riffle Rockfill/Boulders		24	$100	$2,400
Rockfill - Erosion Protection	m^3	800	$90	$72,000
Impermeable Liner	m^2	400	$25	$10,000
Diversion Structure and Upper Fishway Channel				
Control Structure	m^3	3	$2,000	$5,000
Timber Stoplogs	m	14	$150	$2,100
Operation Platform (incl. mounts, plates, etc. & install)	LS	1	$30,000	$30,000
Excavation	m^3	300	$10	$3,000
Fill Placement	m^3	50	$20	$1,000
Channel Rockfill/Boulders	m^3	90	$90	$8,100
Riffle/Rockfill Boulders	m^3	8	$100	$800
Impermeable Liner	m^2	300	$25	$7,500
Steel Sheetpiles	m^2	48	$1,000	$48,000
Box Culvert				
2400mm x 1800mm	m	10	$4,000	$40,000
Beveled Ends	m	5	$4,800	$24,000
Concrete for Fishway Exit	m^3	1	$2,000	$2,000
Timber Stoplogs for Fishway Exit	m^3	7	$150	$1,050
Excavation	m^3	400	$10	$4,000
Foundation Preparation	m^3	50	$100	$5,000
Road Sub-base Granular Fill	m^3	100	$60	$6,000
Asphalt	m^3	20	$250	$5,000
Fishway Exit Channel				
Excavation	m^3	500	$10	$5,000
Rockfill	m^3	250	$90	$22,500
Revegetation	LS	1	$30,000	$30,000
Public Safety				
Fencing (Supply and Installation)	m	200	$100	$20,000
Miscellaneous	LS	1	$10,000	$10,000
Construction Access & Care-of-Water				
Temporary PTH 6 Traffic Diversion	LS	1	$100,000	$100,000
Downstream Cofferdam (Installation and Removal)	LS	1	$150,000	$150,000
Construction Activities and Site Restoration				
Temporary Erosion & Sediment Control Measures	LS	1	$50,000	$50,000
Drainage Relocation	LS	1	$50,000	$50,000
Indirect Cost				
Fish Passage Monitoring Program	LS	1	$150,000	$150,000
TOTAL				**$1,081,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

TOTAL COST SUMMARY - LMB OUTLET CHANNEL ROUTE D

Construction Component	**Estimated Cost**
Earth Works	$ 129,865,000
Control Structure	
Sitework & Structure	$ 14,678,000
Gates, Guides and Hoists	$ 9,500,000
Bridges	$ 12,167,000
Electrical Power Supply	
Permanent Power	$ 190,000
Construction Power	$ 2,000,000
Land Acquisition	$ 4,290,000
Fish Passage	$ 1,081,000
Sub-total	**$ 173,771,000**
Mitigation Cost (5%)	$ 8,688,550
Engineering, Contract Admin., Approvals (20%)	$ 34,754,200
Sub-total	**$ 217,214,000**
Contingency Cost (20%)	$ 43,442,800
TOTAL	**$ 260,657,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LMB OUTLET CHANNEL ROUTE D

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
EARTHWORKS				
Mobilization/Demobilization	LS	1	$500,000	$500,000
Channel Excavation				
Earth Excavation	m^3	10,843,300	$10	$108,433,000
Construction Dewatering	LS	1	$3,000,000	$3,000,000
Inlet Works				
Sediment Control Groins / Cofferdams				
Earthfill (Placement)	m^3	35,000	$20	$700,000
Riprap (Placement)	m^3	30,000	$90	$2,700,000
Cofferdam Closure Section				
Earthfill (Placement)	m^3	30,000	$20	$600,000
Riprap (Placement)	m^3	5,000	$90	$450,000
Removal (80% of volume)	m^3	28,000	$20	$560,000
Inlet Excavation (includes dewatering)	m^3	25,000	$20	$500,000
Outlet Works				
Cofferdam Closure Section				
Placement (Earthfill)	m^3	10,000	$20	$200,000
Placement (riprap)	m^3	5,000	$90	$450,000
Removal (80%)	m^3	12,000	$20	$240,000
Outlet Excavation (includes dewatering)	m^3	10,000	$20	$200,000
Other				
Revegetation (75% of footprint area)	ha	644	$8,000	$5,148,000
Construction Camp (5% of Total Costs)			5%	$6,184,050
CONTRACT 1 TOTAL				**$129,865,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LMB OUTLET CHANNEL ROUTE D

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
CONTROL STRUCTURE (3-BAY)				
SITEWORK & STRUCTURE				
Foundation Preparation				
- Spillway Structure	sq metre	677	$20	$14,000
Approaches and Traffic Control	LS	1	$3,000,000	$3,000,000
Reinforced Concrete				
Main Spillway	cubic metre	2,500	$1,700	$4,250,000
D/S Wing Walls	cubic metre	120	$2,300	$276,000
U/S Wing Walls	cubic metre	40	$2,300	$92,000
Genset Pad	cubic metre	20	$1,000	$20,000
Precast Concrete Bridge	sq metre	350	$2,500	$875,000
Miscellaneous Steel Items				
U/S Walkway and Bridge	kg	7,500	$15	$113,000
Stair Towers	kg	8,500	$15	$128,000
Guardrails	kg	7,500	$15	$113,000
Downstream Walkway and Bridge	kg	7,500	$15	$113,000
Gate, Guide, and Hoist Installation	LS	1	$1,020,000	$1,020,000
Miscellaneous Embedded and Non-Embedded Items	LS	1	$300,000	$300,000
Backfill / Slope Protection				
Rip Rap	cubic metre	960	$90	$87,000
TOTAL DIRECT COSTS				**$10,401,000**
Indirect Costs			20%	$2,080,000
General Contractor Travel & Camp			5%	$624,000
TOTAL CONTROL STRUCTURE CONSTRUCTION COSTS				**$13,105,000**
General Contractor Bonding			1%	$131,050
General Contractor Insurance			1%	$131,050
General Contractor Overhead and Profit			10%	$1,310,500
TOTAL				**$14,678,000**

GATES GUIDES AND HOISTS (Design and Supply Only)				
Main Spillway Gates	kg	66,000	$18	$1,188,000
U/S Stoplogs	kg	12,000	$12	$144,000
D/S Stoplogs	kg	6,000	$12	$72,000
Main Gate Guides	kg	12,000	$23	$270,000
U/S Stoplog Guides	kg	9,600	$19	$180,000
D/S Stoplog Guides	kg	9,600	$19	$180,000
Steel Gate Hoist Superstructure	kg	31,000	$12	$372,000
Pre Fabricated Hoist Housing	sq metre	125	$1,900	$238,000
Main Gate Hoists & Controls	LS	3	$900,000	$2,700,000
U/S Stoplog Monorail Crane c/w Follower	LS	1	$1,200,000	$1,200,000
Maintenance Hoist	LS	1	$400,000	$400,000
D/S Stoplog Hoist	LS	1	$1,000,000	$1,000,000
Downstream stoplog hoist superstructure	kg	16,000	$12	$192,000
Supporting M&E Equipment	LS	1	$500,000	$500,000
TOTAL GATES, GUIDES AND HOISTS CONSTRUCTION COST				**$8,636,000**
General Contractor Overhead and Profit			10%	$863,600
TOTAL				**$9,500,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LMB OUTLET CHANNEL ROUTE D

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
BRIDGES				
Municipal Road at Stn. 2+600				
Bridge Construction Cost	m^2	913	$2,500	$2,781,500
Approaches and Traffic Control	LS	1	$500,000	$500,000
Municipal Road at Stn. 12+625				
Bridge Construction Cost	m^2	1,188	$2,500	$3,470,000
Approaches and Traffic Control	LS	1	$500,000	$500,000
Municipal Road at Stn. 16+675				
Bridge Construction Cost	m^2	1,566	$2,500	$4,415,000
Approaches and Traffic Control	LS	1	$500,000	$500,000
Municipal Road at Stn. 21+225				
Bridge Construction Cost	m^2	961	$2,500	$2,903,000
Approaches and Traffic Control	LS	1	$500,000	$500,000
TOTAL				**$12,167,000**

ELECTRICAL POWER SUPPLY				
Permanent Power				
Integration to Existing Manitoba Hydro Line	km	1	$150,000	$150,000
750 kVA Pad Mount	LS	1	$40,000	$40,000
Construction Power				
Diesel Generated	LS	1	$2,000,000	$2,000,000
TOTAL				**$2,190,000**

LAND ACQUISITION				
Purchase	ha	858	$5,000	$4,290,000
CONTRACT 1 TOTAL				**$4,290,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LMB OUTLET CHANNEL ROUTE D

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
FISHWAY				
Mobilization/Demobilization	LS	1	$200,000	$200,000
Fishway Entrance and Lower Fishway Channel				
Excavation	m^3	400	$10	$4,000
Fill Placement	m^3	100	$20	$2,000
Channel Rockfill/Boulders	m^3	120	$90	$10,800
Riffle Rockfill/Boulders		24	$100	$2,400
Rockfill - Erosion Protection	m^3	800	$90	$72,000
Impermeable Liner	m^2	400	$25	$10,000
Diversion Structure and Upper Fishway Channel				
Control Structure	m^3	3	$2,000	$5,000
Timber Stoplogs	m	14	$150	$2,100
Operation Platform (incl. mounts, plates, etc. & install)	LS	1	$30,000	$30,000
Excavation	m^3	300	$10	$3,000
Fill Placement	m^3	50	$20	$1,000
Channel Rockfill/Boulders	m^3	90	$90	$8,100
Riffle/Rockfill Boulders	m^3	8	$100	$800
Impermeable Liner	m^2	300	$25	$7,500
Steel Sheetpiles	m^2	48	$1,000	$48,000
Box Culvert				
2400mm x 1800mm	m	10	$4,000	$40,000
Beveled Ends	m	5	$4,800	$24,000
Concrete for Fishway Exit	m^3	1	$2,000	$2,000
Timber Stoplogs for Fishway Exit	m^3	7	$150	$1,050
Excavation	m^3	400	$10	$4,000
Foundation Preparation	m^3	50	$100	$5,000
Road Sub-base Granular Fill	m^3	100	$60	$6,000
Asphalt	m^3	20	$250	$5,000
Fishway Exit Channel				
Excavation	m^3	500	$10	$5,000
Rockfill	m^3	250	$90	$22,500
Revegetation	LS	1	$30,000	$30,000
Public Safety				
Fencing (Supply and Installation)	m	200	$100	$20,000
Miscellaneous	LS	1	$10,000	$10,000
Construction Access & Care-of-Water				
Temporary PTH 6 Traffic Diversion	LS	1	$100,000	$100,000
Downstream Cofferdam (Installation and Removal)	LS	1	$150,000	$150,000
Construction Activities and Site Restoration				
Temporary Erosion & Sediment Control Measures	LS	1	$50,000	$50,000
Drainage Relocation	LS	1	$50,000	$50,000
Indirect Cost				
Fish Passage Monitoring Program	LS	1	$150,000	$150,000
TOTAL				**$1,081,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

TOTAL COST SUMMARY - LSM OUTLET CHANNEL WITH OUTLET AT JOHNSON BEACH

Construction Component	**Estimated Cost**
Earth Works	
Reach 1	$ 42,496,000
Reach 2	$ 12,858,000
Reach 3	$ 32,990,000
Control Structure	
Spillway	$ 23,139,000
Gates, Guides and Hoists	$ 15,351,000
Access Road	
Reach 1	$ 15,600,000
Reach 3	$ 8,000,000
Electrical Power Supply	
Permanent Power	$ 1,720,000
Construction Power	$ 3,636,000
Sub-total	**$ 155,790,000**
Mitigation Cost (5%)	$ 7,789,500
Engineering, Contract Admin., Approvals (20%)	$ 31,158,000
Sub-total	**$ 194,740,000**
Contingency Cost (20%)	$ 38,948,000
TOTAL	**$ 233,690,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LSM OUTLET CHANNEL WITH OUTLET AT JOHNSON BEACH

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
REACH 1 EARTHWORKS				
Mobilization/Demobilization	LS	1	$500,000	$500,000
Excavation (Widening Existing Channel)				
General Excavation	m^3	2,212,000	$10	$22,120,000
Outlet Cofferdam				
Placement	m^3	10,000	$20	$200,000
Removal	m^3	10,000	$20	$200,000
Construction Dewatering	LS	1	$500,000	$500,000
Inlet Works				
Cofferdam				
Placement (Earthfill)	m^3	85,000	$20	$1,700,000
Placement (riprap)	m^3	15,000	$90	$1,350,000
Removal (80%)	m^3	80,000	$20	$1,600,000
Inlet Excavation (includes dewatering)	m^3	70,000	$20	$1,400,000
Extansion to Big Buffalo Lake				
General Excavation	m^3	225,000	$10	$2,250,000
Outlet Cofferdam				
Placement (Earthfill)	m^3	5,000	$20	$100,000
Placement (riprap)	m^3	900	$90	$81,000
Removal	m^3	5,900	$20	$118,000
North & South Cofferdams				
Placement (Earthfill)	m^3	240,000	$20	$4,800,000
Construction Dewatering	LS	1	$1,000,000	$1,000,000
Other				
Revegetation (75% of footprint area)	ha	222	$11,500	$2,553,000
Construction Camp (5% of total costs)				$2,023,600
TOTAL				**$42,496,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LSM OUTLET CHANNEL WITH OUTLET AT JOHNSON BEACH

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
REACH 2 EARTHWORKS				
Mobilization/Demobilization	LS	1	$500,000	$500,000
Dikes				
Peat Excavation	m^3	260,000	$10	$2,600,000
Clearing/Grubbing	ha	13	$16,500	$214,500
Earthfill	m^3	349,100	$20	$6,982,000
Buffalo Creek Erosion Protection				
Riprap, bank shaping, filter fabric, etc…	lm	600	$3,000	$1,800,000
Other				
Revegetation	ha	13	$11,500	$149,500
Construction Camp (5% of total costs)				$612,300
TOTAL				**$12,858,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LSM OUTLET CHANNEL WITH OUTLET AT JOHNSON BEACH

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
REACH 3 TO JOHNSON BEACH EXCAVATION				
Mobilization/Demobilization	LS	1	$500,000	$500,000
Excavation				
General Excavation	m^3	1,693,000	$10	$16,930,000
Construction Dewatering	LS	1	$1,000,000	$1,000,000
Outlet Works				
Cofferdam Closure Section				
Placement (Earthfill)	m^3	10,000	$20	$200,000
Placement (riprap)	m^3	5,000	$90	$450,000
Removal (80%)	m^3	12,000	$20	$240,000
Outlet Excavation (includes dewatering)	m^3	10,000	$20	$200,000
Diversion Structure & Inlet Weir				
Earthfill	m^3	9,000	$20	$180,000
Riprap	m^3	2,000	$90	$180,000
Culvert Structure & Misc.	LS	1	$2,000,000	$2,000,000
Drop Structures				
Riprap	m^3	85,000	$90	$7,650,000
Other				
Revegetation (75% of footprint area)	ha	164	$11,500	$1,888,875
Construction Camp (5% of total costs)				$1,570,944
TOTAL				**$32,990,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LSM OUTLET CHANNEL WITH OUTLET AT JOHNSON BEACH

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
CONTROL STRUCTURE				
SITEWORK & STRUCTURE				
Foundation Preparation				
- Spillway Structure	sq metre	1,300	$20	$26,000
Approaches and Traffic Control	LS	1	$3,000,000	$3,000,000
Reinforced Concrete				
Main Spillway	cubic metre	4,500	$1,700	$7,650,000
D/S Wing Walls	cubic metre	120	$2,300	$276,000
U/S Wing Walls	cubic metre	40	$2,300	$92,000
Genset Pad	cubic metre	20	$1,000	$20,000
Precast Concrete Bridge	sq metre	680	$2,500	$1,700,000
Miscellaneous Steel Items				
U/S Walkway and Bridge	kg	15,000	$15	$225,000
Stair Towers	kg	8,500	$15	$128,000
Guardrails	kg	15,000	$15	$225,000
Downstream Walkway and Bridge	kg	15,000	$15	$225,000
Gate, Guide, and Hoist Installation	LS	1	$2,050,000	$2,050,000
Miscellaneous Embedded and Non-Embedded Items	LS	1	$600,000	$600,000
Backfill / Slope Protection				
Rip Rap	cubic metre	1,995	$90	$180,000
TOTAL DIRECT COSTS				**$16,397,000**
Indirect Costs			20%	$3,279,000
General Contractor Travel & Camp			5%	$984,000
TOTAL CONTROL STRUCTURE CONSTRUCTION COSTS				**$20,660,000**
General Contractor Bonding			1%	$206,600
General Contractor Insurance			1%	$206,600
General Contractor Overhead and Profit			10%	$2,066,000
TOTAL				**$23,139,000**

GATES GUIDES AND HOISTS (Design and Supply Only)				
Main Spillway Gates	kg	132,000	$18	$2,376,000
U/S Stoplogs	kg	12,000	$12	$144,000
D/S Stoplogs	kg	6,000	$12	$72,000
Main Gate Guides	kg	24,000	$23	$540,000
U/S Stoplog Guides	kg	19,200	$19	$360,000
D/S Stoplog Guides	kg	19,200	$19	$360,000
Steel Gate Hoist Superstructure	kg	62,000	$12	$744,000
Pre Fabricated Hoist Housing	sq metre	250	$1,900	$475,000
Main Gate Hoists & Controls	LS	6	$900,000	$5,400,000
U/S Stoplog Monorail Crane c/w Follower	LS	1	$1,200,000	$1,200,000
Maintenance Hoist	LS	1	$400,000	$400,000
D/S Stoplog Hoist	LS	1	$1,000,000	$1,000,000
Downstream stoplog hoist superstructure	kg	32,000	$12	$384,000
Supporting M&E Equipment	LS	1	$500,000	$500,000
TOTAL GATES, GUIDES AND HOISTS CONSTRUCTION COST				**$13,955,000**
General Contractor Overhead and Profit			10%	$1,395,500
TOTAL				**$15,351,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LSM OUTLET CHANNEL WITH OUTLET AT JOHNSON BEACH

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
ACCESS ROAD				
Reach 1				
Upgrade Forestry Road	km	61	$100,000	$6,100,000
Construct All-season Road	km	19	$500,000	$9,500,000
Reach 3				
Construct All-season Road	km	16	$500,000	$8,000,000
TOTAL				**$23,600,000**

ELECTRICAL POWER SUPPLY				
Permanent Power				
Integration to Existing Manitoba Hydro Line	km	11	$150,000	$1,650,000
750 kVA Pad Mount	LS	1	$70,000	$70,000
Construction Power				
Generator Rental	LS	1	$1,098,000	$1,098,000
Mobilization/Demobilization	LS	1	$119,000	$119,000
Maintenance Cost	LS	1	$138,000	$138,000
Operating Cost	LS	1	$2,281,000	$2,281,000
TOTAL				**$5,356,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

TOTAL COST SUMMARY - LSM OUTLET CHANNEL WITH OUTLET EAST OF WILLOW POINT

Construction Component	**Estimated Cost**
Earth Works	
Reach 1	$ 42,501,000
Reach 2	$ 12,858,300
Reach 3	$ 42,162,356
Control Structure	
Spillway	$ 23,139,000
Gates, Guides and Hoists	$ 15,351,000
Access Road	
Reach 1	$ 15,600,000
Reach 3	$ 8,000,000
Electrical Power Supply	
Permanent Power	$ 1,720,000
Construction Power	$ 3,636,000
Sub-total	**$ 164,970,000**
Mitigation Cost (5%)	$ 8,248,500
Engineering, Contract Admin., Approvals (20%)	$ 32,994,000
Sub-total	**$ 206,210,000**
Contingency Cost (20%)	$ 41,242,000
TOTAL	**$ 247,450,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LSM OUTLET CHANNEL WITH OUTLET EAST OF WILLOW POINT

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
REACH 1 EARTHWORKS				
Mobilization/Demobilization	LS	1	$500,000	$500,000
Excavation (Widening Existing Channel)				
General Excavation	m^3	2,212,500	$10	$22,125,000
Outlet Cofferdam				
Placement	m^3	10,000	$20	$200,000
Removal	m^3	10,000	$20	$200,000
Construction Dewatering	LS	1	$500,000	$500,000
Inlet Works				
Cofferdam				
Placement (Earthfill)	m^3	85,000	$20	$1,700,000
Placement (riprap)	m^3	15,000	$90	$1,350,000
Removal (80%)	m^3	80,000	$20	$1,600,000
Inlet Excavation (includes dewatering)	m^3	70,000	$20	$1,400,000
Extansion to Big Buffalo Lake				
General Excavation	m^3	225,000	$10	$2,250,000
Outlet Cofferdam				
Placement (Earthfill)	m^3	5,000	$20	$100,000
Placement (riprap)	m^3	900	$90	$81,000
Removal	m^3	5,900	$20	$118,000
North & South Cofferdams				
Placement (Earthfill)	m^3	240,000	$20	$4,800,000
Construction Dewatering	LS	1	$1,000,000	$1,000,000
Other				
Revegetation (75% of footprint area)	ha	222	$11,500	$2,553,000
Construction Camp (5% of total costs)			5%	$2,023,850
TOTAL				**$42,501,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LSM OUTLET CHANNEL WITH OUTLET EAST OF WILLOW POINT

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
REACH 2 EARTHWORKS				
Mobilization/Demobilization	LS	1	$500,000	$500,000
Dikes				
Peat Excavation	m^3	260,000	$10	$2,600,000
Clearing/Grubbing	ha	13	$16,500	$214,500
Earthfill	m^3	349,100	$20	$6,982,000
Buffalo Creek Erosion Protection				
Riprap, bank shaping, filter fabric, etc…	lm	600	$3,000	$1,800,000
Other				
Revegetation	ha	13	$11,500	$149,500
Construction Camp (5% of total costs)			5%	$612,300
TOTAL				**$12,858,300**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LSM OUTLET CHANNEL WITH OUTLET EAST OF WILLOW POINT

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
REACH 3 TO JOHNSON BEACH EXCAVATION				
Mobilization/Demobilization	LS	1	$500,000	$500,000
Excavation				
General Excavation	m^3	2,520,000	$10	$25,200,000
Construction Dewatering	LS	1	$1,000,000	$1,000,000
Outlet Works				
Cofferdam Closure Section				
Placement (Earthfill)	m^3	10,000	$20	$200,000
Placement (riprap)	m^3	5,000	$90	$450,000
Removal (80%)	m^3	12,000	$20	$240,000
Outlet Excavation (includes dewatering)	m^3	10,000	$20	$200,000
Diversion Structure & Inlet Weir				
Earthfill	m^3	9,000	$20	$180,000
Riprap	m^3	2,000	$90	$180,000
Culvert Structure & Misc.	LS	1	$2,000,000	$2,000,000
Drop Structures				
Riprap	m^3	85,000	$90	$7,650,000
Other				
Revegetation (75% of footprint area)	ha	205	$11,500	$2,354,625
Construction Camp (5% of total costs)				$2,007,731
TOTAL				**$42,162,356**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LSM OUTLET CHANNEL WITH OUTLET EAST OF WILLOW POINT

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
CONTROL STRUCTURE				
SITEWORK & STRUCTURE				
Foundation Preparation				
- Spillway Structure	sq metre	1,300	$20	$26,000
Approaches and Traffic Control	LS	1	$3,000,000	$3,000,000
Reinforced Concrete				
Main Spillway	cubic metre	4,500	$1,700	$7,650,000
D/S Wing Walls	cubic metre	120	$2,300	$276,000
U/S Wing Walls	cubic metre	40	$2,300	$92,000
Genset Pad	cubic metre	20	$1,000	$20,000
Precast Concrete Bridge	sq metre	680	$2,500	$1,700,000
Miscellaneous Steel Items				
U/S Walkway and Bridge	kg	15,000	$15	$225,000
Stair Towers	kg	8,500	$15	$128,000
Guardrails	kg	15,000	$15	$225,000
Downstream Walkway and Bridge	kg	15,000	$15	$225,000
Gate, Guide, and Hoist Installation	LS	1	$2,050,000	$2,050,000
Miscellaneous Embedded and Non-Embedded Items	LS	1	$600,000	$600,000
Backfill / Slope Protection				
Rip Rap	cubic metre	1,995	$90	$180,000
TOTAL DIRECT COSTS				**$16,397,000**
Indirect Costs			20%	$3,279,000
General Contractor Travel & Camp			5%	$984,000
TOTAL CONTROL STRUCTURE CONSTRUCTION COSTS				**$20,660,000**
General Contractor Bonding			1%	$206,600
General Contractor Insurance			1%	$206,600
General Contractor Overhead and Profit			10%	$2,066,000
TOTAL				**$23,139,000**

GATES GUIDES AND HOISTS (Design and Supply Only)				
Main Spillway Gates	kg	132,000	$18	$2,376,000
U/S Stoplogs	kg	12,000	$12	$144,000
D/S Stoplogs	kg	6,000	$12	$72,000
Main Gate Guides	kg	24,000	$23	$540,000
U/S Stoplog Guides	kg	19,200	$19	$360,000
D/S Stoplog Guides	kg	19,200	$19	$360,000
Steel Gate Hoist Superstructure	kg	62,000	$12	$744,000
Pre Fabricated Hoist Housing	sq metre	250	$1,900	$475,000
Main Gate Hoists & Controls	LS	6	$900,000	$5,400,000
U/S Stoplog Monorail Crane c/w Follower	LS	1	$1,200,000	$1,200,000
Maintenance Hoist	LS	1	$400,000	$400,000
D/S Stoplog Hoist	LS	1	$1,000,000	$1,000,000
Downstream stoplog hoist superstructure	kg	32,000	$12	$384,000
Supporting M&E Equipment	LS	1	$500,000	$500,000
TOTAL GATES, GUIDES AND HOISTS CONSTRUCTION COST				**$13,955,000**
General Contractor Overhead and Profit			10%	$1,395,500
TOTAL				**$15,351,000**

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LAKE MANITOBA AND LAKE ST. MARTIN
OUTLET CHANNELS CONCEPTUAL DESIGN - STAGE 2

DETAILED COST ESTIMATE - LSM OUTLET CHANNEL WITH OUTLET EAST OF WILLOW POINT

ITEM/CONTRACT	Unit	Quantity	Unit Cost	Cost (2015 $)
ACCESS ROAD				
Reach 1				
Upgrade Forestry Road	km	61	$100,000	$6,100,000
Construct All-season Road	km	19	$500,000	$9,500,000
Reach 3				
Construct All-season Road	km	16	$500,000	$8,000,000
TOTAL				**$23,600,000**

ELECTRICAL POWER SUPPLY				
Permanent Power				
Integration to Existing Manitoba Hydro Line	km	11	$150,000	$1,650,000
750 kVA Pad Mount	LS	1	$70,000	$70,000
Construction Power				
Generator Rental	LS	1	$1,098,000	$1,098,000
Mobilization/Demobilization	LS	1	$119,000	$119,000
Maintenance Cost	LS	1	$138,000	$138,000
Operating Cost	LS	1	$2,281,000	$2,281,000
TOTAL				**$5,356,000**

DRAFT

KGS GROUP
CONSULTING ENGINEERS



