Appendix A
Soils Investigation Report

Soils Investigation Report	TREK Geotechnical: North Kildonan Feedermain Detailed Design – Geotechnical Report
Addendum No.1	TREK Geotechnical: North Kildonan Feedermain – Micro Tunnelling Option Considerations

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North Kildonan Feedermain Detailed Design - Geotechnical Report

Prepared for:

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TREK GEOTECHNICAL Quality Engineering | Valued Relationships

January 15, 2014 Our File No. 0115 004 00

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RE: North Kildonan Feedermain – Geotechnical Report

TREK Geotechnical Inc. is pleased to submit our geotechnical report for the detailed design of the North Kildonan Feedermain

Please contact Nelson Ferreira if you have any questions.

Sincerely,

TREK Geotechnical Inc.
Per:

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NJF:jh
Encl.

Revision History

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Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 Introduction and Background

The existing North Kildonan feedermain was constructed in 1972 and is a critical component of the City of Winnipeg's water distribution system. Where it crosses the Red River just north of the Kildonan Settlers Bridge, the feedermain consists of a 600 mm diameter steel pipe placed on top of the channel bottom (Drawing 01). A major leak in the pipe at the river crossing occurred in the fall of 2012 and temporary repairs to the pipe were completed in the spring of 2013. As part of the current Operating and Capital Works budget, the City of Winnipeg plans to replace the river crossing segment of the feedermain in 2014.

A preliminary engineering study was completed by Associated Engineering in July 2013 with geotechnical support from TREK Geotechnical Inc. (TREK). The geotechnical work was a desktop study using existing soil and groundwater information and limited stability modelling. Based on the outcome of the preliminary study, the Water and Waste Department determined that horizontal directional drilling (HDD) is the preferred method of installation for the new pipe segment and Associated Engineering proposed a new feedermain alignment to suit this installation method. In support of detailed design, the geotechnical scope of work carried out by TREK includes review of existing information, a sub-surface investigation, assessment of sub-surface conditions, in particular the condition of the bedrock, a riverbank slope stability analysis, and recommendations for stabilization and erosion protection works if required. This report summarizes the geotechnical component of the detailed design.

2.0 Review of Existing Information

Existing information was reviewed for geotechnical information pertinent to the project. The information was provided by various departments within the City of Winnipeg (Water and Waste, Public Works, Waterways) and Associated Engineering. The information reviewed includes the following:

- **Preliminary Engineering for the Rehabilitation or Replacement of the North Kildonan Feedermain (Associated Engineering July 2013):** The report includes relevant historical information, a preliminary riverbank stability assessment, and geotechnical considerations and recommendations for various new feedermain rehabilitation or replacement options.
- **North Kildonan Feedermain Record Drawings (Various Years):** As-built drawings from 1972 for the current feedermain (Drawing No.:D-1251) contained relevant information on riverbank and riverbed geometry, indicated the riverbanks in the vicinity of the feedermain had been improved and a riprap blanket had been placed on the riverbank.
- **Forcemain Sub-Surface Investigation (KGS Group, November 2012):** Three test holes were drilled into limestone bedrock on the south side of the Settlers Bridge and piezometers were installed into overburden soils and bedrock to measure groundwater levels. Test holes logs are included in Appendix B.

- **Settlers Bridge Design and Construction (Various Reports 1988 to 1990):** Relevant information includes test logs, record drawings of the construction works which included riprap and riverbank stabilization on the west bank (rock columns), and performance monitoring results related to ground movements and groundwater levels. Test hole logs are included in Appendix B.
- **Aerial Photos (Various Years from 1948 to 2008):** Aerial photo interpretation was undertaken on stereo pairs to identify historical riverbanks movements or evidence of historical riverbank erosion.
- **Survey Information –** Survey information included Lidar survey (2008) and a river bed profile along the existing feedermain provided by the COW. Barnes & Duncan Land Surveying and Geomatics completed a detailed survey in the fall of 2013 of the riverbank and sonar soundings of the riverbed in the vicinity of the existing and proposed feedermain.

A site plan and cross-sections were generated (Drawing 01 to 04) from the information gathered and collected during this assignment which includes test hole locations, relevant bridge works, bridge monitoring instrumentation locations, and interpreted soil and bedrock units.

3.0 Sub-Surface Investigation

A sub-surface investigation was carried out along the proposed feedermain alignment to supplement existing information in the general area of the crossing. The intent of the investigation was to determine sub-surface conditions that may impact the constructability and performance of the proposed feedermain such as the presence of wet silts and sands (potential to slough), delineation of alluvial and lacustrine soils (riverbank stability implications) and competence of the bedrock (hydraulic fracturing, loss of drill fluid).

Four test holes were initially planned along the proposed feedermain alignment; one test hole at each riverbank and two within the river channel. The riverbank test holes (TH13-01 and TH13-04) were to be drilled just into the bedrock on the east and west banks respectively to obtain information primarily for riverbank stability assessment and shoring. The test holes within the channel (TH 13-02 and TH13-03) were to be drilled 18 m into bedrock to determine conditions to the proposed depth of the new feedermain installation within the rock. These test holes were to be drilled off of a barge before freeze-up as ice conditions in the winter to support drilling equipment are known to be poor; open water is common in this channel section immediately downstream of the outfall from the North End Water Pollution Control Centre. However, the barge could not be launched due to low river levels at the time of the investigation (early November) and drilling test holes within the channel was therefore not possible. The sub-surface investigation was subsequently modified to exclude the channel test holes but obtain additional bedrock information at the riverbank locations. This included drilling to a greater depth on the east side of the river (TH13-01) and adding an additional deep test hole on the west bank (TH13-05).

TH13-01, TH13-04 and TH13-05 were drilled on November 7th and 8th, 2013 at the locations shown on Drawing 01. Drilling was performed by Paddock Drilling Ltd. (Brandon, MB) under the supervision of TREK personnel. Test holes were drilled using an Acker SS3 and CME-850 track mounted drill rigs equipped with either 125 mm diameter augers or 170 mm hollow stem augers. Test holes were drilled to power auger refusal where the drilling method was switched to HQ coring equipment to advance the test holes. TH13-01 and TH13-05 were drilled approximately 20 m into bedrock (~37m total depth) while TH13-04 was drilled approximately 4 m into bedrock (~22 m total depth). A standpipe piezometer was installed in the bedrock in TH13-04 and TH13-05 to measure short term groundwater levels in the bedrock. Standpipe piezometers were installed in each of the alluvial and bedrock units in TH 13-01 to measure short term levels in these two units and determine vertical flow direction (gradient).

Sub-surface soils observed during the drilling were visually classified based on the Unified Soil Classification System (USCS). Other pertinent information such as drilling, groundwater and backfill conditions was also recorded. Samples retrieved during drilling include disturbed grab (auger flight) samples, relatively undisturbed Shelby tubes, and bedrock core. All samples were transported to TREK's laboratory in Winnipeg, Manitoba for laboratory testing and further classification. Laboratory testing consisted of moisture content determination on all samples. Undrained shear strength testing (pocket penetrometer, Torvane and unconfined compression) and unit weight determination was also completed on select samples. Unconfined compression test were performed on select rock core samples at Thurber Engineering Ltd.'s Laboratory in Edmonton, Alberta.

Test hole logs are attached in Appendix A and include soil and rock descriptions, the elevation of soil and rock units encountered and other pertinent information such as groundwater levels and sloughing conditions. Laboratory testing results on soil samples are included on the individual test hole logs in Appendix A or separately in Appendix C and Appendix D (unconfined compression test results bedrock core samples). Test hole locations were surveyed by Barnes & Duncan Land Surveying and Geomatics. Existing test hole logs from previous investigations by the KGS Group (KGS) and Dyregrov and Burgess in the immediate area of the crossing are included in Appendix B with their locations shown on Drawing 01. Test holes by Dyregrov and Burgess are referred to herein as TH1 to 23 and DMT 1 to 7 (dilatometer test). The KGS test holes drilled in 2012 at the forcemain are referred to herein as TH 12-01, TH 12-02 and TH 12-03.

4.0 Sub-surface Conditions

4.1 General Soil and Bedrock Stratigraphy

The soil stratigraphy on the west riverbank generally consists of lacustrine clay with shallow silt layers (TH1 to TH4, TH12-03). A thin veneer (1.5 m thick) of alluvial clay was encountered in TH5 and TH13-04 which increased in thickness to 9 m towards the river (TH12).

The east riverbank generally consists of alluvial clays, silts, sands and gravels (TH13-01 drilled on the east bank along the proposed alignment). A lacustrine clay layer is evident in TH12-01, 06 and

TH07 on the east bank and tends to increase in thickness away from the river. Lacustrine clay was not encountered in the east riverbank along the proposed feedermain (TH13-01).

Based on information from previous geotechnical investigations for the bridge, the riverbed stratigraphy is expected to consist of relatively thin alluvial deposits overlying till and limestone bedrock. Till and bedrock may be exposed in areas of the riverbed (based on observations by divers during a recent inspection).

The interpreted soil and bedrock units are shown in cross-section on Drawing 02 and a brief description of these units is provided below. Where the descriptions provided include a consolidation of test hole data from previous investigations they are referred to herein as "overall". Where the results are specific to test holes drilled by TREK along the feedermain alignment, they are referred to as such. All interpretations of soil stratigraphy for the purposes of design should refer to the detailed test hole logs in Appendix A. Information from investigations by others attached in Appendix B cannot be corroborated by TREK and should therefore be considered as supplemental information only.

4.1.1 Clay Fill

Clay fill was encountered on the east riverbank in TH13-01 which was drilled through an existing road bed. The clay fill is silty and contains trace gravel and trace organics, brown, moist, stiff and of high plasticity. Moisture contents range from 23% to 26%, with an average of 25%.

4.1.2 Lacustrine Clay

The lacustrine clay is silty, brown to grey, moist, and of high plasticity. Trace silt inclusions are present throughout the stratum and sand and gravel inclusions are present near the silt till contact. Overall, undrained shear strengths on relatively undisturbed (Shelby Tubes) samples range from 23kPa to 75 kPa with an average of 50 kPa, indicating a soft to firm consistency. In comparison, the average undrained shear strength in TH13-04 drilled along the feedermain alignment is 44.5 kPa. Overall bulk unit weights range from 16.2 to 18.3 kN/m^3 with an average of 16.9 kN/m^3 compared to an average of 18 kN/m^3 in TH 13-04. Moisture contents range from 28% to 61%, with an average of 50% in TH 13-04.

Silt layers were encountered within the upper 2 to 4 m of the lacustrine clay at test hole locations outside of vicinity of the river channel and at prairie elevation (*e.g.* TH 3). The silt is light brown, moist to wet, soft, and contains varying amounts of fine grained sand.

4.1.3 Alluvial Deposits

West Riverbank

Alluvial clay was encountered at the surface of four test holes in the vicinity of the riverbank on the west bank (TH13-04, TH5, TH12, and TH13). The thickness of the layer ranges from 1.5 m (TH13-04) to 9 m in TH 12 drilled along the bridge alignment. The alluvial clay is silty, brown becoming grey with depth, moist, stiff and of medium to high plasticity. An undrained shear strength of 23 kPa

was measured on one sample in TH12 where the thickest layer was encountered. Overall bulk unit weights range from 17.7 to 18 with an average of 17.8 kN/m^3. Moisture contents range from 25% to 28% based on two samples.

East Riverbank

Alluvial soils on the east river bank consist of varying proportions of clay, silt, sand, and gravel as identified in TH13-01, TH6 to 8, TH12-01 and TH12-02. The consistency of the alluvial soils varies considerably over short distances ranging from loose (soft) to dense (stiff) and moist to saturated depending on the location of the water table. An undrained shear strength of 23 and 53 kPa and a bulk unit weight of 18.7 kN/m3 was measured in TH13-01. Moisture contents range from 18% to 37% with an average of 30% in TH13-01.

4.1.4 Silt Till

Silt till is present below the lacustrine and alluvial deposits at an overall contact elevation between 210.7 and 216.0 m with average overall contact elevation of 213.4 m. The till matrix is predominately low plastic silt with varying amounts of clay, sand, and gravel and can contain cobbles and boulders. The till is light brown, moist to wet, loose to dense. Standard Penetration Tests blow counts (N) of 8 to 50 blows per 300mm with an average of 28 were measured in the till in TH13-01 (N= 29, 50) and TH12-02 (N=8).

4.1.5 Limestone Bedrock

The till is underlain with bedrock at overall contact elevations between 209.2 and 211.0 m. Along the feedermain alignment, the contact elevation is estimated to be 210.2 m. The bedrock at the west riverbank consisted of dolomite or dolomitic limestone while the east riverbank consists of mudstone, dolomitic mudstone, dolomite and dolomitic limestone. The bedrock is brown to grey, vuggy, and can contain chert nodules, laminations, and calcareous mudstone. The bedrock units encountered are consistent with geological maps of the area which indicate that the crossing is located on either side of a geological contact between the Selkirk Member and the lower part of the Fort Garry Member of the Red River Formation.

The top metre of bedrock may be broken, highly fractured, or consists of thinly bedded rock. Horizontal and vertical fractures were noted throughout the bedrock units below this upper zone. The fractures tended to be rough and undulating with some of the fractures being in-filled with clay (rock flour). The bedrock is considered to be generally sound (RQD > 70% over 3.0m) which is consistent with previous sub-surface investigations. Photos of core samples are shown on Figure 01 & 02. Test holes drilled along the proposed alignment indicate the bedrock at the east riverbank (TH13-01) contains two zones of unsound bedrock; RQDs of less than 35% were recorded between elevations 207.5 m to 202.7 m and elevations 196.6 m to 193.5 m. A zone of unsound bedrock was also encountered in the vicinity of TH16 during drilling of test holes during design of the bridge.

Unconfined compressive strengths testing was completed on 7 bedrock core samples chosen to reflect the geology at both the west and east riverbanks at variable elevations, in different bedrock types and in bedrock of differing quality. The measured unconfined compressive strengths range from 11.9 to

49.1 MPa with an average 32.3 MPa. These values are consistent with strength testing data from Manitoba Department of Energy and Mines for the Selkirk Member and Lower Fort Garry Member (Bannatyne, 1988). Results from unconfined compression testing are included in Appendix D.

4.2 Groundwater Conditions

Groundwater conditions observed by TREK at the time of drilling are shown as notes on individual test hole logs. These notes refer to depths of seepage observed in open holes drilled using solid stem augers and water levels recorded in open holes immediately after retrieving augers and/or drill casing. Seepage conditions could not be observed when test holes were advanced using hollow stem augers and drill casing. Seepage conditions are also indicated on test hole logs prepared by others (Dyregrov and Burgess, KGS). These logs indicate seepage and sloughing can occur within the wet alluvial soils, silt till and near-surface silt layers. It is important to recognize that the short-term groundwater levels observed may vary seasonally, after heavy precipitation events or as a result of construction activities.

Piezometric (groundwater) elevations measured in TREK's test holes drilled along the proposed feedermain alignment are summarized in Table 4.1 with levels as of November 28th 2013 shown on the individual test hole logs in Appendix A. Groundwater levels measured along the forcemain south of the bridge are summarized in Table 4.2.

Table 4.1 – Groundwater Monitoring Data (TREK THs)

TREK Test Hole # >	TH13-01	TH13-01	TH13-04	TH13-05	River Level
Piezometer # >	SP1A	SP1B	SP4	SP5	At Bridge
Piezometer Tip Elev. (m) >	207.24	215.17	205.55	191.21	
Geologic Unit >	Bedrock	Alluvial Sand	Bedrock	Bedrock	
Date	Geodetic Elevation (m)				
6-Nov-13	-	-	222.97	-	-
7-Nov-13	223.18	222.99	-	-	-
14-Nov-13	-	-	223.16	223.30	-
28-Nov-13	223.18	222.41	223.24	223.30	221.92

Table 4.2 – Groundwater Monitoring Data (KGS THs)

Test Hole # >	TH12-02	TH12-02B	TH12-02B	TH12-03	TH12-03B	TH 12-03B	River
Piezometer Type >	SPT	SPT	PN	STP	STP	PN	Level
Piez. Tip Elev. (m) >	202.31	210.76	216.86	200.82	209.86	219.00	At
Geologic Unit >	Bedrock	Silt Till	Silty Sand	Bedrock	Silt Till	Silty Clay	Bridge
Date	Geodetic Elevation (m)						
15 May-13	225.05	225.2	223.26	225.11	225.20	226.04	226.33

4.2.1 Bedrock Aquifer

Groundwater levels in the bedrock aquifer on November 28th range from elevation 223.2 to 223.3 m compared to a river elevation of 221.9 m. This river elevation is representative of winter river levels which are drawn down from a regulated summer water elevation of about 223.7 m. Groundwater levels in the bedrock aquifer in May of 2013 were at about elevation 225.1 m compared to a spring river level of 226.3 m. Historical data collected from a Provincial observation well about 1.5 km west of the crossing indicates that regional groundwater levels are highest during the period from October through June with the lowest levels in late July or early August. The measured groundwater levels at the site are therefore likely reflective of the high end of the seasonal range of regional groundwater levels.

Groundwater levels in the till at the site compare well with bedrock aquifer levels indicating the two geologic units are hydraulically connected. During the high river stage in May of 2013, the river level was about 1.2 m higher than measured in the bedrock aquifer while in November of 2013, levels in the aquifer were about 1.3 m above the river level. These results show that a hydraulic connection exists between the river and aquifer but that groundwater levels may be influenced by regional levels; groundwater flow may be downward during high river levels (in particular when the river stage is higher than regional levels) and upward during low river levels when the regional groundwater levels remain higher than the river stage.

4.2.2 Overburden

A slight downward flow is evident between the alluvial soils on the east riverbank and the river in late November 2013 after the river has drawn down (TH 13-01). In May of 2013 however, the piezometric elevation measured in the silty sand at the forcemain south of the bridge on the east riverbank was considerably lower than the river stage (Elev. 223.3 m compared with a river Elev. of 226.3 m as seen in TH 12-02B). This reading is unexpected as groundwater levels in permeable riverbank soils are generally strongly influenced by river levels (i.e. higher levels in the silty sand would be expected at this river stage). The pneumatic piezometer installed in TH12-02B may be malfunctioning (common for pneumatic piezometers). In this regard, further instrumentation monitoring along the feedermain will be undertaken in the spring of 2014 to assess seasonal groundwater levels at a high river stage, especially in the alluvial soils.

5.0 Riverbank Stability Analysis

5.1 Design Objective

The design factor of safety (FS) associated with riverbank instabilities must reflect the uncertainty in parameters used in the analysis and the consequences of continued movements (e.g. creep movements) or failure of the riverbank. In this regard, riverbanks with a minimum FS greater than 1.3 are considered to be relatively stable, however, creep movements are possible. A factor of safety greater than 1.5 was therefore selected as the design objective for the stability of the ground through

which the feedermain passes since ground movements are unlikely to occur and in recognition of the consequences of a failure.

5.2 Slope Stability Analysis

A slope stability analysis was conducted on 5 cross-sections (Cross-Section A to E) along and near the feedermain to evaluate the riverbank stability in the vicinity of the feedermain. The cross-sections were generated from the survey information. The locations of the analyzed cross-sections are shown in plan on Drawing 01 and in section on Drawings 02 to 04. Iterations were performed to determine the set-back distance where the stability of the riverbank was greater than a Factor of Safety (FS) of 1.5 under typical groundwater conditions (*i.e.* to satisfy the design objective).

5.3 Numerical Model Description

The stability analysis was conducted using a steady-state finite element (FEM) seepage model (Seep/W) and a limit-equilibrium slope stability model (Slope/W) from the GeoStudio 2007 software package (Geo-Slope International Inc.).

The seepage model determined seepage gradients which were then incorporated into the stability model to calculate factors of safety against slope instabilities. Seepage gradients through the lacustrine and alluvial clays are common in riverbanks within Winnipeg; downward seepage occurs in the upper bank area, while upward seepage from the glacial till or bedrock aquifer occurs beneath the toe of the riverbank, in particular at low river levels. Consistent with the monitoring results, the groundwater elevation in the glacial till was assumed to be 1.3 m above the Winter River level for all modeling cases. Groundwater levels within the riverbank were set at approximately 2.0 m depth below ground surface in the upper bank area. A Winter River Level (WRL) at Elevation 221.8 m was used in the analysis. Flow in the unsaturated zone was not considered in the model.

The slope stability model used the Morgenstern-Price method of slices to calculate factors of safety. Critical local and global slip surfaces were determined using a grid and radius slip surface method. The soil units used in the model include the lacustrine soils (clay), alluvial soils, embankment fill, and till encountered on each bank as shown in Drawing 02. A till contact elevation of 212.0 m was assumed in both the seepage and stability models.

Table 5.1 lists soil properties used for the soil units in the numerical modeling. The soil properties assumed for the lacustrine soils are considered appropriate for Winnipeg clays along riverbanks which have experienced movements in the past. The strength properties selected for the alluvial soils are reflective of a clayey silt which is considered to be close to the lower bound of possible strength values for alluvial soils. The abutment fill properties were assigned identical properties as the alluvial soils. Properties assumed for the till are reflective of a loose to compact silt, sand and gravel matrix. The denser till and/or bedrock units are not incorporated as slip surfaces will tend not to extend into the till in any case; they typically run along the weaker clay at the till contact.

Table 5.1 - Soil Properties used in Stability Modeling

Soil Description	Unit Weight (kN/m^3)	Cohesion (kPa)	Friction Angle (deg)	Hydraulic Conductivity (m/s)
Lacustrine Clay	17	5	14	$1x10^{-10}$
Alluvial Soils	18	2	23	$1x10^{-09}$
Glacial Till	19	10	30	$1x10^{-07}$
Abutment Fill (Clay)	18	2	23	$1x10^{-09}$

5.4 Stability Modelling Results

The stability analysis was run on both sides of the channel to determine the minimum FS for each riverbank and the geometry of the theoretical slip surface associated with a minimum FS of 1.5. The analysis indicates the existing FS for both banks (for the critical slip surface) is greater than 1.3. The location of the point on the ground which coincides with a minimum FS of 1.5 is shown as a set-back in plan on Drawing 05 and in section in Drawing 06. The proposed entry/exit points for the new feedermain and the pipe alignment are located within the riverbank beyond these set-backs and the pipe profile remains outside of a theoretical slip surface associated with a FS of 1.5 (i.e. the stability of the ground at all points along the pipe alignment is greater than 1.5). An example slope stability model output has been included as Figure 03.

5.4.1 West Riverbank

Cross section B is perpendicular to a localized steeper portion of the riverbank as shown on Drawing 01. A minimum FS of 1.38 was calculated along Cross-section B with the entry point of a theoretical slip surface with a FS of 1.5 shown on Drawing 05. However, the minimum factors of safety for Cross-Section A and C, located on either side of the proposed feedermain, are greater than 1.5. Cross-sections A and C are cut perpendicular to the bank where the grades are flatter and considered more representative of the overall riverbank geometry at this location. In our opinion, the overall stability of the west riverbank in the vicinity of the proposed feedermain satisfies the design objective and therefore a set-back distance is not required.

5.4.2 East Riverbank

The minimum FS for at the east riverbank along Cross-section D and E is 1.34 and 1.35, respectively. Cross-section A was not analyzed since the section is not aligned perpendicular to the riverbank and therefore not considered to be representative. The entry point of theoretical slip surfaces along Sections D and E with a FS of 1.5 are shown as a set-back line on Drawing 05.

6.0 Geotechnical Considerations and Recommendations

6.1 Feedermain Alignment and Profile

The entry/exit points and profile for the proposed feedermain (Drawing 05 and Drawing 06) are located within the riverbank on both sides where the factor of safety against slope instabilities is greater than 1.5. Bank stabilization works are not considered necessary. If the profile on the east riverbank is modified to be within the set-back indicated, additional slope stability analysis will need to be undertaken to determine if riverbank stabilization measures are required.

6.2 Erosion Protection

A riprap blanket in the lower bank area was placed in 1970s based on recorded drawings and anecdotal information. The recorded drawing indicates that riprap was placed on each riverbank along the feedermain, and in the vicinity of the outfalls, but the extent and details of the riprap blanket are not clearly noted. The lower bank area was visually inspected in late October and early November 2013 during lower levels (Figures 04 & 05). Existing riprap was visible on the west riverbank as indicated on Drawing 05, however, the extent and integrity of the riprap could not be verified. There was no visual evidence of riprap on the east riverbank. It is suspected that the riprap on both banks may have been largely covered by river deposits over the years. Erosion of the lower bank area below an approximately elevation 226 m is evident on both riverbanks (Figures 04 & 05).

It is recommended that a riprap blanket be placed in the lower bank area to supplement the existing riprap and minimize the potential for toe erosion which will result in a reduction in stability over time. The riprap blanket should extend 1.5m below normal summer river level at an elevation of 222.6 m while the upper limit of the blanket will depend on areas requiring cover. The maximum recommended extent of the riprap blanket is illustrated in plan on Drawing 05 and in section in Drawing 07 and may be modified to suit site conditions during construction. The stability of the riverbank was re-assessed with the inclusion of a riprap blanket and had a negligible change in the calculated FS.

The riprap should consist of durable, quarried limestone with particle sizes ranging from 100 mm to 450 mm in diameter. The riprap should be placed on top of non-woven geotextile (Geotex 801 or equivalent) at a thickness of 0.75 m. Table 6.1 shows the proposed riprap gradation.

Table 6.1 – Riprap Gradation

Sieve Size (mm)	Percent Passing	
	Min	Max
450	100	100
300	25	50
100	0	15

Vegetation above the riprap blanket will help minimize erosion above and behind the blanket. Bare areas and areas disturbed due to construction activities above the riprap blanket will need to be re-vegetated. Topsoil and seeding or placement of sod is an acceptable means of re-establishing vegetation.

6.3 Excavations and Shoring

6.3.1 General

It is our understanding that excavations less than 5 m deep on either riverbank will be required for installation of the proposed feedermain and to make the necessary connections with the existing pipe. Open excavations and cantilevered walls may suitable for excavations up to 3 to 4 m. Braced walls may be required for deeper excavations where temporary shoring is necessary.

All excavations must be carried out in compliance with the appropriate regulation(s) under the Manitoba Workplace Safety and Health Act and in this regard, it is anticipated that trench cages and/or temporary shoring may be required. Where open excavations are made, flattening of side slopes may be required, in particular if saturated soils (silt and alluvial soils) are encountered. Gravel buttresses could be used to prevent wet silts and sands from flowing into excavations, in conjunction with sump pits used to dewater the excavation.

Considerable difficulties can be expected when advancing excavations below the water table in alluvial soils on the east side of the river. Depending on the depth of excavation, dewatering wells may be required to lower water levels to below the base of the excavation; the requirement for this will depend on water levels at the time of construction. Basal instability associated with groundwater pressure in the till is not expected to be of concern based on the anticipated excavation depth (<5m). Once the final design is complete the need for groundwater control, working mat, etc. can be reviewed and appropriate recommendations made at that time. In this regard, additional information on groundwater levels should be obtained when shoring design is carried out and during construction.

A certain amount of ground movement behind the shoring will occur, and is largely unavoidable. The amount of movement that will occur cannot be accurately predicted, mainly because the movement is as much a function of excavation procedures and workmanship as it is a function of theoretical considerations. It is anticipated that the design of temporary shoring will be the responsibility of the Contractor. The proposed shoring design should be reviewed prior to construction and the performance of the excavation system monitored during and subsequent to construction.

6.3.2 Cohesive Soils

In clay and clay fill soils, a bulk unit weight of 18.0 kN/m^3 should be used for the clay/clay fill units, and 19.0 kN/m^3 for clayey silts for the calculation of lateral earth pressures. Cantilevered (unbraced) walls should be designed using the earth pressure coefficients outlined in Table 6.2 for the appropriate earth pressure condition. Braced excavations in cohesive soils should be designed using the earth pressure distributions shown on Drawing 08. The effect of any surcharge loads must be

added to the force on the wall in addition to the calculated earth pressures, as noted in the figures. The appropriate earth pressure condition should be used to calculate the lateral earth pressure due to surcharge loads.

Table 6.2. Recommended Design Parameters for Cantilevered Walls - Cohesive Soils

Earth Pressure Condition	Earth Pressure Coefficient
	Clay / Clay Fill
Active (K_a)	0.5
At-rest (K_o)	0.65
Passive (K_p)	2.0
	Clayey Silts
Active (K_a)	0.4
At-rest (K_o)	0.60
Passive (K_p)	2.3

6.3.3 Non-cohesive Soils

In non-cohesive soils (e.g. sands and gravels), cantilevered walls should be designed to resist lateral pressures based on a triangular earth pressure distribution defined as follows using the earth pressure coefficients (K) outlined in Table 6.3 for the appropriate earth pressure condition.

$$P = K \gamma D$$

Where P = lateral earth pressure at depth D (kPa)
K = earth pressure coefficient
γ = soil/backfill unit weight (kN/m^3)
D = depth below ground surface (m)

A bulk unit weight of 21 kN/m^3 for silts and sands should be used for the calculation of lateral earth pressures where water pressure will not be present behind the wall. Where water pressures are present, the soil unit weight should be reduced to its submerged (buoyant) weight to calculate the lateral earth pressure and the water pressure should be added.

Table 6.3 Recommended Design Parameters for Cantilevered Walls in Alluvial Soils

Earth Pressure Condition	Earth Pressure Coefficient
Active (K_a)	0.35
At-rest (K_o)	0.5
Passive (K_p)	2.9

Braced excavations in the non-cohesive soils should be designed using the apparent earth pressure distribution shown on Drawing 09. Hydrostatic pressure below the water table and the effect of any surcharge loads must be added to the force on the wall in addition to the calculated earth pressures. The appropriate earth pressure condition should be used to calculate the lateral earth pressure due to surcharge loads.

6.4 Horizontal Directional Drilling

Horizontal Directional Drilling (HDD) may be affected by the following geotechnical considerations:

- Varying soil deposits above bedrock including lacustrine clay, alluvial soils, and silt till,
- Varying water levels in soil units and the potential for seepage, sloughing and caving in alluvial and till units below the water table,
- Varying bedrock conditions and strengths,
- Potential for hydro fracturing,
- Vertical fractures in the shallow bedrock may provide a seepage path for drill fluid to discharge into the river.
- Bedrock fractures may be infilled with clay (rock flour), particularly in zones of unsound bedrock

7.0 Permitting

Prior to construction, a City of Winnipeg Waterways permit is required. This report will form part of the application submission for the permit along with additional details related site access, stock piling and other pertinent construction activities that may impact riverbank stability.

8.0 Closure

The geotechnical information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings of this report were based on information provided (field investigation, laboratory testing, geometries). Soil conditions are natural deposits that

can be highly variable across a site. If sub-surface conditions are different than the conditions previously encountered on-site or those presented here, we should be notified to adjust our findings if necessary.

All information provided in this report is subject to our standard terms and conditions for engineering services, a copy of which is provided to each of our clients with the original scope of work, or a mutually executed standard engineering services agreement. If these conditions are not attached, and you are not already in possession of such terms and conditions, contact our office and you will be promptly provided with a copy.

This report has been prepared by TREK Geotechnical Inc. (the Consultant) for the exclusive use of Associated Engineering (the Client) and their agents for the work product presented in the report. Any findings or recommendations provided in this report are not to be used or relied upon by any third parties, except as agreed to in writing by the Client and Consultant prior to use.

9.0 References

Bannatyne, B.B, 1988. Dolomite Resources of Southern Manitoba. Manitoba Energy and Mines Geological Services, Economic Geology Report ER85-1

Figures

Figure 01 : TH13-01 Core Samples

Figure 02 : TH13-05 Core Samples

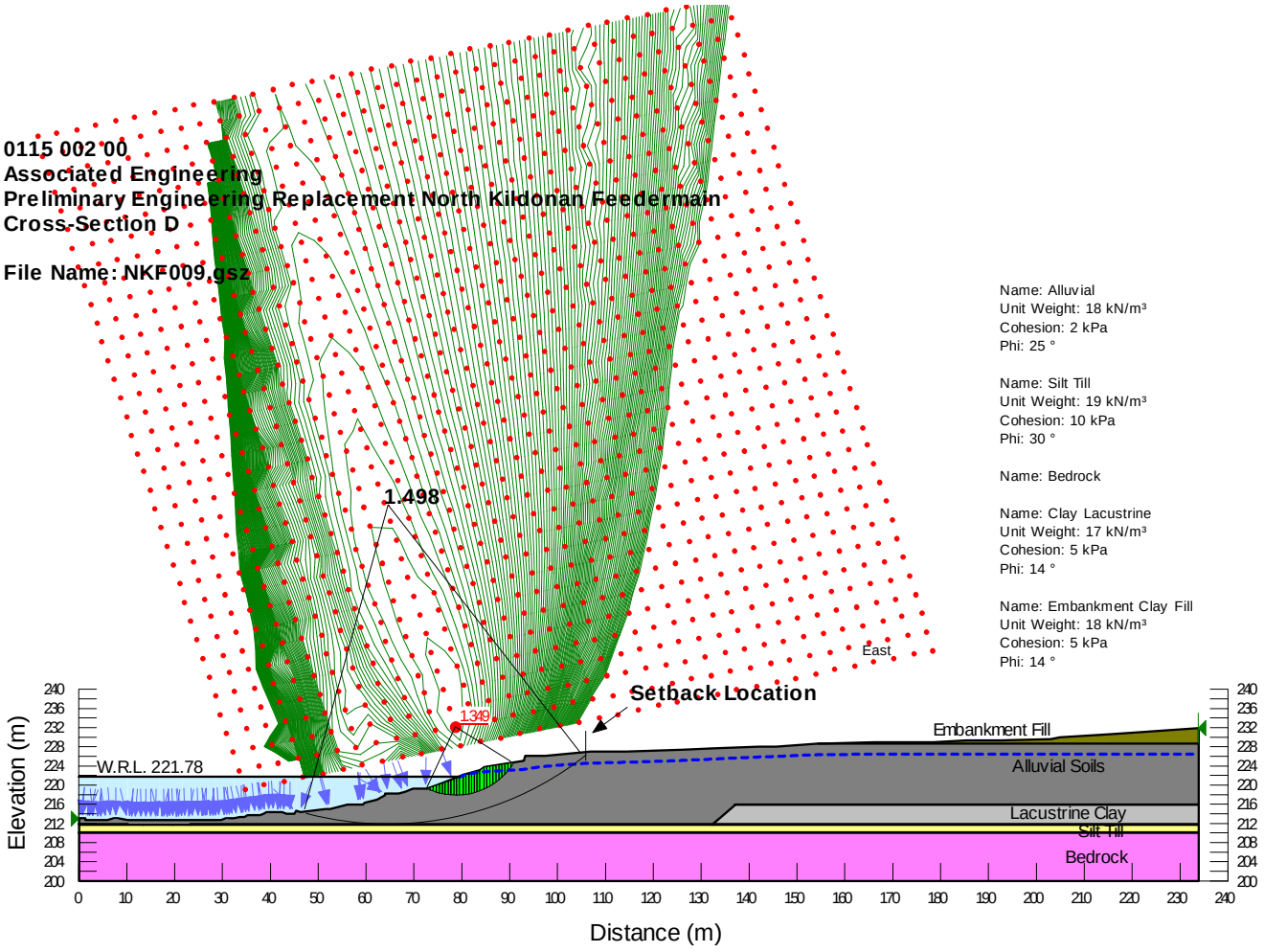

Figure 03 Slope Stability Model Output

Figure 04: West Riverbank (October 23, 2013)

Figure 05: East Riverbank (November 8, 2013)

Drawings

TREK GEOTECHNICAL

0115 004 00
Associated Engineering
Detailed Design of North Kildonan Feedermain

Tabloid (279mm x 432mm)

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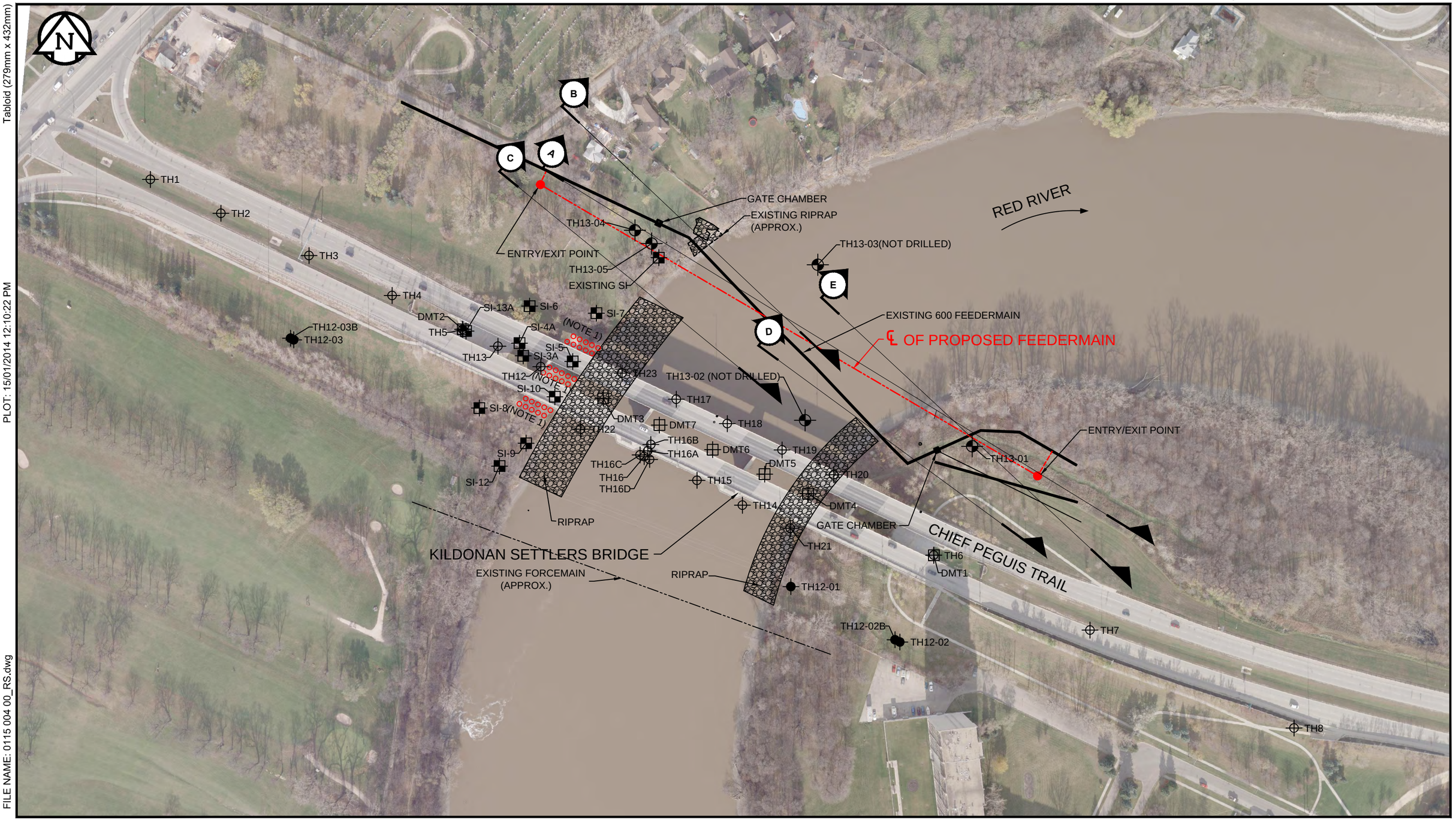


0 20 40 60 80m
SCALE : 1:2000 (279mm x 432mm)

LEGEND :

- TEST HOLE (TREK, 2013)
- TEST HOLE (DYREGROV, 1988)
- TEST HOLE (KGS, 2012)
- SLOPE INDICATORS
- DILATOMETER TESTING (DYREGROV, 1998)
- ROCK COLUMNS

NOTES :

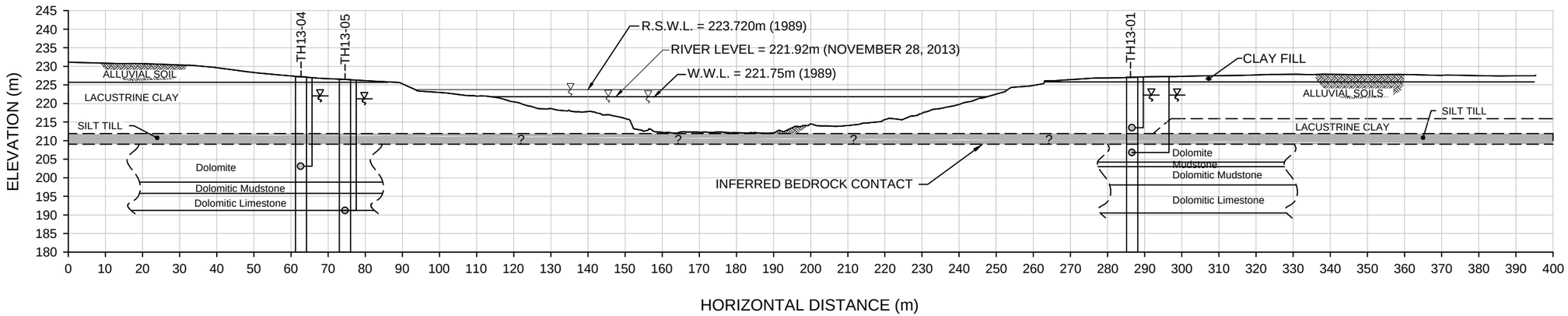
1. ROCK COLUMNS SHOWN ARE NOT TO SCALE
2. 2008 AERIAL IMAGE IN PROVIDED BY CITY OF WINNIPEG
3. SURVEY INFORMATION PROVIDED BY BARNES AND DUNCAN LAND SURVEYERS AND CITY OF WINNIPEG (LIDAR)

Drawing 01
Test Hole Location Plan

Tabloid (279mm x 432mm)

PLOT: 15/01/2014 12:11:52 PM

CROSS-SECTION A



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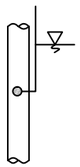


GROUND WATER LEVEL IN STANDPIPE PIEZOMETER NOVEMBER 28, 2013

W.W.L. = WINTER WATER LEVEL

R.S.W.L. = REGULATED SUMMER WATER LEVEL

FILE NAME: 0115 004 00_RS.dwg

0 12.5 25 37.5 50m
SCALE : 1:1250 (279mm x 432mm)

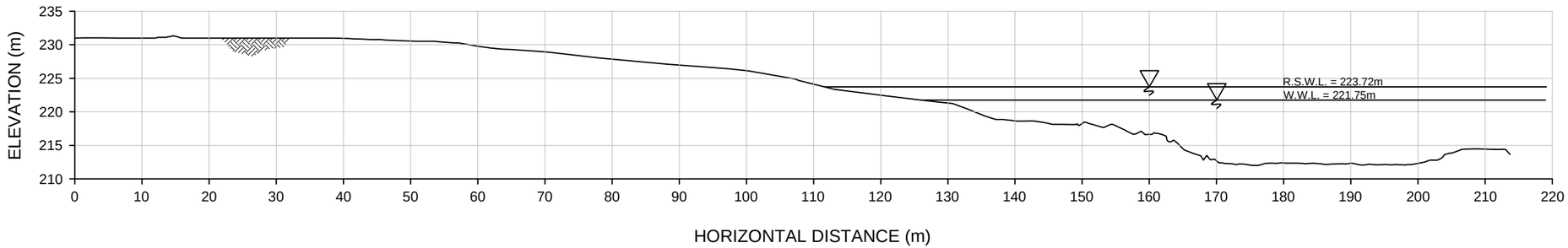
Drawing 02
Inferred Soil and Bedrock Stratigraphy

Tabloid (279mm x 432mm)

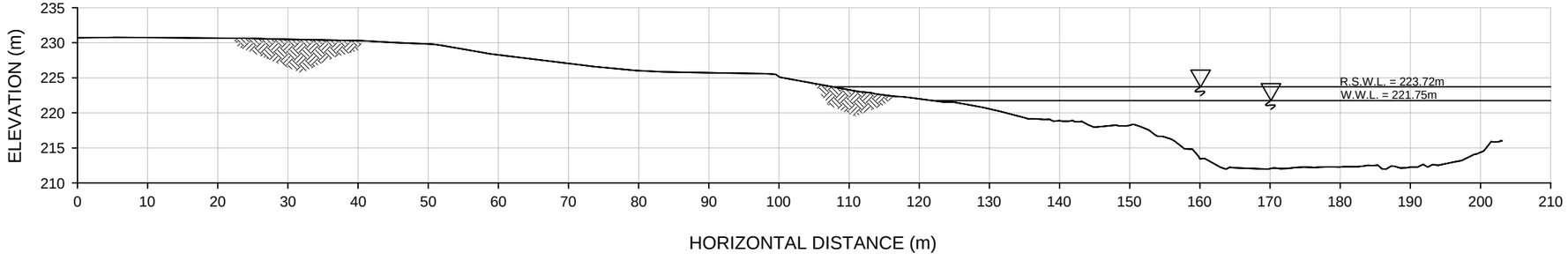
PLOT: 15/01/2014 12:12:36 PM

FILE NAME: 0115 004 00_RS.dwg

CROSS-SECTION B



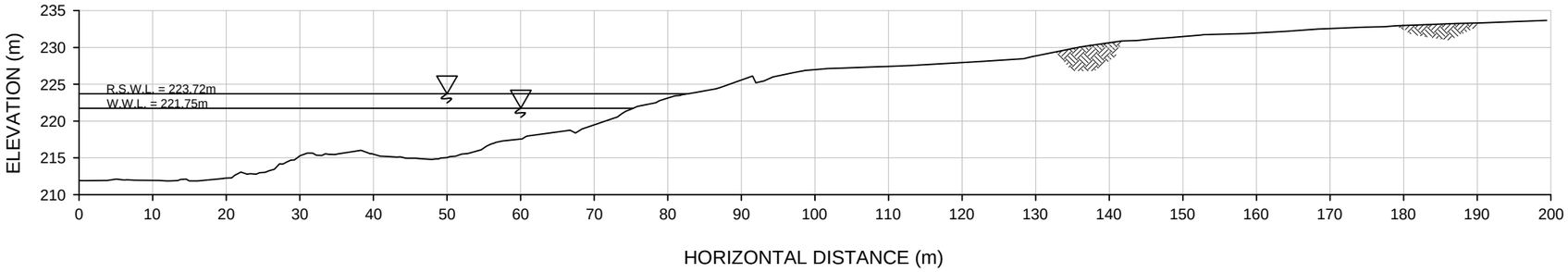
CROSS-SECTION C



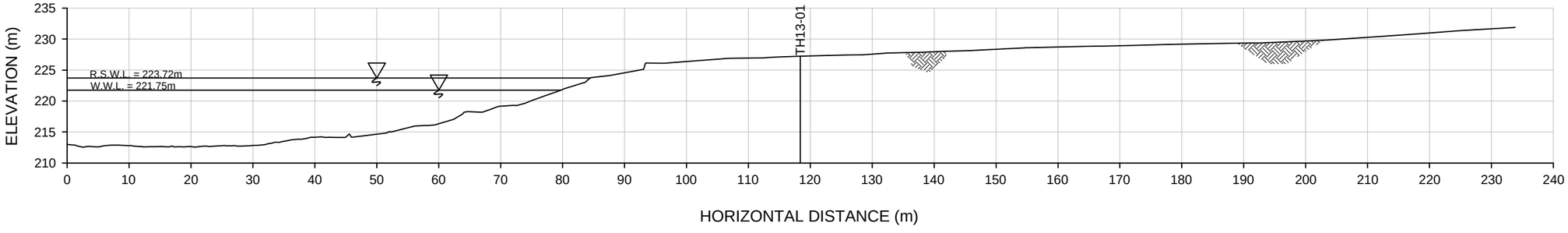
0 7.5 15 22.5 30m
SCALE : 1:750 (279mm x 432mm)

Drawing 03
CROSS-SECTION B AND C

CROSS-SECTION D



CROSS-SECTION E



0 7.5 15 22.5 30m
SCALE : 1:750 (279mm x 432mm)

Drawing 04
CROSS-SECTION D AND E

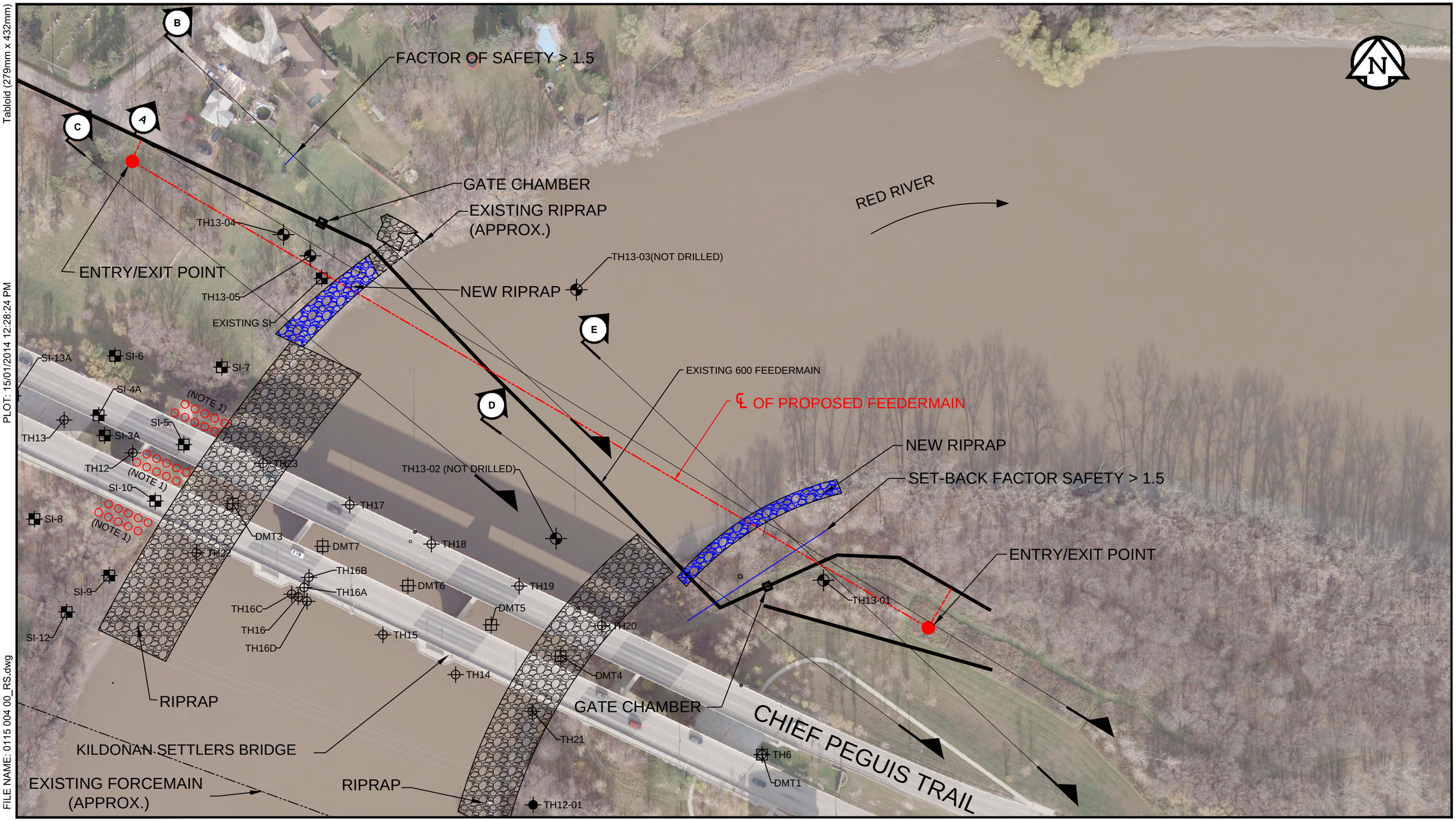
TREK GEOTECHNICAL

0115 004 00
Associated Engineering
Detailed Design of North Kildonan Feedermain

Tabloid (279mm x 432mm)

PLOT: 15/01/2014 12:28:24 PM

FILE NAME: 0115 004 00_RS.dwg



0 12.5 25 37.5 50m
SCALE : 1:1250 (279mm x 432mm)

LEGEND :

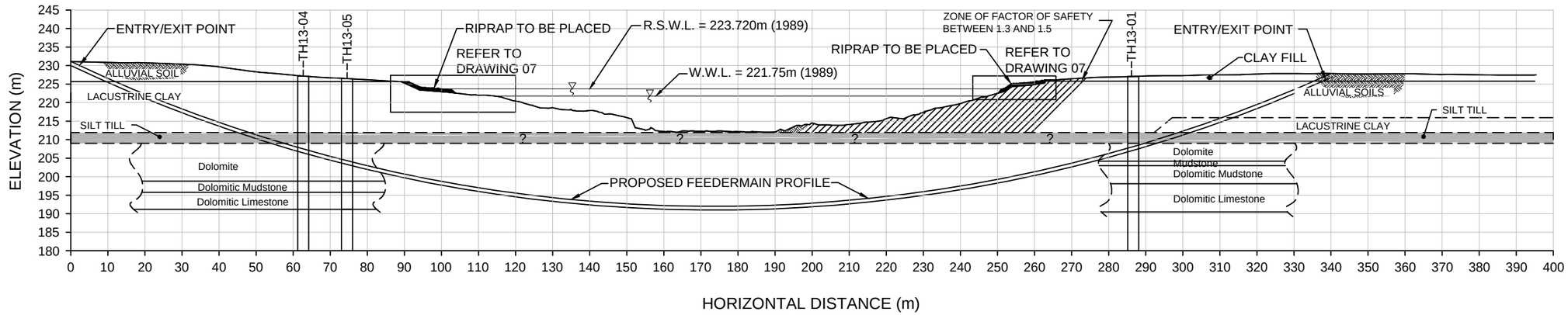
- TEST HOLE (TREK, 2013)
- TEST HOLE (DYREGROV, 1988)
- TEST HOLE (KGS, 2012)
- SLOPE INDICATORS
- DILATOMETER TESTING (DYREGROV, 1998)
- ROCK COLUMNS

NOTES :

1. ROCK COLUMNS SHOWN ARE NOT TO SCALE
2. 2008 AERIAL IMAGE IN PROVIDED BY CITY OF WINNIPEG
3. SURVEY INFORMATION PROVIDED BY BARNES AND DUNCAN LAND SURVEYERS AND CITY OF WINNIPEG (LIDAR)

Drawing 05
Riverbank Stability Plan

CROSS-SECTION A



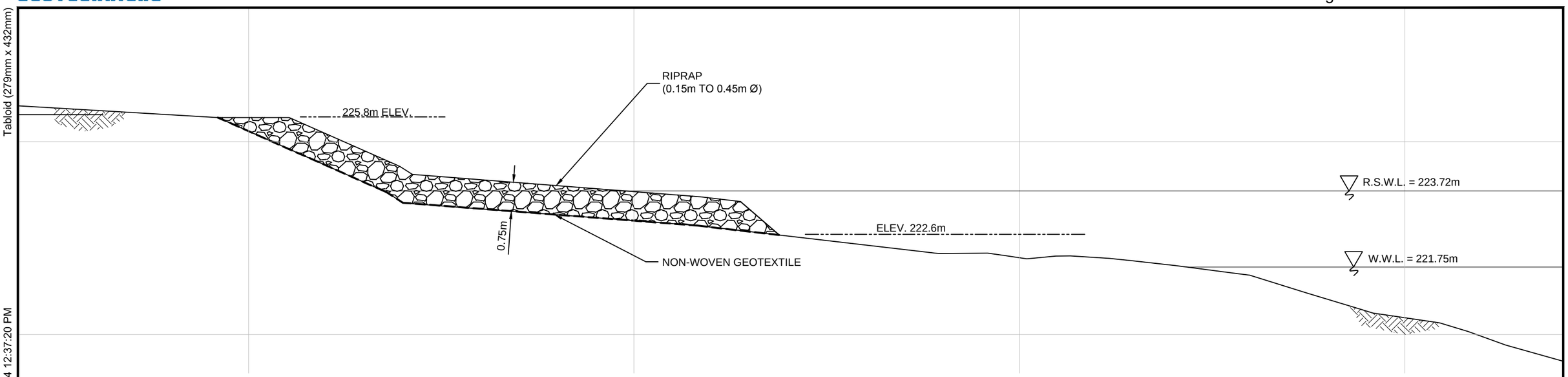
0 12.5 25 37.5 50m
SCALE : 1:1250 (279mm x 432mm)

Drawing 06
Riverbank Stability and Proposed Feedermain Profile

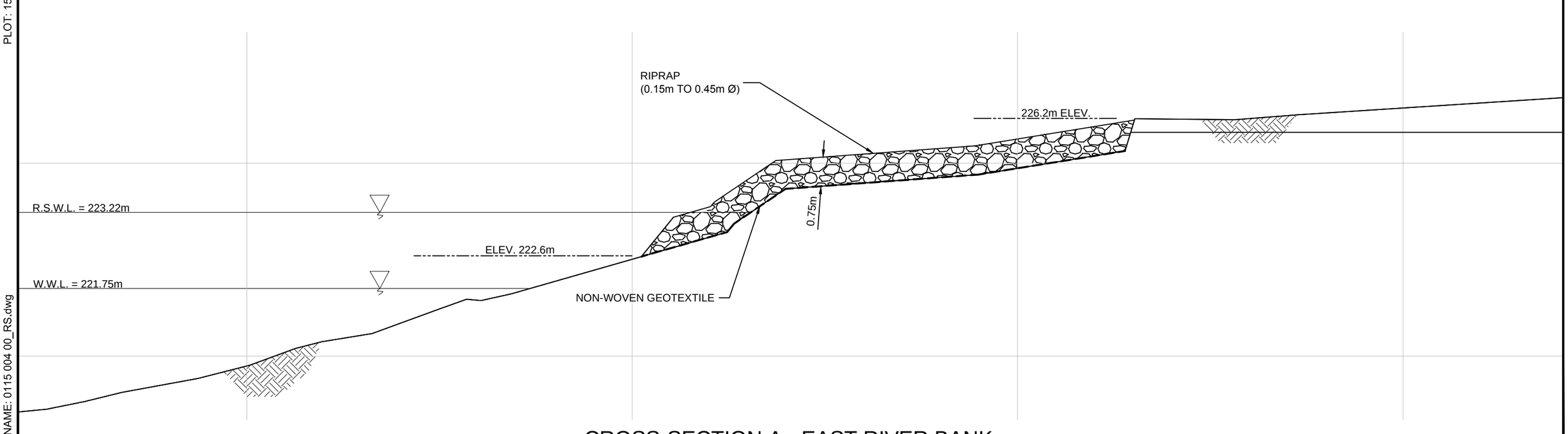
TREK GEOTECHNICAL

0115 004 00
Associated Engineering
Detailed Design of North Kildonan Feedermain

Tabloid (279mm x 432mm)



CROSS-SECTION A - WEST RIVER BANK



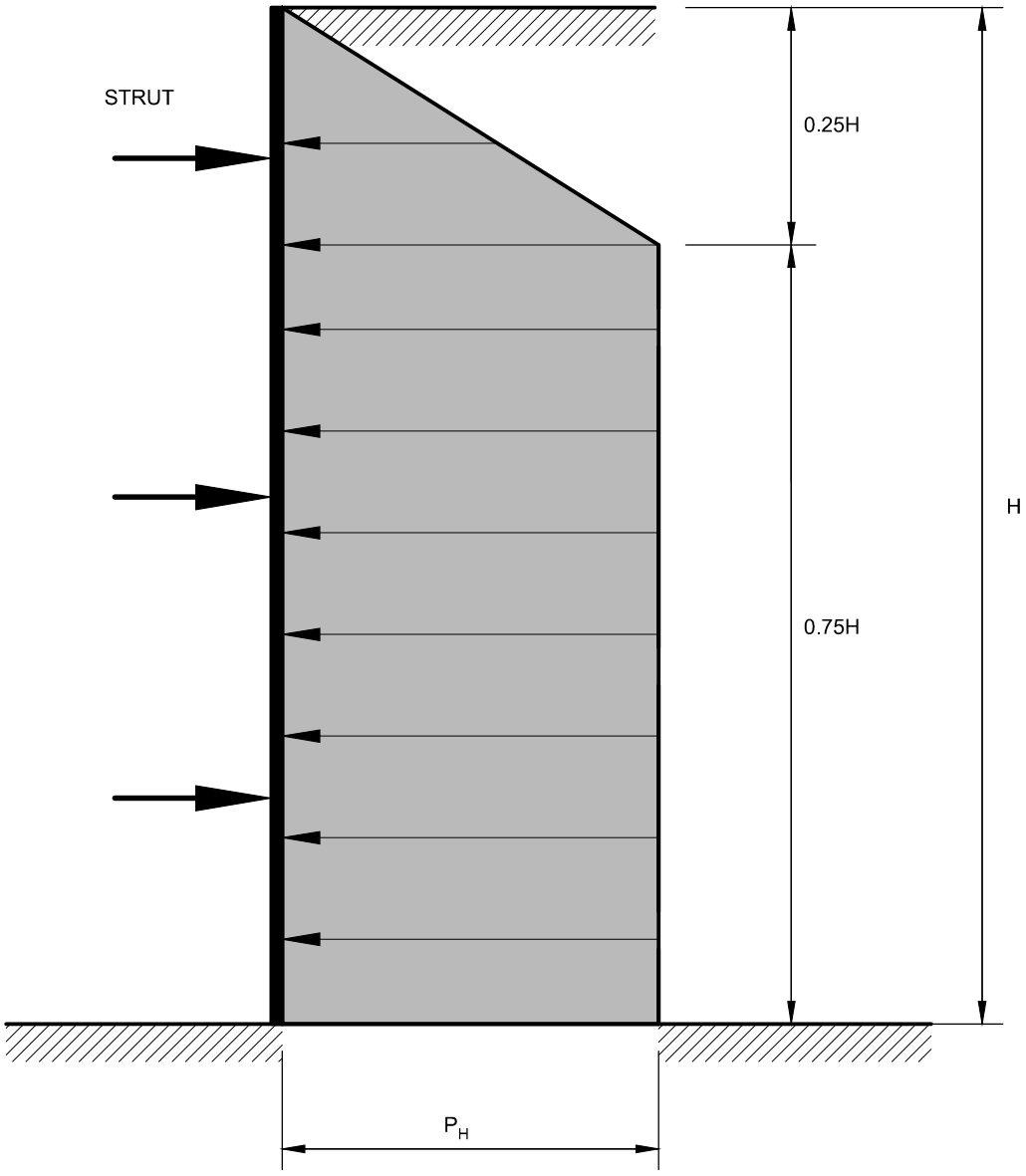
CROSS-SECTION A - EAST RIVER BANK

PLOT: 15/01/2014 12:37:20 PM

FILE NAME: 0115 004 00_RS.dwg

0 1 2 3 4m
SCALE : 1:100 (279mm x 432mm)

Drawing 07
Riprap Blanket Detail



$P_H = 0.5\ \gamma\ H$

WHERE :

H = DEPTH OF EXCAVATION (m)

P_H = LATERAL EARTH PRESSURE (kP_a)

γ = BULK SOIL UNIT WEIGHT (kN/m^3)

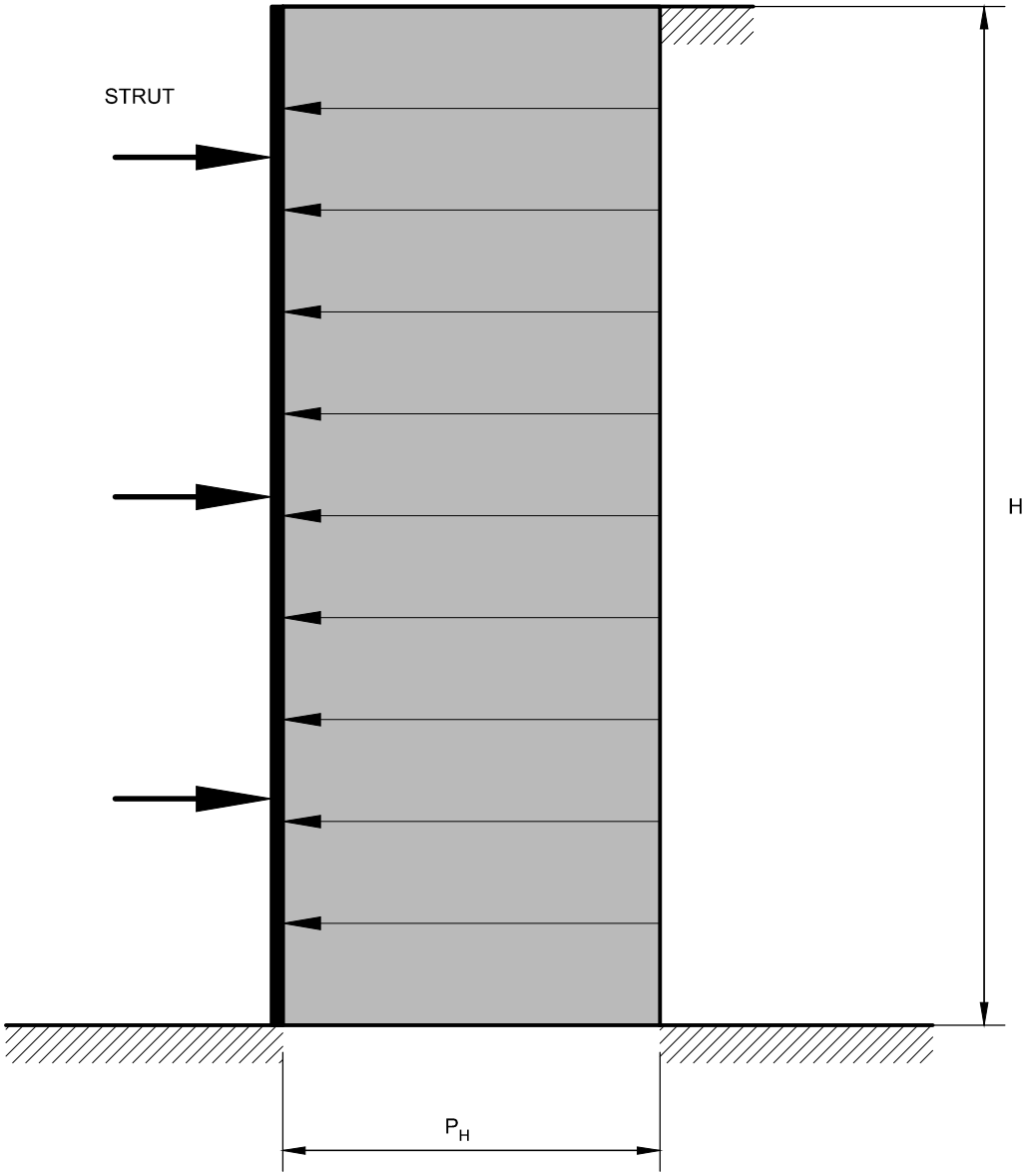
NOTE:

- ADD SURFACE LOAD SURCHARGE IF APPLICABLE

Drawing 08

Lateral Earth Pressure Distribution

Braced Excavation in Cohessive Soil



P_H = 0.65 K_a γ H

WHERE :

H = DEPTH OF EXCAVATION (m)

P_H = LATERAL EARTH PRESSURE (kPa)

γ = BULK SOIL UNIT WEIGHT (kN/m³)

K_a = ACTIVE EARTH PRESSURE COEFFICIENT

NOTES:

- ADD SURFACE LOAD SURCHARGE IF APPLICABLE
- ADD HYDROSTATIC WATER PRESSURE IF APPLICABLE

Drawing 09

Lateral Earth Pressure Distribution

Braced Excavation in non-Cohessive Soil

Appendix A

Test Hole Logs

Sub-Surface Log

Test Hole TH13-01

Client:	Associated Engineering	**Project Number:**	0115 004 00
Project Name:	Detailed Design North Kildonan Feedermain	**Location:**	UTM N-5534866.43, E-636644.43
Contractor:	Paddock Drilling Ltd.	**Ground Elevation:**	227.36 m
Method:	Acker SS3 Track Mount (see notes for drilling method)	**Date Drilled:**	7 November 2013

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) | Split Barrel (SB) | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders

Backfill Legend: Bentonite | Cement | Drill Cuttings | Filter Pack Sand | Grout | Slough

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)
	0	CLAY (FILL) - silty, trace gravel (<25mm), trace organics, trace silt inclusions (<20mm) - brown - moist, frozen to 1.1m, stiff when thawed - high plasticity	G	G29		
	1		G	G30		
225.8			G	G31		
	2	CLAY (ALLUVIAL) - silty, some fine to medium grained sand, trace organics (roots) - brown - moist, stiff - intermediate plasticity	G	G32		
224.6						
	3	SILT (ALLUVIAL) - trace clay to clayey, trace fine and medium grained sand, trace organics (roots) - brown - moist, very soft - low to intermediate plasticity	G	G33		
			T	T34		
	4		G	G35		
	5	- sandy and wet below 5.0 m	SB	SB36A		
			SB	SB36B		
	6		SB	SB36C		
			SB	SB37A		
	7	- soft below 6.6 m	SB	SB37B		
			SB	SB37C		
	8		SB	SB38A		
219.0						
	9	SAND (ALLUVIAL) - silty, trace to some clay to 10.7m - brown - wet, loose - no plasticity - poorly graded, fine and medium grained sand	SB	SB38B		
	10		SB	SB39		
	11	- no clay, some silt below 10.7 m	SB	SB40		

Bulk Unit Wt (kN/m³): 16 17 18 19 20 21

Particle Size (%): 0 20 40 60 80 100 — PL MC LL — 0 20 40 60 80 100

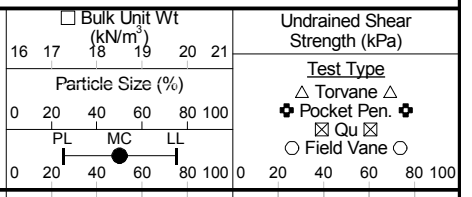
Undrained Shear Strength (kPa) — Test Type: △ Torvane △ ✿ Pocket Pen. ✿ ☒ Qu ☒ ○ Field Vane ○ — 0 20 40 60 80 100

Logged By: Stephen Renner **Reviewed By:** Nelson Ferreira **Project Engineer:** Nelson Ferreira

Sub-Surface Log

Test Hole TH13-01

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)
215.2						
214.6		CLAY (ALLUVIAL) - silty, some fine to medium grained sand, trace organics (roots) - brown - moist, stiff - intermediate plasticity		T41		
	13			SB42A		
		SAND (TILL) - trace silt, trace clay - brown - wet, loose - no to low plasticity - poorly graded, fine and medium grained sand		SB42B		
	14	- dense below 14.6 m				
	15			SB43		
				SS44		29
	16	- trace till inclusions (<20mm) below 15.7 m		SS45B		
				SS45A		50
	17	- boulder at 16.7 m				
				CB56		
209.2	18	DOLOMITE (BEDROCK) - beige, vertical and horizontal, rough undulating fractures, slightly altered, clay infilling		CB57	75	
	19					
	20					
		- 0.1 m clay (rock flour) seams between 20.7 m and 20.8 m		CB58	30	
	21					
		- 0.2 m clay (rock flour) seams between 21.6 and 21.8 m - yellowish fractured limestone between 21.8 to 24.3 m		CB59	0	
	22					
204.2	23	MUDSTONE (BEDROCK) - beige to brown, layered to varved, highly fractured with clay infill.		CB60	17	
	24					
203.0		DOLOMITIC MUDSTONE (BEDROCK) - mottled light brown to grey, minor rough undulating sub vertical fractures.		CB61	91	
	25					
	26					



49100 ☒

Logged By: Stephen Renner **Reviewed By:** Nelson Ferreira **Project Engineer:** Nelson Ferreira

SUB-SURFACE LOG 0115 004 00 DETAILED DESIGN NORTH KILDONAN FEEDERMAIN - LOGS.GPJ TREK GEOTECHNICAL.GDT 15/1/14

Sub-Surface Log

Test Hole TH13-01

Elevation (m)	Depth (m)	Soil Symbol	Standpipe	Standpipe	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)	Bulk Unit Wt (kN/m³) 16 17 18 19 20 21	Particle Size (%) 0 20 40 60 80 100	PL MC LL 0 20 40 60 80 100	Undrained Shear Strength (kPa) Test Type △ Torvane △ ✪ Pocket Pen. ✪ ☒ Qu ☒ ○ Field Vane ○ 0 20 40 60 80 100
	27				- chalk nodules at 26.8 m		CB62	96					
	28						CB63	62					
198.1	29				DOLOMITIC LIMESTONE (BEDROCK) - beige to grey mottled, some chert nodules (grey) in a dolomitic limestone matrix (beige), vuggy.		CB64	73					31200 ☒
	30												21800 ☒
	31						CB65	35					
	32												
	33						CB66	31					
	34				- 0.3 m thick highly fractured layer at 33.5 m		CB67	74					33100 ☒
	35				- fractures decreasing below 34.7 m								
	36						CB68	94					
190.5													

END OF TEST HOLE At 36.9 m in DOLOMITIC LIMESTONE (BEDROCK)

Notes:
1) Power auger refusal at 16.9 m depth.
2) Seepage observed below 5.3 m
3) Water level at 1.5 m depth immediately after dilling prior to coring.
4) Test hole drilled using solid stem auger up to 4.6 m then switched to hollow stem auger. At power auger refusal, switched to HQ coring.

Logged By: Stephen Renner **Reviewed By:** Nelson Ferreira **Project Engineer:** Nelson Ferreira

Sub-Surface Log

Test Hole TH13-04

Client:	Associated Engineering	**Project Number:**	0115 004 00
Project Name:	Detailed Design North Kildonan Feedermain	**Location:**	UTM N-5534987.21, E-636455.82
Contractor:	Paddock Drilling Ltd.	**Ground Elevation:**	227.19 m
Method:	Acker SS3 Track Mount (see notes for drilling method)	**Date Drilled:**	6 November 2013

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) | Split Barrel (SB) | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders

Backfill Legend: Bentonite | Cement | Drill Cuttings | Filter Pack Sand | Grout | Slough

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number
225.7	0	CLAY (ALLUVIAL) - silty, some gravel, trace fine sand, trace to some organics (roots and rootlets) - dark brown - moist, very stiff - high plasticity	G	G46
	1		G	G47
	1.7	CLAY (LACUSTRINE) - silty to 2.4m, some gravel, trace fine sand, trace organics (roots and rootlets), trace oxidation - dark brown, moist, soft to firm, high plasticity	G	G48
	2		SB	SB01
	2.4	- grey below 2.4 m	SB	SB02
	2.7	- trace silt inclusions (<15mm) and soft below 2.7 m	G	G49
	3		T	T03
	3.7	- firm to stiff, trace to some oxidation below 3.7 m	SB	SB04
	4		SB	SB05
	5		SB	SB06
	5.8	- trace coarse sand below 5.8 m	SB	SB07
	6		T	T08
	7		SB	SB09
	7.3	- trace gravel (<25mm) below 7.3 m	SB	SB10
	7.9	- trace to some silt inclusions (<15mm) below 7.9 m	SB	SB11
	8		SB	SB12
	9		T	T13
	10		SB	SB14
	10.4	- trace till inclusions (<75mm) below 10.4 m	SB	SB15
	11		SB	SB16
			SB	SB17

RQD (%) | SPT (N)

Bulk Unit Wt (kN/m³): 16 17 18 19 20 21

Particle Size (%): 0 20 40 60 80 100

PL MC LL: 0 20 40 60 80 100

Undrained Shear Strength (kPa)

Test Type: △ Torvane △ ✤ Pocket Pen. ✤ ☒ Qu ☒ ○ Field Vane ○

0 20 40 60 80 100

>>✤

Logged By: Stephen Renner **Reviewed By:** Nelson Ferreira **Project Engineer:** Nelson Ferreira

Sub-Surface Log

Test Hole TH13-04

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)
	13			SB18		
	14	- trace to some till inclusions below 14.0 m		SB19		
				SB20		
				SB21		
212.2	15			SB22		
211.8		SILT (TILL) - trace clay, trace gravel (<25mm), trace sand - light brown, moist, loose, low plasticity		SS23		
211.3		CLAY - silty, trace gravel - grey, moist, soft to firm, high plasticity				
	16	SILT (TILL) - trace clay, trace gravel (<25mm), trace sand (poorly graded) - light brown, moist, loose, low plasticity - dense below 16.4 m		SB24		
				SB25		
210.1	17	DOLOMITE (BEDROCK) - beige, vertical and horizontal, rough undulating fractures, slightly altered, clay infilling		CB26	86	
	18					
	19			CB27	100	
	20					
				CB28	100	
205.5	21					

Bulk Unit Wt (kN/m^3): 16 17 18 19 20 21

Particle Size (%): 0 20 40 60 80 100

PL MC LL

0 20 40 60 80 100

Undrained Shear Strength (kPa)

Test Type

△ Torvane △

✤ Pocket Pen. ✤

☒ Qu ☒

○ Field Vane ○

0 20 40 60 80 100

END OF TEST HOLE at 21.6 m in DOLOMITE (BEDROCK)

Notes:

1) Power auger refusal at 16.7 m.
2) No seepage or sloughing observed.
3) Water level at 4.2 m depth immediately after drilling prior to coring.
4) Test hole drilled using solid stem augers to 16.7 m then drill method switched to HQ coring.

Logged By: Stephen Renner **Reviewed By:** Nelson Ferreira **Project Engineer:** Nelson Ferreira

Sub-Surface Log

Test Hole TH13-05

Client:	Associated Engineering	**Project Number:**	0115 004 00
Project Name:	Detailed Design North Kildonan Feedermain	**Location:**	UTM N-5534979.78, E-636465.14
Contractor:	Paddock Drilling Ltd.	**Ground Elevation:**	226.26 m
Method:	CME-850 Track Mount (see notes for drilling method)	**Date Drilled:**	15 November 2013

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) | Split Barrel (SB) | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders

Backfill Legend: Bentonite | Cement | Drill Cuttings | Filter Pack Sand | Grout | Slough

Elevation (m)	Depth (m)	Soil Symbol	Standpipe	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)	Bulk Unit Wt (kN/m³) 16 17 18 19 20 21 / Particle Size (%) 0 20 40 60 80 100 / PL MC LL	Undrained Shear Strength (kPa) Test Type △ Torvane △ ✿ Pocket Pen. ✿ ☒ Qu ☒ ○ Field Vane ○ 0 20 40 60 80 100
	0			- overburden soils not logged - drilling advanced to power auger refusal then drilling method switched to HQ coring						
	1									
	2									
	3									
	4									
	5									
	6									
	7									
	8									
	9									
	10									
	11									

Logged By: Martial Lemoine **Reviewed By:** Nelson Ferreira **Project Engineer:** Nelson Ferreira

Sub-Surface Log

Test Hole TH13-05

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)	Bulk Unit Wt (kN/m³) 16 17 18 19 20 21	Particle Size (%) 0 20 40 60 80 100	PL MC LL 0 20 40 60 80 100	Undrained Shear Strength (kPa) Test Type △ Torvane △ ✪ Pocket Pen. ✪ ☒ Qu ☒ ○ Field Vane ○ 0 20 40 60 80 100
210.1	16									
210.0		SILT (TILL) - trace clay, trace sand, trace gravel - light grey, moist, loose, no to low plasticity		SS69						
				CB70	0					
	17	DOLOMITE (BEDROCK) - beige, vertical and horizontal, rough undulating fractures, slightly altered, clay infilling		CB71	38					
208.7										
	18	DOLOMITE (BEDROCK) - beige to light grey layering, massive, minor vugs, minor vertical and horizontal tight fractures		CB72	73					39500 ☒
	19									
	20			CB73	95					
	21									
	22			CB74	83					39500 ☒
	23	- visible hairline fractures between 22.9 m to 24.4 m		CB75	98					
	24									
201.9		DOLOMITE (BEDROCK) - beige layers with light brown mottled and cream coloured layers, massive, minor vertical and horizontal tight fractures		CB76	92					
	25									
	26			CB77	75					

Logged By: Martial Lemoine **Reviewed By:** Nelson Ferreira **Project Engineer:** Nelson Ferreira

Sub-Surface Log

Test Hole TH13-05

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)
198.8	27					
	28	DOLOMITIC MUDSTONE (BEDROCK) - mottled light brown to grey, light brown mottles are soft calcareous mudstone, grey mottles are hard dolomite, trace chert nodules, vuggy, rough undulating sub vertical fractures 0.1 m thick clay (rock flour) seam at 28.7 m		CB78	69	
	29			CB79	92	
195.8	30					
	31	DOLOMITIC LIMESTONE (BEDROCK) - beige to grey mottled, some chert nodules (grey) in a dolomitic limestone matrix (beige), vuggy, minor, very rough, angular, subhorizonal fracturing.		CB80	100	
	32			CB81	100	
	33			CB82	99	
	34			CB83	85	
191.2	35					

Bulk Unit Wt (kN/m³): 16 17 18 19 20 21

Particle Size (%): 0 20 40 60 80 100

PL MC LL

0 20 40 60 80 100

Undrained Shear Strength (kPa)

Test Type

△ Torvane △

✤ Pocket Pen. ✤

☒ Qu ☒

○ Field Vane ○

0 20 40 60 80 100

11900 ☒

END OF TEST HOLE At 35.1 m in DOLOMITIC LIMESTONE (BEDROCK)

Notes:

1) Power auger refusal at 16.2 m.
2) No seepage or sloughing observed.
3) Water level at 3.7 m depth immediately after dilling prior to coring.
4) Test hole drilled using solid stem augers to 16.2 m then drilling method switched to HQ coring.

Logged By: Martial Lemoine **Reviewed By:** Nelson Ferreira **Project Engineer:** Nelson Ferreira

Appendix B

Test Hole Logs (By Others)

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	6/08/87	87422	1

DRILL TYPE: 450 & 500 mm Augers

DATUM: Geodetic

SURFACE ELEVATION: 230.63 m

WATER CONTENT: W_P - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DEPTH (M)	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
0	Fill				
	Clay -black				
1	Clay -silty -brown -stiff -alluvial				
2	Silt -tan -wet to saturated -firm				
3					
4	Clay -mottled brown -highly plastic -stiff -lacustrine				
5					
6			U		qu=109.7kpa γ_w=16.48kn/m³ pp=146.0kpa Tv=84.7kpa
7					
8	End hole at 7.6 m. Seepage and caving from 2.4 to 2.7 m.				

Plate A-2

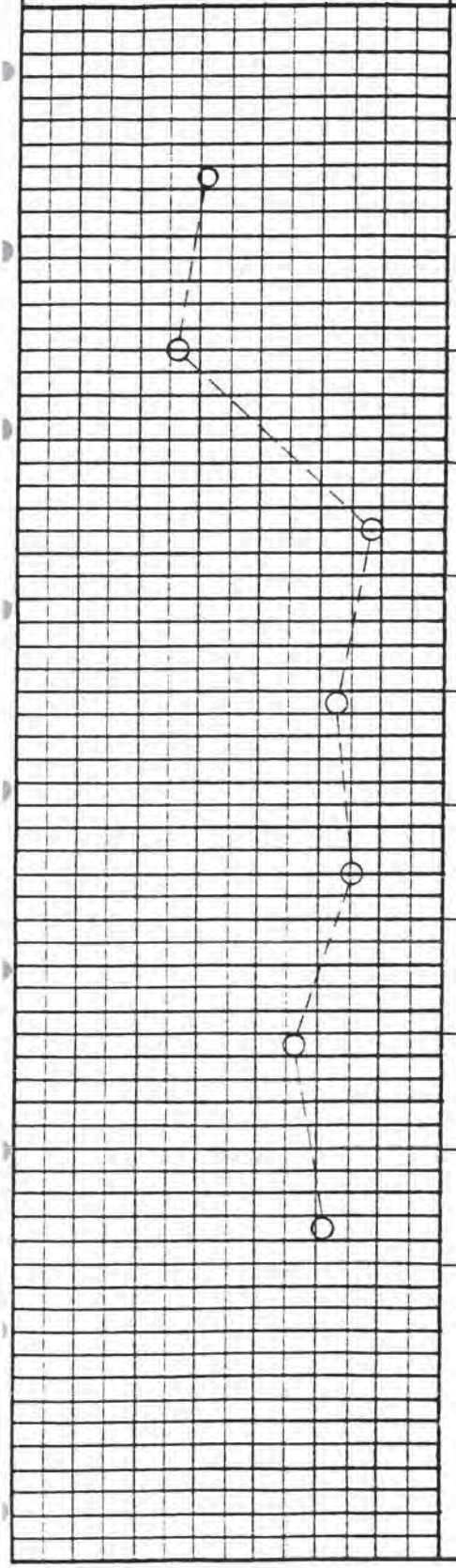
DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	6/08/87	87422	2

DRILL TYPE: 450 &500 mm Augers



DEPTH (M)	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
0	Fill -clay, silt, some gravel				
1	Clay -black				
2	Clay -silty -brown -stiff				
3	Silt -tan -saturated				
4	Clay -mottled brown -highly plastic -firm to stiff -lacustine				
5			U		qu=47.2kpa γ_w=16.51kn/m^3 pp=93.4kpa Tv=81.2kpa
6					
7					
8	grey		U		qu=150.1kpa γ_w=16.85kn/m^3 pp=125.4kpa Tv=77.8kpa
9					
10					
11	End hole at 10.7 m. Seepage and caving from silt layer.		U		qu=131.8kpa γ_w=17.60kn/m^3 pp=117.8kpa Tv=60.3kpa

Plate A-3

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	6/08/87	87422	3

DRILL TYPE: 500 mm Auger

WATER CONTENT: W_P - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DATUM: Geodetic

SURFACE ELEVATION: 230.58 m

DEPTH (M)	SOIL DESCRIPTION	SOIL SAMPLE CONDITION	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS
0	Topsoil				
	Clay -silty -brown -stiff				
1					
2					
	Silt -tan -wet to saturated				
3					
	Clay -mottled brown -highly plastic -stiff to firm -lacustrine		U		qu=57.4kpa γ_w=16.40kn/m^3 pp=132.9kpa Tv=71.3kpa
4					
5					
	- - - grey				
6			U		qu=117.3kpa γ_w=16.27kn/m^3 pp=119.7kpa Tv=74.7kpa
7					
8					
9			U		qu=148.5kpa γ_w=16.81kn/m^3 pp=95.8kpa Tv=60.6kpa
10					
11					
12					qu=147.3kpa γ_w=16.58kn/m^3 pp=68.9kpa Tv=54.6kpa
13					
	End of hole at 13.7 m in clay.		U		

Plate A-4

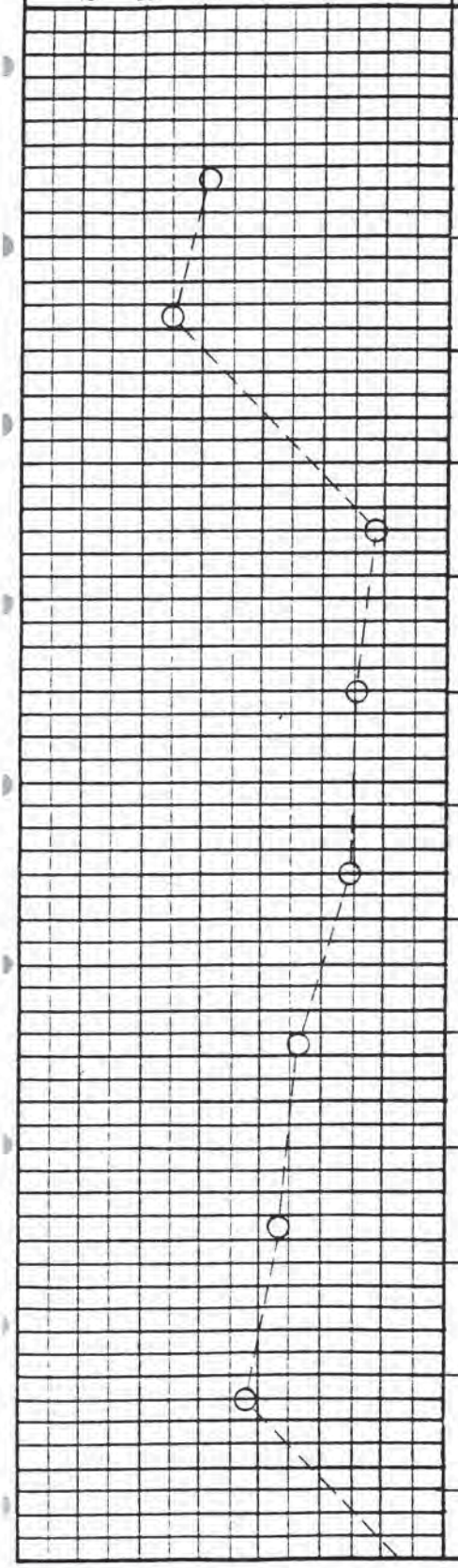
DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	6/08/87	87422	4

DRILL TYPE: 450 & 500 mm Augers



SOIL SYMBOL	SOIL DESCRIPTION	CONDITION	TYPE	PENETRATION RESISTANCE	OTHER TESTS
	DATUM Geodetic SURFACE ELEVATION 230.64 m				
	Fill -clay -concrete rubble				
	Clay -silty -brown				
	Silt -tan -wet to saturated				
	Clay -mottled brown -highly plastic -stiff to firm -lacustrine				
			U		γ_w=16.30kn/m^3 pp=108.9kpa Tv=57.4kpa
	---grey				
			U		qu=135.1kpa γ_w=17.00kn/m^3 pp=147.5kpa Tv=72.8kpa
			U		qu=106.7kpa γ_w=16.72kn/m^3 pp=93.8kpa Tv=56.0kpa

Plate A-5

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	6/08/87	87422	4

DRILL TYPE: 450 & 500 mm Augers

DATUM: Geodetic

SURFACE ELEVATION: 230.64 m

WATER CONTENT — W_P - □ W - ○ W_L - △. PERCENT %, 10 20 30 40 50 60

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
14		Clay -grey -highly plastic -lacustrine		U		qu=68.2kpa γ_w=16.04kn/m^3 pp=94.2kpa Tv=47.4kpa
15						
16						
17						qu=128.4kpa γ_w=16.51kn/m^3 pp=81.4kpa Tv=43.6kpa
18		Silt (Glacial Till) -sandy, gravelly -wet -loose to 19.5 m -medium dense below 19.5 m				
19						
20						
21		End of hole at 20.4 m. -Smooth auger refusal -Possible bedrock at 20.4 m -Water inflow from 20.4 m -Water level stabilized at 9.4 m in about 15 minutes				

Plate A-6

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	6/08/87	87422	5

DRILL TYPE: 450 & 500 mm Augers

WATER CONTENT — W_P - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH (M)	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
0	DATUM Geodetic SURFACE ELEVATION 228.72 m				
0	Fill -silty -clay				
1	Clay -black				
1	Clay -silty -brown -alluvial				See Dilatometer Test Results (DMT 2)
3	Clay -mottled brown -highly plastic -stiff to firm -lacustrine				
5			U		qu=53.7kpa γ_w=16.18kn/m^3 pp=112.5kpa Tv=59.4kpa
6	--grey				
8			U		qu=114.2kpa γ_w=17.38kn/m^3 pp=122.6kpa Tv=62.7kpa
11			U		qu=95.3kpa γ_w=17.78kn/m^3 pp=66.1kpa Tv=39.7kpa

Plate A-7

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	6/08/87	87422	5

DRILL TYPE: 450 & 500 mm Augers

DATUM: Geodetic

SURFACE ELEVATION: 228.72 m

WATER CONTENT — W_p - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
14		Clay (cont'd)		U		qu=118.4kpa γ_w=16.51kn/m^3 pp=103.4kpa Tv=49.3kpa
15						
16		Silt (Glacial Till) -sandy gravelly -clayey -loose				
17						
18						
19		End of hole at 18.7 m -Possible bedrock -No seepage				

Plate A-8

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN. SDG | CKD. NCB | DATE OF INVEST. 10/08/87 | JOB NO. 87422 | HOLE NO. 6

DRILL TYPE: Hollowstem 550 & 600 mm Augers

WATER CONTENT: W_P - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM Geodetic; SURFACE ELEVATION 227.47 m)	SOIL SAMPLE: CONDITION / TYPE / PENETRATION RESISTANCE	OTHER TESTS
0		Clay -silty -some sand -alluvial -stiff to 1.2 m -soft from 1.2 to 3.3 m		See dilatometer test results to 15.2 m depth (DMT 1)
1				
2				
3			U	γ_w=17.90kg/m^3 pp=114.9kpa
4		Sand -little to some silt -trace to some clay -fine to medium grained		MA
5		very dense, 5.2 - 6.4 m		
6		medium grained, grey, saturated	U	MA pp=35.9kpa
7				
8		Silt -some sand -some to little clay -firm to stiff	U	MA γ_w=18.00 kg/m^3 pp=67.0kpa Tv=31.6kpa
9			U	γ_w=17.71kg/m^3 pp=88.6kpa Tv=15.8kpa
10			U	MA γ_w= 14.97kg/m^3 pp=52.7kpa
11				
12		Clay -silty, very stiff, alluvial	U	pp=148.4kpa Tv=67.0kpa
13		End of hole at 12.5 m Standpipe piezometers SP 1 and SP 2 installed		

Plate A-9

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	10/08/87	87422	6

DRILL TYPE: Hollowstem 550 & 600 mm Augers

WATER CONTENT — W_P - □ W - ○ W_L - △. PERCENT %. 10 20 30 40 50 60

DEPTH | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | OTHER TESTS

DATUM: Geodetic

SURFACE ELEVATION: 227.47 m

SP 1
Tip at 12.2 m
Sand to 11.6 m
Bentonite to 10.4 m
230 mm Ø augers

SP 2
Tip at 6.1 m
Sand at 5.6 m
Bentonite to 4.6 m
230 mm Ø augers
Pipe ID - 19 mm

Plate A-10

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	7/08/87	87422	7

DRILL TYPE: 450 & 600 mm Augers

WATER CONTENT — W_p - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM Geodetic; SURFACE ELEVATION 227.13 m)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
0		~~Topsoil~~				
1		Silt -sandy -some clay -brown -alluvial				
2						
3		Sand -some silt -trace clay – – – saturated				MA
4						
5		Silt -some sand and clay -grey -wet -firm				
6						
7						
8				U		MA γ_w=17.95kg/m^3 pp=61.3kpa Tv=32.6kpa
9		Sand -fine grained -grey, saturated Silt -some sand and clay				
10		Clay -grey -highly plastic -firm – – – 100 mm gravel layer, shells				
11				U		qu=67.7kpa γ_w=18.34kg/m^3 pp=151.2kpa Tv=69.9kpa
12						
13						

Plate A-11

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	7/08/87	87422	7

WATER CONTENT: W_P - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE
		DATUM Geodetic SURFACE ELEVATION 227.13 m			
14		---Clay & Glacial Till			
15					
		Silt (Glacial Till) -wet, loose, clayey			
16					
		End of hole at 16.2 m. -Smooth auger refusal -Water seepage 20 minutes after completion of drilling -600 mm casing to 10 m depth -Possible bedrock at 16.2 m			
17					

DRILL TYPE: 550 &600 mm Augers

OTHER TESTS

Plate A-12

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	7/08/87	87422	8

DRILL TYPE: 550 & 600 mm Augers

WATER CONTENT — W_p - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM Geodetic; SURFACE ELEVATION 227.17 m)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
0		Fill -clay, concrete rubble				
1		Silt -clayey, brown, stiff -alluvial				
2		Sand -fine grained -some silt -brown				
3		---saturated		U		γ_w=18.01kg/m^3 pp=56.2kpa Tv=39.7kpa
4						
5						
5		---grey				
6						
7						
8						
9		Silt -some sand and clay -wet -stiff to firm		U		qu=57.3kpa γ_w=16.97kg/m^3 pp=183.8kpa Tv=62.2kpa
10						
11		---50 mm gravel layer				
12				U		qu=49.1kpa γ_w=15.97kg/m^3 pp=101.5kpa Tv=57.4kpa
13		Clay -grey -highly plastic -stiff to firm				

Plate A-13

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	7/08/87	87422	8

DRILL TYPE: 550 & 600 mm Augers

DATUM: Geodetic

SURFACE ELEVATION: 227.17 m

WATER CONTENT: W_P - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
14		Clay (cont'd)				
15		---gravelly				
16		Silt (Glacial Till) -sandy, gravelly -some clay -tan -seepage from 16.5 m				
17						
18		End of hole at 17.7 m -Rough auger refusal at 17.7 m -Water level at 7.2 m on completion of drilling -600 mm casing to 4.6 below grade				

Plate A-14

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	27/08/87	87422	12

DRILL TYPE: Hollow Stem

DATUM: Geodetic

SURFACE ELEVATION: 226.74 m

WATER CONTENT: W_p - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
0		Fill -clay -some gravel				P1 Pneumatic piezometer tip @ 7.8m sand to 7.1 m bent. to6.1m
1		Clay -silty -brown -stiff -alluvial -medium to highly plastic				
2						
3				U		qu=46.4kpa γ_w=18.00kn/m^3 pp=97.0kpa Tv=27.8kpa
4						
5		--grey				
6				U		γ_w=17.37kn/m^3 pp=59.8kpa
7						
8						
9				U		qu=67.4kpa γ_w=19.95kn/m^3 pp=143.6kpa
10		Clay -mottled brown to grey -highly plastic -lacustrine				
11						
12				U		qu=51.2kpa γ_w=17.60kn/m^3 pp=87.8kpa Tv=58.4kpa
13		End of hole at 12.8 m. Install pneumatic piezometer				

Plate A-18

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	27/08/87	87422	13

DRILL TYPE: Hollow Stem

WATER CONTENT — W_p - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DATUM: Geodetic

SURFACE ELEVATION: 227.60 m

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE CONDITION	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS
0		Fill -clay -some gravel				Station - 3+90.9
1		Clay -silty -brown -alluvial				
2		Clay -mottled brown -highly plastic -stiff to firm -lacustrine				
3						
4						
5						
6				U		qu=56.5kpa γ_w=16.77kn/m^3 pp=93.8kpa Tv=48.8kpa
7						
8						
9						
10						
11						
12				U		
13						

Plate A-19

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	27/08/87	87422	13

DRILL TYPE: Hollow Stem

DATUM: Geodetic

SURFACE ELEVATION: 227.60 m

WATER CONTENT — W_P - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
14		Clay (cont'd)				
15						
16						
17						
18		Silt (Glacial Till) -sandy and gravelly -bouldery				
19		End of hole at 18.6 in glacial till.				
20		Backfill with sand to 14.9. Place pneumatic piezometer @ 14.9 (P2) Sand to 14.2 m Bentonite to 13.1 m Set pneumatic piezometer (P3) with tip @ 9.1 m. Sand to 8.5 m. Bentonite to 7.5 m.				

Plate A-20

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
SDG	NCB	18/09/87	87422	14

DRILL TYPE: B-24, 75 mm Bit

WATER CONTENT: W_P - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DATUM: Geodetic

SURFACE ELEVATION: 223.64

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
0		Water				
1						
2						
3						
4						
5						
6						
7						
8		Overburden Soils				For DMT results see DMT 5
9		Glacial Till				
10						
11						
12						
13						
		Limestone Bedrock				

Plate A-21

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: Kildonan Corridor

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
NCB	NCB	18/09/87	87422	14

DRILL TYPE: B-24, 75 mm Bit

WATER CONTENT — W_P - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM Geodetic; SURFACE ELEVATION 223.64 m)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
14		Sound Rock				Rec. - 100%
15		Sound Rock 25 mm clay seam at 15.2 m				Rec. - 91% RQD -80%
16		Sound Rock 25 mm clay seam at 16.7 m				REC. -94% RQD -75%
17						
18		Sound Rock No clay seams				Rec. -100% RQD - 95%
19						
20		End hole at 19.1 m. Rock surface estimated at Elev. - 210.38 m. Top 150 mm unsound.				

Plate A-22

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 24/09/87	JOB NO. 87422	HOLE NO. 15

WATER CONTENT: W_P - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH m | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | DRILL TYPE | OTHER TESTS

DATUM

SURFACE ELEVATION 223.67 m

1
2
3
4
5
6
7
8
9
10
11
12
13

WATER

ALLUVIAL SOILS

GLACIAL TILL
(depth to till extrapolated from DMT 6)

LIMESTONE BEDROCK

PLATE A-23

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN. | CKD. | DATE OF INVEST. 24/09/87 | JOB NO. 87422 | HOLE NO. 15

WATER CONTENT: W_P - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	DRILL TYPE / OTHER TESTS
14		BROKEN ROCK				
		SOUND ROCK				REC - 99% RQD - 60%
		NO RECOVERY				
15		SOUND ROCK				REC - 99% RQD - 60%
		NO RECOVERY				
16		SOUND ROCK				REC - 99% RQD - 79%
17		SOUND ROCK				REC - 100% RQD - 70%
18		NO RECOVERY				
		BROKEN ROCK				
19		SOUND ROCK				REC - 84% RQD - 17%
20		SOUND ROCK				REC - 100% RQD - 45%
21						
22		End hole at 21.7 m. Rock surface estimated at elev. 210.53 Top 0.9 m unsound rock.				

PLATE A-24

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 25/09/87	JOB NO. 87422	HOLE NO. 16

WATER CONTENT: W_P - □ W - ○ W_L - Δ. PERCENT % (10 20 30 40 50 60)

DEPTH m | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | DRILL TYPE | OTHER TESTS

DATUM

SURFACE ELEVATION 223.61 m

Depth (m)	Soil description
0	WATER
9	ALLUVIAL SOILS
10	GLACIAL TILL -SOFT/LOOSE -PUSHED DRILL RODS TO BEDROCK SURFACE
13	LIMESTONE BEDROCK

FOR TESTS IN ALLUVIUM SEE DMT 7

PLATE A-25

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN. | CKD. | DATE OF INVEST. 25/09/87 | JOB NO. 87422 | HOLE NO. 16

WATER CONTENT: W_P - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	DRILL TYPE / OTHER TESTS
14		BROKEN ROCK TO 13.7 m				
		3 - 6mm clay seams at 14.0 m				REC - 75%
15		SOUND ROCK				REC - 95% RQD - 68%
16						
		225 mm seam or soft rock				REC - 98%
17						
18		SOUND ROCK				REC - 93%
19						
		NO RECOVERY				
20		Abandon hole at 20.1 m Drill rods jamming				

PLATE A-26

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 06/10/87	JOB NO. 87422	HOLE NO. 16A

WATER CONTENT — W_P - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH m | SOIL SYMBOL | SOIL DESCRIPTION — DATUM — SURFACE ELEVATION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | DRILL TYPE | OTHER TESTS

1
2
3
4
5
6
7
8
9
10
11
12
13

WATER

ALLUVIAL SOILS

GLACIAL TILL
(depth extrapolated from DMT 7)

PLATE A-27

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 06/10/87	JOB NO. 87422	HOLE NO. 16A

WATER CONTENT — W_P - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DRILL TYPE

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION DATUM SURFACE ELEVATION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		GLACIAL TILL				
14		LIMESTONE BEDROCK				REC - 100% ROD - 67%
15		UNSOUND ROCK NO CORE RECOVERY				
16						
17						
18						
19						
20		UNSOUND ROCK NO CORE RECOVERY				
21						
22						
23		UNSOUND ROCK				REC - 30%
24		End hole at 23.6 m.				

PLATE A-28

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 07/10/87	JOB NO. 87422	HOLE NO. 16B

WATER CONTENT: W_P - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH m | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | DRILL TYPE | OTHER TESTS

DATUM

SURFACE ELEVATION 223.69 m

Depth (m)	Soil Description
0 – 9	WATER
9 – 10	ALLUVIUM
10 – 13	GLACIAL TILL (depth to till extrapolated from DMT 7)

PLATE A-29

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 07/10/87	JOB NO. 87422	HOLE NO. 16B

WATER CONTENT: W_P - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DRILL TYPE:

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION 223.69 m)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
14		LIMESTONE BEDROCK SOUND ROCK				REC - 100% ROD - 56%
15		SOUND ROCK				REC - 98% ROD - 83%
16						
17		SOUND ROCK				REC - 96% ROD - 90%
18		SOUND ROCK				REC - 94% ROD - 73%
19						
20		NO RECOVERY				
		End hole at 20.0 m Drill rods jamming in broken rock and clay.				

PLATE A-30

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 14/10/87	JOB NO. 87422	HOLE NO. 16C

WATER CONTENT

Wp - □ W - ○ W_L - △

PERCENT %

10 20 30 40 50 60

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION

SOIL SAMPLE: CONDITION | TYPE | PENETRATION RESISTANCE

DRILL TYPE

OTHER TESTS

1 2 3 4 5 6 7 8 9 10 11 12 13

WATER

ALLUVIUM

GLACIAL TILL
(depth to till extranolated from DMT 7)

PLATE A-31

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN. | CKD. | DATE OF INVEST. 14/10/87 | JOB NO. 87422 | HOLE NO. 16C

WATER CONTENT: W_p - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DRILL TYPE

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
14		LIMESTONE BEDROCK SOUND ROCK				REC - 100% RQD - 85%
15		SOUND ROCK				REC - 92% RQD - 91%
16						
17		SOUND ROCK				REC - 98% RQD - 96%
18		SOUND ROCK				REC - 100% RQD - 100%
19		NO RECOVERY				
20		BROKEN ROCK, NO RECOVERY NO RECOVERY				
21		SOUND ROCK				REC - 93% RQD - 73%
22						
23		End hole at 22.3 m.				

PLATE A-32

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 15/10/87	JOB NO. 87422	HOLE NO. 16D

WATER CONTENT: W_P - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION — DATUM — SURFACE ELEVATION

SOIL SAMPLE: CONDITION | TYPE | PENETRATION RESISTANCE

DRILL TYPE

OTHER TESTS

Depth (m)	Soil Description
0 – 10	WATER
10 – 11	ALLUVIUM
11 – 13	GLACIAL TILL (depth to glacial till extrapolated from DMT 7)
13	LIMESTONE BEDROCK

PLATE A-33

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN. | CKD. | DATE OF INVEST. 15/10/87 | JOB NO. 87422 | HOLE NO. 16D

WATER CONTENT — W_P - □ W - ○ W_L - △ — PERCENT % — 10 20 30 40 50 60

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	DRILL TYPE / OTHER TESTS
14		150 mm clay or soft rock				REC - 69%
		---- 150 mm clay or soft rock				RQD - 67%
15		NO RECOVERY				
16		SOUND ROCK				REC - 88%
17		SOUND ROCK				REC - 100% RQD - 93%
18		SOUND ROCK				
		NO RECOVERY				
19		SOUND ROCK				
20		UNSOUND ROCK				REC - 30% RQD - 10%
21		SOUND ROCK				REC - 80%
22		BROKEN ROCK				RQD - 63%
		End hole at 22.5 m.				

PLATE A-34

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 06/10/87	JOB NO. 87422	HOLE NO. 17

WATER CONTENT: W_P - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION 223.65 m

SOIL SAMPLE: CONDITION | TYPE | PENETRATION RESISTANCE

DRILL TYPE

OTHER TESTS

1 2 3 4 5 6 7 8 9 10 11 12 13

WATER

ALLUVIAL SOILS

For tests in alluvium see DMT 7

GLACIAL TILL

VERY DENSE? HARD BELOW 11.2 m

PLATE A-35

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN. | CKD. | DATE OF INVEST. 06/10/87 | JOB NO. 87422 | HOLE NO. 17

WATER CONTENT (W_p - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60)	DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	DRILL TYPE / OTHER TESTS
	14	A	GLACIAL TILL				
			LIMESTONE BEDROCK				
	15		NO RECOVERY 14.3 to 15.5 m				
	16		SOUND ROCK				REC - 99% RQD - 99%
	17		SOUND ROCK				REC - 97% RQD - 75%
	18		SOUND ROCK				REC - 97% RQD - 79%
	19		SOUND ROCK				REC 100%
	20		BROKEN ROCK				REC 0%
			SOUND ROCK				REC - 100% RQD - 70%
	21		SOUND ROCK				REC - 93% RQD - 30%
	22						
	23		End hole at 22.6 m.				

PLATE A-36

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 21/09/87	JOB NO. 87422	HOLE NO. 18

WATER CONTENT: W_p - □ w - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH m | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | DRILL TYPE | OTHER TESTS

DATUM

SURFACE ELEVATION 223.68

DEPTH m	SOIL DESCRIPTION
1	WATER
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	GLACIAL TILL
12	
13	LIMESTONE BEDROCK, BROKEN TO 13.1m
	SOUND ROCK, 13.1 - 13.8 m

PLATE A-37

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN. | CKD. | DATE OF INVEST. 21/09/87 | JOB NO. 87422 | HOLE NO. 18

WATER CONTENT — W_P - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM; SURFACE ELEVATION 223.68 m)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	DRILL TYPE / OTHER TESTS
14		NO RECOVERY 13.8 - 13.9 m SOUND ROCK 25 mm clay seam at 14.6 m				REC - 87% RQD - 82%
15		SOUND ROCK				REC - 95% RQD - 87%
16						
17		SOUND ROCK				REC - 95% RQD - 65%
18		SOUND ROCK				REC - 95% RQD - 87%
19						
20		SOUND ROCK				REC - 95%
21		SOUND ROCK				REC - 93%
22						
23		End hole at 22.3 m.				

PLATE A-38

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 19/09/87	JOB NO. 87422	HOLE NO. 19

WATER CONTENT: W_p - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH m | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | DRILL TYPE | OTHER TESTS

DATUM

SURFACE ELEVATION 223.62

1 2 3 4 5 6 7 8 9 10 11 12 13

WATER

GLACIAL TILL
(depth to glacial till extrapolated from DMT 5)

PLATE A-39

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN. | CKD. | DATE OF INVEST. 19/09/87 | JOB NO. 87422 | HOLE NO. 19

WATER CONTENT — W_p - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	DRILL TYPE / OTHER TESTS
		GLACIAL TILL				
14		LIMESTONE BEDROCK BROKEN ROCK TO 14.6 m				REC - 30%
15		SOUND ROCK				REC - 100%
16						
		SOUND ROCK				REC - 96% RQD - 94%
17						
18		SOUND ROCK				REC - 96% RQD - 74%
19						
		SOUND ROCK				REC - 97%
20						
21		End hole at 20.7 m.				

PLATE A-40

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 03/10/87	JOB NO. 87422	HOLE NO. 20

WATER CONTENT: W_P - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DRILL TYPE

OTHER TESTS

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM; SURFACE ELEVATION 223.61 m)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE
1		WATER			
2		ALLUVIAL SOILS (for test results see DMT 4)			
3					
4					
5					
6					
7					
8		GLACIAL TILL (depth to till extrapolated from DMT 4)			
9					
10					
11					
12					
13		LIMESTONE BEDROCK			

PLATE A-41

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 03/10/87	JOB NO. 87422	HOLE NO. 20

WATER CONTENT — Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION 223.61 m)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	DRILL TYPE / OTHER TESTS
14		BROKEN ROCK 13.4 - 14.0 m SOUND ROCK BELOW 14.0 m				REC - 64% RQD - 53%
15		SOUND ROCK				REC - 97% RQD - 81%
16						
17		SOUND ROCK				REC - 95% RQD - 93%
18		SOUND ROCK				REC - 92% RQD - 69%
19		100 mm clay seam				
20		SOUND ROCK				REC - 97% RQD - 73%
21		SOUND ROCK				REC - 92% RQD - 79%
22						
23		End hole at 22.6 m.				

PLATE A-42

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 28/09/87	JOB NO. 87422	HOLE NO. 21

WATER CONTENT: W_P - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH m | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | DRILL TYPE | OTHER TESTS

DATUM

SURFACE ELEVATION 223.63 m

1 — WATER

2 — ALLUVAIL SOILS
(for test results see DMT 4)

3

4

5

6

7

8 — GLACIAL TILL
(depth to till extrapolated from DMT 4)

9

10

11

12

13 — LIMESTONE BEDROCK

PLATE A-43

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN. | CKD. | DATE OF INVEST. 28/09/87 | JOB NO. 87422 | HOLE NO. 21

DRILL TYPE

WATER CONTENT — W_p - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
14		NO RECOVERY TO 14.2 m				
		SOUND ROCK, 14.2 - 14.8 m				
15		25 mm clay seam				REC - 99%
		SOUND ROCK				RQD - 44%
16						
		SOUND ROCK				REC - 97%
17						RQD - 81%
18		6 mm clay seams (2)				REC - 95%
		12 mm clay seam				RQD - 45%
		SOUND ROCK				
19						
		SOUND ROCK				REC - 98%
20						RQD - 67%
21		SOUND ROCK				REC - 100%
22						RQD - 36%
23		End hole at 22.4 m.				

PLATE A-44

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 23/09/87	JOB NO. 87422	HOLE NO. 22

WATER CONTENT: W_P - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DEPTH m | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | DRILL TYPE | OTHER TESTS

DATUM

SURFACE ELEVATION 223.68 m

Depth (m)	Soil description
1	WATER
2	ALLUVIAL SOILS (for testing see DMT 3)
8	GLACIAL TILL (depth to glacial till extrapolated from DMT 3)
13	LIMESTONE BEDROCK

PLATE A-45

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 23/09/87	JOB NO. 87422	HOLE NO. 22

WATER CONTENT: W_P - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION 223.68 m)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
14		BROKEN ROCK, 13.0-13.8 m				no REC
		SOUND ROCK				REC - 99% RQD - 45%
		SOUND ROCK				REC - 99% RQD - 83%
15						
16		SOUND ROCK				REC - 96% RQD - 73%
17						
18		SOUND ROCK				REC - 93% RQD - 66%
19		End hole at 19.0 m.				

PLATE A-46

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 22/09/87	JOB NO. 87422	HOLE NO. 23

WATER CONTENT: W_p - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH M | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | DRILL TYPE | OTHER TESTS

DATUM

SURFACE ELEVATION 223.70 m

DEPTH M	SOIL DESCRIPTION
1	WATER
2	ALLUVIAL SOILS (For testing see DMT 3)
8	GLACIAL TILL (Depth to till extrapolated from DMT 3)
13	LIMESTONE BEDROCK

PLATE A-47

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN. | CKD. | DATE OF INVEST. 22/09/87 | JOB NO. 87422 | HOLE NO. 23

DRILL TYPE

WATER CONTENT — W_p - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION 223.70 m)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
14		SOUND ROCK				REC.- 87% RQD. - 83%
15		SOUND ROCK				REC. - 97% RQD - 70%
16						
17		SOUND ROCK				REC. - 100% RQD - 88%
18		SOUND ROCK				REC. - 95% RQD - 47%
19						
20		SOUND ROCK				REC. - 97% RQD - 61%
21		End hole at 20.9 m.				

PLATE A-48

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 22/09/87	JOB NO. 8/422	HOLE NO. DMT 3

WATER CONTENT: W_p - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION 223.70 m

SOIL SAMPLE: CONDITION | TYPE | PENETRATION RESISTANCE

DRILL TYPE

OTHER TESTS

Depth (m)	Soil Description
1	WATER
2	SILT - clayey
3	CLAY - silty
4	
5	
6	STRATIFIED SILTY CLAY AND CLAYEY SILT
7	
8	End Dilatometer testing at 7.9 m. Refusal on glacial till or boulder at 7.9 m.

UNDRAINED SHEAR STRENGTH (kPa)

10.3
11.3
12.1
13.1
13.9
14.8
15.8
16.6
15.8
26.9
20.7
19.8
31.2
27.9
34.5
38.6

PLATE A-49

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN. | CKD. | DATE OF INVEST. 30/09/87 | JOB NO. 87422 | HOLE NO. DMT 4

DRILL TYPE

WATER CONTENT

W_p - □ W - ○ W_L - △

PERCENT %

10 20 30 40 50 60

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION 223.61)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS: UNDRAINED SHEAR STRENGTH (kPa)
1		WATER				
2		CLAYEY SILT				28 27
3						27 36
4		STRATIFIED SILT, SAND, AND CLAY				45 39
5						
6		SILTY SAND				$\phi=34^{o}$ $\phi=36^{o}$
7		SILTY CLAY				51 59
8		End dilatometer test at 7.5 m. Refusal on boulder or glacial till.				58

PLATE A-50

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 30/09/87	JOB NO. 87422	HOLE NO. DMT 5

WATER CONTENT — W_p - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION 223.61

SOIL SAMPLE: CONDITION | TYPE | PENETRATION RESISTANCE

DRILL TYPE

OTHER TESTS

WATER

1

2

3

4

5

6

7

8

9

CLAYEY SILT, SILTY CLAY AND SAND

End dilatometer testing at 8.5 m
Refusal on glacial till

UNDRAINED SHEAR STRENGTH (kPa)
— 24
— 34
— $\phi = 39^{o}$

PLATE A-51

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 30/09/87	JOB NO. 87422	HOLE NO. DMT 6

WATER CONTENT — W_P - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60

DEPTH m | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | DRILL TYPE | OTHER TESTS

DATUM

SURFACE ELEVATION 223.61

WATER

1 2 3 4 5 6 7 8 9 10

ALLUVIAL SOILS

11 12

Drill rod pushed from 10.0 to 10.6 m. Refusal on glacial till or boulder at 10.6 m.

PLATE A-52

DYREGROV & BURGESS

BOREHOLE LOG

PROJECT: KILDONAN CORRIDOR

LOGGED/DWN.	CKD.	DATE OF INVEST. 30/09/87	JOB NO. 87422	HOLE NO. DMT 7

WATER CONTENT: W_P - □ W - ○ W_L - △. PERCENT % (10 20 30 40 50 60)

DEPTH m | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | DRILL TYPE | OTHER TESTS

DATUM

SURFACE ELEVATION

1 2 3 4 5 6 7 8 9 10 11 12 13

WATER

GLACIAL TILL - soft/loose

- Drill rods pushed with no rotation from 10.4 to 13.1 m. Refusal on probable bedrock at 13.1 m.

PLATE A-53

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH12-02**

CLIENT CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT
PROJECT Chief Peguis Bridge Sewer Replacement
SITE East of Red River and South of Chief Peguis Trail
LOCATION South of Existing Sewermain on the Upper Bank
DRILLING METHOD Acker Track Drill Rig, 125 mm ø Solid Stem and HQ Core Barrel

JOB NO. 12-0107-018
GROUND ELEV. 228.37
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 11/8/2012
UTM (m) N 5,534,757
E 636,604

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80)	PL MC LL % (20 40 60 80)
	0			**SILTY CLAY FILL** - Brown, moist, stiff, intermediate to high plasticity, some medium to coarse grained sand, some fine grained gravel, trace coarse grained gravel, trace rootlets.			S	1				
	1	5		**SILTY CLAY** - Brown, moist, stiff, high plasticity, trace fine to medium grained sand.								
	2			- Increased sand content below 1.83 m.			S	2				
	3	10		**SILTY SAND** - Brown, moist, loose, fine to medium grained, with silt, trace clay.			S	3				
	4			**SAND** - Brown, moist, compact, fine to medium grained, trace silt.								
	5	15		- Water noticed on sample at ~ 5.49 m.			S	4				
	6	20		**SANDY SILT** - Brown, moist, firm, intermediate to high plasticity, trace oxidation.								
				SILTY SAND - Brown, moist, soft, fine to medium grained, trace oxidation.			S	5				
	7			- Grey, no oxidation below 6.71 m.								
				SAND - Grey, moist, compact, medium grained, some fine and coarse grained sand.								
		25		**SILTY CLAY** - Grey, moist, firm, high plasticity.								
	8			- Medium grained sand layer between 7.39 and 7.47 m.								
				SILTY SAND - Grey, moist, soft, fine to medium grained sand, with silt.			S	6				
				- Organic layer between 8.53 and 8.64 m.								
	9	30		**SILTY CLAY** - Grey, moist, firm, high plasticity, trace fine grained sand.								
				- Increased sand between 9.75 and 9.96 m.			S	7				

SAMPLE TYPE ▨ Auger Grab ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	DRAFT	11/26/12

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH12-02**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
	11	35		- Increased sand between 10.36 and 10.52 m.							
				SILTY SAND - Grey, moist, compact, medium grained, trace fine grained sand, trace clay. - Test hole squeezing at 10.67 m.			S	8			
	12	40		- 25 mm thick organic layer at 12.50 m.							
	13			- Decreased sand between 12.95 and 13.26 m.							
		45					S	9			
	14			**SILTY CLAY** - Grey, moist, firm, high plasticity, trace coarse grained sand, trace fine grained gravel, trace silt nodules.							
	15	50		- Grain Size Distribution: Gravel (1.0%), Sand (8.8%), Silt (21.9%), Clay (57.0%) at 14.63 m.			S	10			
	16			**SILT TILL** - Tan, moist, compact, with medium to coarse grained sand, some fine grained gravel, trace coarse grained gravel. - Loose, decreased gravel below 16.46 m.			S	11			
		55					S	12	100	▲ 2 ▲ 4 ▲ 4	
	17										
	18						S	13			
		60		- Auger refusal at 18.34 m on bedrock. Switched over to core below 18.34 m.							
	19			**LIMESTONE BEDROCK** - White, competent, vertical and horizontal fractures.			R	1	98		
	20	65									
							R	2	98		
	21	70									

SAMPLE TYPE ▦ Auger Grab ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	DRAFT	11/26/12

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH12-02**

ELEVATION (m)	DEPTH (m)	(ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
	22	75		- Increased fractures below 22.94 m. - Vertical fracture between 23.01 and 23.67 m.		22.2		R3	98		
	23										
	24	80						R4	100		
	25					25.8		R5	100		
	26	85		END OF TEST HOLE AT 26.06 m		26.1					
	27	90		Notes: 1. Installed casagrande standpipe at a depth of 26.06 m with a stick-up of 0.84 m. 2. Backfilled test hole with silica sand between 26.06 and 22.17 m and bentonite chips from 22.17 m to grade.							
	28										
	29	95									
	30	100									
	31										
	32	105									
	33	110									

SAMPLE TYPE ▨ Auger Grab ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	DRAFT	11/26/12

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH12-01**

CLIENT CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT

PROJECT Chief Peguis Bridge Sewer Replacement

SITE East of Red River and South of Chief Peguis Trail

LOCATION North of Existing Sewermain on the Lower Bank

DRILLING METHOD Acker Track Drill Rig, 125 mm ø Solid Stem and HQ Core Barrel

JOB NO. 12-0107-018
GROUND ELEV. 226.37
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 11/7/2012
UTM (m) N 5,534,788
E 636,543

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80)	PL MC LL % (20 40 60 80)
	1	5		**SILTY CLAY** - Brown, damp, firm, intermediate plasticity, trace rootlets, trace fine grained sand, trace fine grained gravel.		S1				
	2			**SAND & GRAVEL** - Light grey, moist, dense, medium to coarse grained sand, fine to coarse grained gravel, some clay.		S2				
	3	10		- Hole squeezing at 1.83 m.						
	4					S3				
		15		**SAND** - Brown, moist to wet, loose, fine to medium grained, trace oxidation.						
	5			- Water noticed on sample below 4.57 m.						
				- Grey, no oxidation below 5.33 m.		S4				
	6	20								
				SILTY CLAY - Grey, moist, firm, high plasticity.		S5				
	7			**SAND** - Grey, moist, loose, medium grained, trace coarse grained sand.						
		25								
	8			- Some to with silt, reduced sand below 7.92 m.		S6				
	9	30		**SILTY CLAY** - Grey, moist, firm, high plasticity, trace silt nodules, trace medium grained sand, trace fine grained gravel.						

SAMPLE TYPE Auger Grab Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	DRAFT	11/26/12

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH12-01**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80) / PL MC LL % (20 40 60 80)
	11	35		- Stiff below 10.06 m.	S7				
				- Reduced fine grained gravel below 10.67 m.					
	12	40		- Grain Size Distribution: Gravel (1.2%), Sand (11.7%), Silt (30.5%), Clay (56.6%) at 11.58 m.	S8				
				- Reduced silt nodules below 12.50 m.					
	13			- Firm below 12.95 m. - Grain Size Distribution: Gravel (0.8%), Sand (10.2%), Silt (23.7%), Clay (65.3%) at 13.11 m.	S9				
		45							
	14			**SILTY TILL** - Tan, moist, compact, with medium to coarse grained sand, some fine grained gravel, trace coarse grained gravel.					
				- Loose, reduced coarse grained sand, reduced fine to coarse grained gravel below 14.63 m.	S10				
	15	50							
	16				S11				
		55		- Auger refusal at 16.76 m on bedrock. Switched over to core below 16.76 m.					
	17			**LIMESTONE BEDROCK** - White, fractured with vertical and horizontal fractures.	R1		85		
	18	60			R2		98		
	19				R3		100		
		65		- Clay seam at 19.69 m.					
	20			- Clay between 20.12 and 20.19 m.					
	21				R4		100		
		70		- Yellow fractured limestone between 21.41 and 22.25 m.					

SAMPLE TYPE Auger Grab Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	DRAFT	11/26/12

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH12-01**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
	22	75		· Reduced fractures below 22.25 m.		R5	100		
	23								
	24	80				R6	100		
				· Increased fractures below 24.69 m.					
	25					R7	100		
	26	85		**END OF TEST HOLE AT 25.91 m**					
	27	90		Notes: 1. Water level measured at 15.70 m below grade after drilling. 2. Backfilled test hole with a thick bentonite grout mixture and bentonite chips.					
	28								
	29	95							
	30	100							
	31								
	32	105							
	33								
		110							

SAMPLE TYPE Auger Grab Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	DRAFT	11/26/12

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH12-02B**

CLIENT CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT

PROJECT Chief Peguis Bridge Sewer Replacement

SITE East of Red River and South of Chief Peguis Trail

LOCATION ~3 m West of TH12-02

DRILLING METHOD Acker Track Drill Rig, 125 mm ø Solid Stem

JOB NO. 12-0107-018

GROUND ELEV.

TOP OF PVC ELEV.

WATER ELEV.

DATE DRILLED 11/9/2012

UTM (m) N

E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80) / PL MC LL % (20 40 60 80)
	1	5		**SILTY CLAY FILL** - Brown, moist, stiff, intermediate to high plasticity, some medium to coarse grained sand, some fine grained gravel, trace coarse grained gravel, trace rootlets.							
				SILTY CLAY - Brown, moist, stiff, high plasticity, trace fine to medium grained sand.							
	2			- Increased sand content below 1.83 m.							
				SAND - Brown, moist, compact, fine to medium grained, trace coarse grained sand, trace silt, trace clay.							
	3	10		**SILTY SAND** - Brown, moist, loose, fine to medium grained, with silt, trace clay.							
	4			**SAND** - Brown, moist, compact, fine to medium grained, trace silt.							
	5	15		- Water noticed on sample at ~ 5.49 m.							
				SANDY SILT - Brown, moist, firm, intermediate to high plasticity, trace oxidation.							
	6	20		**SILTY SAND** - Brown, moist, soft, fine to medium grained, trace oxidation.							
				- Grey, no oxidation below 6.71 m.							
	7			**SAND** - Grey, moist, compact, medium grained, some fine and coarse grained sand.							
		25		**SILTY CLAY** - Grey, moist, firm, high plasticity.							
				- Medium grained sand layer between 7.39 and 7.47 m.							
	8			**SILTY SAND** - Grey, moist, soft, fine to medium grained sand, with silt.							
				- Organic layer between 8.53 and 8.64 m.							
	9	30		**SILTY CLAY** - Grey, moist, firm, high plasticity, trace fine grained sand.							
				- Increased sand between 9.75 and 9.96 m.							

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	DRAFT	11/26/12

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH12-02B**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
	11	35		- Increased sand between 10.36 and 10.52 m.						20 40 60	20 40 60 80
				SILTY SAND - Grey, moist, compact, medium grained, trace fine grained sand, trace clay.							
				- Test hole squeezing at 10.67 m.	PN	11.4					
						11.6					
	12	40		- 25 mm thick organic layer at 12.50 m.							
	13			- Decreased sand between 12.95 and 13.26 m.							
		45									
	14			**SILTY CLAY** - Grey, moist, firm, high plasticity, trace coarse grained sand, trace fine grained gravel, trace silt nodules.							
	15	50									
	16			**SILT TILL** - Tan, moist, compact, with medium to coarse grained sand, some fine grained gravel, trace coarse grained gravel.		16.8					
		55		- Loose, decreased gravel below 16.46 m.		17.4					
	17					17.7					
	18	60		**AUGER REFUSAL AT 18.34 m**		18.3					
	19			Notes: 1. Stratigraphy assumed from TH12-02 drilled ~3 m away. 2. Installed casagrande standpipe at a depth of 17.68 m with a slick-up of 0.91 m. 3. Installed PN 034983 at a depth of 11.58 m. below grade. 4. Backfilled test hole with silica sand between 17.68 and 16.76 m and bentonite chips from 16.76 m to grade.							
	20	65									
	21	70									

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	DRAFT	11/26/12

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH12-03**

CLIENT CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT
PROJECT Chief Peguis Bridge Sewer Replacement
SITE West of Red River and South of Chief Peguis Trail
LOCATION North of Existing Sewermain on the Upper Bank
DRILLING METHOD CME Track Drill Rig, 125 mm ø Solid Stem and HQ Core Barrel

JOB NO. 12-0107-018
GROUND ELEV. 230.84
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 11/13/2012
UTM (m) N 5,534,926
E 636,265

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION
	0			**SILTY CLAY FILL** - Black, moist, stiff, high plasticity, trace rootlets.
				- Trace medium to coarse grained sand, trace fine to coarse grained gravel below 0.23 m.
	1	5		**SILTY CLAY** - Brown, moist, stiff, high plasticity, trace coarse grained sand.
				- No sand below 1.22 m.
	2			**SILTY SAND TO SANDY SILT** - Light brown, moist, soft/loose, fine grained sand.
	3	10		**SILTY CLAY** - Brown, moist, stiff, high plasticity, trace silt nodules (~1-3 mm diameter).
				- 10 mm diameter gravel piece at 3.73 m.
	4	15		
	5			- Grey below 5.49 m.
	6	20		- Firm below 6.10 m.
	7	25		
	8			
	9	30		- Slightly increased silt nodules (up to 5 mm diameter) below 9.14 m.

PIEZ. LOG | DEPTH (m) | SAMPLE TYPE NUMBER | RECOVERY %

SAMPLE TYPE: S1, S2, S3, S4, S5, S6

SPT (N) blows/0.15 m ▲
DYNAMIC CONE (N) blows/ft △
20 40 60

Cu POCKET PEN (kPa) ★
Cu TORVANE (kPa) ◆
20 40 60 80
PL MC LL
%
20 40 60 80

SAMPLE TYPE ⊠ Auger Grab ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	DRAFT	11/26/12

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH12-03**

ELEVATION (m)	DEPTH (m) (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ Cu TORVANE (kPa) ◆ PL MC LL %
	11 35					S7			
	12 40		- Trace silt pockets below 12.19 m.			S8			
			- Trace fine grained gravel below 12.50 m.						
	13 45					S9			
	14								
	15 50					S10			
			- Reduced silt, trace coarse grained sand, no fine grained gravel below 15.24 m.						
	16					S11			
	17 55		- Occasional silt pockets/nodules below 16.92 m.						
			- Grain Size Distribution: Gravel (0.7%), Sand (7.5%), Silt (19.4%), Clay (72.4%) at 17.68 m.			S12			
	18 60		- Trace fine grained gravel below 18.29 m.						
	19								
			SILT TILL - Tan with grey, moist, compact, fine to coarse grained sand, fine grained gravel, trace clay.			S13			
	20 65					S14	61	▲ 11 ▲ 1 ▲ 3	
					21.0	S15			
	21 70		- Auger refusal at 21.03 m on bedrock. Switched over to core below 21.03 m.			R1	88		
			LIMESTONE BEDROCK - White, competent, horizontal fractures.						

SAMPLE TYPE ▨ Auger Grab ☒ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	DRAFT	11/26/12

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH12-03**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL / %
	22	75		- Thin clay seam at 21.77 m. - Vertical fracture between 21.84 and 22.05 m.				R2	100	20 40 60	20 40 60 80
	23										
	24	80				23.9		R3	97		
	25										
	26	85						R4	100		
	27					27.6					
	28	90						R5	97		
	29	95		- Rubble zone between 28.46 and 28.52 m. - Vertical fracture between 28.52 and 28.70 m.				R6	100		
	30	100				29.7		R7	100		
	31			**END OF TEST HOLE AT 30.02 m**		30.0					
	32	105		Notes: 1. Installed casagrande standpipe at a depth of 30.02 m with a stick-up of 0.91 m. 2. Backfilled test hole with silica sand between 30.02 and 27.58 m, bentonite chips from 27.58 to 23.93 m, slough from 23.93 to 21.03 m and bentonite chips from 21.03 m to grade.							
	33	110									

SAMPLE TYPE ⊠ Auger Grab ⊠ Split Spoon ▮ Core Barrel

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	DRAFT	11/26/12

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KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH12-03B**

CLIENT CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT

PROJECT Chief Peguis Bridge Sewer Replacement

SITE West of Red River and South of Chief Peguis Trail

LOCATION ~2 m West of TH12-03

DRILLING METHOD CME Track Drill Rig, 125 mm ø Solid Stem

JOB NO. 12-0107-018

GROUND ELEV.

TOP OF PVC ELEV.

WATER ELEV.

DATE DRILLED 11/14/2012

UTM (m) N E

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80) / PL MC LL % (20 40 60 80)
	1	5		**SILTY CLAY FILL** - Black, moist, stiff, high plasticity, trace rootlets. - Trace medium to coarse grained sand, trace fine to coarse grained gravel below 0.23 m.							
				SILTY CLAY - Brown, moist, stiff, high plasticity, trace coarse grained sand.							
				- No sand below 1.22 m.							
	2										
		10		**SILTY SAND TO SANDY SILT** - Light brown, moist, soft/loose, fine grained sand.							
	3										
				SILTY CLAY - Brown, moist, stiff, high plasticity, trace silt nodules (~1-3 mm diameter).							
	4	15		- 10 mm diameter gravel piece at 3.73 m.							
	5			- Grey below 5.49 m.							
	6	20		- Firm below 6.10 m.							
	7										
		25									
	8										
	9	30		- Slightly increased silt nodules (up to 5 mm diameter) below 9.14 m.							

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	DRAFT	11/26/12

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH12-03B**

ELEVATION (m)	DEPTH (m)	(ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
	11	35			PN	11.6				20 40 60	20 40 60 80
	12	40		- Trace silt pockets below 12.19 m.		11.8					
				- Trace fine grained gravel below 12.50 m.							
	13	45									
	14										
	15	50		- Reduced silt, trace coarse grained sand, no fine grained gravel below 15.24 m.							
	16										
	17	55		- Ocassional silt pockets/nodules below 16.92 m.							
	18	60		- Trace fine grained gravel below 18.29 m.							
	19										
	20	65		SILT TILL - Tan with grey, moist, compact, fine to coarse grained sand, fine grained gravel, trace clay.		20.1					
						20.7					
	21	70		AUGER REFUSAL AT 20.98 m		21.0					
				Notes: 1. Stratigraphy assumed from TH12-03 drilled ~2 m away.							

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	DRAFT	11/26/12

GEOTECHNICAL SOIL LOG P:\PROJECTS\2012\12-0107-018\DESIGN\GEO\LOGS\CHIEF PEGUIS TRAIL SEWERMAIN.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH12-03B**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △ (20 40 60)	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ (20 40 60 80) / PL MC LL % (20 40 60 80)
	22			2. Installed casagrande standpipe at a depth of 20.98 m with a stick-up of 0.66 m. 3. Installed PN 034985 at a depth of 11.64 m. below grade. 4. Backfilled test hole with silica sand between 20.98 and 20.12 m and bentonite chips from 20.12 m to grade. 5. Test hole squeezing at 8.53 m shortly after drilling.						
	23	75									
	24	80									
	25										
	26	85									
	27	90									
	28										
	29	95									
	30	100									
	31										
	32	105									
	33	110									

SAMPLE TYPE

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	C. FRIESEN	DRAFT	11/26/12

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2012\2012-0107-013\DESIGN\GEO\LOGS\CHIEF PEGUIS TRAIL SEWERMAIN.GPJ

Appendix C

Laboratory Testing Results

TREK GEOTECHNICAL

Lab Requisition

TREK GEOTECHNICAL
1712 St. James Street
Winnipeg, Manitoba R3H 0L3
T 204.975.9433 F 204.975.9435

PROJECT: Detailed Design N.K. Feedermain PROJECT NO: 0115 004 00

CLIENT: Associated Engineering FIELD TECHNICIAN: SR

TEST HOLE NUMBER	SAMPLE NUMBER	DEPTH OF SAMPLE	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILLARY TESTS					Soil Description/ Comments
H13-01	G29	0.5-1'		X											CLAY (FILL)
	G30	3-3.5'		X											CLAY (FILL)
	G31	4.5-5'		X											CLAY (FILL).
	G32	6-7'		X											CLAY
	G33	9.5-10'		X											ALLUVIAL SILT
	T34	10-12'				X				X					-11-
	G35	14-14.5'		X											-11-
	SB36A	15.5-16.5'		X											-11-
	SB36B	17.5-18.5'		X											11
	SB36C	19.5-20'		X											11
	SB37A	20-21		X											11
	SB37B	21'6"-21'8"		X											11
	SB37C	24-24.5'		X											11
	SB38A	26-27'		X											11
	SB38B	28-29'		X											Sand Silty
	SB39	33-34'		X			X								11
	SB40	37-38		X											11 Silt
	T41	40-42'								X					Sand silty / Clayey - maybe transition
	SB42A	42-43.5'		X											w Sand silty
	SB42B	43.5-45'		X		/	X								Silt Clayey
	SB43	49-50'		X			X								Sand
	SS44	50-51.5'		X											11
	SS45B	55-56.5'		X											Till
	SS45A	54-55'									SLOUGH (TILL)				NO MOISTURE (JUST TO LOOK)
✓	CB56	55'6"-61'													
✓	CB57	61'-66'													
✓	CB58	66'-71'													
✓	CB59	71'-76'													
✓	CB60	76'-81'													
✓	CB61	81-86													
✓	CB62	86-91'													
✓	CB63	91'-96'													
✓	CB64	96'-101'													
✓	CB65	101-106'													
✓	CB66	106'-111'													
✓	CB67	111'-116'													
✓	CB68	116'-121'													

REQUESTED BY: BT

REQUISTION DATE: Nov 15/13

REPORT TO: NJF

REQUISITION NO.

SHEET 1 OF 3

TREK GEOTECHNICAL

Lab Requisition

TREK GEOTECHNICAL
1712 St. James Street
Winnipeg, Manitoba R3H 0L3
T 204.975.9433 F 204.975.9435

PROJECT: Detailed Design N.K. Feedermain PROJECT NO: 0115 004 00

CLIENT: Associated Engineering FIELD TECHNICIAN: SR / BH.

TEST HOLE NUMBER	SAMPLE NUMBER	DEPTH OF SAMPLE	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILLARY TESTS	Rock Tube + visual				Soil Description/ Comments
TH13-04	SB1	6'-8'		X											CLAY
	SB2	8'-10'													
	T3	10'-12'													
	SB4	12'-14'													
	SB5	14'-16'													
	SB6	16'-18'													
	SB7	18'-20'													
	T8	20'-22'													
	SB9	22'-24'													
	SB10	24'-26'													
	SB11	26'-28'													
	SB12	28'-30'													
	T13	30'-32'													
	SB14	32'-34'													
	SB15	34'-36'													
	SB16	36'-38'													
	SB17	38'-40'													
	T18	40'-42'													may be transition
	SB19	42'-44'													
	SB20	44'-46'													
	SB21	46'-48'													
	SB22	49'4"-50'													SILT (TILL)
SS	SB23	50'-51.5'													CLAY
	SB24	52'-54'													SILT (TILL)
SS	SB25	54'-54'4"													SILT (TILL)
	CB26	55'8"-61'													ROCK (Boulder)
	CB27	61'-66'													limestone
	CB28	66'-71'													limestone
TH13-04 (adjacent)	*G29	1.5-2.5'													CLAY
	*G30	4'-5'													
	*G31	6'-7'													
	*G32	9-10'													

* Re label sample tags : G29 → 46
G30 → 47
G31 → 48
G32 → 49.

REQUESTED BY: BT

REQUISITION DATE: Nov 15/13

REPORT TO: NJF

REQUISITION NO.

SHEET 2 OF 3

TREK GEOTECHNICAL

Lab Requisition

TREK GEOTECHNICAL
1712 St. James Street
Winnipeg, Manitoba R3H 0L3
T 204.975.9433 F 204.975.9435

PROJECT: Detailed Design N.K. Feedermain PROJECT NO: 0115 004 00

CLIENT: Associated Engineering FIELD TECHNICIAN: ML

TEST HOLE NUMBER	SAMPLE NUMBER	DEPTH OF SAMPLE	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILLARY TESTS					Soil Description/ Comments
TH13-05	SS-69	53'-54'5"		✓											
	CB70	53.5'-55'													
	CB71	55'-60'													
	CB72	60'-65'													
	CB73	65'-70'													
	CB74	70'-75'													
	CB75	75'-79'10"													
	CB76	79'10"-84'8"													
	CB77	84'8"-89'7"													
	CB78	89'7"-94'3"													
	CB79	94'3"-99'1"													
	CB80	99'1"-102'6"													
	CB81	102'6"-106'													
	CB82	106'-110"													
	CB83	110'-115'													

REQUESTED BY: BT

REQUISITION DATE: Nov 15/13

REPORT TO: NJF

REQUISITION NO.

SHEET 3 OF 3

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Moisture Content Report
ASTM D2216-98

Project No. 0115 004 00
Client Associated Engineering
Project Detailed Design North Kildonan Feedermain

Sample Date 22-Oct-13
Test Date 24-Oct-13
Technician Chiran Peiris

Test Hole	TH13-01	TH13-01	TH13-01	TH13-01	TH13-01	TH13-01
Depth (m)	0.2 - 0.3	0.9 - 1.1	1.4 - 1.5	1.8 - 2.1	2.9 - 4.6	5.9 - 6.1
Sample #	G29	G30	G31	G32	G33	G35
Tare ID	P30	K3	F32	F124	D8	N99
Mass of tare	8.3	8.4	8.2	8.3	8.4	8.4
Mass wet + tare	339.3	399.8	439.9	224.7	390.2	403.8
Mass dry + tare	270.3	327.4	352.9	191.4	306.6	309.4
Mass water	69.0	72.4	87.0	33.3	83.6	94.4
Mass dry soil	262.0	319.0	344.7	183.1	298.2	301.0
Moisture %	26.3%	22.7%	25.2%	18.2%	28.0%	31.4%

Test Hole	TH13-01	TH13-01	TH13-01	TH13-01	TH13-01	TH13-01
Depth (m)	4.3 - 4.4	4.7 - 4.9	5.3 - 5.6	6.1 - 6.4	6.6 - 6.6	7.3 - 7.5
Sample #	SB 36A	SB 36B	SB 36C	SB 37A	SB 37B	SB 37C
Tare ID	F104	E10	Z30	Z75	F102	F66
Mass of tare	8.5	8.8	8.3	8.4	8.5	8.4
Mass wet + tare	588	468.8	653.3	446.3	387.3	649.9
Mass dry + tare	444.3	363.1	479.5	334.3	296.3	498.5
Mass water	143.7	105.7	173.8	112.0	91.0	151.4
Mass dry soil	435.8	354.3	471.2	325.9	287.8	490.1
Moisture %	33.0%	29.8%	36.9%	34.4%	31.6%	30.9%

Test Hole	TH13-01	TH13-01	TH13-01	TH13-01	TH13-01	TH13-01
Depth (m)	7.9 - 8.2	8.5 - 8.8	10.1 - 10.4	11.3 - 11.6	12.8 - 13.3	13.3 - 13.7
Sample #	SB 38A	SB 38B	SB 39	SB 40	SB 42A	SB 42B
Tare ID	H79	E96	N90	Z64	Z101	F33
Mass of tare	8.4	8.6	8.5	8.2	8.3	8.4
Mass wet + tare	398.0	599.7	656.3	470.9	474.1	457.6
Mass dry + tare	296.2	486.4	501.9	379.0	386.3	361.1
Mass water	101.8	113.3	154.4	91.9	87.8	96.5
Mass dry soil	287.8	477.8	493.4	370.8	378.0	352.7
Moisture %	35.4%	23.7%	31.3%	24.8%	23.2%	27.4%

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Moisture Content Report
ASTM D2216-98

Project No. 0115 004 00
Client Associated Engineering
Project Detailed Design North Kildonan Feedermain

Sample Date 22-Oct-13
Test Date 24-Oct-13
Technician Chiran Peiris

Test Hole	TH13-01	TH13-01	TH13-01	TH13-04	TH13-04	TH13-04
Depth (m)	14.9 - 15.2	15.2 - 15.7	16.8 - 17.2	1.8 - 2.4	2.4 - 3.0	3.7 - 4.3
Sample #	SB 43	SB 44	SB 45B	SB 1	SB 2	SB 4
Tare ID	W39	F29	N54	F56	D29	Z50
Mass of tare	8.2	8.3	8.3	8.2	8.1	8.2
Mass wet + tare	403.8	379.1	294.2	359.7	403.0	626.7
Mass dry + tare	318.9	315.9	268.0	228.2	258.3	410.1
Mass water	84.9	63.2	26.2	131.5	144.7	216.6
Mass dry soil	310.7	307.6	259.7	220.0	250.2	401.9
Moisture %	27.3%	20.5%	10.1%	59.8%	57.8%	53.9%

Test Hole	TH13-04	TH13-04	TH13-04	TH13-04	TH13-04	TH13-04
Depth (m)	4.3 - 4.9	4.9 - 5.5	5.5 - 6.1	6.7 - 7.3	7.3 - 7.9	7.9 - 8.5
Sample #	SB 5	SB 6	SB 7	SB 9	SB 10	SB 11
Tare ID	N71	N37	H41	N68	P21	W16
Mass of tare	8.4	8.6	8.4	8.3	8.5	8.3
Mass wet + tare	466.7	502.5	369.4	402.5	481.1	505.9
Mass dry + tare	306.8	327.4	250.7	283.3	326.2	344.5
Mass water	159.9	175.1	118.7	119.2	154.9	161.4
Mass dry soil	298.4	318.8	242.3	275.0	317.7	336.2
Moisture %	53.6%	54.9%	49.0%	43.3%	48.8%	48.0%

Test Hole	TH13-04	TH13-04	TH13-04	TH13-04	TH13-04	TH13-04
Depth (m)	8.5 - 9.1	9.8 - 10.4	10.4 - 11.0	11.0 - 11.6	11.6 - 12.2	12.8 - 13.4
Sample #	SB 12	SB 14	SB 15	SB 16	SB 17	SB 19
Tare ID	F89	F53	F55	Z130	W27	A103
Mass of tare	8.3	8.5	8.4	8.3	8.2	8.4
Mass wet + tare	649.4	602.3	542.2	781.3	552.8	551.4
Mass dry + tare	421.3	472.1	363.0	520.3	354.8	382.3
Mass water	228.1	130.2	179.2	261.0	198.0	169.1
Mass dry soil	413.0	463.6	354.6	512.0	346.6	373.9
Moisture %	55.2%	28.1%	50.5%	51.0%	57.1%	45.2%

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Moisture Content Report
ASTM D2216-98

Project No. 0115 004 00
Client Associated Engineering
Project Detailed Design North Kildonan Feedermain

Sample Date 22-Oct-13
Test Date 24-Oct-13
Technician Chiran Peiris

Test Hole	TH13-04	TH13-04	TH13-04	TH13-04	TH13-04	TH13-04
Depth (m)	13.4 - 14.0	14.0 - 14.6	15.1 - 15.2	15.2 - 15.7	15.8 - 16.5	16.5 - 16.6
Sample #	SB 20	SB 21	SB 22	SB 23	SB 24	SB 25
Tare ID	A26	E38	W65	W15	P08	F14
Mass of tare	8.2	8.3	8.3	8.3	8.5	8.5
Mass wet + tare	402.6	568.1	582.7	350.7	486.7	337.1
Mass dry + tare	265.1	415.6	529.6	261.9	439.4	310.3
Mass water	137.5	152.5	53.1	88.8	47.3	26.8
Mass dry soil	256.9	407.3	521.3	253.6	430.9	301.8
Moisture %	53.5%	37.4%	10.2%	35.0%	11.0%	8.9%

Test Hole	TH13-04	TH13-04	TH13-04	TH13-04		
Depth (m)	0.5 - 0.8	1.2 - 1.5	1.8 - 2.1	2.7 - 3.0		
Sample #	G46	G47	G48	G49		
Tare ID	D15	K1	N65	N72		
Mass of tare	8.4	8.3	8.4	8.4		
Mass wet + tare	366.8	373.1	414.0	380.5		
Mass dry + tare	296.0	294.2	260.6	244.0		
Mass water	70.8	78.9	153.4	136.5		
Mass dry soil	287.6	285.9	252.2	235.6		
Moisture %	24.6%	27.6%	60.8%	57.9%		

Test Hole						
Depth (m)						
Sample #						
Tare ID						
Mass of tare						
Mass wet + tare						
Mass dry + tare						
Mass water						
Mass dry soil						
Moisture %						

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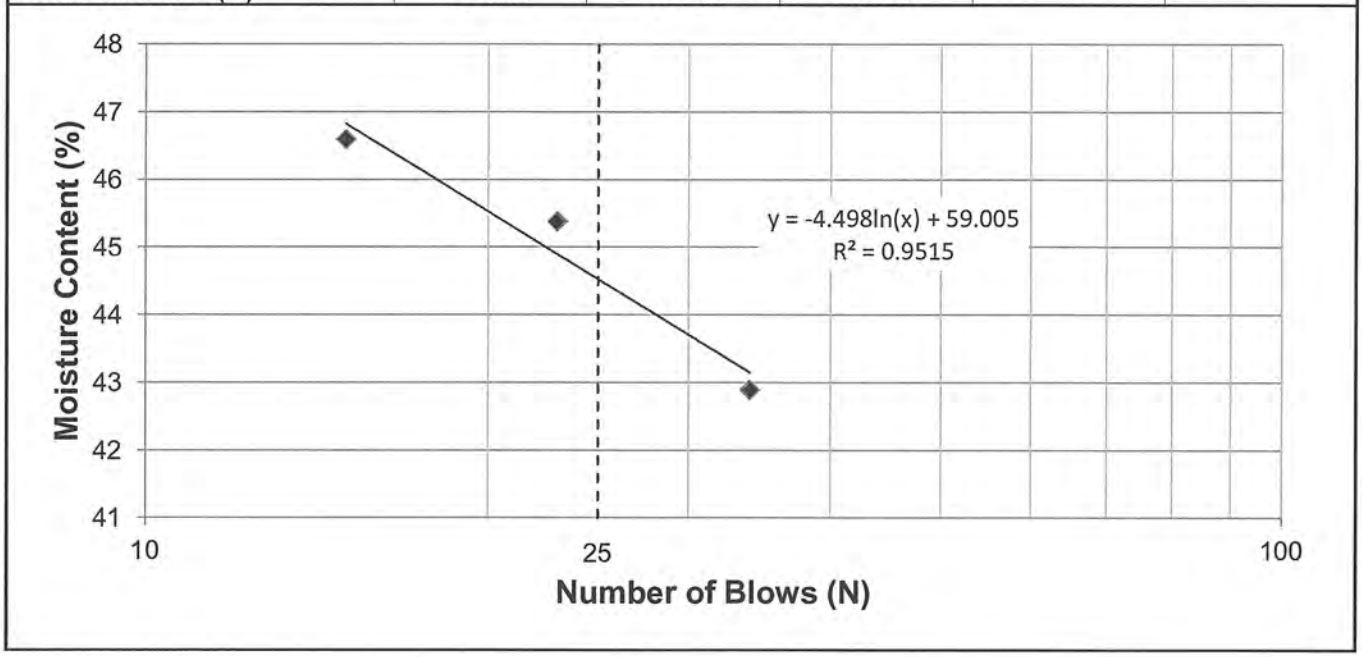
Atterberg Limits
ASTM D4318

Project No.	0115 004 00
Client	Associated Engineering
Project	Detailed design of North Kildonan Feedermain
Test Hole	TH13-01
Sample #	T 34
Depth (m)	3-3.5
Sample Date	12-Nov-13
Test Date	25-Nov-13
Technician	Chiran Peiris

Liquid Limit	45
Plastic Limit	15
Plasticity Index	29

Liquid Limit

Trial #	1	2	3	4	5
Number of Blows (N)	34	15	23		
Mass Wet Soil + Tare (g)	18.021	19.111	19.345		
Mass Dry Soil + Tare (g)	16.832	17.544	17.640		
Mass Tare (g)	14.060	14.181	13.883		
Mass Water (g)	1.189	1.567	1.705		
Mass Dry Soil (g)	2.772	3.363	3.757		
Moisture Content (%)	42.893	46.595	45.382		



Plastic Limit

Trial #	1	2	3	4	5
Mass Wet Soil + Tare (g)	20.660	20.395			
Mass Dry Soil + Tare (g)	19.799	19.534			
Mass Tare (g)	14.222	13.986			
Mass Water (g)	0.861	0.861			
Mass Dry Soil (g)	5.577	5.548			
Moisture Content (%)	15.438	15.519			

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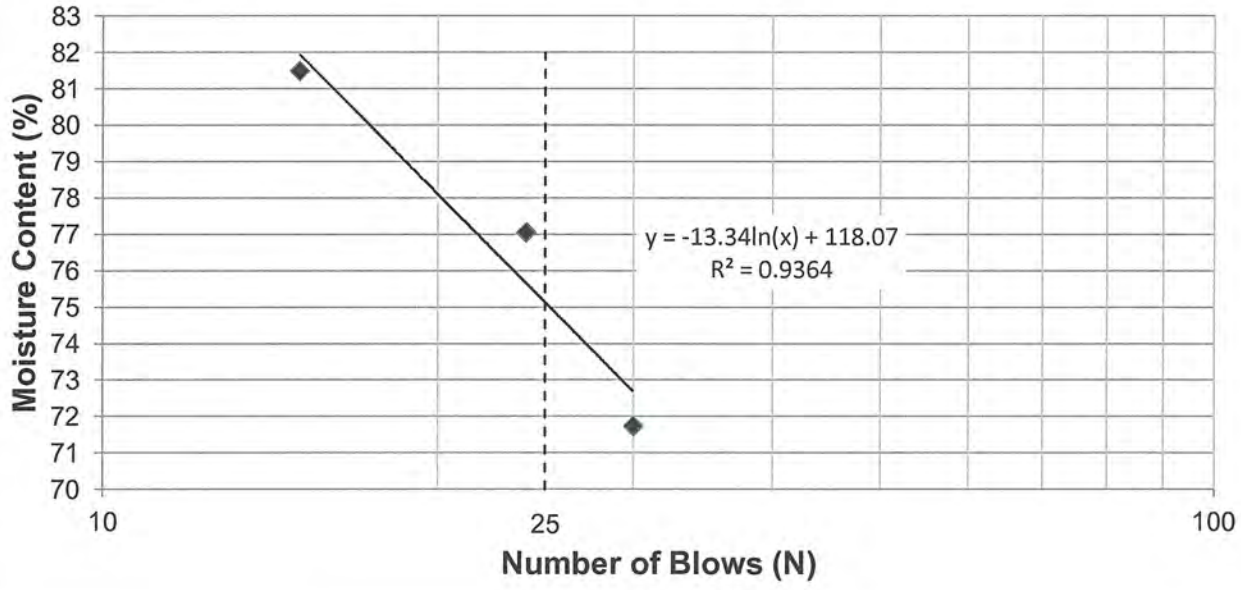
Atterberg Limits
ASTM D4318

Project No.	0115 004 00
Client	Associated Engineering
Project	Detailed design of North Kildonan Feedermain
Test Hole	TH13-01
Sample #	T 08
Depth (m)	6-6.7
Sample Date	15-Nov-13
Test Date	25-Nov-13
Technician	Chiran Peiris

Liquid Limit	75
Plastic Limit	18
Plasticity Index	57

Liquid Limit

Trial #	1	2	3	4	5
Number of Blows (N)	30	24	15		
Mass Wet Soil + Tare (g)	19.850	20.389	18.145		
Mass Dry Soil + Tare (g)	17.367	17.635	16.305		
Mass Tare (g)	13.906	14.061	14.047		
Mass Water (g)	2.483	2.754	1.840		
Mass Dry Soil (g)	3.461	3.574	2.258		
Moisture Content (%)	71.742	77.057	81.488		



Plastic Limit

Trial #	1	2	3	4	5
Mass Wet Soil + Tare (g)	20.611	20.638			
Mass Dry Soil + Tare (g)	19.619	19.630			
Mass Tare (g)	14.222	13.967			
Mass Water (g)	0.992	1.008			
Mass Dry Soil (g)	5.397	5.663			
Moisture Content (%)	18.381	17.800			

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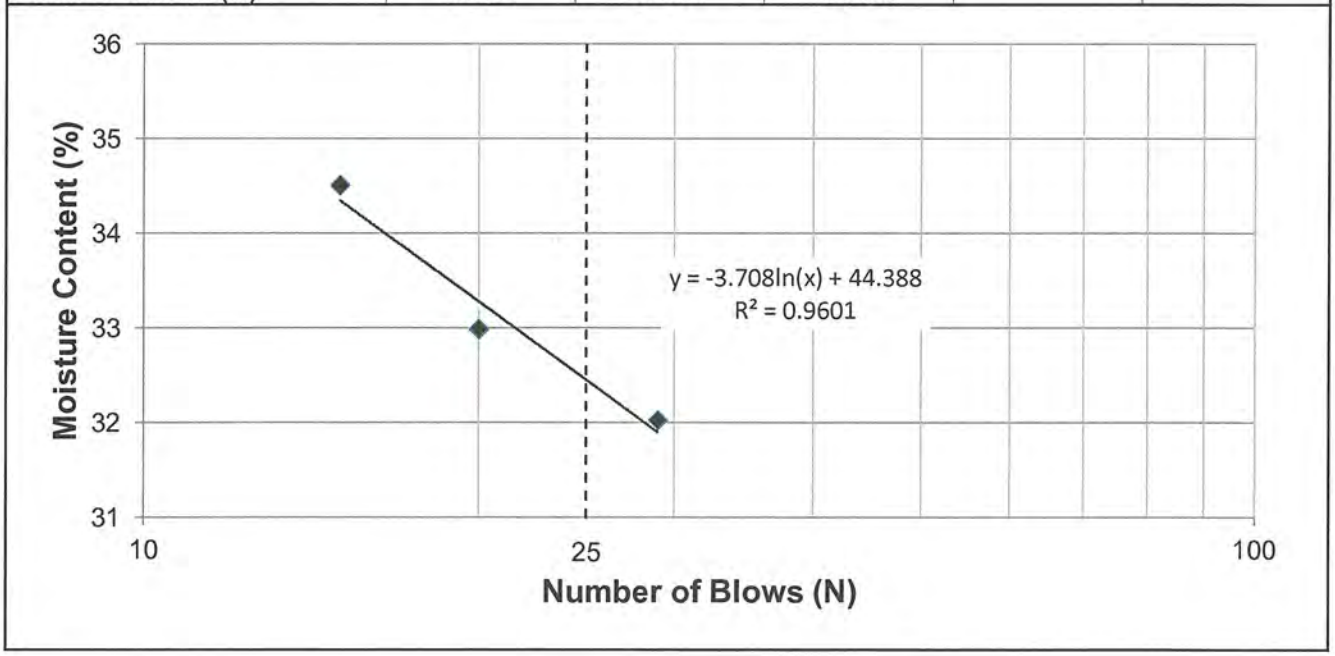
Atterberg Limits
ASTM D4318

Project No.	0115 004 00
Client	Associated Engineering
Project	Detailed design of North Kildonan Feedermain
Test Hole	TH13-01
Sample #	SB 42B
Depth (m)	13-13.7
Sample Date	15-Nov-13
Test Date	25-Nov-13
Technician	Chiran Peiris

Liquid Limit	32
Plastic Limit	15
Plasticity Index	17

Liquid Limit

Trial #	1	2	3	4	5
Number of Blows (N)	15	20	29		
Mass Wet Soil + Tare (g)	19.717	20.793	21.239		
Mass Dry Soil + Tare (g)	18.267	19.125	19.516		
Mass Tare (g)	14.065	14.069	14.136		
Mass Water (g)	1.450	1.668	1.723		
Mass Dry Soil (g)	4.202	5.056	5.380		
Moisture Content (%)	34.507	32.991	32.026		



Plastic Limit

Trial #	1	2	3	4	5
Mass Wet Soil + Tare (g)	20.928	20.248			
Mass Dry Soil + Tare (g)	20.033	19.440			
Mass Tare (g)	14.121	14.019			
Mass Water (g)	0.895	0.808			
Mass Dry Soil (g)	5.912	5.421			
Moisture Content (%)	15.139	14.905			

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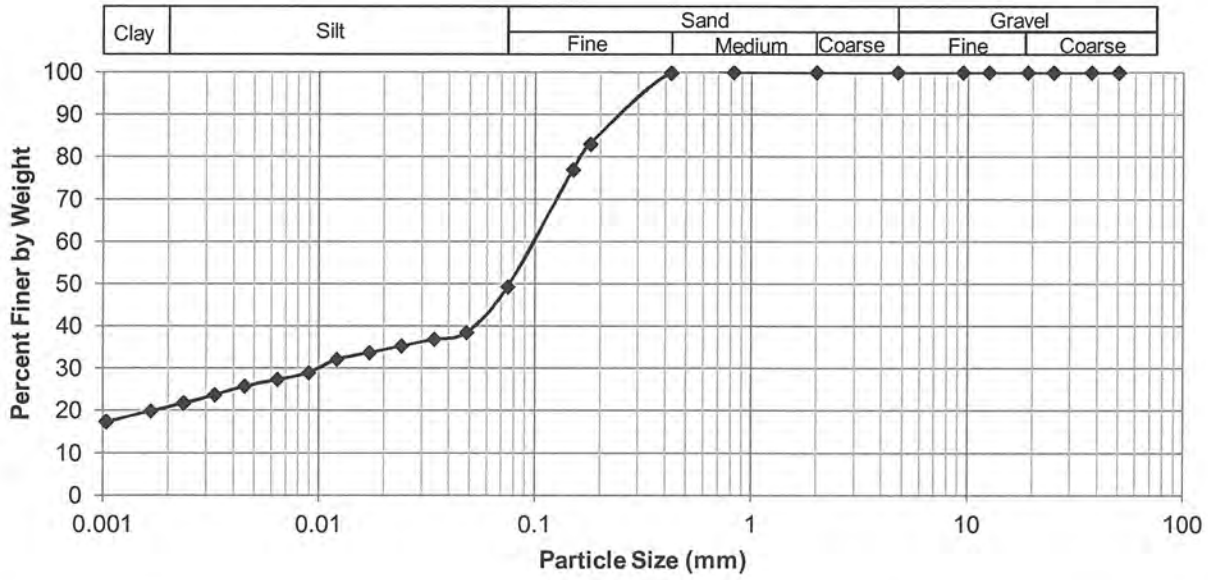
Grain Size Analysis (Hydrometer Method)
ASTM D422

Project No.	0115 004 00
Client	Associated Engineering
Project	Detailed Design North Kildonan Feedermain
Test Hole	TH13-01
Sample #	SB 39
Depth (m)	4.6 - 5.0
Sample Date	15-Nov-13
Test Date	22-Nov-13
Technician	Chiran Peiris

Gravel	0.0%
Sand	50.7%
Silt	27.3%
Clay	22.0%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	100.00	0.0750	49.26
37.5	100.00	2.00	100.00	0.0484	38.46
25.0	100.00	0.825	100.00	0.0343	36.87
19.0	100.00	0.425	99.84	0.0242	35.28
12.5	100.00	0.180	83.00	0.0171	33.69
9.50	100.00	0.150	76.96	0.0121	32.11
4.75	100.00	0.075	49.26	0.0089	28.93
				0.0064	27.34
				0.0045	25.75
				0.0033	23.74
				0.0024	21.74
				0.0017	19.86
				0.0010	17.39

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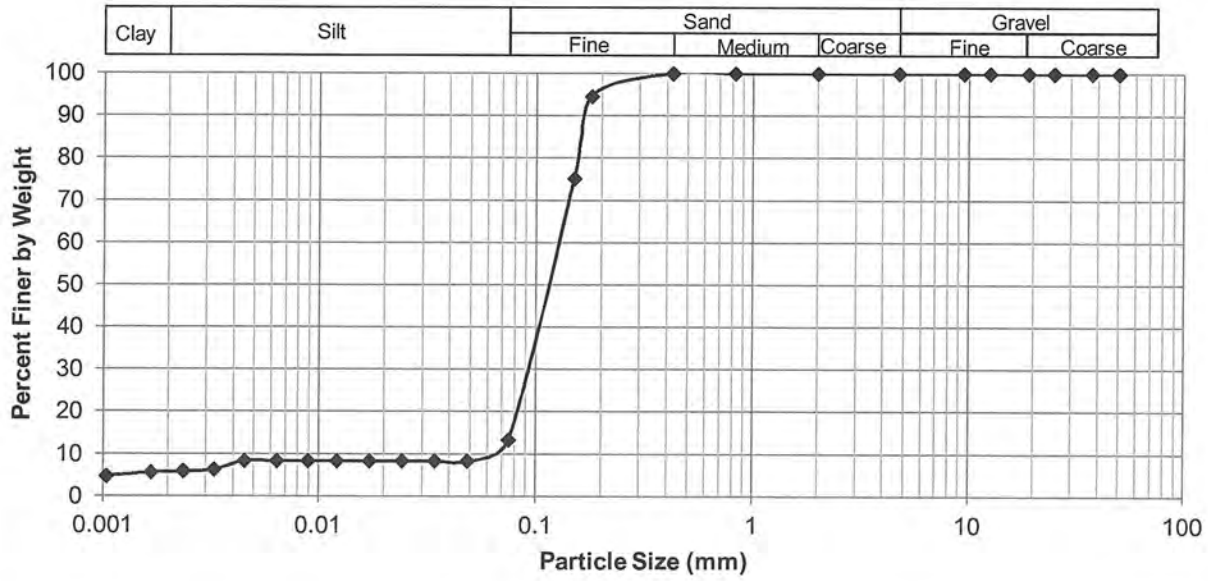
Grain Size Analysis (Hydrometer Method)
ASTM D422

Project No.	0115 004 00
Client	Associated Engineering
Project	Detailed Design North Kildonan Feedermain
Test Hole	TH13-01
Sample #	SB 43
Depth (m)	4.6 - 5.0
Sample Date	15-Nov-13
Test Date	22-Nov-13
Technician	Chiran Peiris

Gravel	0.0%
Sand	50.7%
Silt	27.3%
Clay	22.0%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	100.00	0.0750	13.29
37.5	100.00	2.00	100.00	0.0484	8.28
25.0	100.00	0.825	99.98	0.0343	8.28
19.0	100.00	0.425	99.96	0.0242	8.28
12.5	100.00	0.180	94.55	0.0171	8.28
9.50	100.00	0.150	75.09	0.0121	8.28
4.75	100.00	0.075	13.29	0.0089	8.28
				0.0064	8.28
				0.0045	8.28
				0.0033	6.27
				0.0024	5.86
				0.0017	5.57
				0.0010	4.68

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Shelby Tube Visual

Project No.	0115 004 00
Client	Associated Engineering
Project	Detailed Design North Kildonan Feedermain
Test Hole	TH13-01
Sample #	T34
Depth (m)	3.0 - 3.7
Sample Date	15-Nov-13
Test Date	20-Nov-13
Technician	Hachem Ahmed

Tube Extraction

Recovery (mm) 550

Bottom - 3.7 m **3.0 m - Top**

PP Tv Visual Moisture	Some clay	Qu γ_{Bulk} With clay
180 mm	210 mm	160 mm

Visual Classification

Material	Silt (Alluvial)
Composition	Some clay to with clay
Trace sand	
Trace oxidation	
Trace organics (roots)	
Color	dark grey
Moisture	moist
Consistency	stiff
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.70
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	68.7

Pocket Penetrometer

Reading	**1**	1.30
	2	1.60
	3	1.40
	Average	1.43
Undrained Shear Strength (kPa)		70.3

Moisture Content

Tare ID	N03
Mass tare (g)	8.4
Mass wet + tare (g)	493.8
Mass dry + tare (g)	370.3
Moisture %	34.1%

Unit Weight

Bulk Weight (g)		1097.00
Length (mm)	**1**	140.95
	2	140.82
	3	140.93
	4	140.14
Average Length (m)		0.141
Diam. (mm)	**1**	71.94
	2	71.66
	3	72.51
	4	72.37
Average Diameter (m)		0.072
Volume (m^3)		5.75E-04
Bulk Unit Weight (kN/m^3)		18.7
Bulk Unit Weight (pcf)		119.1
Dry Unit Weight (kN/m^3)		14.0
Dry Unit Weight (pcf)		88.8

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Unconfined Compressive Strength
ASTM D2166

Project No.	0115 004 00
Client	Associated Engineering
Project	Detailed Design North Kildonan Feedermain
Test Hole	TH13-01
Sample #	T34
Depth (m)	3.0 - 3.7
Sample Date	15-Nov-13
Test Date	20-Nov-13
Technician	Hachem Ahmed

Unconfined Strength

	kPa	ksf
Max q_u	45.1	0.9
Max S_u	22.5	0.5

Specimen Data

Description Silt (Alluvial) - Some clay to with clay, Trace sand, Trace oxidation, Trace organics (roots), dark grey, moist, stiff, high plasticity

Length	140.7	(mm)
Diameter	72.1	(mm)
L/D Ratio	2.0	
Initial Area	0.00409	(m^2)
Load Rate	1.00	(%/min)

Moisture %	34%	
Bulk Unit Wt.	18.7	(kN/m^3)
Dry Unit Wt.	14.0	(kN/m^3)
Liquid Limit	-	
Plastic Limit	-	
Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	**kPa**	**ksf**
0.70	68.7	1.43

Vane Size
m

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	**kPa**	**ksf**
1.30	63.8	1.33
1.60	78.5	1.64
1.40	68.7	1.43
1.43	**70.3**	**1.47**

Failure Geometry

Sketch:

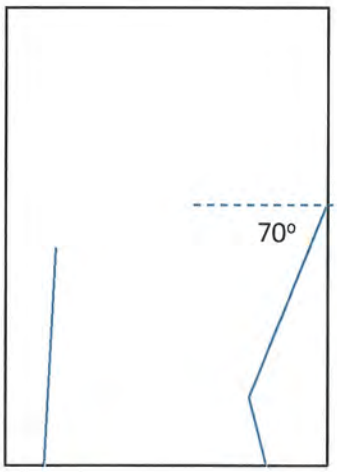

Photo:

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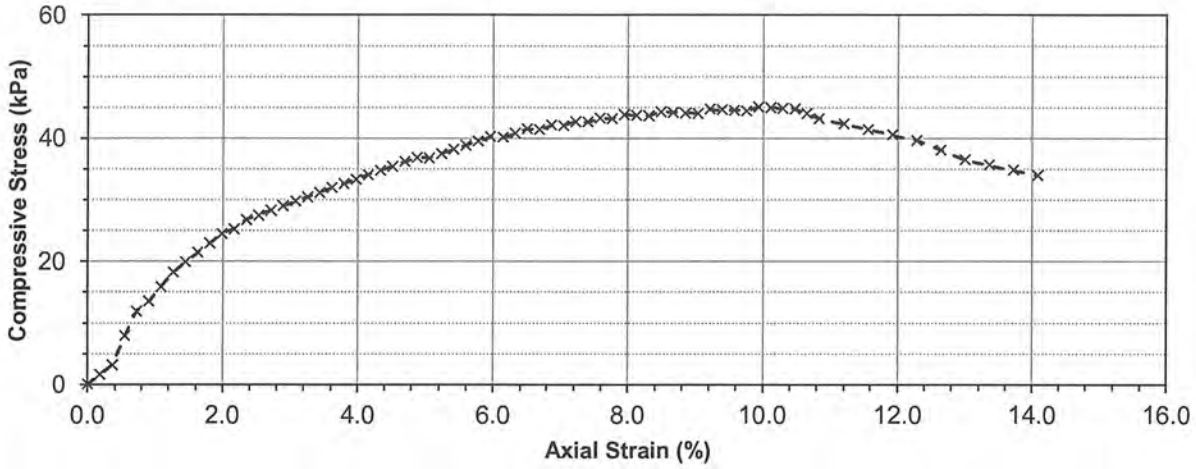
Unconfined Compressive Strength
ASTM D2166

Project No. 0115 004 00
Client Associated Engineering
Project Detailed Design North Kildonan Feedermain

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0	0.0000	0.00	0.004085	0.0	0.00	0.00
10	2	0.2540	0.18	0.004092	6.5	1.60	0.80
20	4	0.5080	0.36	0.004100	13.1	3.19	1.59
30	10	0.7620	0.54	0.004107	32.7	7.96	3.98
40	15	1.0160	0.72	0.004115	49.1	11.93	5.97
50	17	1.2700	0.90	0.004122	55.7	13.50	6.75
60	20	1.5240	1.08	0.004130	65.5	15.86	7.93
70	23	1.7780	1.26	0.004137	75.3	18.21	9.11
80	25	2.0320	1.44	0.004145	82.4	19.89	9.94
90	27	2.2860	1.62	0.004153	89.0	21.43	10.72
100	29	2.5400	1.81	0.004160	95.6	22.98	11.49
110	31	2.7940	1.99	0.004168	102.2	24.53	12.26
120	32	3.0480	2.17	0.004176	105.5	25.27	12.63
130	34	3.3020	2.35	0.004183	112.1	26.80	13.40
140	35	3.5560	2.53	0.004191	115.4	27.53	13.77
150	36	3.8100	2.71	0.004199	118.7	28.27	14.13
160	37	4.0640	2.89	0.004207	122.0	29.00	14.50
170	38	4.3180	3.07	0.004214	125.3	29.73	14.87
180	39	4.5720	3.25	0.004222	128.6	30.46	15.23
190	40	4.8260	3.43	0.004230	131.9	31.18	15.59
200	41	5.0800	3.61	0.004238	135.2	31.90	15.95
210	42	5.3340	3.79	0.004246	138.5	32.61	16.31
220	43	5.5880	3.97	0.004254	141.8	33.32	16.66
230	44	5.8420	4.15	0.004262	145.1	34.03	17.02

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Unconfined Compressive Strength
ASTM D2166

Project No. 0115 004 00
Client Associated Engineering
Project Detailed Design North Kildonan Feedermain

Unconfined Compression Test Data (cont'd)

Elapsed Time (s)	Axial Disp. (mm)	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	45	6.0960	4.3323	0.004270	148.3	34.74	17.37
250	46	6.3500	4.51	0.004278	151.7	35.46	17.73
260	47	6.6040	4.69	0.004286	155.0	36.16	18.08
270	48	6.8580	4.87	0.004294	158.3	36.85	18.43
280	48	7.1120	5.05	0.004303	158.3	36.78	18.39
290	49	7.3660	5.23	0.004311	161.6	37.48	18.74
300	50	7.6200	5.42	0.004319	164.9	38.17	19.08
310	51	7.8740	5.60	0.004327	168.1	38.86	19.43
320	52	8.1280	5.78	0.004336	171.4	39.54	19.77
330	53	8.3820	5.96	0.004344	174.7	40.22	20.11
340	53	8.6360	6.14	0.004352	174.7	40.15	20.07
350	54	8.8900	6.32	0.004361	178.0	40.82	20.41
360	55	9.1440	6.50	0.004369	181.4	41.51	20.75
370	55	9.3980	6.68	0.004377	181.4	41.43	20.71
380	56	9.6520	6.86	0.004386	184.6	42.10	21.05
390	56	9.9060	7.04	0.004394	184.6	42.02	21.01
400	57	10.1600	7.22	0.004403	187.9	42.68	21.34
410	57	10.4140	7.40	0.004412	187.9	42.60	21.30
420	58	10.6680	7.58	0.004420	191.2	43.26	21.63
430	58	10.9220	7.76	0.004429	191.2	43.18	21.59
440	59	11.1760	7.94	0.004438	194.5	43.84	21.92
450	59	11.4300	8.12	0.004446	194.5	43.75	21.87
460	59	11.6840	8.30	0.004455	194.5	43.66	21.83
470	60	11.9380	8.48	0.004464	197.8	44.31	22.16
480	60	12.1920	8.66	0.004473	197.8	44.23	22.11
490	60	12.4460	8.85	0.004481	197.8	44.14	22.07
500	60	12.7000	9.03	0.004490	197.8	44.05	22.03
510	61	12.9540	9.21	0.004499	201.1	44.70	22.35
520	61	13.2080	9.39	0.004508	201.1	44.61	22.30
530	61	13.4620	9.57	0.004517	201.1	44.52	22.26
540	61	13.7160	9.75	0.004526	201.1	44.43	22.22
550	62	13.9700	9.93	0.004535	204.4	45.07	22.53
560	62	14.2240	10.11	0.004544	204.4	44.98	22.49
570	62	14.4780	10.29	0.004554	204.4	44.89	22.44
580	62	14.7320	10.47	0.004563	204.4	44.80	22.40
590	61	14.9860	10.65	0.004572	201.1	43.99	21.99
600	60	15.2400	10.83	0.004581	197.8	43.18	21.59
620	59	15.7480	11.19	0.004600	194.5	42.29	21.14
640	58	16.2560	11.55	0.004619	191.2	41.40	20.70
660	57	16.7640	11.91	0.004638	187.9374	40.52	20.26
680	56	17.2720	12.27	0.004657	184.6457	39.65	19.83
700	54	17.7800	12.64	0.004676	178.0178	38.07	19.04
720	52	18.2880	13.00	0.004695	171.4345	36.51	18.26
740	51	18.7960	13.36	0.004715	168.1428	35.66	17.83

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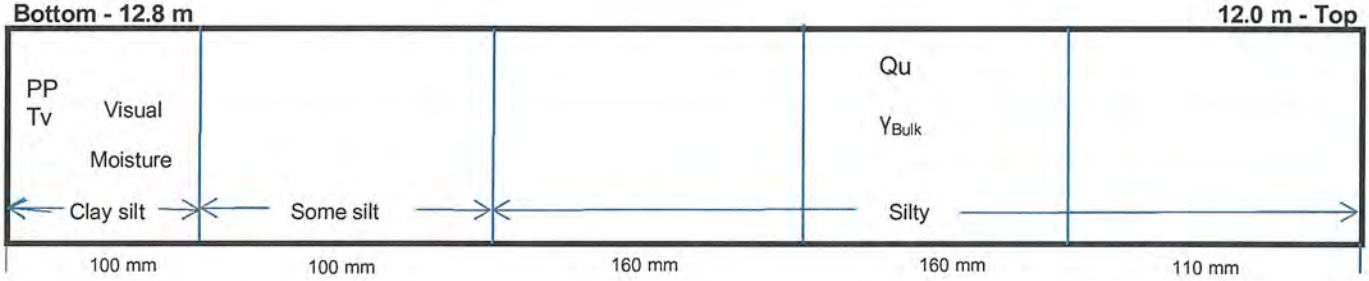
Shelby Tube Visual

Project No.	0115 004 00
Client	Associated Engineering
Project	Detailed Design North Kildonan Feedermain
Test Hole	TH13-01
Sample #	T41
Depth (m)	12 - 12.8
Sample Date	15-Nov-13
Test Date	21-Nov-13
Technician	Hachem Ahmed

Tube Extraction

Recovery (mm) 630

Bottom - 12.8 m **12.0 m - Top**



Visual Classification

Material	Caly and silt (Alluvial)
Composition	Some silt to silty
Trace organics	
Trace oxidation	
Color	Dark grey
Moisture	Moist
Consistency	Stiff
Plasticity	Intermediate
Structure	-
Gradation	-

Torvane

Reading	0.52
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	51.0

Pocket Penetrometer

Reading	**1**	1.10
	2	1.20
	3	1.10
	Average	1.13
Undrained Shear Strength (kPa)		55.6

Moisture Content

Tare ID	f151
Mass tare (g)	8.4
Mass wet + tare (g)	409.4
Mass dry + tare (g)	309.3
Moisture %	33.3%

Unit Weight

Bulk Weight (g)		1161.70
Length (mm)	**1**	151.52
	2	151.64
	3	151.82
	4	151.37
Average Length (m)		0.152
Diam. (mm)	**1**	72.38
	2	72.58
	3	72.38
	4	72.55
Average Diameter (m)		0.072
Volume (m^3)		6.25E-04
Bulk Unit Weight (kN/m^3)		18.2
Bulk Unit Weight (pcf)		116.0
Dry Unit Weight (kN/m^3)		13.7
Dry Unit Weight (pcf)		87.0

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Unconfined Compressive Strength

ASTM D2166

Project No.	0115 004 00
Client	Associated Engineering
Project	Detailed Design North Kildonan Feedermain
Test Hole	TH13-01
Sample #	T41
Depth (m)	12 - 12.8
Sample Date	15-Nov-13
Test Date	21-Nov-13
Technician	Hachem Ahmed

Unconfined Strength

	kPa	ksf
Max q_u	106.6	2.2
Max S_u	53.3	1.1

Specimen Data

Description Caly and silt (Alluvial) - Some silty to silt, Trace organics, Trace oxidation, Dark grey, Moist, Stiff, Intermediate

Length	151.6	(mm)
Diameter	72.5	(mm)
L/D Ratio	2.1	
Initial Area	0.00413	(m^2)
Load Rate	1.00	(%/min)

Moisture %	33%	
Bulk Unit Wt.	18.2	(kN/m^3)
Dry Unit Wt.	13.7	(kN/m^3)
Liquid Limit	-	
Plastic Limit	-	
Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	**kPa**	**ksf**
0.52	51.0	1.07

Vane Size
m

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	**kPa**	**ksf**
1.10	54.0	1.13
1.20	58.9	1.23
1.10	54.0	1.13
1.13	**55.6**	**1.16**

Failure Geometry

Sketch:

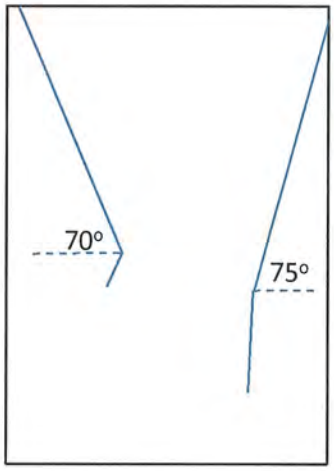

Photo:

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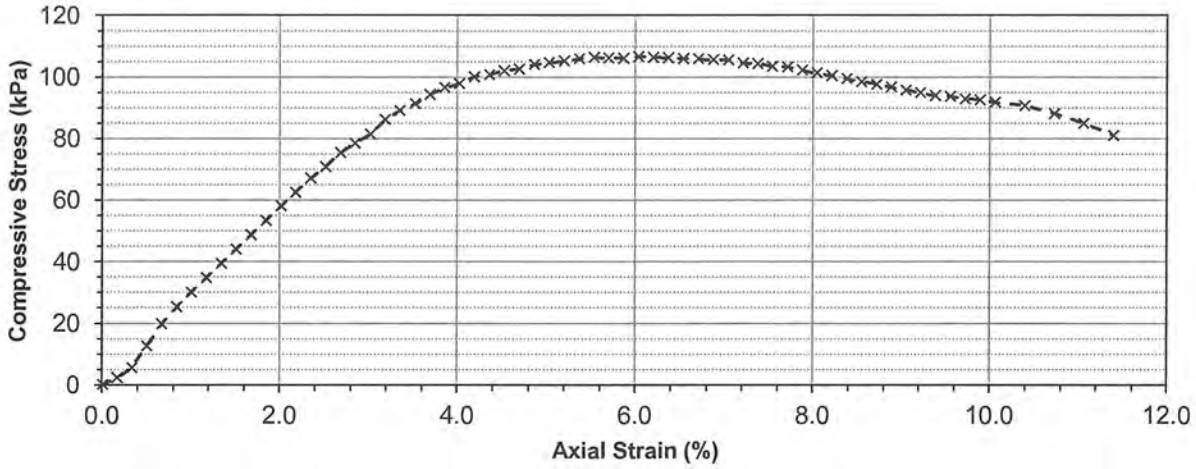
Unconfined Compressive Strength
ASTM D2166

Project No. 0115 004 00
Client Associated Engineering
Project Detailed Design North Kildonan Feedermain

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0	0.0000	0.00	0.004125	0.0	0.00	0.00
10	3	0.2540	0.17	0.004132	9.8	2.37	1.19
20	7	0.5080	0.34	0.004139	22.9	5.53	2.76
30	16	0.7620	0.50	0.004146	52.4	12.63	6.32
40	25	1.0160	0.67	0.004153	82.4	19.85	9.92
50	32	1.2700	0.84	0.004160	105.5	25.36	12.68
60	38	1.5240	1.01	0.004167	125.3	30.07	15.04
70	44	1.7780	1.17	0.004174	145.1	34.75	17.38
80	50	2.0320	1.34	0.004181	164.9	39.43	19.71
90	56	2.2860	1.51	0.004188	184.6	44.09	22.04
100	62	2.5400	1.68	0.004195	204.4	48.72	24.36
110	68	2.7940	1.84	0.004203	224.2	53.35	26.67
120	74	3.0480	2.01	0.004210	244.0	57.96	28.98
130	80	3.3020	2.18	0.004217	263.8	62.55	31.28
140	86	3.5560	2.35	0.004224	283.5	67.12	33.56
150	91	3.8100	2.51	0.004231	300.0	70.91	35.45
160	97	4.0640	2.68	0.004239	319.8	75.45	37.73
170	101	4.3180	2.85	0.004246	333.1	78.45	39.22
180	105	4.5720	3.02	0.004253	346.6	81.48	40.74
190	111	4.8260	3.18	0.004261	366.8	86.08	43.04
200	115	5.0800	3.35	0.004268	380.2	89.09	44.54
210	118	5.3340	3.52	0.004276	390.3	91.29	45.65
220	122	5.5880	3.69	0.004283	403.8	94.28	47.14
230	125	5.8420	3.85	0.004290	413.9	96.47	48.24

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Unconfined Compressive Strength
ASTM D2166

Project No. 0115 004 00
Client Associated Engineering
Project Detailed Design North Kildonan Feedermain

Unconfined Compression Test Data (cont'd)

Elapsed Time (s)	Axial Disp. (mm)	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	127	6.0960	4.0214	0.004298	420.6	97.87	48.93
250	130	6.3500	4.19	0.004305	430.7	100.04	50.02
260	131	6.6040	4.36	0.004313	434.1	100.65	50.32
270	133	6.8580	4.52	0.004321	440.8	102.03	51.01
280	134	7.1120	4.69	0.004328	444.2	102.63	51.31
290	136	7.3660	4.86	0.004336	451.0	104.01	52.00
300	137	7.6200	5.03	0.004343	454.3	104.59	52.30
310	138	7.8740	5.19	0.004351	457.7	105.19	52.59
320	139	8.1280	5.36	0.004359	461.1	105.78	52.89
330	140	8.3820	5.53	0.004367	464.4	106.35	53.18
340	140	8.6360	5.70	0.004374	464.4	106.16	53.08
350	140	8.8900	5.86	0.004382	464.4	105.98	52.99
360	141	9.1440	6.03	0.004390	467.8	106.56	53.28
370	141	9.3980	6.20	0.004398	467.8	106.37	53.18
380	141	9.6520	6.37	0.004406	467.8	106.18	53.09
390	141	9.9060	6.53	0.004414	467.8	105.99	52.99
400	141	10.1600	6.70	0.004421	467.8	105.80	52.90
410	141	10.4140	6.87	0.004429	467.8	105.61	52.80
420	141	10.6680	7.04	0.004437	467.8	105.42	52.71
430	140	10.9220	7.21	0.004445	464.4	104.47	52.23
440	140	11.1760	7.37	0.004453	464.4	104.28	52.14
450	139	11.4300	7.54	0.004462	461.1	103.34	51.67
460	139	11.6840	7.71	0.004470	461.1	103.15	51.58
470	138	11.9380	7.88	0.004478	457.7	102.21	51.11
480	137	12.1920	8.04	0.004486	454.3	101.27	50.64
490	136	12.4460	8.21	0.004494	451.0	100.34	50.17
500	135	12.7000	8.38	0.004502	447.6	99.41	49.71
510	134	12.9540	8.55	0.004511	444.2	98.48	49.24
520	133	13.2080	8.71	0.004519	440.8	97.55	48.78
530	132	13.4620	8.88	0.004527	437.5	96.64	48.32
540	131	13.7160	9.05	0.004536	434.1	95.71	47.86
550	130	13.9700	9.22	0.004544	430.7	94.79	47.40
560	129	14.2240	9.38	0.004552	427.4	93.88	46.94
570	129	14.4780	9.55	0.004561	427.4	93.71	46.86
580	128	14.7320	9.72	0.004569	424.0	92.80	46.40
590	128	14.9860	9.89	0.004578	424.0	92.62	46.31
600	127	15.2400	10.05	0.004586	420.6	91.72	45.86
620	126	15.7480	10.39	0.004603	417.2	90.64	45.32
640	123	16.2560	10.72	0.004621	407.1	88.11	44.06
660	119	16.7640	11.06	0.004638	393.6676	84.88	42.44
680	114	17.2720	11.39	0.004656	376.8533	80.95	40.47
700	105	17.7800	11.73	0.004673	346.5609	74.16	37.08

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Shelby Tube Visual

Project No.	0115 004 00
Client	Associated Engineering
Project	Detailed Design North Kildonan Feedermain
Test Hole	TH13-04
Sample #	T08
Depth (m)	6.1 - 6.7
Sample Date	15-Nov-13
Test Date	21-Nov-13
Technician	HA

Tube Extraction

Recovery (mm) 450

Bottom - 6.7 **6.1 m - Top**

Visual Classification

Material	Clay
Composition	Silty
Trace silt inclusions (< 10mm dia.)	
Trace gravel	
Color	Dark grey
Moisture	Moist
Consistency	Firm
Plasticity	High plasticity
Structure	-
Gradation	-

Torvane

Reading	0.35
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	34.3

Pocket Penetrometer

Reading	**1**	0.70
	2	0.75
	3	0.70
	Average	0.72
Undrained Shear Strength (kPa)		35.1

Moisture Content

Tare ID	P10
Mass tare (g)	8.3
Mass wet + tare (g)	470.6
Mass dry + tare (g)	304.4
Moisture %	56.1%

Unit Weight

Bulk Weight (g)		1152.10
Length (mm)	**1**	150.91
	2	150.83
	3	150.90
	4	150.88
Average Length (m)		0.151
Diam. (mm)	**1**	72.38
	2	71.83
	3	72.08
	4	72.63
Average Diameter (m)		0.072
Volume (m^3)		6.18E-04
Bulk Unit Weight (kN/m^3)		18.3
Bulk Unit Weight (pcf)		116.3
Dry Unit Weight (kN/m^3)		11.7
Dry Unit Weight (pcf)		74.5

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Unconfined Compressive Strength

ASTM D2166

Project No.	0115 004 00
Client	Associated Engineering
Project	Detailed Design North Kildonan Feedermain
Test Hole	TH13-04
Sample #	T08
Depth (m)	6.1 - 6.7
Sample Date	15-Nov-13
Test Date	21-Nov-13
Technician	HA

Unconfined Strength

	kPa	ksf
Max q_u	90.0	1.9
Max S_u	45.0	0.9

Specimen Data

Description Clay - Silty, Trace silt inclusions (< 10mm dia.), Trace gravel, Dark grey, Moist, Firm, High plasticity

Length	150.9	(mm)
Diameter	72.2	(mm)
L/D Ratio	2.1	
Initial Area	0.00410	(m^2)
Load Rate	1.00	(%/min)

Moisture %	56%	
Bulk Unit Wt.	18.3	(kN/m^3)
Dry Unit Wt.	11.7	(kN/m^3)
Liquid Limit	-	
Plastic Limit	-	
Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	**kPa**	**ksf**
0.35	34.3	0.72

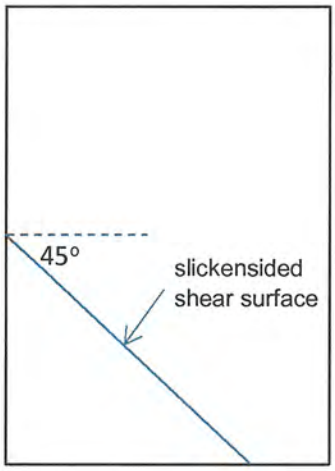
Vane Size
m

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	**kPa**	**ksf**
0.70	34.3	0.72
0.75	36.8	0.77
0.70	34.3	0.72
0.72	**35.2**	**0.73**

Failure Geometry

Sketch:



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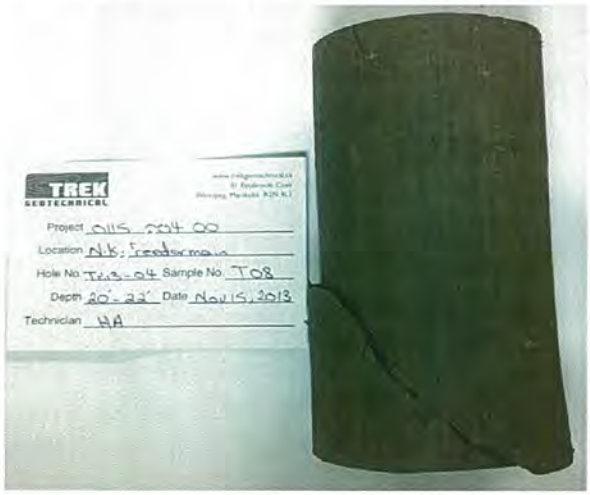

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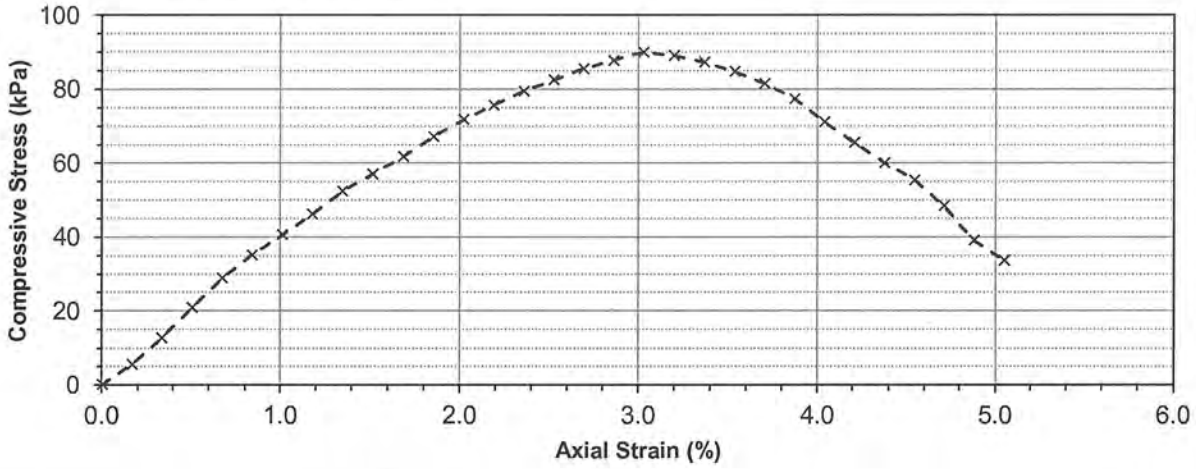
Unconfined Compressive Strength
ASTM D2166

Project No. 0115 004 00
Client Associated Engineering
Project Detailed Design North Kildonan Feedermain

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0	0.0000	0.00	0.004098	0.0	0.00	0.00
10	7	0.2540	0.17	0.004104	22.9	5.58	2.79
20	16	0.5080	0.34	0.004111	52.4	12.74	6.37
30	26	0.7620	0.51	0.004118	85.7	20.81	10.41
40	36	1.0160	0.67	0.004125	118.7	28.77	14.38
50	44	1.2700	0.84	0.004132	145.1	35.10	17.55
60	51	1.5240	1.01	0.004139	168.1	40.62	20.31
70	58	1.7780	1.18	0.004146	191.2	46.12	23.06
80	66	2.0320	1.35	0.004153	217.6	52.39	26.20
90	72	2.2860	1.52	0.004161	237.4	57.06	28.53
100	78	2.5400	1.68	0.004168	257.2	61.70	30.85
110	85	2.7940	1.85	0.004175	280.2	67.12	33.56
120	91	3.0480	2.02	0.004182	300.0	71.74	35.87
130	96	3.3020	2.19	0.004189	316.5	75.56	37.78
140	101	3.5560	2.36	0.004196	333.1	79.37	39.69
150	105	3.8100	2.53	0.004204	346.6	82.44	41.22
160	109	4.0640	2.69	0.004211	360.0	85.49	42.74
170	112	4.3180	2.86	0.004218	370.1	87.75	43.87
180	115	4.5720	3.03	0.004226	380.2	89.98	44.99
190	114	4.8260	3.20	0.004233	376.9	89.03	44.51
200	112	5.0800	3.37	0.004240	370.1	87.29	43.64
210	109	5.3340	3.54	0.004248	360.0	84.75	42.37
220	105	5.5880	3.70	0.004255	346.6	81.45	40.72
230	100	5.8420	3.87	0.004263	329.7	77.35	38.67

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Unconfined Compressive Strength
ASTM D2166

Project No. 0115 004 00
Client Associated Engineering
Project Detailed Design North Kildonan Feedermain

Unconfined Compression Test Data (cont'd)

Elapsed Time (s)	Axial Disp. (mm)	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	92	6.0960	4.0403	0.004270	303.3	71.03	35.52
250	85	6.3500	4.21	0.004278	280.2	65.51	32.76
260	78	6.6040	4.38	0.004285	257.2	60.01	30.01
270	72	6.8580	4.55	0.004293	237.4	55.30	27.65
280	63	7.1120	4.71	0.004300	207.7	48.31	24.15
290	51	7.3660	4.88	0.004308	168.1	39.03	19.52
300	44	7.6200	5.05	0.004316	145.1	33.61	16.81

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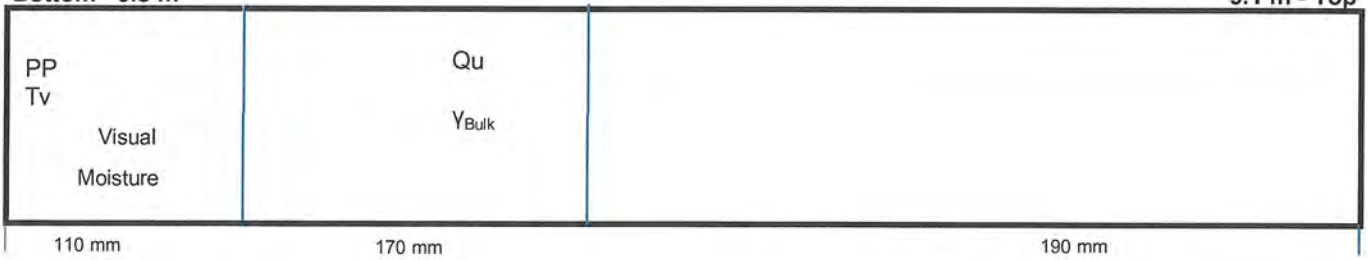
Shelby Tube Visual

Project No.	0115 004 00
Client	Associated Engineering
Project	Detailed Design North Kildonan Feedermain
Test Hole	TH13-04
Sample #	T13
Depth (m)	9.1 - 9.8
Sample Date	15-Nov-13
Test Date	21-Nov-13
Technician	Hachem Ahmed

Tube Extraction

Recovery (mm) 450

Bottom - 9.8 m **9.1 m - Top**



Visual Classification

Material	Clay
Composition	Silty
Trace silt inclusions	
Trace gravel	
Color	Dark grey
Moisture	Moist
Consistency	Firm
Plasticity	High plasticity
Structure	-
Gradation	-

Torvane

Reading	0.25
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	24.5

Pocket Penetrometer

Reading	**1**	0.60
	2	0.50
	3	0.80
	Average	0.63
Undrained Shear Strength (kPa)		31.1

Moisture Content

Tare ID	K22
Mass tare (g)	8.5
Mass wet + tare (g)	462.8
Mass dry + tare (g)	351.3
Moisture %	32.5%

Unit Weight

Bulk Weight (g)		1196.70
Length (mm)	**1**	152.25
	2	152.31
	3	152.35
	4	152.39
Average Length (m)		0.152
Diam. (mm)	**1**	71.81
	2	72.71
	3	72.43
	4	72.32
Average Diameter (m)		0.072
Volume (m^3)		6.26E-04
Bulk Unit Weight (kN/m^3)		18.8
Bulk Unit Weight (pcf)		119.4
Dry Unit Weight (kN/m^3)		14.2
Dry Unit Weight (pcf)		90.1

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Unconfined Compressive Strength
ASTM D2166

Project No.	0115 004 00
Client	Associated Engineering
Project	Detailed Design North Kildonan Feedermain
Test Hole	TH13-04
Sample #	T13
Depth (m)	9.1 - 9.8
Sample Date	15-Nov-13
Test Date	21-Nov-13
Technician	Hachem Ahmed

Unconfined Strength

	kPa	ksf
Max q_u	78.3	1.6
Max S_u	39.1	0.8

Specimen Data

Description Silty clay - trace silt inclusions, trace gravel, dark grey, moist, firm, high plasticity

Length	152.3	(mm)
Diameter	72.3	(mm)
L/D Ratio	2.1	
Initial Area	0.00411	(m^2)
Load Rate	1.00	(%/min)

Moisture %	33%	
Bulk Unit Wt.	18.8	(kN/m^3)
Dry Unit Wt.	14.2	(kN/m^3)
Liquid Limit	-	
Plastic Limit	-	
Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	**kPa**	**ksf**
0.25	24.5	0.51

Vane Size
m

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	**kPa**	**ksf**
0.60	29.4	0.61
0.50	24.5	0.51
0.80	39.2	0.82
0.63	**31.1**	**0.65**

Failure Geometry

Sketch:

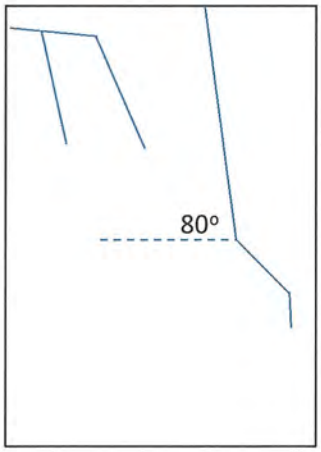

Photo:

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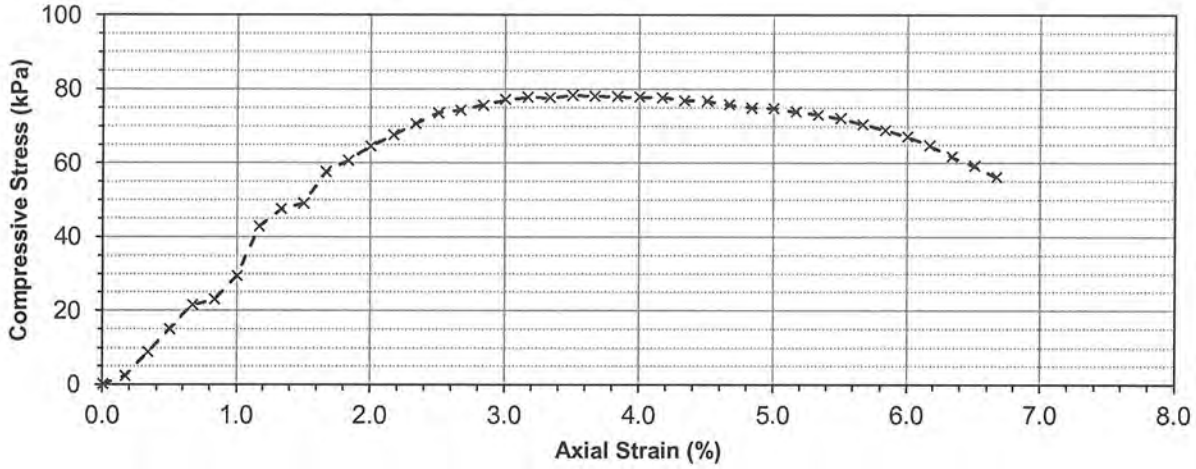
Unconfined Compressive Strength
ASTM D2166

Project No. 0115 004 00
Client Associated Engineering
Project Detailed Design North Kildonan Feedermain

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0	0.0000	0.00	0.004107	0.0	0.00	0.00
10	3	0.2540	0.17	0.004114	9.8	2.38	1.19
20	11	0.5080	0.33	0.004121	36.0	8.73	4.37
30	19	0.7620	0.50	0.004128	62.2	15.07	7.54
40	27	1.0160	0.67	0.004135	89.0	21.53	10.76
50	29	1.2700	0.83	0.004142	95.6	23.08	11.54
60	37	1.5240	1.00	0.004149	122.0	29.40	14.70
70	54	1.7780	1.17	0.004156	178.0	42.83	21.42
80	60	2.0320	1.33	0.004163	197.8	47.52	23.76
90	62	2.2860	1.50	0.004170	204.4	49.01	24.51
100	73	2.5400	1.67	0.004177	240.7	57.62	28.81
110	77	2.7940	1.83	0.004184	253.9	60.67	30.34
120	82	3.0480	2.00	0.004191	270.4	64.50	32.25
130	86	3.3020	2.17	0.004199	283.5	67.53	33.77
140	90	3.5560	2.33	0.004206	296.7	70.56	35.28
150	94	3.8100	2.50	0.004213	309.9	73.56	36.78
160	95	4.0640	2.67	0.004220	313.2	74.22	37.11
170	97	4.3180	2.83	0.004227	319.8	75.66	37.83
180	99	4.5720	3.00	0.004235	326.4	77.08	38.54
190	100	4.8260	3.17	0.004242	329.7	77.73	38.86
200	100	5.0800	3.33	0.004249	329.7	77.59	38.80
210	101	5.3340	3.50	0.004257	333.1	78.25	39.13
220	101	5.5880	3.67	0.004264	333.1	78.12	39.06
230	101	5.8420	3.84	0.004271	333.1	77.98	38.99

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Unconfined Compressive Strength
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Project No. 0115 004 00
Client Associated Engineering
Project Detailed Design North Kildonan Feedermain

Unconfined Compression Test Data (cont'd)

Elapsed Time (s)	Axial Disp. (mm)	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	101	6.0960	4.0020	0.004279	333.1	77.85	38.92
250	101	6.3500	4.17	0.004286	333.1	77.71	38.86
260	100	6.6040	4.34	0.004294	329.7	76.79	38.39
270	100	6.8580	4.50	0.004301	329.7	76.65	38.33
280	99	7.1120	4.67	0.004309	326.4	75.76	37.88
290	98	7.3660	4.84	0.004316	323.1	74.86	37.43
300	98	7.6200	5.00	0.004324	323.1	74.73	37.37
310	97	7.8740	5.17	0.004331	319.8	73.84	36.92
320	96	8.1280	5.34	0.004339	316.5	72.95	36.48
330	95	8.3820	5.50	0.004347	313.2	72.05	36.03
340	93	8.6360	5.67	0.004354	306.6	70.42	35.21
350	91	8.8900	5.84	0.004362	300.0	68.78	34.39
360	89	9.1440	6.00	0.004370	293.4	67.15	33.58
370	86	9.3980	6.17	0.004378	283.5	64.77	32.38
380	82	9.6520	6.34	0.004385	270.4	61.65	30.83
390	79	9.9060	6.50	0.004393	260.4	59.28	29.64
400	75	10.1600	6.67	0.004401	247.3	56.19	28.09

Appendix D

Unconfined Compressing Testing Results (bedrock cores)

THURBER

TREK GEOTECHNICAL INC.
19-6104-3

LABORATORY TESTING RESULTS
DECEMBER 2013

DRILL HOLE NUMBER	SAMPLE #	DEPTH		COMPRESSIVE STRENGTH		MATERIAL
		FROM (FT)	TO (FT)	C_u (MPa)	Strain (%)	
TH13-01	CB57	65' 4"	66'	49.1	0.056	Limestone
	CB64	99' 9"	100' 5"	31.2	0.042	Limestone
	CB65	101' 4"	102' 2"	21.8	0.045	Limestone
	CB67	114'	114' 11"	33.1	0.066	Limestone
TH13-05	CB72	62' 9"	63' 6"	39.5	0.048	Limestone
	CB74	71' 5"	72' 4"	39.5	0.081	Limestone
	CB79	97' 4"	98' 3"	11.9	0.037	Limestone

THURBER ENGINEERING LTD.

UNCONFINED COMPRESSION TEST REPORT

TREK GEOTECHNICAL INC
FILE NUMBER : 19-6104-3

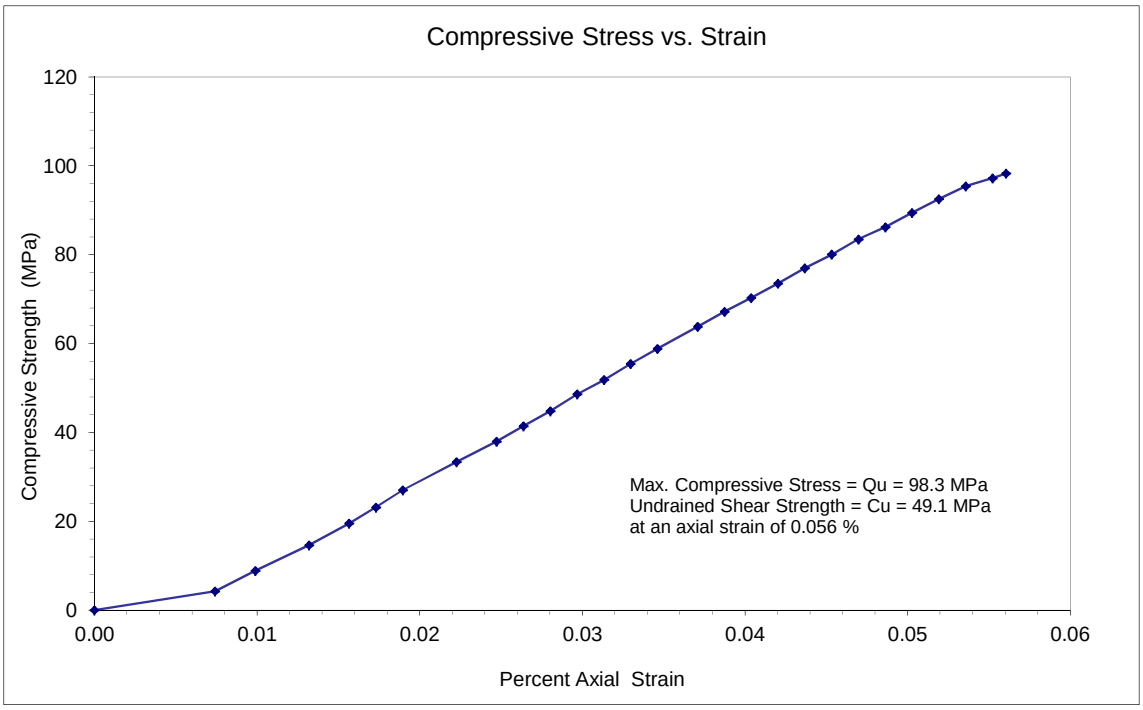
REPORT DATE: Dec 4/13
REPORT NUMBER: UC13-1c

Unconfined Compressive Strengths

TEST DATE: Dec 4/13
SAMPLE: TH13-01, CB57, @ 65'-4" to 66'
DESCRIPTION: Limestone, massive.

SPECIMEN DETAILS:

Wet Density (kg/m^3):	2487
Dry Density (kg/m^3):	2478
Moisture Content (%):	0.4



THURBER

THURBER ENGINEERING LTD.

UNCONFINED COMPRESSION TEST REPORT

TREK GEOTECHNICAL INC
FILE NUMBER : 19-6104-3

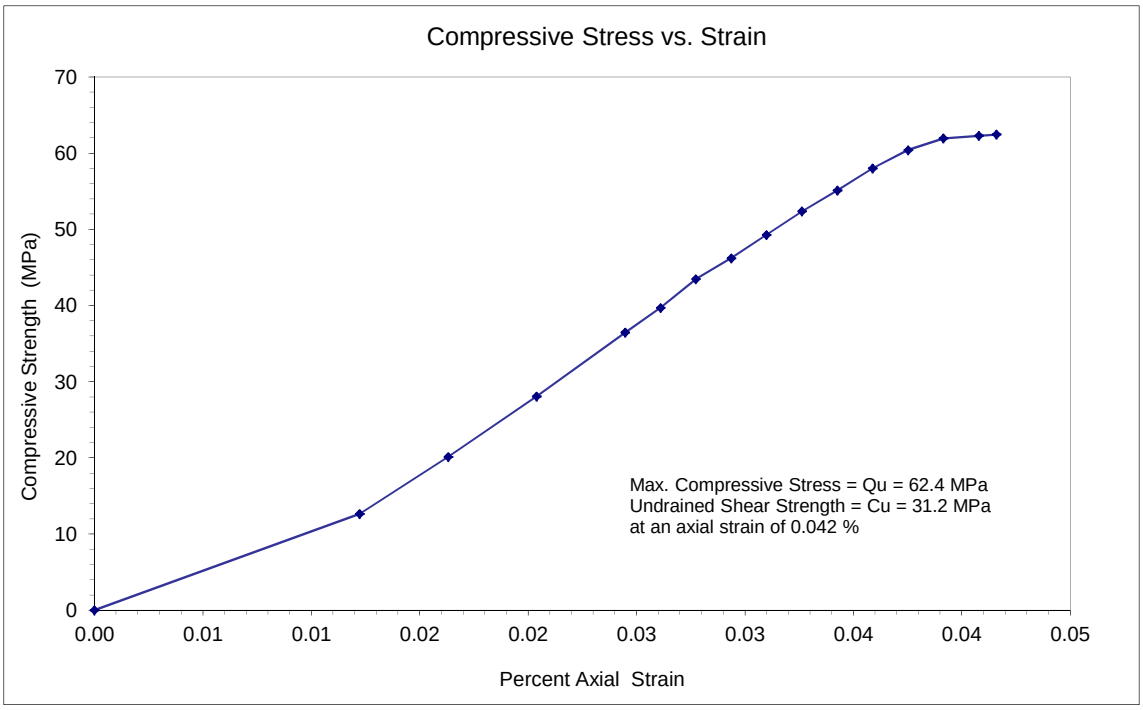
REPORT DATE: Dec 4/13
REPORT NUMBER: UC13-4c

Unconfined Compressive Strengths

TEST DATE: Dec 4/13
SAMPLE: TH13-01, CB64, @ 99'-9" to 100'-5"
DESCRIPTION: Limestone, nodular.

SPECIMEN DETAILS:

Wet Density (kg/m^3):	2561
Dry Density (kg/m^3):	2535
Moisture Content (%):	1.0



THURBER

THURBER ENGINEERING LTD.

UNCONFINED COMPRESSION TEST REPORT

TREK GEOTECHNICAL INC
FILE NUMBER : 19-6104-3

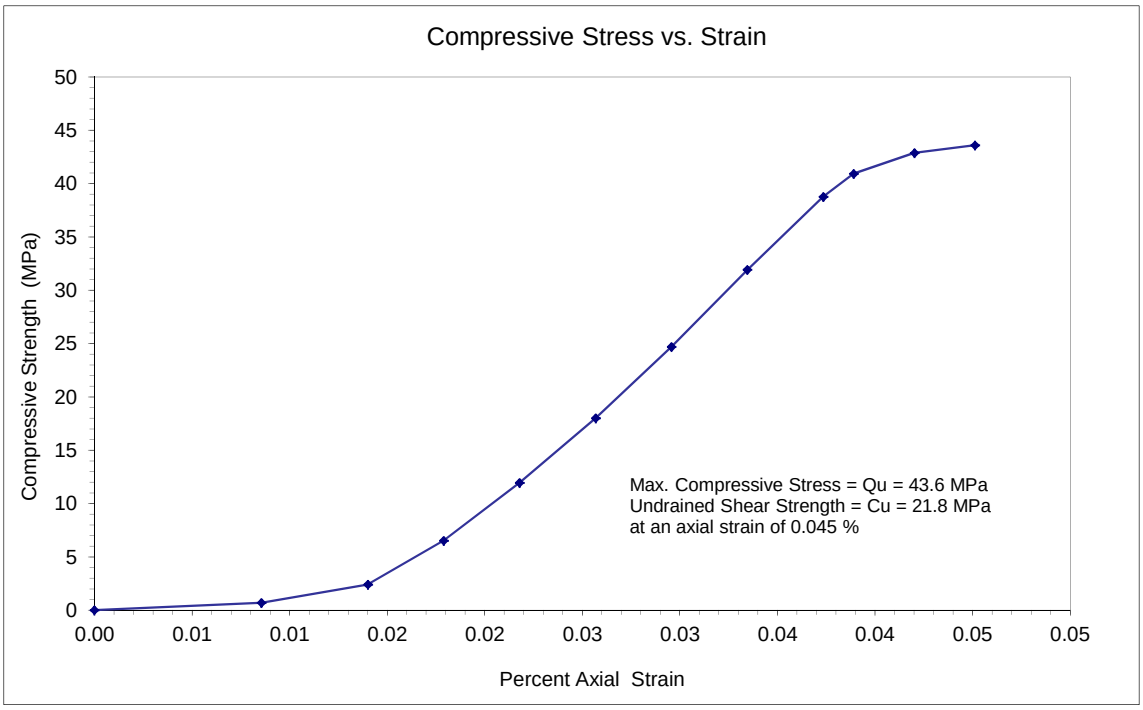
REPORT DATE: Dec 4/13
REPORT NUMBER: UC13-2c

Unconfined Compressive Strengths

TEST DATE: Dec 4/13
SAMPLE: TH13-01, CB65, @ 101'-4" to 102'-2"
DESCRIPTION: Limestone, nodular.

SPECIMEN DETAILS:

Wet Density (kg/m^3):	2305
Dry Density (kg/m^3):	2206
Moisture Content (%):	4.5



THURBER ENGINEERING LTD.

UNCONFINED COMPRESSION TEST REPORT

TREK GEOTECHNICAL INC
FILE NUMBER : 19-6104-3

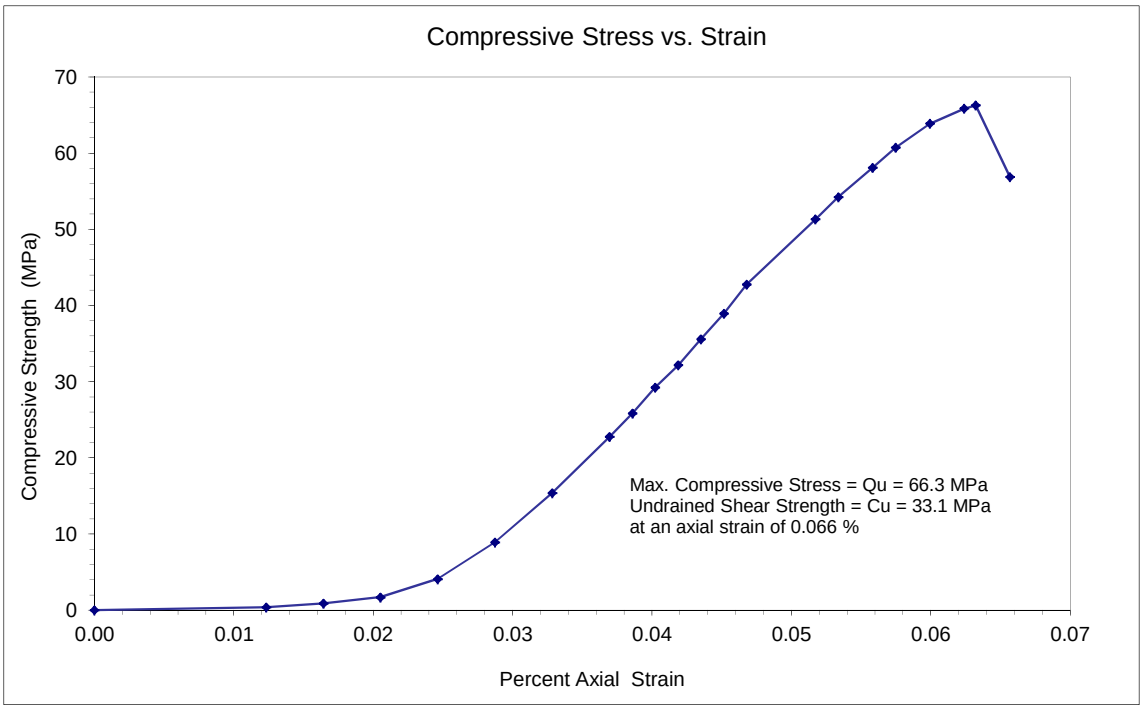
REPORT DATE: Dec 4/13
REPORT NUMBER: UC13-3c

Unconfined Compressive Strengths

TEST DATE: Dec 4/13
SAMPLE: TH13-01, CB67, @ 114' to 114'-11"
DESCRIPTION: Limestone, nodular.

SPECIMEN DETAILS:

Wet Density (kg/m^3):	2547
Dry Density (kg/m^3):	2502
Moisture Content (%):	1.8



THURBER

THURBER ENGINEERING LTD.

UNCONFINED COMPRESSION TEST REPORT

TREK GEOTECHNICAL INC
FILE NUMBER : 19-6104-3

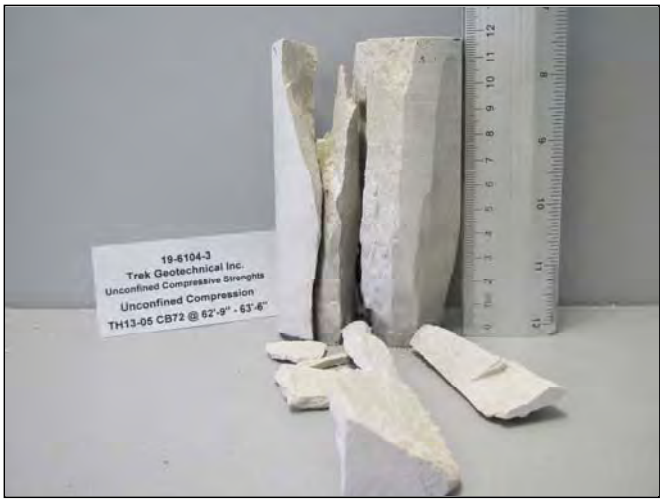
REPORT DATE: Dec 4/13
REPORT NUMBER: UC13-5c

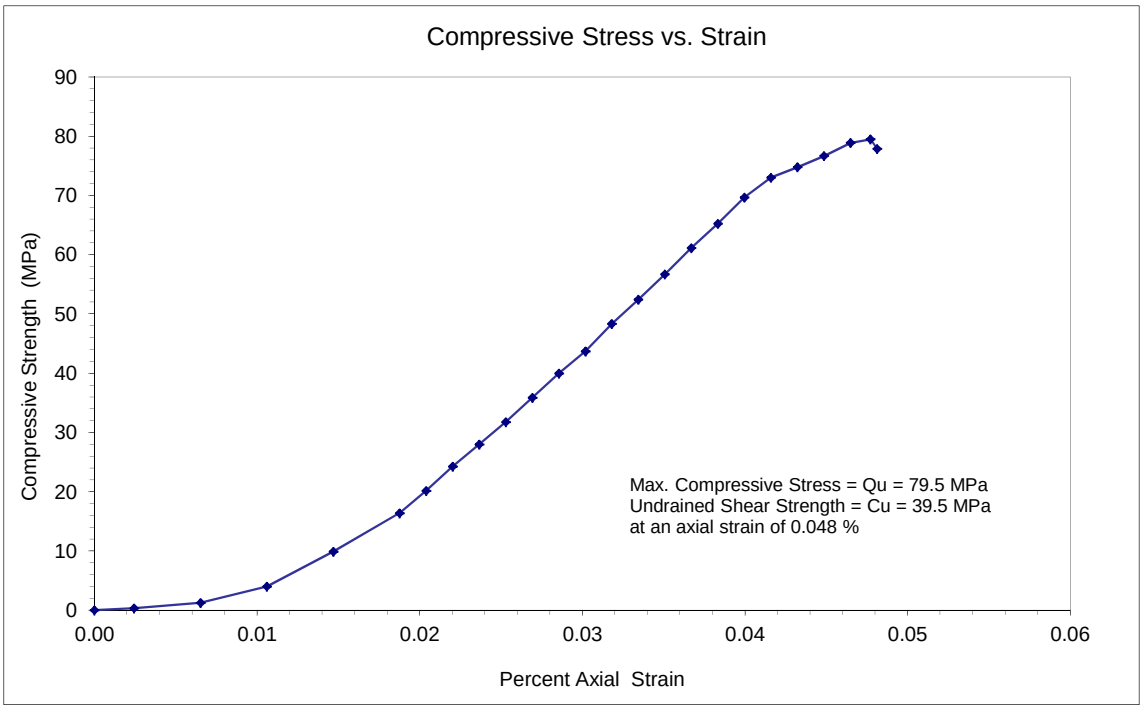
Unconfined Compressive Strengths

TEST DATE: Dec 4/13
SAMPLE: TH13-05, CB72, @ 62'-9" to 63'-6"
DESCRIPTION: Limestone, massive.

SPECIMEN DETAILS:

Wet Density (kg/m^3):	2647
Dry Density (kg/m^3):	2633
Moisture Content (%):	0.6





THURBER

THURBER ENGINEERING LTD.

UNCONFINED COMPRESSION TEST REPORT

TREK GEOTECHNICAL INC
FILE NUMBER : 19-6104-3

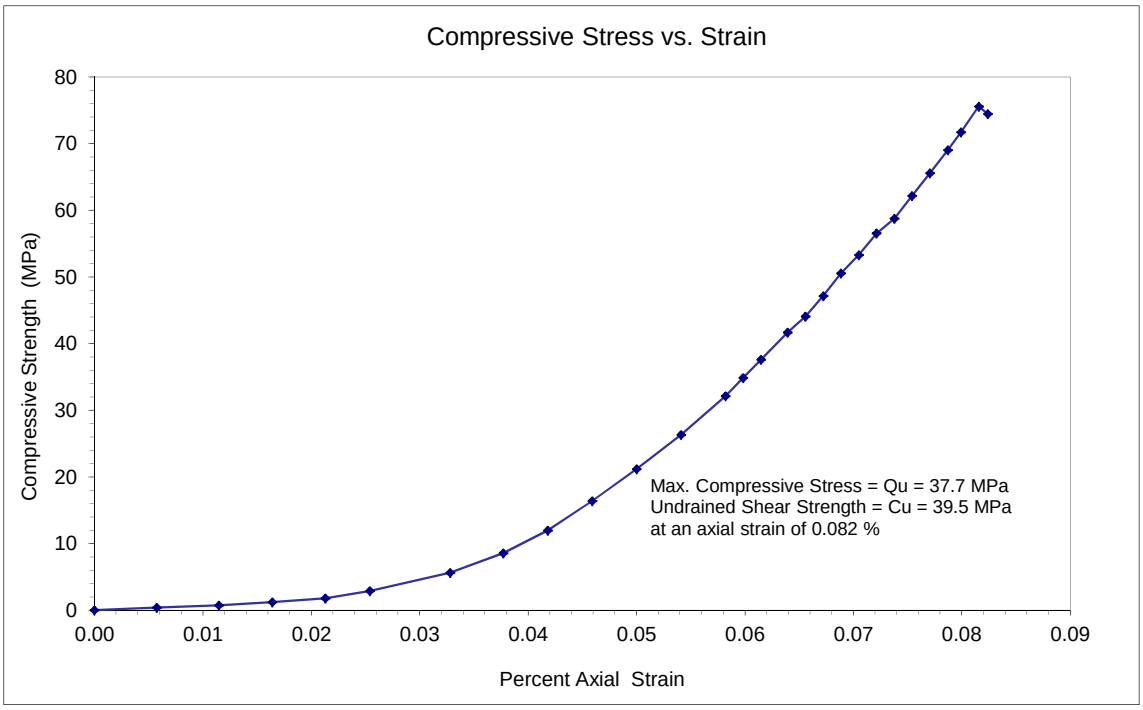
REPORT DATE: Dec 4/13
REPORT NUMBER: UC13-6c

Unconfined Compressive Strengths

TEST DATE: Dec 4/13
SAMPLE: TH13-05, CB74, @ 71'-5" to 72'-4"
DESCRIPTION: Limestone, massive.

SPECIMEN DETAILS:

Wet Density (kg/m^3):	2534
Dry Density (kg/m^3):	2496
Moisture Content (%):	1.5



THURBER

THURBER ENGINEERING LTD.

UNCONFINED COMPRESSION TEST REPORT

TREK GEOTECHNICAL INC
FILE NUMBER : 19-6104-3

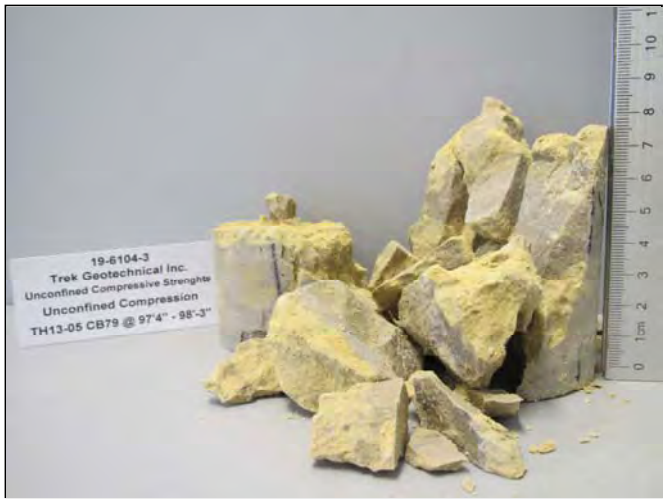
REPORT DATE: Dec 4/13
REPORT NUMBER: UC13-7c

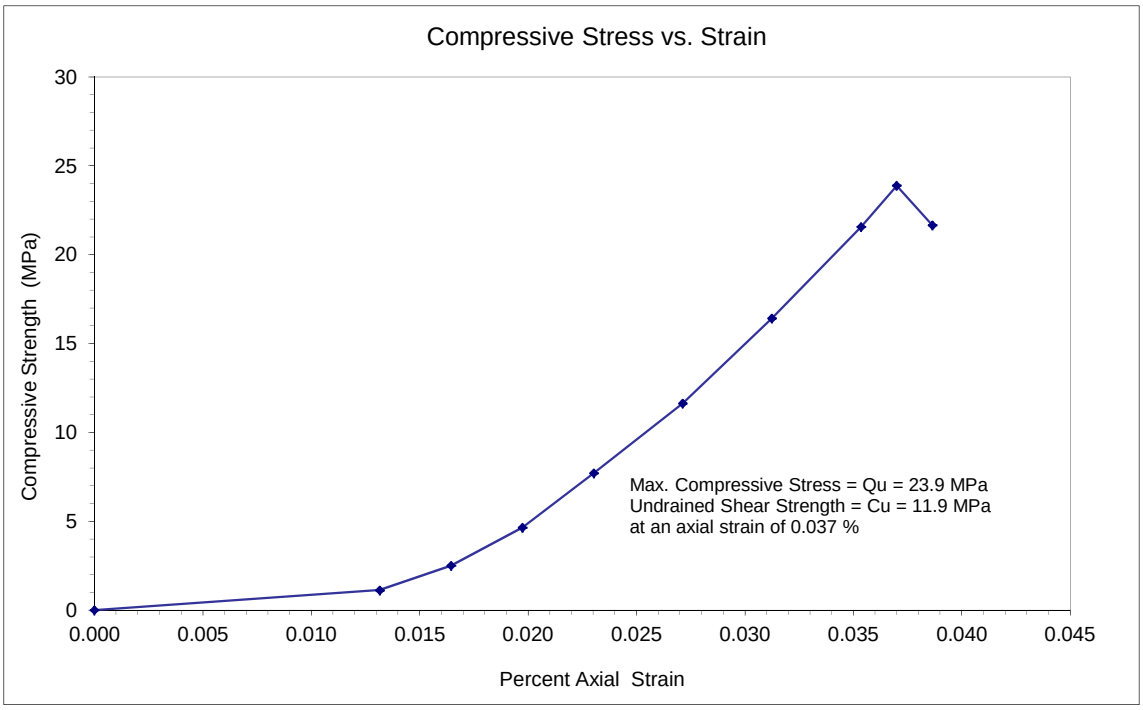
Unconfined Compressive Strengths

TEST DATE: Dec 4/13
SAMPLE: TH13-05, CB79, @ 97'-4" to 98'-3"
DESCRIPTION: Limestone, nodular.

SPECIMEN DETAILS:

Wet Density (kg/m^3):	2388
Dry Density (kg/m^3):	2256
Moisture Content (%):	5.8





Appendix A
Soils Investigation Report

Addendum No.1	TREK Geotechnical: North Kildonan Feedermain – Micro Tunnelling Option Considerations

TREK GEOTECHNICAL Quality Engineering | Valued Relationships

February 11, 2015 File No. 0115 004 00

Mr. Colin McKinnon, P.Eng., PMP
Associated Engineering
203 - # Five Donald Street
Winnipeg, Manitoba
R3L 2T4

RE North Kildonan Feedermain – Micro Tunnelling Option Considerations
Addendum No. 1

This letter is an addendum to the geotechnical report issued by TREK Geotechnical Inc. (TREK) on January 15th, 2014 to Associated Engineering for the detailed design of the North Kildonan Feedermain replacement. TREK understands that a micro tunneling installation option is now under consideration; our January 2014 provided geotechnical considerations for directional drilling. The addendum provides commentary and geotechnical considerations for the micro tunnelling option, including shaft locations relative to riverbank set-backs, and suitability of the installation technique for the soil and bedrock conditions at the site. Geological and hydrogeological information for the area relevant to the micro tunnelling option is provided in the attached letter from W.L Gibbons & Associates Inc.

Shafts and Tunnel Alignment

The shaft and tunnel locations for the micro tunnelling option are provided in plan and profile on Drawing 10 and 11 respectively (attached). The shafts are located about 58 m and 44 m from the regulated summer water level (RSWL) of 223.72 m on the west and east sides of the river respectively. A temporary working shaft will be required on each bank with the diameter to be determined by the contractor. A permanent 1.5 m diameter shaft is to be installed within the temporary shafts to carry the 600 mm diameter feedermain. A tunnel is to be bored between the two shafts at an approximate elevation 203.0 m and a 1.2 m diameter casing is to be installed within the tunnel to carry the feedermain below the river at that elevation.

Riverbank Set-Back

A stability analysis was performed to evaluate the existing stability of the west and east riverbanks and to identify the geometry of a theoretical slip surface associated with a minimum factor of safety (FS) of 1.5 in the vicinity of each shaft. Details of the analysis and the rationale for selecting a factor of safety design objective of 1.5 are provided in the January 2014 geotechnical report. The analysis indicates the existing FS for both banks (for the critical slip

surface) is greater than 1.3 and is considered to be greater than 1.5 on the west bank when taking 3-D geometric affects into consideration. The location of the point on the ground which coincides with a minimum FS of 1.5 is shown as a set-back in plan on Drawing 10 and in section in Drawing 11.

Since both the west and east shafts are located where the factor of safety is greater than 1.5, riverbank stabilization works are not considered necessary.

Sub-Surface Conditions

The geotechnical report includes sub-surface information based on test holes drilled near the alignment and historical test holes drilled for the nearby Kildonan Settlers Bridge. The bedrock and groundwater conditions are key considerations in evaluating the suitability of the micro tunneling option. Sub-surface information pertinent to the micro tunnelling installation method are summarized herein. Detailed descriptions of soil types, bedrock, and groundwater conditions encountered at the site are presented in TREK's January 2014 geotechnical report. All interpretations of soil/bedrock stratigraphy and groundwater conditions for design and construction should refer to the January 2014 geotechnical report.

The bedrock stratigraphy generally consists of dolomite, dolomitic mudstone and dolomitic limestone. A thin layer of mudstone was encountered on the east bank between the dolomite and dolomitic mudstone at about elevation 203.0 m. The top metre of bedrock below the till (dolomite) may be broken, highly fractured, or thinly bedded. Below the upper 1 m, the dolomite is generally competent (sound) with a rock quality designation (RQD) greater than 70%. Test holes drilled along the proposed alignment indicate the bedrock at the east riverbank (TH13-01) contains two zones of unsound bedrock; RQDs of less than 35% were recorded from elevations 207.5 m to 202.7 m and from elevations 196.6 m to 193.5 m. A zone of unsound bedrock was also encountered in the vicinity of TH16, drilled during sub-surface exploration work for the design of the bridge.

Groundwater levels measured in the glacial till and bedrock are comparable, indicating the two geological units are hydraulically connected. Measured groundwater levels also show that a hydraulic connection exists between the river and the till/bedrock aquifer, but may also be influenced by regional levels.

Geotechnical Considerations for Micro Tunnelling Option

The following geotechnical considerations apply to the proposed mirco tunneling option:

- Seepage and sloughing can be expected from alluvial soils and till during shaft excavation and installation of shoring. Dewatering may be required to maintain a stable excavation base.

- Groundwater can be expected in the shafts within the till/bedrock units. Groundwater levels in the till and bedrock are strongly influenced by the river and therefore, groundwater levels in these units can be higher in the spring/summer and lower in the fall/winter.

- The proposed horizontal tunnel alignment is within the top 7 m of the bedrock at about elevation 203.0 m. Significant variability in rock quality and strength can be expected within this zone and bedrock fractures may be infilled with clay (rock flour), particularly in unsound bedrock.

- Open horizontal and vertical fractures in the shallow bedrock coincident along the tunnel alignment may produce significant quantities of groundwater from the shallow (Upper Carbonate) bedrock aquifer. These fractures may also be hydraulically connected to the channel bottom.

Closure

The geotechnical information provided in this letter is in accordance with current engineering principles and practices (Standard of Practice). The findings of this letter were based on information provided (field investigation, laboratory testing, geometries). Soil conditions are natural deposits that can be highly variable across a site. If sub-surface conditions are different than the conditions previously encountered on-site or those presented here, we should be notified to adjust our findings if necessary.

All information provided in this letter is subject to our standard terms and conditions for engineering services, a copy of which is provided to each of our clients with the original scope of work, or a mutually executed standard engineering services agreement. If these conditions are not attached, and you are not already in possession of such terms and conditions, contact our office and you will be promptly provided with a copy.

This letter has been prepared by TREK Geotechnical Inc. (the Consultant) for the exclusive use of Associated Engineering (the Client) and their agents for the work product presented in the report. Any findings or recommendations provided in this letter are not to be used or relied upon by any third parties, except as agreed to in writing by the Client and Consultant prior to use.

If you have any questions or require any additional information, please contact the undersigned.

Kind Regards,

TREK Geotechnical
Per:

PROVINCE OF MANITOBA
N. J. FERREIRA
Member
22892
REGISTERED PROFESSIONAL ENGINEER
Feb. 11, 2015

Nelson John Ferreira M.Sc., P.Eng.
Geotechnical Engineer

Reviewed By:

Ken Skaftfeld, M.Sc., P.Eng.
Senior Geotechnical Engineer

Attachments:
Drawing 10 & 11
W.L Gibbons Letter Report

APEGM
Certificate of Authorization
Trek Geotechnical Inc.
No. 4877 Date: Feb. 15, 2015

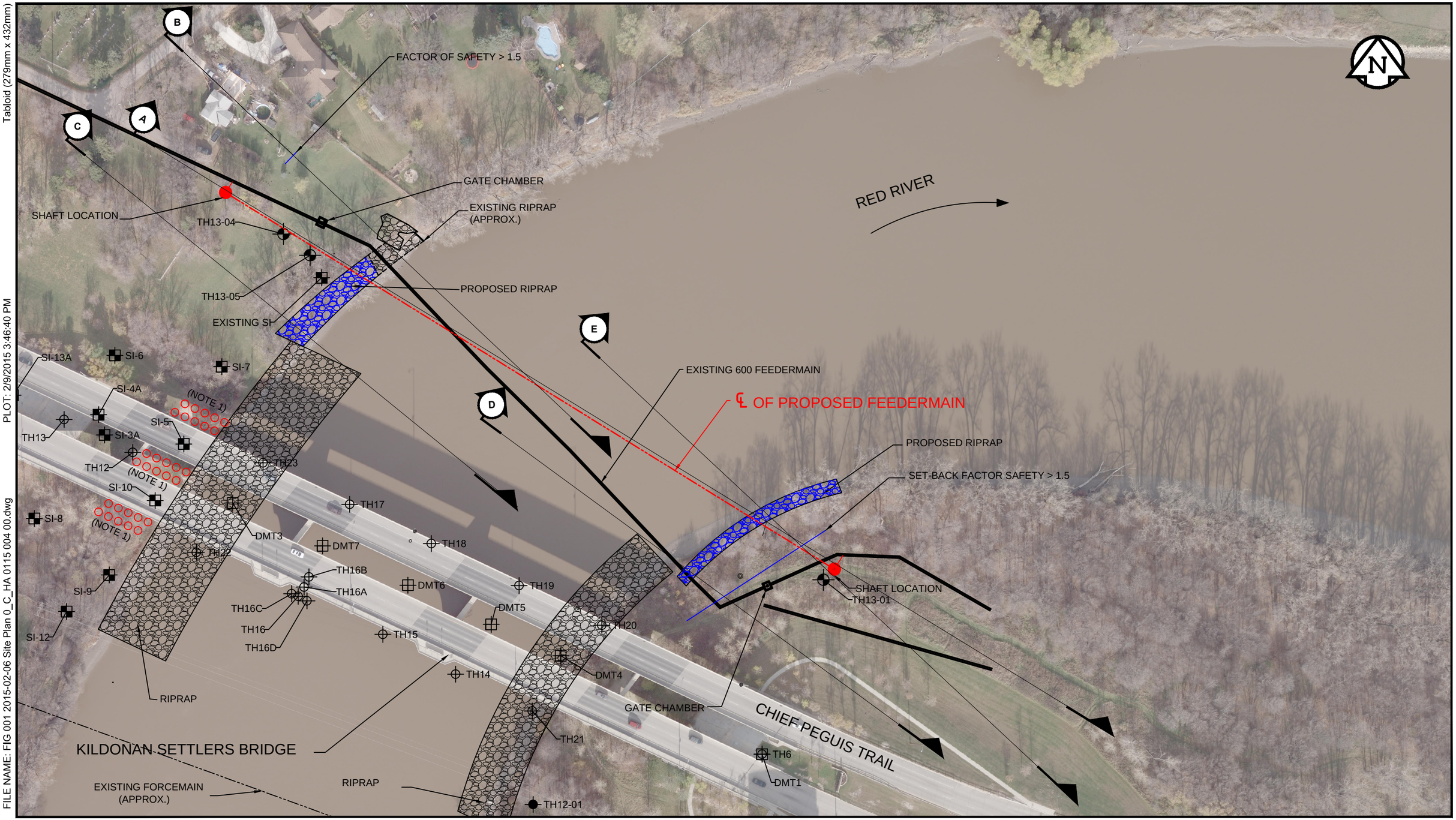
TREK GEOTECHNICAL

0115 004 00
Associated Engineering
Detailed Design of North Kildonan Feedermain

Tabloid (279mm x 432mm)

PLOT: 2/9/2015 3:46:40 PM

FILE NAME: FIG 001 2015-02-06 Site Plan 0_C_HA 0115 004 00.dwg



0 12.5 25 37.5 50m
SCALE : 1:1250 (279mm x 432mm)

LEGEND :

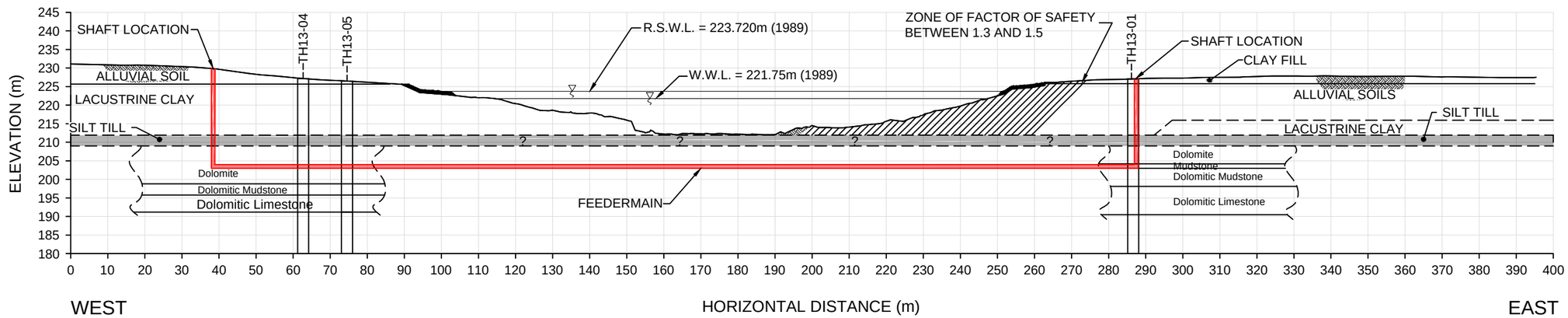
- TEST HOLE (TREK, 2013)
- TEST HOLE (DYREGROV, 1988)
- TEST HOLE (KGS, 2012)
- SLOPE INDICATORS
- DILATOMETER TESTING (DYREGROV, 1998)
- ROCK COLUMNS

NOTES :

1. ROCK COLUMNS SHOWN ARE NOT TO SCALE
2. 2008 AERIAL IMAGE IN PROVIDED BY CITY OF WINNIPEG
3. SURVEY INFORMATION PROVIDED BY BARNES AND DUNCAN LAND SURVEYERS AND CITY OF WINNIPEG (LIDAR)

Drawing 10
Riverbank Stability Plan
Micro Tunnelling Option

CROSS-SECTION A



0 12.5 25 37.5 50m
SCALE : 1:1250 (279mm x 432mm)

Drawing 11
Riverbank Stability and Proposed Feedermain Profile
Micro Tunnelling Option

W.L. Gibbons & Associates Inc.
64 St. Andrew Road Winnipeg, MB R2M 3H6

Technical Memorandum

Date: February 10, 2015

To: Nelson Ferreira, P.Eng.

From: Steve Wiecek, P.Geo., P.Eng.

Subject: North Kildonan Feedermain

In response to your request of February 8 2015, W.L. Gibbons & Associates Inc. (WLG) is pleased to provide the following supplementary information concerning the geologic and hydrogeologic properties in the area of the proposed North Kildonan Feedermain.

Limestone Abrasivity

We are unaware of any abrasivity testing having been done specifically on the limestone and dolomite bedrock in the Winnipeg area. Based on published literature, limestone typically has a CHERCHAR Abrasivity Index (CAI) in the range of 0.75 to 1.75, which is considered to be a low to medium abrasivity. As is noted in the Trek Report for this project (North Kildonan Feedermain Detailed Design – Geotechnical Report), the bedrock beneath this site consists of a complex assemblage of dolomitic limestone, dolomite, dolomitic mudstone and mudstone. As such the abrasivity properties of the bedrock will vary across the site, and will likely trend towards the medium abrasivity end of the typical range due to the dolomitic nature of most of the bedrock. It is also noted, that chert nodules are present within the bedrock, which would increase the abrasivity due to the silica content.

Presence of Gas in the Bedrock

Gas has been encountered within the bedrock in the Winnipeg area, particularly methane and hydrogen sulphide gas. As such, the contractor should take the appropriate precautions to protect any workers that may be entering any tunnels or excavations. These precautions would include but not be limited to ongoing air quality monitoring, and the implementation of procedures for working in environments were the accumulation of various gases is a potential concern.

Groundwater Quality

The groundwater within the bedrock aquifer beneath the site has a total dissolved solids (TDS) concentration in the range of 600 to 1,000 mg/l. Groundwater with a TDS concentration of less than 1,000 mg/l is considered to be fresh water (brackish water has a TDS concentration between 1,000 and 10,000 mg/l, and saline water has a TDS concentration of greater than

10,000 mg/l). Although the water is considered fresh based on TDS concentration, testing of the water quality should be completed at the time of construction to verify that the water quality is acceptable for discharge to the intended discharge point (river, stormwater system or wastewater system), or if containment and treatment is required before discharge.