Appendix A

Functional Design Report

AECOM

Manitoba Hydro

Laurie River Generating Stations I and II Wastewater Treatment System Upgrade Functional Design Report

Prepared by:

AECOM
99 Commerce Drive
Winnipeg, MB, Canada R3P 0Y7
www.aecom.com

204 477 5381 tel
204 284 2040 fax

Project Number:

60265529.400

Date:

December, 2012

APEGM

Certificate of Authorization

AECOM Canada Ltd.

No. 4671 Date: December 19/2012

AECOM
99 Commerce Drive
Winnipeg, MB, Canada R3P 0Y7
www.aecom.com

204 477 5381 tel
204 284 2040 fax

December 19, 2012

Trevor Ouellette, P.Eng.
Manitoba Hydro, Power Projects Department
Engineering Services Division
360 Portage Avenue, 20th Floor
Winnipeg, MB R3C 2P4

Dear Mr. Ouellette:

Project No: **60265529.400**

Regarding: **Laurie River Generating Stations I and II Wastewater Treatment System Upgrade Functional Design Report**

The Functional Design Report for the Laurie River Generating Station I and II Wastewater Treatment System Upgrade is provided in the attached document. If you would like to discuss the document in person please call and we can arrange a meeting.

Sincerely,
AECOM Canada Ltd.

Paul Barsalou

Paul Barsalou, M.Sc.,P.Eng.
Project Manager
Paul.barsalou@aecom.com
Encl.
PB:td

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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
0		November 26, 2012	Draft Report
1	Paul Barsalou	December 17, 2012	Final Report

AECOM Signatures

Report Prepared By:

Paul Barsalou, M.Sc., P.Eng
Project Manager

PROVINCE OF MANITOBA
P. R. BARSALOU
December 19/2012
REGISTERED PROFESSIONAL ENGINEER

Report Reviewed By:

John Wiebe, B.Eng., EIT
Project Engineer

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1. Introduction

1.1 Scope

Functional design and subsequent detailed work is underway for upgrades to the sewer and water services at the Laurie River Generation Stations I & II (GS1 and GS2) and the main camp adjacent to GS1. The work will include new sewer and water piping within the camp as well as a new wastewater lift station, forcemain and lagoon. Upgrading the two Generating Stations with bathroom facilities will also be important components in the project. The facility is to be commissioned by the fall of 2013.

1.2 Work Completed

In mid 2012, a visit was completed to collect information at the Laurie River sites. The following work was carried out as part of this functional design:

- Topographical Survey – A detailed topographical survey helped identify all relevant features of the site including: existing roads, buildings, hydro lines and telephone lines, existing culverts, ditches or drainage courses, tree lines etc.
- Topographic maps have been developed showing the site and the proposed works.
- The proposed outfall route was traced through a natural drainage path and out to the receiving stream, downstream of GS1.
- Local bench marks were identified for a GPS survey which will be used during construction.
- The GPS survey picked up the location and elevation of areas around the lagoon and forcemain.
- The Environment Act Proposal is being completed based on the current functional design and upon information collected during the site visit.
- Photographs of the site were taken, with a focus on the proposed lagoon outfall route.
- All of the buildings were entered and the sewer and water lines were located. The services will be replaced, in addition to the main lines.

1.3 Design Codes and Criteria

The site redevelopment work is following current Manitoba practices including:

- Separation of sewer and watermains by 3 m horizontally.
- Sizing of sewer and water piping for domestic consumption.
- Fire water supply lines into the community will be provided as 150 mm, however, Manitoba Hydro is independently completing all work on the Fire Pumping system and the flow requirement estimates.
- The lagoon is being designed to produce high quality effluent similar to that recently licensed at the Keewatinoow Camp Lagoon.
- An Environment Act Proposal will be forwarded to Manitoba Conservation regarding the proposed development to obtain a licence.
- An application will be completed during detailed design to allow Manitoba Conservation to designate the operator level requirement for the lagoon and wastewater collection system.
- The site is in a remote location with cold weather. The systems will be designed specifically for the site conditions including items such as: dual heat tracing, recirculation systems, and insulation.

- A work permit application has been submitted to Manitoba Conservation for clearfelling, piling and burning.

- A land purchase application has been issue for the development area through Manitoba Hydro.

- This is a private access location that is not open to the public.

1.4 Location

Laurie River Generating Stations I and II are located on Laurie River approximately 64 km south of Lynn Lake in northwestern Manitoba. A location plan is provided in Appendix D.

2. Geotechnical Summary

2.1 Initial Site Assessment

The Conceptual Design Report, prepared by AECOM, recommended construction of a lift station and facultative lagoon at the Laurie River GS I camp. Further to this conceptual design report, the technical memorandum prepared in March 2011, provided preliminary lagoon sizing and preliminary construction estimates for a clay liner lagoon and a membrane lined lagoon.

A geotechnical report was submitted by AECOM to Manitoba Hydro in February 2011. It determined that there was ample clay to create a clay lined lagoon that will meet the provincial requirements of $1x10^{-7}$ cm/s. The clay would need to be excavated and re-worked to provide the required hydraulic conductivity. A synthetic liner was another option reviewed in the March 2011 technical memorandum. The cost difference between the two options was minimal as the majority of the cost for either option was mobilization. A clay lined lagoon was selected based on the long term durability and increased ease of future desludging. The February 2011 geotechnical report is included in **Appendix A**.

The clay required for construction will come from within the footprint of the lagoon and perimeter ditching, so additional borrow area will not be required for liner material.

2.2 Design Review by Geotechnical

The design underwent a geotechnical review because one of the berms was 3.5 m high. This is higher than the 3.0 m height recommended in the initial siting assessment. The high berm was included to accommodate the slope running across the site and the shallow bedrock. A review of the berm stability showed that the design has a good factor of safety and that there are no geotechnical concerns. A copy of the report is provided in **Appendix B**.

3. Wastewater Generation Estimates

A previous report, "Laurie River Generating Stations I & II, Wastewater System Final Conceptual Design Report - Summary" was prepared for Manitoba Hydro in March 2010 by AECOM. The population from the report was recently reassessed and increased from the original estimate. The main reason for the increase is recent experience in other Manitoba Hydro camps. It has been noted recently that the presence of a camp kitchen contributes more significantly to the wastewater flows being generated in the camp than originally estimated. Also, there is always some leaking in buildings that are unoccupied. A higher per capita flow rate was included for the kitchen at low occupancy in the camp to account for the base water consumption.

The design population is assumed to be 20 people for six months of the year and 5 people for six months of the year. **Table 1** breaks down the various wastewater flows to the lagoon based on the populations during each 6 month period. All wastewater flows from the two Laurie River Generation Stations will be trucked to the lagoon and the camp will be piped.

An allowance of 20% of additional process water flows has been included to account for an upgraded water treatment plant in the future.

Table 1: Annual Flow Distribution

Six Months (182 Days)				
Flow	**Flow (Lpcd)**	**Population**	**Daily Flow (L/d)**	**Total Hydraulic Volume (L) Over 182 Days**
Population	250	20	5,000	910,000
Kitchen Waste	100	20	2,000	364,000
Truck Waste			100	18,200
Water Treatment Plant Reject (assume 20%)			1,420	258,440
			Sub-Total	**1,550,640 L**
Six Months (183 days)				
Flow	**Flow (Lpcd)**	**Population**	**Flow (L/d)**	**Total Hydraulic Volume (L) Over 183 Days**
Population	250	5	1,250	228,750
Kitchen Waste	200	5	1,000	183,000
Truck Waste			100	18,300
Water Treatment Plant Reject (assume 20%)			470	86,010
			Sub-Total	**516,060 L**
			Total	**2,066,700 L/yr Use 2,067,000 L/yr Or 2067 m^3/yr**

Note:

1. *No value for infiltration has been estimated as the piping will be all new.*

4. Application to Province for Borrow Material

The site footprint will provide enough clay for construction of the lagoon. Clay will come from within the cell for re-compaction, and from the perimeter ditching. No application will be completed for clay borrow as it will be from the area being developed. Clay material will be reworked to form the liner.

Manitoba Hydro is currently preparing a new granulary quary development near Laurie River 2 Station. It is believed that this quarry will be in operation for June, 2013. The proposed new quarry location is given below.

NW Corner:	56 14 47N	101 8 18W
NE Corner:	56 14 41N	101 7 54W
SW Corner:	56 14 20N	101 8 34W
SE Corner:	56 14 20N	101 8 14W

A second site may also be used as a quarry, however, it is further away from the worksite and is not preferred. The site is identified as 18 kilometers away from the side towards the air field. It is unknown whether this site has ever been permitted, however it has historically been used as an aggregate source and has already been cleared.

As a backup, an application will be forwarded to the Province for use of approximately 700 m^3 of granular materials at this existing second borrow. It has granular material that can be used for both road construction and pipe bedding. Some aggregate screening work will be required.

Approximately 100m^3 of material is already stockpiled at the camp from previous works. This granular will be used first prior to use of borrow materials.

5. Lagoon Design

5.1 Lagoon Sizing

Due to the northern location of this lagoon, it is recommended that the primary cell be sized based on the *Federal Guidelines* for organic loading of 22 kg BOD/ha/day. *Provincial Guidelines* limit the amount of organic loading to 56 kg BOD/ha/day assuming an influent BOD loading rate of 0.076 kg BOD/person/day. By using the Federal guidelines, the primary cell will be larger but will also allow for increased primary treatment during the colder months. Further calculations make the actual size of the primary cell larger than the original design due to physical constructability in the field.

The organic loading is provided below:

- Per capita loading 0.076 kg BOD / capita / day
- Loading during 5 person period 0.38 kg BOD / day
- Loading during 20 person period 1.52 kg BOD / day
- Average loading 0.95 kg BOD / day

Primary Cell Sizing

- Maximum design loading rate 22 kg BOD / hectare / day
- Surface area required during average flow period
  - 0.95 kg BOD / 22 *10,000m^2/hectare 432 m^2 of surface area
- Surface area required during maximum flow period
  - 1.52 kg BOD / 22 *10,000m^2/hectare 691 m^2 of surface area

Although the primary cell area was calculated based on loading, a larger cell was selected based on physical constructability using heavy machinery.

Detailed calculations for the lagoon sizing are included in **Appendix C.** The primary and secondary cells are sized with the following characteristics:

- Liquid depth of primary and secondary cells 1.5 m
- Freeboard of 1 m
- Dike slope of 4:1
- Primary cell storage – half of total cell volume
- Secondary cell storage – top 1.2 m of 1.5 m depth
- Common berm width – 3 m
- Perimeter berm width – 3 m

The primary cell calculations result in the following dimensions:

- Volume (entire cell to 1.5 m depth) 747 m^3

- Storage Volume (½ volume of cell) 374 m^3
- Surface area not including freeboard (greater than 691 m^2 for max flow) 819 m^2

The secondary cell size is:

- Total Volume of secondary cell 2,070 m^3
- Total Storage volume (top 1.2 m) 1,759 m^3
- Sludge Storage at bottom 0.3 m of cell 311 m^3
- Surface area (not including 1 m freeboard) 1,848 m^2
- Total Storage volume (primary and secondary)
  - 374 m^3 + 1759 m^3 (greater than the 2067 m^3 required) 2,133 m^3

Cell dimensions, based on the above calculations are as follows:

- Primary Cell area (inside top of berm) 1,375 m^2
- Secondary Cell Dimensions (inside top of berm) = 50 x 52 = 2,600 m^2
- Total Lagoon Dimensions (including outside berms) = 56 x 88.5 = 4,956 m^2

The area required for clearing and the design of the lagoon are presented in drawings within **Appendix D.**

5.2 Outfall

The outfall for the lagoon will be located near the northeast corner of the secondary cell. The outfall will consist of a 200 mm diameter HDPE pipeline that will drain the secondary cell into the drainage ditch, into a wetland area and subsequently to Laurie River via existing natural drainage channels. The outfall pipeline is approximately 50 m in length and will empty onto a rip-rap spillway pad, which will direct effluent into the natural drainage route. The drainage route will be cleared a distance of approximately 200 meters as it flows to the wetland area. The outfall will be sized to drain within a one week period, however with valves, the flow rate will be restricted to allow a “trickle” flow and a three week discharge period. Assuming the secondary cell is drained in 3 weeks the discharge rate will be 55 litres/minute. The discharge route is shown in the drawings within **Appendix D.**

5.3 Truck Dump

Two truck dump locations will be provided; one will be located near the lift station and a backup will be provided at the lagoon. A second dump location is being provided to account for inclement weather.

The lagoon truck dump will be located on the south side of the primary cell. It will consist of a 4 m x 14 m concrete splash pad leading into the lagoon. The lagoon fence will transition from the toe of slope to the top of slope in this area. A gate will be constructed with steel bars for the lower half which will allow sewage to pass through, permitting dumping without requiring the gate to be opened.

The primary truck dump will be the manhole located before the main lift station. The top of the manhole will have a 150 mm opening and a 75 mm camlock fitting for the operator to dispose of waste through. In winter this will be the main disposal location used.

5.4 Fencing

A chain link fence with a height of 1.8 m will be located at the toe of the dyke on both the primary cell and secondary cell. This fence will provide security against wildlife and potential vandalism as well as provide a measure of safety for people.

5.5 Phosphorus Control

Two methods of phosphorus reduction were examined closely for the project, including alum dosing and natural plant uptake.

5.5.1 Alum Dosing

Phosphorus removal (to below 1 mg/L) can be achieved by dosing with aluminum sulphate commonly known as alum. The precipitation method for phosphorus removal involves spraying concentrated alum onto the wastewater in the secondary cell and mixing the wastewater with an outboard motor boat in a grid like pattern. The phosphorus combines with the alum, forming a floc which precipitates to the bottom of the cell, contributing to the sludge bed accumulation. The chemical dosing application occurs approximately one week prior to lagoon discharge sampling in order to allow for adequate settling of the floc. Grab samples are taken from the effluent for quality testing, prior to discharging the cell to ensure that the License limits have been met. This procedure is a reliable method for phosphorus removal and is currently being used in numerous Manitoban and Ontario wastewater lagoons. Alum dose rates can vary from 50 mg/L to 175 mg/L and will vary based on water chemistry.

Personal protective equipment (PPE) is required for all operators during alum dosing. This includes Tyvek suits, facemasks, goggles and gloves. A first aid kit, complete with fresh water should always be nearby. Once all spraying is complete, all pumps, tanks, boat and motor and PPE need to be flushed with clean water, following Manitoba Hydro procedures. Discharge of the lagoon can occur once the allowable phosphorus level of 1 mg/L is shown on the laboratory samples.

This option of alum precipitation is effective but it is difficult in remote areas such as Laurie River. Items of significant concern include:

- Danger to the operator during application of alum and difficult plane access in case of emergency.
- Difficulty in transporting alum to the remote location

For these reasons, the option of alum precipation has not been recommended.

5.5.2 Natural Plant Uptake of Phosphorus

The discharge route is approximately 700 m in length, including flowing through a natural wetland area immediately prior to discharge. Phosphorus will be drawn out of solution along this drainage route by soil adsorption as well as plant uptake. It is anticipated that phosphorus levels will be below 3 mg/l when discharged and less than 1 mg/L prior to entering the receiving stream.

The option of natural phosphorus removal through a trickle discharge and natural plant uptake was selected over alum precipitation. Without the addition of alum, the sludge build up in the lagoon will be slower as well. This will extend the time required between lagoon desludging periods.

5.5.3 Phosphorus Control Recommendation

It is recommended that the natural phosphorus removal process be followed, primarily due to the potential hazards surrounding alum use and the long discharge route. It is believed that phosphorus will be

removed from solution over this discharge route, such that the effluent will have less than 1 mg/L of phosphorus.

Water samples can be collected as a baseline in the wet lands area, prior to commissioning and discharge of the lagoon to help confirm that phosphorus is being removed. It is also recommended that the discharge route vegetation be cut and removed every 5 to 10 year period to allow new vegetation to grow and uptake the phosphorus from the effluent.

5.6 Discharge

Effluent will not be discharged between the 1st day of November of any year and the 15th day of June the following year. The proposed wastewater treatment lagoon effluent will be discharged through a 50 m outfall onto a 10 m long riprap spillway. The effluent will then flow along approximately 200 m of drainage channel, and then 500 m of natural wetland and out to the receiving stream. A drawing showing the discharge route is provided in **Appendix D.**

Assuming the total 1,678m^3 of wastewater is discharged from the secondary cell over a 3 week period, the total instantaneous discharge rate will be 55 L/minute or 3.3 m^3/hour. The second step in discharging the lagoon includes release of half of the primary cell (389m^3) to the secondary cell, which is then retested prior to discharge. As this volume of treated wastewater is significantly lower than the secondary cell, it will not exceed the 55 L/minute noted in the initial discharge of the secondary cell.

5.7 Sludge Disposal

This lagoon has been designed with low loading rates and a full 1 year of storage. For this reason, sludge buildup will be slow. It is anticipated that the sludge will not need to be removed for 25 years. At year 15, work should be done to confirm this estimate with completion of a sludge survey.

It is anticipated that the sludge will be dewatered in the future using large sludge filter bags (Geo Bags). With this method, lagoon sludge will be combined with a dewatering polymer and then pumped directly into a filter bag which retains the solids while allowing water to pass through small openings in the bag. The bag will be allowed to sit on the internal dyke of the lagoon, in the freeboard zone so that all free liquid drains back to the lagoon cells. After an estimated 6 month period, the retained material will be cut open and the sludge will be transported to an approved permitted landfill by truck and or rail. A separate licence will be required for the disposal of the sludge in the existing landfill or other location.

5.8 Lagoon Access Road

An access road is required to service the proposed lagoon site. The access road will be 6 m wide and its cross section will consist of compacted subgrade and a pit run gravel travel surface.

A perimeter access road will be installed on top of the berms for vehicle access. Pit run gravel wil also be used for this traffic surface.

6. Wastewater Lagoon Effluent Quality

The wastewater treatment lagoon has been designed to treat effluent to meet the effluent discharge limits as outlined in **Table 2**.

Table 2: Anticipated Effluent Limits

Parameter	Value
TP (1)	1 mg/L
BOD_5	25 mg/L
TSS	25 mg/L (excluding growing algae)
Fecal Coliform	200 / 100mL
Total Coliform	1,500 / 100mL

Note: (1): Anticipated phosphorus level following natural uptake in drainage channel.

It is anticipated that at the time of discharge the effluent will have the following characteristics:

- 10 mg/L ammonia;
- 10 mg/L organic nitrogen;
- 1 mg/L nitrates;
- 20 mg/L total Kjeldahl nitrogen (TKN); and
- pH of 7-9.

The wastewater lagoon is designed for one year of storage and the primary cell is designed for a low loading rate. At times when there is limited camp activity during the year, the population will be lower and the lagoon may only partially fill, with an equivalent of significantly more than one year of storage. During these low use periods, the effluent quality will be better than noted. A yearly discharge will be encouraged at the facility so that the operators remain knowledgeable, even if only a portion of the lagoon contents are released.

7. Piping

7.1 General

The scope of this project focuses on wastewater collection and treatment; however; the potable water piping will also be replaced. Piping will be installed at a depth of 2.0 to 1.0 m, which will not consistently be below frost depth. Shallow bury was selected, as there is limited overburden and deep bury would require significant blasting. To mitigate freezing, all pipes will be insulated and heat traced. The components being replaced are discussed in the following sections. The site plans showing piping are given in **Appendix D**.

7.2 Raw Water Line

The raw water line will be replaced as it exits GS#1 – extending from the Station, across the exterior of the Station Dam Structure, through the camp and back to the GS where it enters the Station. This line will be looped, insulated and heat traced to reduce freezing potential. HDPE pipe is proposed as it is resilient and it can be thawed if it becomes frozen. Double heat tracing will be installed even though only one line will be energized. This will allow for an easy switch over to backup heat tracing incase the primary heat tracing stops working during winter conditions. Conventional hydrants will be placed on the raw water line.

7.3 Treated Water Line

At present, water treatment consists of chlorination at GS#1. In the future it is anticipated that the existing system will be replaced with a treatment plant adjacent to the main garage. To reduce future piping installation, a new looped, insulated and heat traced treated water line will be installed on site. The chlorinated water will be conveyed through this piping in the short term, until the new treatment plant is designed and constructed. When it is constructed, some site tie-in work will be required. Manitoba Hydro will be responsible for updating the fire pumping system in GS#1 and for confirming fire flows. It should be noted that although this project will replace the fire hydrants, the flow may not meet requirements until the Fire Pump system is upgraded.

As the water plant will not be installed right away, part of the newly installed watermains will be left dormant and isolated by valves for future use.

7.4 Gravity Sewer Piping

The main gravity sewer, running parallel to the main road, collects wastewater from the buildings and currently flows down hill towards the existing wastewater treatment facility (towards GS#1). The future gravity collection line will be directed away from the GS and a new lift station will be provided near the maintenance garage. The 150 mm gravity sewer piping will be HDPE, insulated and heat traced.

7.5 Forcemain Piping

Forcemain piping will be installed between the lift station and the lagoon site. Pipe will be HDPE and 75 mm in diameter. Insulation and heat tracing will be used on this line as well. It will be installed at approximately 1.8 m bury due to shallow bedrock. No air releases will be required.

7.6 Holding Tank Wastewater Hauling Removal GS#1

A short, 50 m long, forcemain will be installed at GS#1 so that wastewater can be removed from the small holding tank located in the Station. The forcemain will be 38 mm in diameter and will be both heat traced and insulated. It is required for pumping the Station holding tank contents to a hauling truck at the top of

the hill. It is not practical to back the hauling truck down the slope, adjacent to the Station due to frequent poor weather conditions and a steep access road. The short forcemain will be a combination of exposed and shallow buried installation. If possible, granular material will be mounded over the pipe to provide a degree of insulation.

The pumpout forcemain will terminate at the top of the hill in a locked camlock box. The box will be made of aluminum and will be approximately 300 mm by 300 m by 300 m.

7.7 Holding Tank Wastewater Hauling Removal GS#2

There will be no inground piping installed at GS#2. Wastewater will be hauled from the station holding tank located in the building and transferred to a hauling truck using a portable septic tank hose.

7.8 Truck Hauling of Wastewater

A trailer will be provided for hauling the wastewater. It will be fitted with an insulated 2 m^3 tank with piped connections.

8. Services at Generating Station #1

Wastewater will be generated at GS 1. At present in the existing bathroom, the water fixtures have been disconnected and there is currently a composting toilet. This system will be replaced with the following works:

- Remove composting toilet.
- Install new toilet and reconnect bathroom sink to station untreated water supply system
- Provide a sign saying “Non-Potable Water – Do not Drink”.
- Reroute piping for the existing bathroom to a new enclosed holding tank lift station within the Generating Station.
- A self enclosed lift station is proposed, such as the Environment -1 units, as they are designed for low flow and high head and they are 120 volt.
- The lift station will be vented to the exterior and will have float controls. A high level alarm light will turn on when it is time to empty the system. The operator can plan to empty it every week or two.
- Due to the low water usage at the GS it is not practical to pipe potable water back to the Station from the camp and it is not practical to pump wastewater up the hill into the main camp wastewater system.

9. Services at Generating Station #2

Wastewater will be generated at GS#2. At present in the existing bathroom, the water fixtures have been disconnected and there is currently a composting toilet. This system will be replaced with the following works:

- Remove composting toilet.
- Install new toilet, shower and sink.
- Provide a sign saying “Non-Potable Water – Do not Drink”
- Reroute piping for the modified bathroom to a new enclosed holding tank lift station within the Generating Station.
- A self enclosed lift station is proposed, such as the Environment -1 units, as they are designed for low flow and high head and they are 120 volt.
- The lift station will be vented to the exterior and will have float controls. A high level alarm light will turn on when it is time to empty the system. The operator can plan to empty it every week or two.
- The GS is very isolated so sewer and water services cannot be piped to the main camp.
- Install false floor under the new toilet area.
- Install a new booster pump complete with pressure tank to boost bathroom water pressure from approximately 13 psi to a range of 40 to 60 psi.
- Replace hot water tank with smaller 20 litre tank and suspend from wall.

10. Main Lift Station

A lift station will be used to transfer the wastewater collected in the gravity sewer mains out to the lagoon site. A concrete barrel duplex pump lift station will be used, complete with insulation and a heated head space. There will be a concrete lid will access ports for pump removal and repairs. Isolation and check valves will be provided on each pump. The control panel will be mounted on two 100 mm pressure treated posts. Power will be provided from the control panel for external equipment operation.

An all weather tent will be supplied for set up over the lift station in the event that maintenance needs to performed in poor weather.

11. Site Plans

The lagoon area and piping system site plans are presented in **Appendix D**.

12. Provincial Classification

An application will be made to Manitoba Conservation to classify the wastewater treatment and collection facility. It is anticipated that the lagoon will be classified as a small or Class 1 system, however this will only be determined once an application (typically at the end of design) has been submitted. The collection system will likely be listed as a small or Class 1 system as well.

13. Anticipated Operation and Maintenance

Maintenance activities will be required as noted below:

- Maintain fence and gate to keep animals out;
- Maintain the lift station;
- Maintain valves;
- Maintaining even grass cover on dykes, and mowing so that growth is less than 0.3 m in height;
- Removing all reeds, rushes and trees within the lagoon and on the dykes to below the low water line;
- Maintaining the discharge route and pipeline to allow proper drainage;
- Maintaining a program to prevent and remove burrowing animals;
- Maintaining the access road into the lagoon area; and
- Visually inspecting the interconnecting piping between the cells.

Site staff will have a schedule for significant maintenance periods and should be able to anticipate when a significant population is coming to site. If there are no plans for significant activity, the staff may choose to only discharge half of the lagoon in the fall, so that there is more water cover over the pipes and it is less likely to freeze.

14. Proposed Construction Schedule

The two main constraints at the site are that heavy equipment must be transported by train and the construction window is relatively short due to weather. Keeping this in mind, the anticipated schedule is provided below:

- Functional Design Completion – December, 2012
- Environment Act Proposal Submission based on Functional design – December, 2012
- Complete Detailed Design – January, 2012
- Obtain Licence – March, 2013
- Tender Construction Project – February, 2013
- Mandatory Site Visit for contractors – February, 2013
- Award Project – April, 2013
- Construction Work – May to September, 2013
- Confirmatory Liner Testing August, 2013
- Remove Construction Equipment September, 2013

15. Class C Cost Estimate

A mandatory site visit will be held on site, so that interested contractors see the proposed work locations and get a feel for the difficulty of site access. An estimate has been attached below for all aspects of the project including the piping, the lagoon and lift station and servicing the forcemains.

Table 3: Cost Estimate for Clay Lined Lagoon

Item	Component	1	2	3	4
		Approx. Quantity	Units	Unit Price	Tender Amount
A.	**MOBILIZATION**				
1	Mobilization and Demobilization	1.0	L.S.	$200,000.00	$200,000.00
	SUBTOTAL "A"				**$200,000.00**
B.	**WASTEWATER COLLECTION**				
1	Supply and Install 200 mm SDR 35 PVC Wastewater Sewer, Separate Trench				
	a) Class 4 Backfill	170.0	M	$250.00	$42,500.00
2	Supply and Install SDR 35 PVC Wastewater Sewer Fittings				
	a) 200x100 mm Tee	9.0	Each	$1,500.00	$13,500.00
3	Supply and Install 1200 mm Manhole, c/w Frame and Cover	8.0	vt.m.	$3,750.00	$30,000.00
4	Supply and Install Truck Dump Manhole, Complete	1.0	Each	$20,000.00	$20,000.00
5	Bathroom Retrofit				
	a) Generating Station 1 (GS #1)	1.0	L.S.	$10,000.00	$10,000.00
	b) Generating Station 2 (GS #2)	1.0	L.S.	$30,000.00	$30,000.00
6	Associated Trenching - Wastewater Sewer	170.0	m	$200.00	$34,000.00
7	Associated Excavation – Manholes	3.0	Each	$1,500.00	$4,500.00
8	Associated Excavation - Truck Dump Manhole	1.0	Each	$4,000.00	$4,000.00
	SUBTOTAL "B"				**$189,500.00**
C.	**LIFT STATION AND FORCEMAIN**				
1	Supply and Install Lift Station, Complete				
	a) Lift Station #1	1.0	L.S.	$200,000.00	$200,000.00
	b) Grinder Pump (GS #1)	1.0	L.S.	$10,000.00	$10,000.00
	c) Grinder Pump (GS #2)	1.0	L.S.	$10,000.00	$10,000.00
2	Supply and Install 75 mm DR 17 HDPE Forcemain, Separate Trench, Pre-Insulated				

Item	Component	1	2	3	4
		Approx. Quantity	Units	Unit Price	Tender Amount
	a) Class 4 Backfill	210.0	M	$200.00	$42,000.00
3	Supply and Install 100 mm DR 17 HDPE Forcemain, Separate Trench, Pre-Insulated				
	a) Class 4 Backfill	40.0	M	$200.00	$8,000.00
4	Connection to Existing GS #1	1.0	Each	$2,000.00	
5	Associated Trenching – Forcemain	260.0	M	$200.00	$52,000.00
6	Associated Excavation - Lift Station	1.0	Each	$10,000.00	$10,000.00
	SUBTOTAL "C"				**$332,000.00**
D.	**WATERMAIN**				
1	Supply and Install 50 mm DR 11 HDPE Watermain, Heat Traced, Pre-Insulated				
	a) 50 mm Supply, Common Trench, Class 4 Backfill	145.0	M	$100.00	$14,500.00
	b) 50 mm Return, Common Trench, Class 4 Backfill	160.0	M	$100.00	$16,000.00
2	Supply and Install 150 mm DR 9 HDPE Raw Water Supply Line, Pre-Insulated, Heat Traced				
	a) Common Trench, Class 4 Backfill	140.0	M	$100.00	$14,000.00
	b) Surface, Anchored to Wall	115.0	M	$500.00	$57,500.00
3	Supply and Install 50 mm DR 11 HDPE Raw Water Return Line, Pre-Insulated, Heat Traced				
	a) Common Trench, Class 4 Backfill	140.0	M	$150.00	$21,000.00
	b) Surface, Anchored to Wall	115.0	M	$400.00	$46,000.00
4	Supply and Install HDPE Water Line Fittings, Pre-Insulated				
	a) 150 mm 45 deg Bend	2.0	Each	$2,000.00	$4,000.00
	b) 150 mm 90 deg Bend	1.0	Each	$2,000.00	$2,000.00
	c) 50 mm plug	2.0	Each	$2,000.00	$4,000.00
	d) 150 mm Blind Flange	1.0	Each	$2,000.00	$2,000.00
5	Supply and Install Gate Valve c/w Valve Box, Pre-Insulated				
	a) 150 mm	2.0	Each	$5,000.00	$10,000.00
6	Supply and Install Curb Stop c/w Valve Box, Pre-Insulated				
	a) 50 mm	4.0	Each	$2,500.00	$10,000.00
7	Supply and Install 150 mm On-line Hydrant	4.0	Each	$15,000.00	$60,000.00

Item	Component	1	2	3	4
		Approx. Quantity	Units	Unit Price	Tender Amount
	Assembly, Pre-Insulated				
8	Supply and Install Thermostatic Heat Trace Controller and Sensors	2.0	Each	$5,000.00	$10,000.00
9	Associated Trenching – Watermains	585.0	M	$100.00	$58,500.00
	SUBTOTAL "D"				**$329,500.00**
E.	**SERVICE CONNECTIONS**				
1	Supply and Install HDPE Water Service c/w Pre-Insulated, Heat Traced				
	a) 25 mm, Class 4 Backfill	150.0	M	$150.00	$22,500.00
2	Supply and Install Electrofusion Tee, Pre-Insulated				
	a) 25 mm	9.0	Each	$2,000.00	$18,000.00
3	Supply and Install Curb Stop c/w Valve Box, Pre-Insulated				
	a) 25 mm	9.0	Each	$3,000.00	$27,000.00
4	Heat Trace Thermostatic Controller and Sensors - Water Services				
	a) Supply Complete Unit and Install Sensors	9.0	Each	$2,000.00	$18,000.00
5	Supply and Install 150 mm SDR 35 PVC Sewer Service, Pre-Insulated				
	a) Class 4 Backfill	130.0	M	$200.00	$26,000.00
6	Building Service Connection – Water	9.0	Each	$4,000.00	$36,000.00
7	Building Service Connection - Wastewater Sewer	9.0	Each	$4,000.00	$36,000.00
8	Associated Trenching – Services	280.0	M	$200.00	$56,000.00
	SUBTOTAL "E"				**$239,500.00**
F.	**LAGOON AND RELATED WORKS**				
1	Composite Excavation				
	a) Roads	2,000.0	cu.m.	$12.00	$24,000.00
	b) Lagoon	10,000.0	cu.m.	$12.00	$120,000.00
2	Supply and Install Granular Base Course, Class "C " (Modified)				
	a) Roads	150.0	cu.m.	$75.00	$11,250.00
	b) Lagoon	150.0	cu.m.	$75.00	$11,250.00
3	Supply and Install Traffic Gravel, Class "D"	300.0	cu.m.	$100.00	$30,000.00
4	Supply and Install Corrugated Steel Culverts				
	a) 600 mm	30.0	M	$400.00	$12,000.00
5	Supply and Install Culvert Bedding Gravel	25.0	cu.m.	$75.00	$1,875.00

Item	Component	1	2	3	4
		Approx. Quantity	Units	Unit Price	Tender Amount
6	Clearing and Grubbing	2.0	Ha	$10,000.00	$20,000.00
7	250 mm PVC SDR 35 Interconnection	23.0	M	$200.00	$4,600.00
8	250 mm PVC SDR 35 Overflow	15.0	M	$200.00	$3,000.00
9	250 mm PVC SDR 25 Outfall	25.0	M	$200.00	$5,000.00
10	Fencing	400.0	M	$30.00	$12,000.00
11	Truck Dump	1.0	Each	$30,000.00	$30,000.00
12	Wastewater Hauling trailer and Shelter Tent	1	Each	10,000	$10,000
	SUBTOTAL "F"				**$294,975.00**
G.	**MISCELLANEOUS**				
1	Supply and Install Box Insulation	200.0	M	$150.00	$30,000.00
	SUBTOTAL "G"				**$30,000.00**
	SUBTOTAL ESTIMATED PRICE				**$1,615,475.00**
	10% Contingency				**$161,547.50**
	Total Estimated Price				**$1,777,022.50**

Appendix A

Geotechnical Report

AECOM
99 Commerce Drive
Winnipeg, MB, Canada R3P 0Y7
www.aecom.com

204 477 5381 tel
204 284 2040 fax

Memorandum

To	Paul Barsalou	Page	1
CC	Faris Khalil		
Subject	Proposed Laurie River Wastewater Lagoon Site Feasibility		
From	Jeremy Fiebelkorn		
Date	February 8, 2011	Project Number	60157739 (500)

1. INTRODUCTION

A new wastewater treatment lagoon is being considered to service the Manitoba Hydro Laurie River Generating Station at Laurie River, MB. The size and location of the proposed facility is yet to be finalized, however the intent is to construct the proposed facility east of the existing fire hall. This memorandum summarizes the geotechnical investigation completed by AECOM at the above site. The purpose of the investigation is to assess the subsurface conditions and determine the suitability of the site for construction of the proposed facility.

2. FIELD INVESTIGATION

Twenty eight test pits were excavated on October 22, 2010 by Hartman Construction Ltd. using Komatsu PC220 LC excavator. Ten test pits (TP10-14 to TP10-23) were completed for the proposed tower location and detailed test pit logs have subsequently been submitted. Five test pits (TP10-24 to TP10-28) were completed along the proposed forcemain alignment, three test pits (TP10-01, TP10-02, TP10-13) were completed along two proposed outfall alignments, two test pits (TP10-11, TP10-12) were completed in an area previously identified as a potential clay borrow source, and eight test pits (TP10-03 to TP10-10) were completed within the footprint of the proposed wastewater lagoon. One standpipe piezometer (SP10-07) was installed within the footprint of the proposed facility to monitor groundwater levels.

In addition to the test pit exploration, forty three probe holes were completed using a steel rod to approximately identify the depth to bedrock. Nine probe-holes (TH10-201 to TH10-209) were completed along the initial proposed outfall alignment, twenty six probe-holes (TH10-01 to TH10-15, TH10-101 to TH10-111) were completed along the proposed forcemain alignment, and eight probe-holes (N1 to N8) were completed within the boundaries of the proposed facility. The locations of the test pits and probe-holes are shown on the Test Hole Locations Plan in Figure 01 of Appendix A.
The test pits were advanced to the maximum reach of the excavator (approximately 3.0m) or to refusal. General site supervision and test pit logging was provided by AECOM personnel. Disturbed samples were collected at intervals such that moisture contents and material type changes are well represented, and undisturbed Shelby tube samples were collected from within the lagoon footprint.

The soil samples were transported to AECOM's Materials Testing Laboratory in Winnipeg for further visual classification and laboratory testing.

The laboratory testing program consisted of the determination of moisture contents, Atterberg limits, hydrometer analyses, Standard Proctor tests, and flexible wall permeability tests. Detailed logs have been prepared for each test pit to record the description and relative position of the various soil strata, location of samples obtained, field and laboratory test results, and other pertinent information, and are provided in Appendix B. A summary of the depth of bedrock contact in the probe-holes is provided in Appendix C.

3. SUBSURFACE CONDITIONS

3.1 Soil Profile

In descending order, the general soil profile is as follows:

- Topsoil
- Silty Clay (homogeneous and laminated)
- Silt
- Bedrock

These soils are described as follows:

Topsoil

Topsoil less than 200 mm thick was encountered at the ground surface in TP10-01 to TP10-24. The topsoil is generally brown, moist and contains rootlets.

Silty Clay

Silty clay of variable thickness was encountered at ground surface, or beneath the topsoil in all test pit locations. In some locations the clay is brown and homogeneous, in others it is laminated with layers of light brown clayey silt. Generally, the clay is moist and soft to firm. Moisture contents range from 19 to 30 percent with an average value of 27 percent. Atterberg limit tests were completed on representative samples, measured liquid and plastic limits range from 45 to 52 percent and 23 to 24 percent respectively

Silt

Low plasticity silt of variable clay and sand content was encountered in TP10-05 beneath the clay and in TP10-07 near the ground surface beneath the topsoil. The silt was grey in colour, and the moisture content measured 10 percent on a representative sample.

3.2 Groundwater Conditions

No seepage or sloughing was observed during the test pit exploration. SP10-07 was noted to be dry at the time of installation, subsequent piezometer readings should be completed as part of the detailed design phase.

4. GEOTECHNICAL CONSIDERATIONS

4.1 Floor of the Proposed Facility

The proposed site is considered feasible for a clay-lined or a geosynthetic-lined sewage lagoon facility. A clay lined facility may be viable if the floor elevation is selected so that it is underlain by at least 1m thick of soil. In this regard, the depth to bedrock should be considered, among other factors, in the selection of the facility floor elevation.

The provincial guidelines for a clay-lined lagoon are to provide at least 1m thick clay seal having a hydraulic conductivity of 1×10^{-9} m/s underlies the floor and the interior surfaces of the facility. The in-situ intermediate to high plastic clays encountered during the test pits exploration were found to have a hydraulic conductivity in the order of 10^{-7} m/s. However the reconstituted clay sample was found to have a hydraulic conductivity in the order of 10^{-10} m/s, results of the flexible wall permeability tests are provided in Appendix D. An effective clay liner can be constructed by excavating, re-working and compacting the readily available clay soil. The clay should be placed in layers not to exceed 300 mm non-compacted thickness at moisture content within 0 and +3 percent of the optimum moisture content and compacted to at least 95 percent Standard Proctor maximum dry density (SPMDD).

If a geosynthetic liner design is selected, the liner should be placed on a 200 mm thick layer of compacted bedding sand. The bedding sand layer should be placed on prepared subgrade. The subgrade preparation consists of re-working and compacting the top 300 mm.

Further design and construction recommendations can be provided once the liner type has been selected.

4.2 Dykes of the Proposed Facility

The subsurface conditions encountered within the outline of the proposed facility is anticipated to provide a suitable foundation for the proposed dykes provided the top 600 mm of the subgrade is excavated, re-placed in layers and compacted to at least 95 percent of SPMDD. The native clay encountered within the designated borrow sources and within the area of the proposed lagoon can be used to construct these dykes. Clay dykes not exceeding 3 m in height can be designed with side slopes not steeper than 4H:1V. Detailed stability analysis is required for slopes greater than 3 m high. The clay should be placed in layers not to exceed 300 mm non-compacted thickness at moisture content within 0 and +3 percent of the optimum moisture content and compacted to at least 95 percent Standard Proctor maximum dry density (SPMDD).

Erosion protection measures will be required on the slope surfaces of the proposed dykes. The exterior slopes can be protected using a suitable vegetation cover. A rip-rap protection layer can be used on the interior slopes to provide protection against rainfall, snowmelt, wave action, or any other erosive actions. Further recommendation can be provided as part of the detailed design phase.

Should you require any further assistance, please do not hesitate to contact the undersigned.

Respectfully submitted,

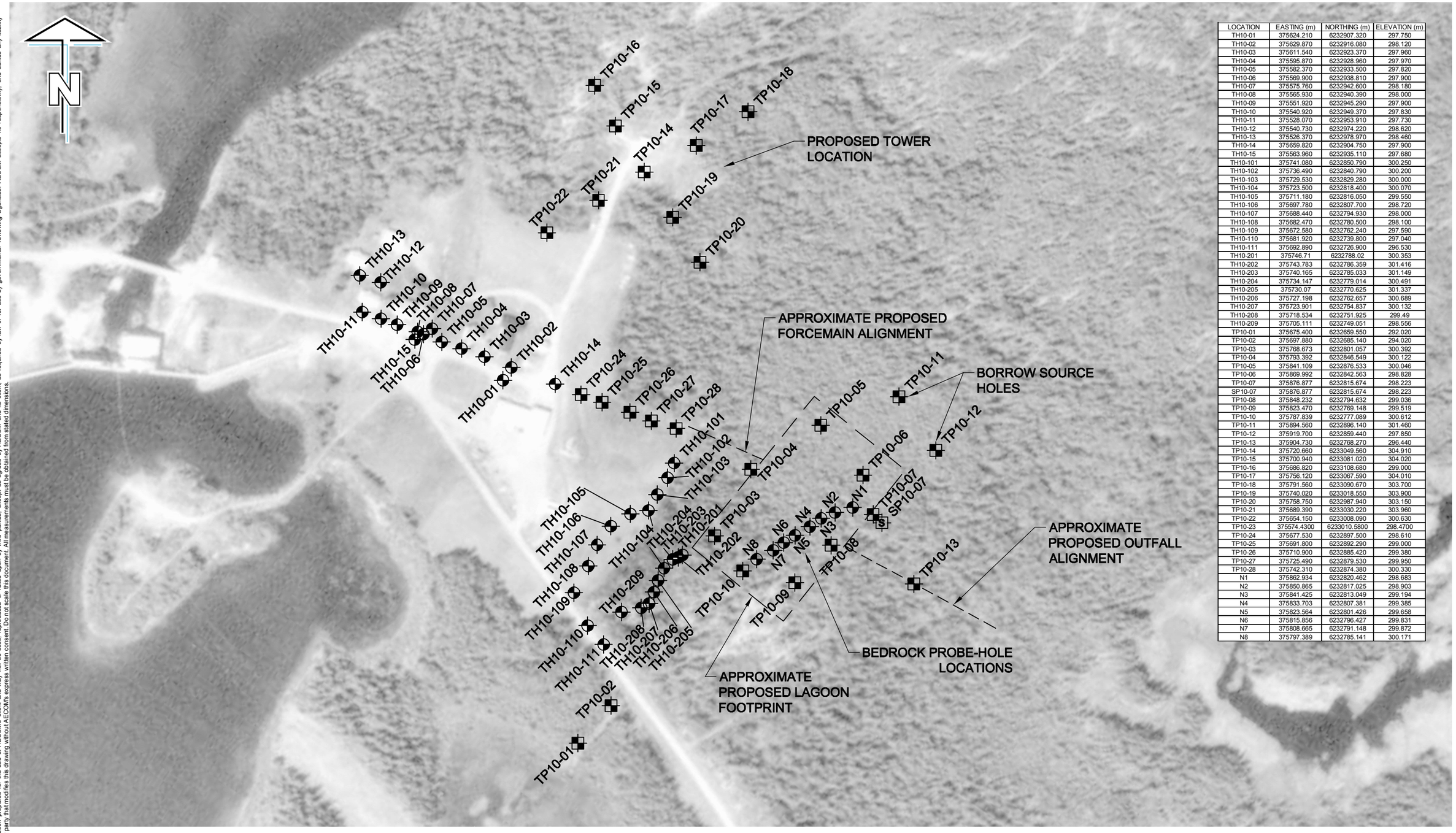
AECOM Canada Ltd.

Jeremy Fiebelkorn, E.I.T.
Geotechnical Engineering,

Reviewed By:

Faris Khalil, P.Eng.
Manager, Geotechnical Engineering

Appendix A
Figures



LOCATION	EASTING (m)	NORTHING (m)	ELEVATION (m)
TH10-01	375624.210	6232907.320	297.750
TH10-02	375629.870	6232916.080	298.120
TH10-03	375611.540	6232923.370	297.960
TH10-04	375595.870	6232928.960	297.970
TH10-05	375582.370	6232933.500	297.820
TH10-06	375569.900	6232938.810	297.900
TH10-07	375575.760	6232942.600	298.180
TH10-08	375565.930	6232940.390	298.000
TH10-09	375551.920	6232945.290	297.900
TH10-10	375540.920	6232949.370	297.830
TH10-11	375528.070	6232953.910	297.730
TH10-12	375540.730	6232974.220	298.620
TH10-13	375526.370	6232978.970	298.460
TH10-14	375659.820	6232904.750	297.900
TH10-15	375563.960	6232935.110	297.680
TH10-101	375741.080	6232850.790	300.250
TH10-102	375736.490	6232840.790	300.200
TH10-103	375729.530	6232829.280	300.000
TH10-104	375723.500	6232818.400	300.070
TH10-105	375711.180	6232816.050	299.550
TH10-106	375697.780	6232807.700	298.720
TH10-107	375688.440	6232794.930	298.000
TH10-108	375682.470	6232780.500	298.100
TH10-109	375672.580	6232762.240	297.590
TH10-110	375681.920	6232739.800	297.040
TH10-111	375692.890	6232726.900	296.530
TH10-201	375746.71	6232788.02	300.353
TH10-202	375743.783	6232786.359	301.416
TH10-203	375740.165	6232785.033	301.149
TH10-204	375734.147	6232779.014	300.491
TH10-205	375730.07	6232770.625	301.337
TH10-206	375727.198	6232762.657	300.689
TH10-207	375723.901	6232754.837	300.132
TH10-208	375718.534	6232751.925	299.49
TH10-209	375705.111	6232749.051	298.556
TP10-01	375675.400	6232659.550	292.020
TP10-02	375697.880	6232685.140	294.020
TP10-03	375768.673	6232801.057	300.392
TP10-04	375793.392	6232846.549	300.122
TP10-05	375841.109	6232876.533	300.046
TP10-06	375869.992	6232842.563	298.828
TP10-07	375876.877	6232815.674	298.223
SP10-07	375876.877	6232815.674	298.223
TP10-08	375848.232	6232794.632	299.036
TP10-09	375823.470	6232769.148	299.519
TP10-10	375787.839	6232777.089	300.612
TP10-11	375894.560	6232896.140	301.460
TP10-12	375919.700	6232859.440	297.850
TP10-13	375904.730	6232768.270	296.440
TP10-14	375720.660	6233049.560	304.910
TP10-15	375700.940	6233081.020	304.020
TP10-16	375686.820	6233108.680	299.000
TP10-17	375756.120	6233067.590	304.010
TP10-18	375791.560	6233090.670	303.700
TP10-19	375740.020	6233018.550	303.900
TP10-20	375758.750	6232987.940	303.150
TP10-21	375689.390	6233030.220	303.960
TP10-22	375654.150	6233008.090	300.630
TP10-23	375574.4300	6233010.5800	298.4700
TP10-24	375677.530	6232897.500	298.610
TP10-25	375691.800	6232892.290	299.000
TP10-26	375710.900	6232885.420	299.380
TP10-27	375725.490	6232879.530	299.950
TP10-28	375742.310	6232874.380	300.330
N1	375862.934	6232820.462	298.683
N2	375850.865	6232817.025	298.903
N3	375841.425	6232813.049	299.194
N4	375833.703	6232807.381	299.385
N5	375823.564	6232801.426	299.658
N6	375815.856	6232796.427	299.831
N7	375808.665	6232791.148	299.872
N8	375797.389	6232785.141	300.171

0 25 50 m SCALE 1:2500

LEGEND

- TEST HOLE (BEDROCK PROBE-HOLE)
- TEST PIT
- STANDPIPE PIEZOMETER

AECOM

Manitoba Hydro
MB Hydro Laurie River

Test Hole Location Plan

Figure - 01

Appendix B
Test Pit Logs

AECOM Canada Ltd.

GENERAL STATEMENT

NORMAL VARIABILITY OF SUBSURFACE CONDITIONS

The scope of the investigation presented herein is limited to an investigation of the subsurface conditions as to suitability for the proposed project. This report has been prepared to aid in the evaluation of the site and to assist the engineer in the design of the facilities. Our description of the project represents our understanding of the significant aspects of the project relevant to the design and construction of earth work, foundations and similar. In the event of any changes in the basic design or location of the structures as outlined in this report or plan, we should be given the opportunity to review the changes and to modify or reaffirm in writing the conclusions and recommendations of this report.

The analysis and recommendations presented in this report are based on the data obtained from the borings and test pit excavations made at the locations indicated on the site plans and from other information discussed herein. This report is based on the assumption that the subsurface conditions everywhere are not significantly different from those disclosed by the borings and excavations. However, variations in soil conditions may exist between the excavations and, also, general groundwater levels and conditions may fluctuate from time to time. The nature and extent of the variations may not become evident until construction. If subsurface conditions differ from those encountered in the exploratory borings and excavations, are observed or encountered during construction, or appear to be present beneath or beyond excavations, we should be advised at once so that we can observe and review these conditions and reconsider our recommendations where necessary.

Since it is possible for conditions to vary from those assumed in the analysis and upon which our conclusions and recommendations are based, a contingency fund should be included in the construction budget to allow for the possibility of variations which may result in modification of the design and construction procedures.

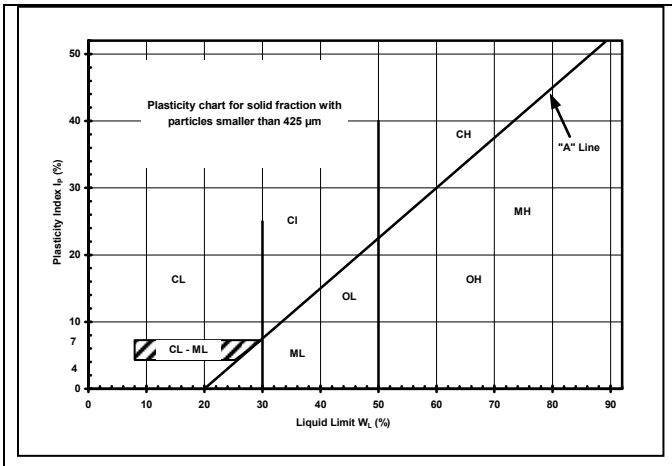
In order to observe compliance with the design concepts, specifications or recommendations and to allow design changes in the event that subsurface conditions differ from those anticipated, we recommend that all construction operations dealing with earth work and the foundations be observed by an experienced soils engineer. We can be retained to provide these services for you during construction. In addition, we can be retained to review the plans and specifications that have been prepared to check for substantial conformance with the conclusions and recommendations contained in our report.

EXPLANATION OF FIELD & LABORATORY TEST DATA

Description				UMA Log Symbols	USCS Classification	Laboratory Classification Criteria			
						Fines (%)	Grading	Plasticity	Notes
COARSE GRAINED SOILS	GRAVELS (More than 50% of coarse fraction of gravel size)	CLEAN GRAVELS (Little or no fines)	Well graded gravels, sandy gravels, with little or no fines		GW	0-5	$C_U > 4$ $1 < C_C < 3$		Dual symbols if 5-12% fines. Dual symbols if above "A" line and $4<W_P<7$ $C_U = \frac{D_{60}}{D_{10}}$ $C_C = \frac{(D_{30})^2}{D_{10} x D_{60}}$
			Poorly graded gravels, sandy gravels, with little or no fines		GP	0-5	Not satisfying GW requirements		
		DIRTY GRAVELS (With some fines)	Silty gravels, silty sandy gravels		GM	> 12		Atterberg limits below "A" line or $W_P<4$	
			Clayey gravels, clayey sandy gravels		GC	> 12		Atterberg limits above "A" line or $W_P<7$	
	SANDS (More than 50% of coarse fraction of sand size)	CLEAN SANDS (Little or no fines)	Well graded sands, gravelly sands, with little or no fines		SW	0-5	$C_U > 6$ $1 < C_C < 3$		
			Poorly graded sands, gravelly sands, with little or no fines		SP	0-5	Not satisfying SW requirements		
		DIRTY SANDS (With some fines)	Silty sands, sand-silt mixtures		SM	> 12		Atterberg limits below "A" line or $W_P<4$	
			Clayey sands, sand-clay mixtures		SC	> 12		Atterberg limits above "A" line or $W_P<7$	
FINE GRAINED SOILS	SILTS (Below 'A' line negligible organic content)	$W_L<50$	Inorganic silts, silty or clayey fine sands, with slight plasticity		ML			Classification is Based upon Plasticity Chart	
		$W_L>50$	Inorganic silts of high plasticity		MH				
	CLAYS (Above 'A' line negligible organic content)	$W_L<30$	Inorganic clays, silty clays, sandy clays of low plasticity, lean clays		CL				
		$30<W_L<50$	Inorganic clays and silty clays of medium plasticity		CI				
		$W_L>50$	Inorganic clays of high plasticity, fat clays		CH				
	ORGANIC SILTS & CLAYS (Below 'A' line)	$W_L<50$	Organic silts and organic silty clays of low plasticity		OL				
		$W_L>50$	Organic clays of high plasticity		OH				
HIGHLY ORGAINIC SOILS			Peat and other highly organic soils		Pt	Von Post Classification Limit		Strong colour or odour, and often fibrous texture	

	Asphalt		Till		
	Concrete		Bedrock (Undifferentiated)		AECOM
	Fill		Bedrock (Limestone)		

When the above classification terms are used in this report or test hole logs, the designated fractions may be visually estimated and not measured.



FRACTION		SEIVE SIZE (mm)		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS	
		Passing	Retained	Percent	Identifier
Gravel	Coarse	76	19	35-50	and
	Fine	19	4.75		
Sand	Coarse	4.75	2.00	20-35	"y" or "ey" *
	Medium	2.00	0.425		
	Fine	0.425	0.075	10-20	some
Silt (non-plastic) or Clay (plastic)		< 0.075 mm		1-10	trace

* for example: gravelly, sandy clayey, silty

Definition of Oversize Material

COBBLES: 76mm to 300mm diameter
BOULDERS: >300mm diameter

LEGEND OF SYMBOLS

Laboratory and field tests are identified as follows:

- q_u - undrained shear strength (kPa) derived from unconfined compression testing.
- T_v - undrained shear strength (kPa) measured using a torvane
- pp - undrained shear strength (kPa) measured using a pocket penetrometer.
- L_v - undrained shear strength (kPa) measured using a lab vane.
- F_v - undrained shear strength (kPa) measured using a field vane.
- γ - bulk unit weight (kN/m^3).
- SPT - Standard Penetration Test. Recorded as number of blows (N) from a 63.5 kg hammer dropped 0.76 m (free fall) which is required to drive a 51 mm O.D. Raymond type sampler 0.30 m into the soil.
- DPPT - Drive Point Pentrometer Test. Recorded as number of blows from a 63.5 kg hammer dropped 0.76 m (free fall) which is required to drive a 50 mm drive point 0.30 m into the soil.
- w - moisture content (W_L, W_P)

The undrained shear strength (Su) of a cohesive soil can be related to its consistency as follows:

Su (kPa)	**CONSISTENCY**
<12	very soft
12 – 25	soft
25 – 50	medium or firm
50 – 100	stiff
100 – 200	very stiff
200	hard

The resistance (N) of a non-cohesive soil can be related to compactness condition as follows

N – BLOWS/0.30 m	**COMPACTNESS**
0 - 4	very loose
4 - 10	loose
10 - 30	compact
30 - 50	dense
50	very dense

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-01**
LOCATION: Proposed Outfall Alignment 1 - 375675.400m E 6232659.550m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 292.02

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ▤ BULK ⊘ NO RECOVERY ◧ CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100	UNDRAINED SHEAR STRENGTH + Torvane + × QU × □ Lab Vane □ △ Pocket Pen. △ ⬘ Field Vane ⬘ (kPa) 50 100 150 200	COMMENTS	ELEVATION
0		TOPSOIL - organics/rootlets throughout -brown, moist							
		CLAY - silty, trace rootlets to ~0.8m -brown, moist, firm -intermediate to high plasticity -homogeneous							
1									291
2									290
3		END HOLE AT 3.0m IN CLAY Notes: 1. No seepage observed; 2. No sloughing observed.							289
4									

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

AECOM

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 3.05 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-02**
LOCATION: Proposed Outfall Alignment 1 - 375697.880m E 6232685.140m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 294.02

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ▤ BULK ⊘ NO RECOVERY ◧ CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100	UNDRAINED SHEAR STRENGTH + Torvane + × QU × □ Lab Vane □ △ Pocket Pen. △ ⬘ Field Vane ⬘ (kPa) 50 100 150 200	COMMENTS	ELEVATION
0		TOPSOIL - organics/rootlets throughout -black, moist							
		CLAY - silty, trace rootlets to ~0.8m -brown, moist, soft -intermediate to high plasticity -homogeneous							
1									293
		-laminated (<5mm thick) -alternating brown clay/grey silt layers, moist, firm -low to intermediate plasticity							
2									292
3		END HOLE AT 3.0m IN CLAY Notes: 1. No seepage observed; 2. No sloughing observed.							291
4									

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

AECOM

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 3.05 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-03**
LOCATION: Proposed Lagoon - 375768.673m E 6232801.057m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 300.39

SAMPLE TYPE: GRAB; SHELBY TUBE; SPLIT SPOON; BULK; NO RECOVERY; CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / UNDRAINED SHEAR STRENGTH	COMMENTS	ELEVATION
0		TOPSOIL - moss and rootlets throughout -brown, moist						
		CLAY - silty, trace rootlets -laminated - alternating brown clay/light brown silt layers, moist, firm to stiff -intermediate to high plasticity		T01				300
1				G01		24.3		
		REFUSAL - END HOLE AT 1.2m ON BEDROCK Notes: 1. No seepage observed; 2. No sloughing observed.						299
2								298
3								297
4								

PENETRATION TESTS: ✳ Becker ✳; ◇ Dynamic Cone ◇; ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

UNDRAINED SHEAR STRENGTH: + Torvane +; × QU ×; □ Lab Vane □; △ Pocket Pen. △; ⬘ Field Vane ⬘ (kPa) 50 100 150 200

AECOM

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 1.22 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-04**
LOCATION: Proposed Lagoon - 375793.392m E 6232846.549m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 300.12

SAMPLE TYPE ■ GRAB ▯ SHELBY TUBE ☒ SPLIT SPOON ▬ BULK ⊘ NO RECOVERY ◧ CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / UNDRAINED SHEAR STRENGTH	COMMENTS	ELEVATION
0		TOPSOIL - rootlets throughout -brown, moist						300
		CLAY - silty, trace rootlets -laminated - alternating brown clay/light brown silt layers, moist, soft -intermediate to high plasticity		T02 G02		30.1		
1								299
				G03		29.4		
		REFUSAL - END HOLE AT 1.8m ON BEDROCK Notes: 1. No seepage observed; 2. No sloughing observed.						
2								298
3								297
4								

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

UNDRAINED SHEAR STRENGTH: + Torvane + × QU × ☐ Lab Vane ☐ △ Pocket Pen. △ ⬘ Field Vane ⬘ (kPa) 50 100 150 200

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 1.83 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

AECOM

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-05**
LOCATION: Proposed Lagoon - 375841.109m E 6232876.533m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 300.05

SAMPLE TYPE ■ GRAB ▯ SHELBY TUBE ☒ SPLIT SPOON ▬ BULK ⊘ NO RECOVERY ◧ CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	UNDRAINED SHEAR STRENGTH: + Torvane + × QU × □ Lab Vane □ △ Pocket Pen. △ ⬘ Field Vane ⬘ (kPa) 50 100 150 200	COMMENTS	ELEVATION
0		TOPSOIL - organics/rootlets throughout -brown, moist							300
		CLAY - silty, trace sand, trace gravel -brown, moist, stiff becoming firm with depth -intermediate to high plasticity							
			■	G04		27.7	+		
			▯	T03				Tube pushed ~2m from TP10-05	
1		-laminated - alternating brown clay/light brown silt layers							299
			■	G05		28	+	Sample G05 - Gravel-0.2%, Sand-2.4%, Silt-33.1%, Clay-64.3%	
		SILT - trace to some sand -grey, moist, firm -low plasticity to non-plastic							
2			■	G06		9.6	+		298
		REFUSAL - END HOLE AT 2.3m ON BEDROCK Notes: 1. No seepage observed; 2. No sloughing observed.							
3									297
4									

AECOM

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 2.29 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-06**
LOCATION: Proposed Lagoon - 375969.992m E 6232842.563m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 298.83

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ▨ SPLIT SPOON ▤ BULK ▨ NO RECOVERY ◧ CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	UNDRAINED SHEAR STRENGTH: + Torvane + × QU × ☐ Lab Vane ☐ △ Pocket Pen. △ ⬘ Field Vane ⬘ (kPa) 50 100 150 200	COMMENTS	ELEVATION
0		TOPSOIL - organics/rootlets throughout -brown, moist							
		CLAY - silty -brown, moist, firm to stiff -intermediate to high plasticity	■	G07		26.1	+		298
1		-laminated - alternating brown clay/light brown silt layers	▥	T04					
		-stiff	■	G08		28.7	+		297
2		REFUSAL - END HOLE AT 2.0m ON BEDROCK							296
3									295
4									

Notes:
1. No seepage observed;
2. No sloughing observed.

AECOM

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 1.98 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-07**
LOCATION: Proposed Lagoon - 375876.877m E 6232815.674m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 298.22

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / UNDRAINED SHEAR STRENGTH	COMMENTS	ELEVATION
0		TOPSOIL - organics/rootlets throughout -brown, moist						
		SILT - clayey, trace rootlets -brown/grey, dry to moist, hard -low plastic						298
		CLAY - silty, trace sand -brown, moist, firm -intermediate to high plasticity		G09		28.7		
1				G10		29.7	Sample G10 - Gravel-0.0%, Sand-2.7%, Silt-21.1%, Clay-76.2%	
		-laminated - alternating layers of brown clay/light brown silt -weathered (crumbly soil)						297
				T05		29.1		
2				G11		28.3		
								296
3		REFUSAL - END HOLE AT 3.0m ON BEDROCK Notes: 1. No seepage observed; 2. No sloughing observed; 3. SP10-07 installed, dry at time of installation.						295
4								

PENETRATION TESTS: Becker | Dynamic Cone | SPT (Standard Pen Test) (Blows/300mm) 0 20 40 60 80 100 | Total Unit Wt (kN/m^3) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

UNDRAINED SHEAR STRENGTH: Torvane | QU | Lab Vane | Pocket Pen. | Field Vane (kPa) 50 100 150 200

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 3.05 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

AECOM

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-08**
LOCATION: Proposed Lagoon - 375848.232m E 6232794.632m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 299.04

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ▨ SPLIT SPOON ▤ BULK ▨ NO RECOVERY ◧ CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100	UNDRAINED SHEAR STRENGTH + Torvane + × QU × □ Lab Vane □ △ Pocket Pen. △ ⬘ Field Vane ⬘ (kPa) 50 100 150 200	COMMENTS	ELEVATION
0		TOPSOIL -organics/rootlets throughout -brown, moist							299
		CLAY - silty, trace rootlets to ~0.8m -brown, moist, stiff becoming firm with depth -intermediate to high plasticity							
				G12		23.8			
1		-laminated - alternating layers of brown clay/light brown silt -firm							298
				G13		29.2			
		REFUSAL - END HOLE AT 1.5m ON BEDROCK Notes: 1. No seepage observed; 2. No sloughing observed.							
2									297
3									296
4									

AECOM

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 1.52 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-09**
LOCATION: Proposed Lagoon - 375823.470m E 6232769.148m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 299.52

SAMPLE TYPE ■ GRAB ▯ SHELBY TUBE ☒ SPLIT SPOON ▬ BULK ⊘ NO RECOVERY ◧ CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / UNDRAINED SHEAR STRENGTH	COMMENTS	ELEVATION
0		TOPSOIL - organics/rootlets throughout -black, moist						
		CLAY - silty, trace rootlets -brown, moist, firm -intermediate to high plasticity	■	G14		23.2		299
		REFUSAL - END HOLE AT 0.6m ON BEDROCK Notes: 1. No seepage observed; 2. No sloughing observed.						
1								298
2								297
3								296
4								

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

UNDRAINED SHEAR STRENGTH: + Torvane + × QU × ☐ Lab Vane ☐ △ Pocket Pen. △ ⬘ Field Vane ⬘ (kPa) 50 100 150 200

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 0.61 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

AECOM

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-10**
LOCATION: Proposed Lagoon - 375787.839m E 6232777.089m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 300.61

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / UNDRAINED SHEAR STRENGTH	COMMENTS	ELEVATION
0		TOPSOIL - organics/rootlets throughout -brown, moist						
		CLAY - silty -laminated - alternating layers of brown clay/light brown silt, moist, firm -intermediate to high plasticity						
				G15		25.5		300
		REFUSAL - END HOLE AT 0.8m ON BEDROCK						
1		Notes: 1. No seepage observed; 2. No sloughing observed.						299
2								298
3								297
4								

PENETRATION TESTS: Becker; Dynamic Cone; SPT (Standard Pen Test) (Blows/300mm) 0 20 40 60 80 100; Total Unit Wt (kN/m^3) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

UNDRAINED SHEAR STRENGTH: Torvane; QU; Lab Vane; Pocket Pen.; Field Vane (kPa) 50 100 150 200

AECOM

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 0.76 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-11**
LOCATION: Borrow Source - 375894.560m E 6232896.140m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 301.46

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ▤ BULK ⊘ NO RECOVERY ◧ CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	UNDRAINED SHEAR STRENGTH: + Torvane + × QU × □ Lab Vane □ △ Pocket Pen. △ ⬘ Field Vane ⬘ (kPa) 50 100 150 200	COMMENTS	ELEVATION
0		TOPSOIL -organics/rootlets throughout -black, moist							
		CLAY - silty -brown, moist, firm -intermediate to high plasticity		G16		27.9			301
1									
		REFUSAL - END HOLE AT 1.5m ON BEDROCK Notes: 1. No seepage observed; 2. No sloughing observed.							300
2									299
3									298
4									

AECOM

LOGGED BY: Matt Lotecki | COMPLETION DEPTH: 1.52 m
REVIEWED BY: Jeremy Fiebelkorn | COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou |

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-12**
LOCATION: Borrow Source - 375919.700m E 6232859.440m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 297.85

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ▨ SPLIT SPOON ▤ BULK ▨ NO RECOVERY ▨ CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / UNDRAINED SHEAR STRENGTH	COMMENTS	ELEVATION
0		TOPSOIL - organics/rootlets throughout -black, moist						
		CLAY - silty -brown, moist, firm -intermediate to high plasticity	■	G17		19.3		
1		-laminated - alternating layers of brown clay/light brown silt	■	G18		28.1		297
2								296
3								295
4		REFUSAL - END HOLE AT 2.4m ON BEDROCK Notes: 1. No seepage observed; 2. No sloughing observed.						294

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

UNDRAINED SHEAR STRENGTH: + Torvane + × QU × ☐ Lab Vane ☐ △ Pocket Pen. △ ⬘ Field Vane ⬘ (kPa) 50 100 150 200

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 2.44 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

AECOM

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-13**
LOCATION: Proposed Outfall Alignment 2 - 375904.730m E 6232768.270m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 296.44

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ⊠ SPLIT SPOON ▤ BULK ⊘ NO RECOVERY ◧ CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100	UNDRAINED SHEAR STRENGTH + Torvane + × QU × □ Lab Vane □ △ Pocket Pen. △ ⬘ Field Vane ⬘ (kPa) 50 100 150 200	COMMENTS	ELEVATION
0		TOPSOIL - organics/rootlets throughout -black, moist							
		CLAY - silty, trace sand -brown, moist, firm -intermediate to high plasticity -weathered (crumbly soil)							296
1									
		-laminated - alternating layers of brown clay/light brown silt		G19		27.1			295
				G20		24.6		Sample G20 - Gravel-0.0%, Sand-4.1%, Silt-46.5%, Clay-49.4%	
2		REFUSAL - END HOLE AT 2.1m ON BEDROCK							294
3		Notes: 1. No seepage observed; 2. No sloughing observed.							293
4									

AECOM

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 2.13 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-24**
LOCATION: Proposed Forcemain Alignment - 375677.530m E 6232897.500m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 298.61

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ⊠ SPLIT SPOON ▤ BULK ⊘ NO RECOVERY ◧ CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / UNDRAINED SHEAR STRENGTH	COMMENTS	ELEVATION
0		CLAY - silty -brown, moist, firm -intermediate to high plasticity						298
1								297
2								296
3		REFUSAL - END HOLE AT 2.4m ON BEDROCK Notes: 1. No seepage observed; 2. No sloughing observed.						295
4								

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100
■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21
Plastic MC Liquid 20 40 60 80 100

UNDRAINED SHEAR STRENGTH: + Torvane + × QU × ☐ Lab Vane ☐ △ Pocket Pen. △ ⬘ Field Vane ⬘ (kPa) 50 100 150 200

AECOM

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 2.44 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-25**
LOCATION: Proposed Forcemain Alignment - 375691.800m E 6232892.290m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 299.00

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / UNDRAINED SHEAR STRENGTH	COMMENTS	ELEVATION
0		CLAY - silty -laminated - alternating layers of brown clay/light brown silt, moist, firm -intermediate to high plasticity						
1								298
2								297
3		REFUSAL - END HOLE AT 2.7m ON BEDROCK Notes: 1. No seepage observed; 2. No sloughing observed.						296
4								

PENETRATION TESTS: Becker; Dynamic Cone; SPT (Standard Pen Test) (Blows/300mm) 0 20 40 60 80 100; Total Unit Wt (kN/m^3) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

UNDRAINED SHEAR STRENGTH: Torvane; QU; Lab Vane; Pocket Pen.; Field Vane (kPa) 50 100 150 200

AECOM

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 2.74 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-26**
LOCATION: Proposed Forcemain Alignment - 375710.900m E 6232885.420m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 299.38

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / UNDRAINED SHEAR STRENGTH	COMMENTS	ELEVATION
0		CLAY - silty -laminated - alternating layers of brown clay/light brown silt, moist, firm -intermediate to high plasticity						299
1								298
2		REFUSAL - END HOLE AT 2.1m ON BEDROCK Notes: 1. No seepage observed; 2. No sloughing observed.						297
3								296
4								

PENETRATION TESTS: ✳ Becker ✳ | ◇ Dynamic Cone ◇ | ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 | ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

UNDRAINED SHEAR STRENGTH: + Torvane + | × QU × | □ Lab Vane □ | △ Pocket Pen. △ | ⬘ Field Vane ⬘ (kPa) 50 100 150 200

AECOM	LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 2.13 m
	REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
	PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-27**
LOCATION: Proposed Forcemain Alignment - 375725.490m E 6232879.530m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 299.95

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / UNDRAINED SHEAR STRENGTH	COMMENTS	ELEVATION
0		CLAY - silty -laminated - alternating layers of brown clay/light brown silt, moist, firm -intermediate to high plasticity						
1								299
2		REFUSAL - END HOLE AT 2.0m ON BEDROCK Notes: 1. No seepage observed; 2. No sloughing observed.						298
3								297
4								296

PENETRATION TESTS: ✳ Becker ✳ | ◇ Dynamic Cone ◇ | ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 | ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

UNDRAINED SHEAR STRENGTH: + Torvane + | × QU × | □ Lab Vane □ | △ Pocket Pen. △ | ⬘ Field Vane ⬘ (kPa) 50 100 150 200

AECOM

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 1.98 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

PROJECT: Proposed Lagoon Geotechnical Investigation	CLIENT: Manitoba Hydro	TESTHOLE NO: **TP10-28**
LOCATION: Proposed Forcemain Alignment - 375742.310m E 6232874.380m N		PROJECT NO.: 60157739
CONTRACTOR: Hartman Construction - Excavation	METHOD: Komatsu PC 220 LC	ELEVATION (m): 300.33

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ⊠ SPLIT SPOON ▤ BULK ⊘ NO RECOVERY ◧ CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100	UNDRAINED SHEAR STRENGTH + Torvane + × QU × □ Lab Vane □ △ Pocket Pen. △ ⬘ Field Vane ⬘ (kPa) 50 100 150 200	COMMENTS	ELEVATION
0		CLAY - silty -laminated - alternating layers of brown clay/light brown silt, moist, firm -intermediate to high plasticity							300
1									299
2									298
		REFUSAL - END HOLE AT 2.4m ON BEDROCK Notes: 1. No seepage observed; 2. No sloughing observed.							
3									297
4									

AECOM

LOGGED BY: Matt Lotecki	COMPLETION DEPTH: 2.44 m
REVIEWED BY: Jeremy Fiebelkorn	COMPLETION DATE: 10/22/10
PROJECT ENGINEER: Paul Barsalou	Page 1 of 1

LOG OF TEST HOLE 60157739 - LAURIE RIVER LAGOON TH-TP LOGS - 22-NOV-10.GPJ UMA WINN.GDT 2/8/11

Appendix C
Bedrock Probe-Holes

Bedrock Probe-Holes

Test Hole ID	Location	Inferred Depth to Bedrock (m)
TH10-01	Proposed Force Main Alignment	1.07
TH10-02	Proposed Force Main Alignment	2.44
TH10-03	Proposed Force Main Alignment	2.44
TH10-04	Proposed Force Main Alignment	2.44
TH10-05	Proposed Force Main Alignment	2.44
TH10-06	Proposed Force Main Alignment	2.74
TH10-07	Proposed Force Main Alignment	1.52
TH10-08	Proposed Force Main Alignment	2.29
TH10-09	Proposed Force Main Alignment	Not encountered
TH10-10	Proposed Force Main Alignment	2.29
TH10-11	Proposed Force Main Alignment	2.13
TH10-12	Proposed Force Main Alignment	1.83
TH10-13	Proposed Force Main Alignment	1.22
TH10-14	Proposed Force Main Alignment	1.98
TH10-15	Proposed Force Main Alignment	2.74
TH10-101	Proposed Force Main Alignment	1.52
TH10-102	Proposed Force Main Alignment	1.52
TH10-103	Proposed Force Main Alignment	1.22
TH10-104	Proposed Force Main Alignment	1.22
TH10-105	Proposed Force Main Alignment	1.37
TH10-106	Proposed Force Main Alignment	1.22
TH10-107	Proposed Force Main Alignment	1.52
TH10-108	Proposed Force Main Alignment	1.52
TH10-109	Proposed Force Main Alignment	1.52
TH10-110	Proposed Force Main Alignment	1.22
TH10-111	Proposed Force Main Alignment	1.52
TH10-201	Proposed Outfall Alignment	1.52
TH10-202	Proposed Outfall Alignment	0.91
TH10-203	Proposed Outfall Alignment	0.30
TH10-204	Proposed Outfall Alignment	0.30
TH10-205	Proposed Outfall Alignment	0.30
TH10-206	Proposed Outfall Alignment	0.30
TH10-207	Proposed Outfall Alignment	0.30
TH10-208	Proposed Outfall Alignment	0.30
TH10-209	Proposed Outfall Alignment	0.30
N1	Proposed Lagoon Centreline (approx.)	2.44
N2	Proposed Lagoon Centreline (approx.)	1.85
N3	Proposed Lagoon Centreline (approx.)	1.65
N4	Proposed Lagoon Centreline (approx.)	2.13
N5	Proposed Lagoon Centreline (approx.)	1.85
N6	Proposed Lagoon Centreline (approx.)	2.44
N7	Proposed Lagoon Centreline (approx.)	1.85
N8	Proposed Lagoon Centreline (approx.)	1.35

AECOM

Appendix D

Flexible Wall Perm. Results

HYDRAULIC CONDUCTIVITY DETERMINATION
FLEXIBLE WALL (ASTM D 5084)

MATERIALS LABORATORY
AECOM
99 Commerce Drive, Winnipeg, MB R3P 0Y7 Canada
tel (204) 477-5381 **fax** (204) 284-2040

Client:	**Manitoba Hydro**	**Sample:**	**G1**
Project:	**Laurie River GS Lagoon**	**Test Hole:**	**TP10-03**
Job#	**60157739**	**Depth:**	
Technician:	**M. Lotecki**	**Date:**	**January 6, 2011**

Material and Test Description

Material:	**Clay-Silty**	Mold Size:	**Flexible Wall**
Color:	**Brown**	Compaction Level Req.:	**-**
Composition:		Moisture Content Req.:	**-**
		Fluid Used:	**Deaired Water**
Structure:		Fluid Reservoir:	**Burettes**
Consistency:			

REMARKS: **Recompacted**

Initial Water Content

Tare ID.	**A33**	
Wet+Tare:	**261.9**	g
Dry+Tare	**208.3**	g
Tare:	**8.10**	g
Wt. Water	*53.6*	g
Wt. Dry:	*200.20*	g
Water Content	*26.77%*	

Initial Density Measurements

Wt. sample wet **628.3** g

	1	2	3	4		
Diam. (mm.)	**72.30**	**72.30**	**72.40**	**72.40**	Avg.=	*72.35*
Length (mm)	**77.40**	**77.40**	**77.30**	**77.00**	Avg.=	*77.28*

Area=	*41.11*	cm^2	Gs =	**2.7**
Volume=	*317.69*	cm^3	e =	*0.731*
Wet Density=	*1.978*	Mg/m^3	Sr =	*98.9%*
Dry Density=	*1.560*	Mg/m^3	n =	*0.422*

Final Water Content

Tare ID.	**R4**	
Wet+Tare:	**995.6**	g
Dry+Tare	**857.5**	g
Tare:	**362.60**	g
Wt. Water	*138.1*	g
Wt. Dry:	*494.90*	g
Water Cont.	*27.90%*	

Final Density Measurements

Wt. sample wet **633.40** g

Diam. (mm.)	**72.40**	**72.50**	**72.60**	**72.60**	Avg.=	*72.53*
Length (mm)	**76.60**	**77.00**	**77.50**	**77.20**	Avg.=	*77.08*

Area =	*41.31*	cm^2	Gs =	**2.7**
Volume =	*318.40*	cm^3	e =	*0.736*
Wet Density =	*1.989*	Mg/m^3	Sr =	*102.4%*
Dry Density =	*1.555*	Mg/m^3	n =	*0.424*

Consolidation Readings:

Cell Pressure:	20	psig.
Bottom Back Pressure:	15	psig.
Top Back Pressure:	15	psig.

Date	Time	Room Temp (deg C)	Burette Readings Top (ml)	Bottom (ml)	Cell (ml)
9-Dec-10	17:45	24.9	5.12	5.84	22.90
10-Dec-10	09:15	25.5	5.48	6.28	23.30
10-Dec-10	14:00	25.5	5.52	6.30	23.40
11-Dec-10	19:00	25.4	5.78	6.50	24.00
13-Dec-10	07:49	24.3	6.01	6.65	24.50
13-Dec-10	15:45	25.1	6.03	6.67	24.60
14-Dec-10	10:40	26.2	6.12	6.70	24.70
15-Dec-10	16:00	25.5	6.22	6.76	24.90
16-Dec-10	17:00	25.4	6.34	6.80	25.00
17-Dec-10	14:40	24.9	6.44	6.86	25.30
19-Dec-10	15:20	25.5	6.56	6.90	25.50
20-Dec-10	09:10	26.3	6.56	6.90	25.50

Consolidation Results:

Cell Press. =	**137.90**	kPa
Bottom=	**103.42**	kPa
Top=	**103.42**	kPa
Pressure Difference	**0.00**	kPa

Elapsed Time (DAYS)	Top Volume Change (CC)	Bottom Volume Change (CC)	Cell Volume Change (CC)	Total Volume Change (CC)	Volume Strain (%)
0	0	0	0	0	0
0.646	-0.36	-0.44	-0.40	-1.20	-0.38
0.844	-0.40	-0.46	-0.50	-1.36	-0.43
2.052	-0.66	-0.66	-1.10	-2.42	-0.76
3.586	-0.89	-0.81	-1.60	-3.30	-1.04
3.917	-0.91	-0.83	-1.70	-3.44	-1.08
4.705	-1.00	-0.86	-1.80	-3.66	-1.15
5.927	-1.10	-0.92	-2.00	-4.02	-1.27
6.969	-1.22	-0.96	-2.10	-4.28	-1.35
7.872	-1.32	-1.02	-2.40	-4.74	-1.49
9.899	-1.44	-1.06	-2.60	-5.10	-1.61
10.642	-1.44	-1.06	-2.60	-5.10	-1.61

Permeation Readings:

Cell Press. =	**20**	psi
Bottom=	**16**	psi
Top=	**14**	psi

Date	Time	Temp (deg C)	Burette Readings Top(ml)	Bottom (ml)	Cell (ml)
20-Dec-10	**10:35**	**26.2**	**9.88**	**0.14**	**25.50**
20-Dec-10	**17:00**	**25.0**	**9.42**	**0.66**	**25.60**
21-Dec-10	**08:00**	**23.9**	**8.44**	**1.74**	**25.90**
21-Dec-10	**14:26**	**23.5**	**7.96**	**2.24**	**25.90**
22-Dec-10	**08:06**	**23.9**	**6.94**	**3.33**	**26.10**
22-Dec-10	**16:00**	**24.3**	**6.45**	**3.81**	**25.90**
24-Dec-10	**11:30**	**24.1**	**4.02**	**6.30**	**26.30**

Avg Temp *24.4* C

Permeation Results:

Cell Press. =	**137.90**	kPa
Bottom=	**110.32**	kPa
Top=	**96.53**	kPa
Pressure Difference	**13.79**	kPa

Elapsed Time (DAYS)	Change Top (ml)	Change Bottom (ml)	Diff. Top (ml)	Diff. Bottom (ml)	Ratio Bot./Top	Average Volume (ml)
	Top	Bottom				
0.000	0.00	0.00	-	-	-	0.00
0.267	0.46	0.52	-	-	-	0.49
0.892	1.44	1.60	1.44	1.60	0.90	1.52
1.160	1.92	2.10	1.46	1.58	0.92	2.01
1.897	2.94	3.19	1.50	1.59	0.94	3.07
2.226	3.43	3.67	1.51	1.57	0.96	3.55
4.038	5.86	6.16	2.92	2.97	0.98	6.01

Regression Output:

Data from 0.0 to 4.038 days

Std Err of Y Est	0.129403	Degrees of Freedom	4
R Squared	0.996668	Trend Slope	1.483473 ml/day
No. of Observations	7	Std Err of Coef.	0.038359

Hydraulic Conductivity Results

Q =	*1.72E-11*	m^3/sec	**i =**	*18.19*	
A =	*4.11E-03*	m^2	**K(t) =**	*2.30E-10*	m/sec
dh =	*1.41*	m.	**Rt(21.7) =**	*0.901222*	
dl =	*0.077275*	m.	**K(20) =**	*2.07E-10*	m/sec

HYDRAULIC CONDUCTIVITY DETERMINATION
FLEXIBLE WALL (ASTM D 5084)

MATERIALS LABORATORY
AECOM
99 Commerce Drive, Winnipeg, MB R3P 0Y7 Canada
tel (204) 477-5381 **fax** (204) 284-2040

Client:	**Manitoba Hydro**	**Sample:**	**T4**
Project:	**Laurie River GS Lagoon**	**Test Hole:**	**TP10-11**
Job#	**60157739**	**Depth:**	**2'**
Technician:	**M. Lotecki**	**Date:**	**December 20, 2010**

Material and Test Description

Material:	**Clay-Silty W/alternating silt layers**	Mold Size:	**Flexible Wall**
Color:	**Brown / lt. brown**	Compaction Level Req.:	**-**
Composition:		Moisture Content Req.:	**-**
		Fluid Used:	**Deaired Water**
Structure:	**Layered**	Fluid Reservoir:	**Burettes**
Consistency:	**Firm - easily crumbled**		

REMARKS:

Initial Water Content

Tare ID.	**L58**	
Wet+Tare:	**296.7**	g
Dry+Tare	**230.8**	g
Tare:	**5.50**	g
Wt. Water	*65.9*	g
Wt. Dry:	*225.30*	g
Water Content	*29.25%*	

Initial Density Measurements

Wt. sample wet **548.3** g

	1	2	3	4		
Diam. (mm.)	**72.10**	**72.10**	**72.20**	**72.00**	Avg.=	*72.10*
Length (mm)	**72.20**	**72.00**	**72.10**	**72.00**	Avg.=	*72.08*

Area=	*40.83*	cm^2	Gs =	**2.7**
Volume=	*294.27*	cm^3	e =	*0.873*
Wet Density=	*1.863*	Mg/m^3	Sr =	*90.5%*
Dry Density=	*1.442*	Mg/m^3	n =	*0.466*

Final Water Content

Tare ID.	**X41**	
Wet+Tare:	**658**	g
Dry+Tare	**517.5**	g
Tare:	**99.30**	g
Wt. Water	*140.5*	g
Wt. Dry:	*418.20*	g
Water Cont.	*33.60%*	

Final Density Measurements

Wt. sample wet **558.80** g

Diam. (mm.)	**71.00**	**71.70**	**72.20**	**72.00**	Avg.=	*71.73*
Length (mm)	**71.50**	**71.60**	**71.80**	**71.80**	Avg.=	*71.68*

Area =	*40.40*	cm^2	Gs =	**2.7**
Volume =	*289.60*	cm^3	e =	*0.869*
Wet Density =	*1.930*	Mg/m^3	Sr =	*104.3%*
Dry Density =	*1.444*	Mg/m^3	n =	*0.465*

Consolidation Readings:

Cell Pressure:	20	psig.
Bottom Back Pressure:	15	psig.
Top Back Pressure:	15	psig.

Date	Time	Room Temp (deg C)	Burette Readings Top (ml)	Bottom (ml)	Cell (ml)
8-Dec-10	16:45	26.2	6.02	5.96	14.00
9-Dec-10	08:40	26.0	6.46	6.48	14.50
10-Dec-10	09:15	25.5	6.86	6.88	15.00
10-Dec-10	14:00	25.5	6.89	6.92	15.10
11-Dec-10	19:00	25.4	7.12	7.16	15.70
13-Dec-10	07:49	24.3	7.32	7.34	15.70
13-Dec-10	15:45	25.1	7.33	7.35	15.70
14-Dec-10	10:40	26.2	7.36	7.40	15.70
15-Dec-10	16:00	25.5	7.42	7.46	15.80
16-Dec-10	17:00	25.4	7.46	7.50	15.90
17-Dec-10	14:40	24.9	7.52	7.54	16.20
19-Dec-10	15:20	25.5	7.54	7.56	16.30
20-Dec-10	09:10	26.3	7.54	7.56	16.30

Consolidation Results:

Cell Press. =	**137.90**	kPa
Bottom=	**103.42**	kPa
Top=	**103.42**	kPa
Pressure Difference	**0.00**	kPa

Elapsed Time (DAYS)	Top Volume Change (CC)	Bottom Volume Change (CC)	Cell Volume Change (CC)	Total Volume Change (CC)	Volume Strain (%)
0	0	0	0	0	0
0.663	-0.44	-0.52	-0.50	-1.46	-0.50
1.688	-0.84	-0.92	-1.00	-2.76	-0.94
1.885	-0.87	-0.96	-1.10	-2.93	-1.00
3.094	-1.10	-1.20	-1.70	-4.00	-1.36
4.628	-1.30	-1.38	-1.70	-4.38	-1.49
4.958	-1.31	-1.39	-1.70	-4.40	-1.50
5.747	-1.34	-1.44	-1.70	-4.48	-1.52
6.969	-1.40	-1.50	-1.80	-4.70	-1.60
8.010	-1.44	-1.54	-1.90	-4.88	-1.66
8.913	-1.50	-1.58	-2.20	-5.28	-1.79
10.941	-1.52	-1.60	-2.30	-5.42	-1.84
11.684	-1.52	-1.60	-2.30	-5.42	-1.84

Permeation Readings:

Cell Press. =	**20**	psi
Bottom=	**16**	psi
Top=	**14**	psi

Date	Time	Temp (deg C)	Burette Readings Top(ml)	Bottom (ml)	Cell (ml)
20-Dec-10	**10:00**	**26.2**	**9.66**	**0.40**	**16.30**
20-Dec-10	**10:01**	**26.2**	**8.76**	**1.22**	**16.30**
20-Dec-10	**10:02**	**26.2**	**7.64**	**2.14**	**16.30**
20-Dec-10	**10:04**	**26.2**	**6.44**	**3.60**	**16.30**
20-Dec-10	**10:06**	**26.2**	**5.08**	**4.74**	**16.30**
20-Dec-10	**10:08**	**26.2**	**3.64**	**6.16**	**16.30**
20-Dec-10	**10:10**	**26.2**	**2.72**	**7.26**	**16.30**
20-Dec-10	**10:12**	**26.2**	**1.60**	**8.28**	**16.30**
20-Dec-10	**10:16**	**26.2**	**-1.02**	**10.90**	**16.30**
20-Dec-10	**10:18**	**26.2**	**-2.56**	**12.44**	**16.30**
20-Dec-10	**10:20**	**26.2**	**-3.90**	**13.80**	**16.30**
20-Dec-10	**10:22**	**26.2**	**-5.14**	**15.02**	**16.30**
20-Dec-10	**10:24**	**26.2**	**-6.36**	**16.14**	**16.30**
20-Dec-10	**10:26**	**26.2**	**-7.22**	**17.08**	**16.30**
20-Dec-10	**10:28**	**26.2**	**-8.12**	**17.86**	**16.30**
20-Dec-10	**10:30**	**26.2**	**-8.94**	**18.78**	**16.30**

Avg Temp *26.2* C

Permeation Results:

Cell Press. =	**137.90**	kPa
Bottom=	**110.32**	kPa
Top=	**96.53**	kPa
Pressure Difference	**13.79**	kPa

Elapsed Time (DAYS)	Change Top (ml)	Change Bottom (ml)	Diff. Top (ml)	Diff. Bottom (ml)	Ratio Bot./Top	Average Volume (ml)
	Top	Bottom				
0.000	0.00	0.00	-	-	-	0.00
0.001	0.90	0.82	-	-	-	0.86
0.001	2.02	1.74	2.02	1.74	1.16	1.88
0.003	3.22	3.20	2.32	2.38	0.97	3.21
0.004	4.58	4.34	2.56	2.60	0.98	4.46
0.006	6.02	5.76	2.80	2.56	1.09	5.89
0.007	6.94	6.86	2.36	2.52	0.94	6.90
0.008	8.06	7.88	2.04	2.12	0.96	7.97
0.011	10.68	10.50	3.74	3.64	1.03	10.59
0.013	12.22	12.04	4.16	4.16	1.00	12.13
0.014	13.56	13.40	2.88	2.90	0.99	13.48
0.015	14.80	14.62	2.58	2.58	1.00	14.71
0.017	16.02	15.74	2.46	2.34	1.05	15.88
0.018	16.88	16.68	2.08	2.06	1.01	16.78
0.019	17.78	17.46	1.76	1.72	1.02	17.62
0.021	18.60	18.38	1.72	1.70	1.01	18.49

Regression Output:

Data from 0.0 to 0.021 days

Std Err of Y Est	0.377711	Degrees of Freedom	4
R Squared	0.99668	Trend Slope	897.1863 ml/day
No. of Observations	16	Std Err of Coef.	13.84001

Hydraulic Conductivity Results

Q =	*1.04E-08*	m^3/sec	**i =**	*19.50*	
A =	*4.08E-03*	m^2	**K(t) =**	*1.30E-07*	m/sec
dh =	*1.41*	m.	**Rt(21.7) =**	*0.865491*	
dl =	*0.072075*	m.	**K(20) =**	*1.13E-07*	m/sec

Appendix B

Berm Stability Report

AECOM
99 Commerce Drive
Winnipeg, MB, Canada R3P 0Y7
www.aecom.com

204 477 5381 tel
204 284 2040 fax

Memorandum

To	Paul Barsalou	Page	1
CC	Greg Grahn, Omar Al-Khayat		
Subject	Proposed Laurie River Wastewater Lagoon Dyke Stability		
From	Mustafa Alkiki		
Date	November 26, 2012	Project Number	60265529 (402)

1. INTRODUCTION

This memorandum summarizes the findings of an additional stability analysis for dykes greater than 3.0 m high at the proposed wastewater treatment lagoon in Manitoba Hydro Laurie River Generating Station at Laurie River, MB. Originally, AECOM memorandum dated February 08, 2011 discussed the findings from October 2010 sub-surface investigation and provided recommendations related to the design and construction of the proposed facility. The previous analysis was limited to 3.0 m high dykes.

2. Dykes Stability

A stability analysis was completed using GeoStudio 2007 software package for the proposed 3.5 m high dykes. The analysis consider short term condition (end of construction) and long term condition for two scenarios, the full reservoir level at 1 m freeboard and minimum reservoir level at 2 m freeboard, as follows:

- Steady state case of full reservoir at 1 m freeboard (Figure 01).
- Steady state case of min. reservoir at 2 m freeboard (Figure 02).
- Short term End of Construction Condition (Figure 03).

An adequate factor of safety (FS) against slope instabilities should be achieved for the proposed dykes. In this regard, a design objective FS of 1.50 and 1.30 has been selected for long and short term conditions, respectively. Analysis was completed using a soil profile based on the 2010 investigation. The surface geometry is based on existing cross section (as provided from water group) and 3.5 m high clay fill with side slopes of 4H:1V. The strength parameters assigned to the subsoil and fill material are presented in Table 01 and were based on correlations with soil index parameters and past experience

Table 01 – Soil Properties for Stability Modelling

Soil	Unit Weight (kN/m3)	Cohesion (kPa)	Friction Angle (Degrees)
Clay Fill	18	5	17
Silty Clay	18	5	17

The results of the stability analysis indicate that current configuration design (up to 3.5 m high and 4H:1V side slopes) would achieve the objective FS of 1.50 under the long term and 1.30 under the short term. The results of stability analysis are presented graphically in attached figures.

Should you require any further assistance, please do not hesitate to contact the undersigned.

Respectfully submitted,

AECOM Canada Ltd.

Mustafa Alkiki, E.I.T.
Geotechnical Engineering

Reviewed By:

Faris Khalil, P.Eng.
Manager, Geotechnical Engineering

Appendix A
Figures

Laurie River Wastewater Lagoon
Dyke Stabilization (3.5 m high)
Slope Stability - Steady Case (1 m freeboard) downstream and upstream

Name: FILL
Unit Weight: 18 kN/m³
Cohesion: 5 kPa
Phi: 17 °

Name: SILTY CLAY
Unit Weight: 18 kN/m³
Cohesion: 5 kPa
Phi: 17 °

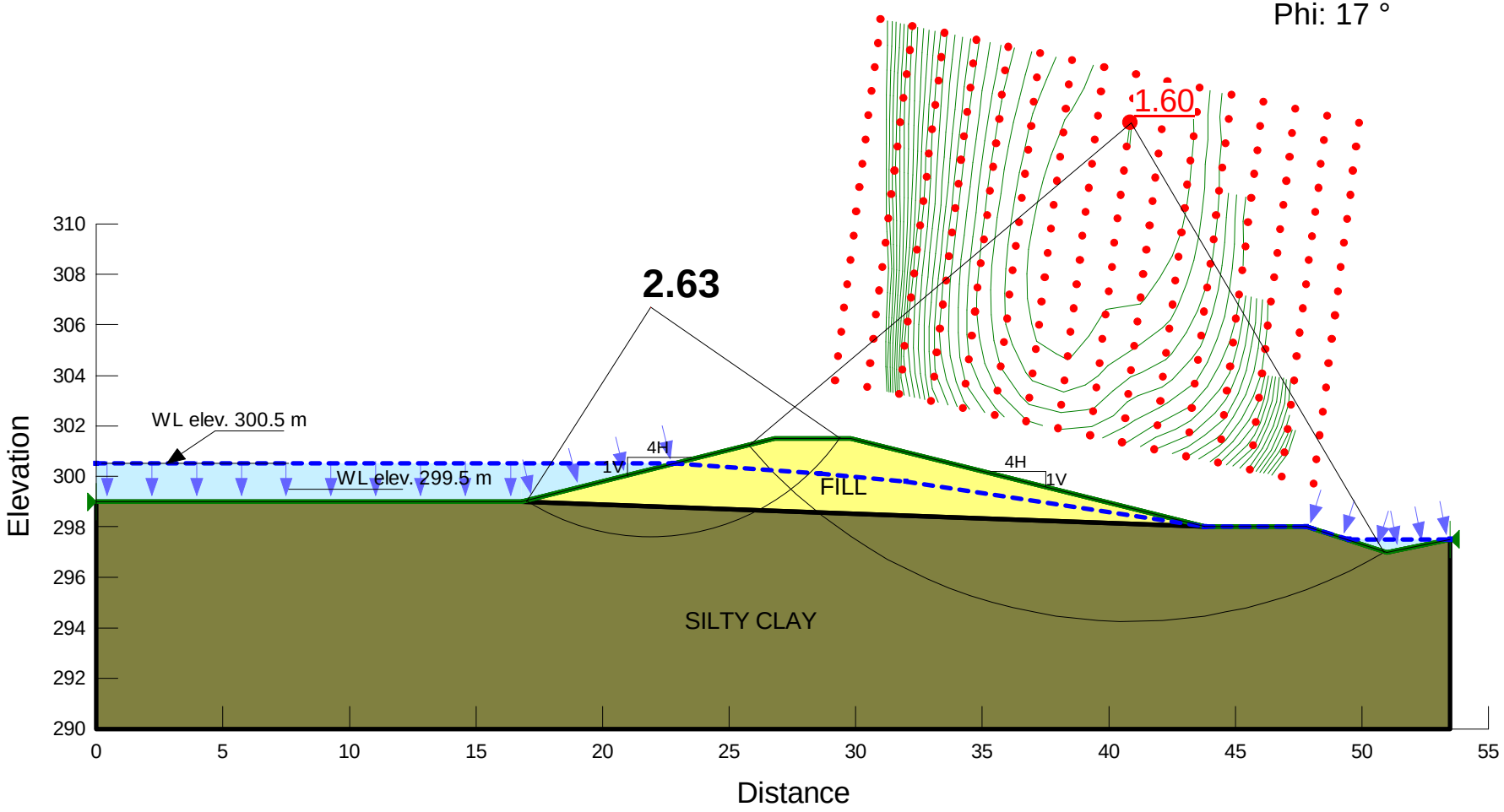


Figure 01

Laurie River Wastewater Lagoon
Dyke Stabilization (3.5 m high)
Slope Stability - Steady Case (2 m freeboard) downstream and upstream

Name: FILL
Unit Weight: 18 kN/m³
Cohesion: 5 kPa
Phi: 17 °

Name: SILTY CLAY
Unit Weight: 18 kN/m³
Cohesion: 5 kPa
Phi: 17 °

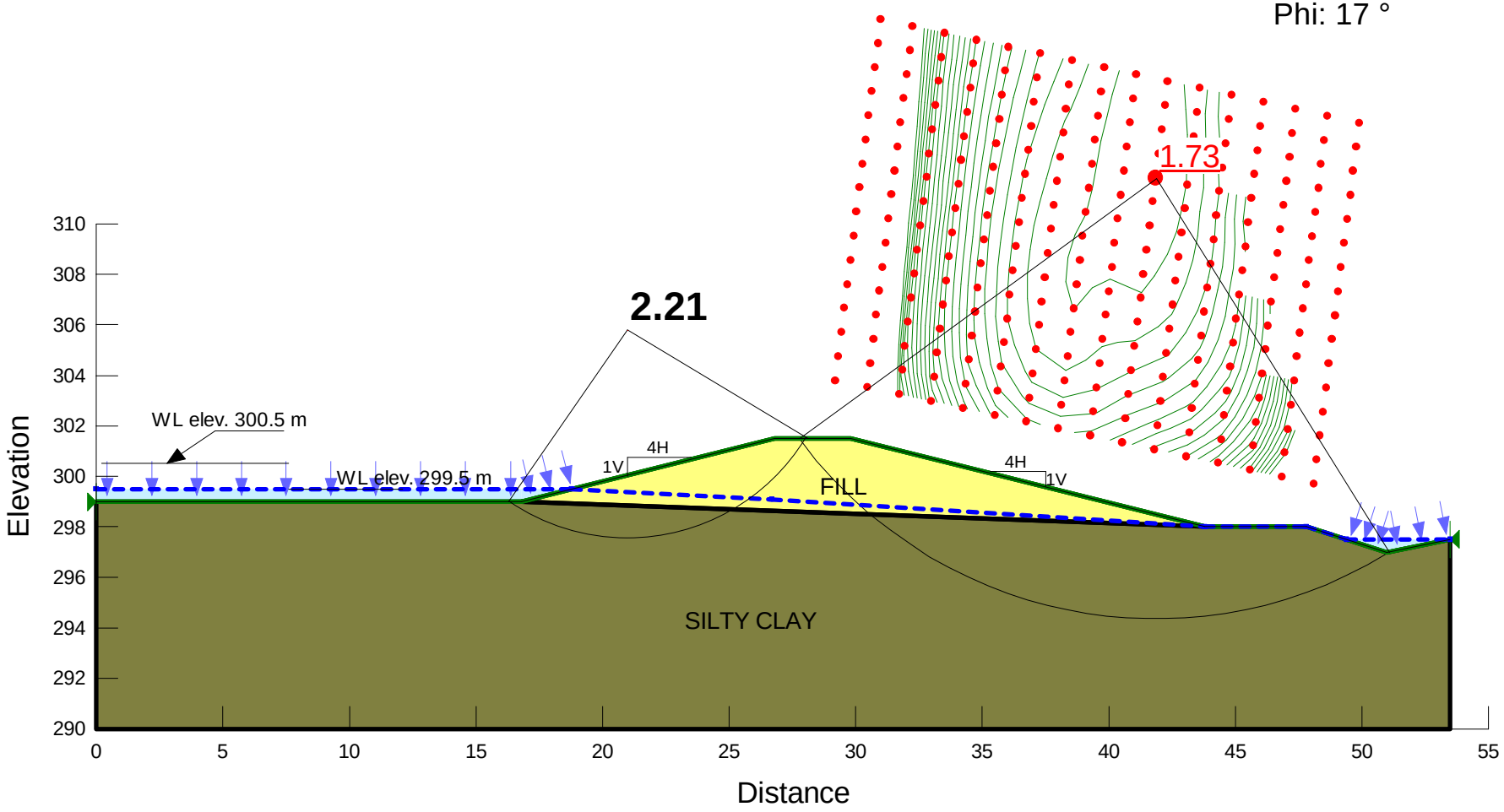


Figure 02

Laurie River Wastewater Lagoon
Dyke Stabilization (3.5 m high)
Slope Stability - Short Term - downstream and upstream

Name: FILL
Unit Weight: 18 kN/m³
Cohesion: 5 kPa
Phi: 17 °

Name: SILTY CLAY
Unit Weight: 18 kN/m³
Cohesion: 5 kPa
Phi: 17 °

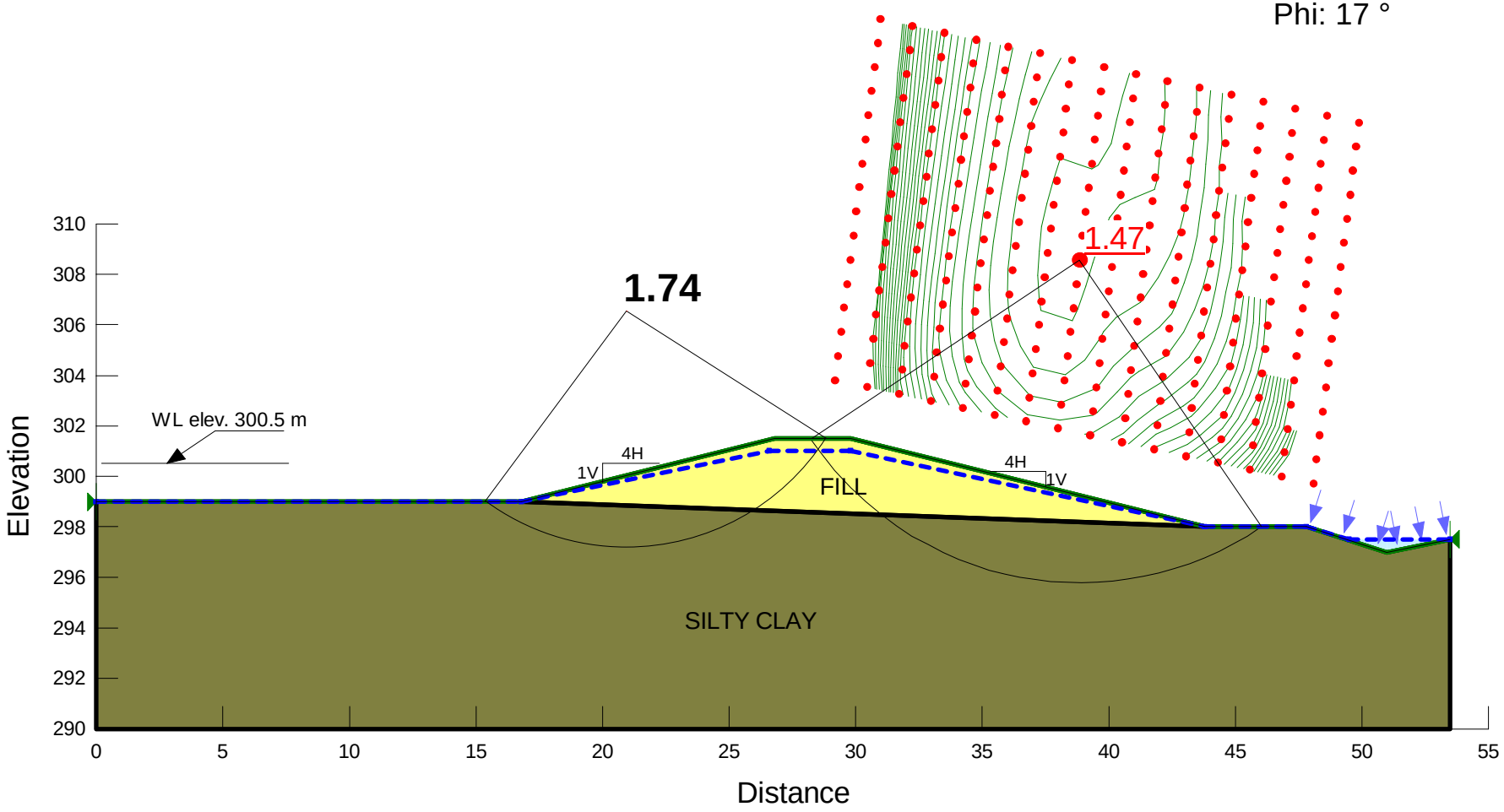


Figure 03

Appendix C

Detailed Lagoon Stability Calculations

Waste Stabilization Pond - Design Check
Laurie River - Option 1

Design Parameters

Piped Flow Population (Based on 2 six-month periods)

- 1st Period Population (182 days)	20	persons
- 2nd Period Population (183 days)	5	persons

Hydraulic Loading

Loading Rate	250	L / Capita / Day
Kitchen Waste Rate for 1st Period	100	L / Capita / Day
Kitchen Waste Rate for 2st Period	200	L / Capita / Day
Total	1,685,750	litres / year
	1,686	m^3 / year
Truck Waste (from Power House)	100	L / Day
- for 365 days	**37**	m^3 / year
WTP Back Wash	20%	Percent of total Loading
	344	m^3 / year
Estimated Infiltration	0	L / mm pipe diam / km pipe / day

Total Hydraulic Loading	2,067	m^3 / year

Organic Loading

Average Loading

	0.076	kg BOD / capita / day
Based on average of the 2 periods	13	persons
	0.952	kg / day

Average Total Organic Loading	0.95	kg BOD / day

Maximum Loading

	0.076	kg BOD / capita / day
Maximum Loading	20	persons
	1.520	kg / day

Maximum Total Organic Loading	1.52	kg BOD / day

Primary Cell Design

Average Loading	0.95	kg BOD / day
Maximum loading	1.52	kg BOD / day
	Design for Average	

Check Surface Area a required

Average

0.95 kg BOD/d / 22 kg/day *10000m2/ha	431	m^2

Maximum

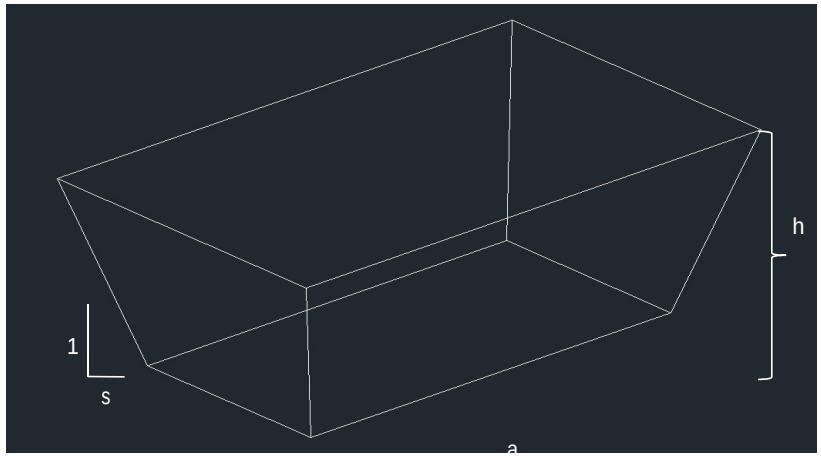
1.52 kg BOD/d / 22 kg/day * 10000m2/ha	691	m^2

Objective is 691 m^2 but modify the area based on Physical Constructability

Design Dimensions

	Primary Cell :	Secondary Cell:	
	- Rectangular shaped	- Rectangular shaped	
	- 7.5m x 30m Bottom	- 32m x 30m Bottom	
	- 1.5m Depth of liquid	- 1.2m Depth of liquid	
	- Storage is half of the total volume	- 0.3m of Sludge Storage =	**311** m^3
	- 1m Free board	- 1m Free board	
	- 4:1 Side slopes	- 4:1 Side slopes	

Bottom Area =	**225**	m^2	**960**	m^2
Surface Area =	**819**	m^2 (Larger than required)	**1848**	m^2
Total Volume =	**747**	m^3	**2,070**	m^3
Storage Volume =	**374**	m^3 (1/2 the total)	**1,759**	m^3



Total Storage Volume = 2,133 m^3 > Required Storage = 2072 m^3

Common Berm Width = 3m
Outside Berm Width = 3m

Detailed Calculations:

$$V = \frac{h\,[\,(ab)+4\,[\,(a+hs)\,(b+hs)+(a+2hs)\,(b+2hs)\,]\,]}{6}$$

Primary Cell:		Secondary Cell:		Secondary Cell:		
Length (a) =	7.5	Length (a) =	32	Length (a) =	34.4	(0.3m above bottom)
Width (b) =	30	Width (b) =	30	Width (b) =	32.4	
Slope (s) =	4 :1	Slope (s) =	4 :1	Slope (s) =	4 :1	
Depth (h) =	1.5	Depth (h) =	1.5	Depth (h) =	1.2	

$V_{Primary}$ =	**747**	m^3	$V_{Secondary}$ =	**2,070**	m^3
			$V_{Secondary}$ =	**1,759**	m^3