Template Version: C020171218 - Main C

THE CITY OF WINNIPEG

APPENDIX 'B'

GEOTECHNICAL REPORT

BID OPPORTUNITY NO. 9-2018

SHOAL LAKE AQUEDUCT CROSSING AND ASSOCIATED ROADWORKS

Quality Engineering | Valued Relationships

Mile 93 Aqueduct Bridge - Detailed Design Geotechnical Investigation Report

Prepared for:	**Distribution:**
Dillon Consulting Ltd. 1558 Wilson Place Winnipeg, Manitoba R3T 0Y4	Mr. Graeme Loeppky, P. Eng.

Project Number:
0022 039 00

Date:
January 9, 2018

January 9, 2018

Our File No. 0022 039 00

Mr. Graeme Loeppky, P.Eng.
Dillon Consulting Ltd.
1558 Wilson Place
Winnipeg, Manitoba
R3T 0Y4

RE: **Mile 93 Aqueduct Bridge - Detailed Design**
Geotechnical Investigation Report

TREK Geotechnical Inc. is pleased to submit our final report for the geotechnical investigation for the detailed design of the Mile 93 Aqueduct Bridge.

Please contact the undersigned if you have any questions or require additional information.

Sincerely,

TREK Geotechnical Inc.
Per:

Brent Hay, P.Eng.
Geotechnical Engineer
Tel: 204.975.9433

Encl.

Revision History

Revision No.	Author	Issue Date	Description
0	BH	January 9, 2018	Final Report

Authorization Signatures

PROVINCE OF MANITOBA
B.S.
HAY
Member
32339
Jan. 9/18
REGISTERED PROFESSIONAL ENGINEER

Prepared By:

Brent Hay, P.Eng.
Geotechnical Engineer

ENGINEERS
GEOSCIENTISTS
MANITOBA
Certificate of Authorization
TREK GEOTECHNICAL INC.
No. 4877 Date: Jan. 9, 2018

Reviewed By:

Nelson Ferreira, Ph.D., P.Eng.
Senior Geotechnical Engineer

Table of Contents

List of Tables

List of Figures

List of Drawings

List of Appendices

1.0 Introduction and Background

TREK Geotechnical Inc. (TREK) was retained by Dillon Consulting Ltd. (Dillon) to complete a geotechnical investigation and provide recommendations related to the detailed design of the proposed bridge crossings at Mile 93 along the Shoal Lake Aqueduct. This detailed design report supersedes the preliminary design report issued by TREK on March 26, 2013. The terms of reference for the work are included in our proposal addressed to Mr. Graeme Loeppky, P.Eng., dated June 20, 2016.

The proposed bridge crossing is located at Mile 93.03 of the City of Winnipeg's Shoal Lake Aqueduct (SLA), in an undeveloped area south of the Trans-Canada Highway. The new bridge is part of the Freedom Road (currently being constructed) connecting the Shoal Lake 40 First Nation to the Trans-Canada Highway. The bridge is required to cross the Shoal Lake Aqueduct which provides water to City of Winnipeg. A location plan of the crossing is shown on Drawing 01 along with the existing ground profile.

The SLA traverses flat and poorly drained organic terrain bounded by a tamarack forest to the north and the Greater Winnipeg Water District (GWWD) Railway to the south. The Aqueduct was constructed in 1919 using a cut and cover technique resulting in a ditch on either side of the structure and spoil material on the north side of the north ditch. The ditches are water-filled year-round and the top of the berm above the Aqueduct is partially exposed.

The ground elevation on the north and south sides of the Aqueduct are at approximately Elev. 325.5 and 324.5 m, respectively with the higher north side elevation resulting in part from spoil material. The ditch invert is at approximately Elev. 322.5 m and is 2 to 3 m wide. The berm above the Aqueduct slopes at about 2H:1V and cresting at about Elev. 323.5 m. A cross section of the proposed crossing at Mile 93 is shown on Drawing 01.

The proposed bridge consists of prefabricated steel box truss ACROW panel structures, approximately 33.5 m in length. Concrete abutments (on piles) will provide support at either end of the bridge deck. Approach embankments will be required to accommodate proposed road alignments and GWWD Railway grades (Mile 93). As part of our assignment, TREK evaluated the stability of the slopes at the Mile 93 Aqueduct crossing and completed a stress-deformation analysis to quantify potential stress changes and/or settlement imposed on the Aqueduct structure.

2.0 Existing Information

Available information pertinent to the geotechnical investigation and preliminary design was reviewed and includes the following:

Falcon River Diversion and Shoal Lake Aqueduct Bridges – Geotechnical Report. (TREK Geotechnical Inc., March 25, 2013). Provides the preliminary design for the Mile 93 Bridge.

Assessment and Rehabilitation of the Shoal Lake Aqueduct – Buoyancy Assessment Program Geotechnical Investigation Mile 84 to Mile 95 (UMA Engineering Ltd., April 2000). Includes survey and sub-surface information along the Aqueduct channel from Mile 84 to 95.

Borehole Logs from Mile 92. 1992 (UMA Engineering, 1994). Includes sub-surface information relative to backfill and cover of the Aqueduct..

Draft Report to City of Winnipeg: Shoal lake Aqueduct – Winter Road Crossing Near Mile 93 (AECOM, May 2010). Contains information relative to the initial assessment of the Mile 93 site for the bridge crossing and preliminary stress analysis on the aqueduct from embankment fills.

3.0 Sub-surface Conditions

3.1 Drilling Program

A sub-surface investigation was undertaken on March 27-28th, 2012 as part of the preliminary design on the south approach area where one test hole (TH12-01) was drilled. A supplementary sub-surface investigation was undertaken from December 7th to 10th, 2016 as part of the detailed design on the north approach area and included drilling one test hole (TH16-01) and excavating one Test Pit (TP17-02). The supplementary investigation took place under the supervision of TREK personnel using a track mounted BX37X geotechnical soils rigs equipped with 125 mm solid stem augers, 170 mm hollow stem augers, continuous sampling equipment and HQ coring equipment. Test holes TH12-01 and TH16-01 were drilled to power auger refusal at depths of 26.4 m and 27.4 m, respectively, followed by bedrock coring to depths of 32.2 m and 33.7 m, respectively. Standpipe piezometer SP16-01 was installed in TH16-01 to 3.6 m upon completion. A test pit (TP16-02) was completed north of the approach area during the supplementary investigation to assess the depth of peat and groundwater conditions. TP16-01 was excavated using a Hitachi 200 LC excavator.

Sub-surface soils encountered during drilling were visually classified based on the Unified Soil Classification System (USCS). Disturbed auger cutting and split spoon samples, relatively undisturbed (Shelby tube) and core samples were collected during drilling. All samples retrieved during drilling were transported to TREK's testing laboratory in Winnipeg, Manitoba for further classification and laboratory testing. Laboratory testing consisted of water content determination on all samples, bulk unit weight measurements, unconfined compressive strength testing on Shelby tube samples, Atterberg limit testing and particle size determination (hydrometer method) on select samples. Soils laboratory testing results are included in Appendix A.

Test hole/pit locations (shown on Drawing 01) and elevations were recorded as part of a Dillon site survey. The test hole/pit logs attached to this report include a description of the soil units encountered during drilling and other pertinent information such as groundwater conditions, standpipe installation details and a summary of the laboratory testing results.

3.2 Soil Stratigraphy

A general description of the soil units encountered at the test hole locations during drilling is provided below. All interpretations of soil stratigraphy for the purposes of design should refer to the detailed information provided on the attached test hole logs.

In general, the stratigraphy across the site consists of 0.5 m to 1.6 m of topsoil and peat overlying alluvial silts and clays followed by highly plastic silty clay. The silty clay was underlain by sand and silt till overtop of amphibolite bedrock. A chlorite schist was observed in TH16-01 between the till and amphibolite bedrock.

The peat on the south bridge approach area is fibrous, dark brown, wet and around an H3 on the von post classification scale. The peat on the north approach area is amorphous with trace roots, brown to black, wet and around an H5 to H6 on the von post scale. The alluvial soils extend to approximately 7.8 m depth within both approaches and consist of intermixed low to intermediate plasticity silts and clays with varying amounts of sand and gravel. In general, the alluvial soils are moist, becoming wet with depth and soft to stiff. The underlying high plasticity silty clay extends to approximately 24 m depth, contains trace sand, trace gravel, is brown becoming grey with depth, moist and is stiff becoming soft to very soft with depth. The clay is underlain by alternating layers of sand or silt till, approximately 4 m thick in total. The sand contains some gravel, trace cobbles, is grey, wet and loose. The silt till is sandy with some gravel, is grey, moist and dense.

The amphibolite bedrock is fine grained, grey to green, homogenous and strong to very strong (R4-R5). The chlorite schist encountered in TH16-01 is approximately 4 m thick, light green to green, rubbled, finely foliated and very soft to soft (R0-R1).

3.3 Groundwater Conditions

Sloughing was observed in TH12-01 at 3.1 m depth within silt, where the upper portion of the test hole was completed with solid stem augers. Sloughing could not be observed in TH16-01 due to the drilling and backfilling method.

Seepage was observed in both test holes within the alluvial soils at approximately 3.0 m depth. A water level of 0.9 m depth was measured in TH12-01 following completion of drilling. The water level in standpipe SP16-01 was measured shortly after installation at 2.5 m below surface. Seepage and sloughing was observed from surface in TP16-01 and a groundwater level was observed coincident with the ground surface upon completion of the test pit.

These observations are short-term and should not be considered reflective of (static) groundwater levels at the site, which would require monitoring over an extended period to determine. It is important to recognize that groundwater conditions may vary seasonally, annually, or as a result of construction activities.

4.0 Slope Stability Analysis

4.1 Numerical Model Description

Slope stability analysis was completed for the proposed Mile 93 bridge geometry provided by Dillon. The stability analysis was conducted using a limit-equilibrium slope stability model (Slope/W) from the GeoStudio 2007 software package (Geo-Slope International Inc.). Slip surfaces were specified with the grid and radius method, with factors of safety calculated using the Morgenstern-Price method of slices. Groundwater conditions were modelled using static piezometric lines.

4.2 Model Geometry

The model geometry is based upon the design grades provided by Dillon and were supplemented with ditch inverts from ice auger soundings carried out during the initial site reconnaissance (February 17, 2012). Cross sections through the centre line of the abutment were generated to represent the stability of full abutment fill height and immediately outside of the wingwall where the fill is at its maximum unsupported height. The preferred layout has the middle of the bridge shifted to the south of the Aqueduct centerline and as a result, the north abutment is about 3 m closer to the Aqueduct than the south abutment. The water level in the ditch at the SLA crossing of Elev. 323.3 m is based on the information obtained in the Dillon October 12, 2012 survey. An ice level of Elev. 323.7 m was measured during a January 2017 Dillon survey, however was not used in the analysis as the October measurements represent a more critical water level.

4.3 Soil Properties

The soil parameters used in the slope stability analysis are based on the field and laboratory testing, and typical values for the nature of soils encountered during the sub-surface investigations. Table 01 presents the engineering properties for the soil units used in the analysis.

Table 01 – Soil Properties for Stability Analysis

Soil Unit	Unit Weight (kN/m^3)	Cohesion (kPa)	Friction Angle (degrees)
Peat	14.0	5	14
Alluvial Silts and Clays	19 to 20.5	2	23
Lacustrine Silty Clay	19.0	5	17
Clay Fill	18.5	5	17
Embankment Fill	21.0	0	40
Silt Till	20.0	0	45

4.4 Groundwater Conditions

In the vicinity of the proposed abutments, groundwater levels were assumed to be approximately at the base of the proposed embankment fill, sloping towards the surveyed ice level in the ditches. Although this ground water level is higher than measured during drilling, it is considered representative of potential ground saturation due to seasonal changes and environmental effects.

4.5 Modelling Results

The factors of safety (FS) for potential slip surfaces (PSS) through the approach fill immediately adjacent to the abutment on both sides of the Aqueduct were determined for the proposed bridge geometry. Any structural support provided by the piles and/or abutment was neglected in the analysis. Three key slip surfaces were examined: the slip surface with the minimum FS at the crossing (critical) which could negatively impact the bridge abutment, a slip surface that extends to the top of the Aqueduct, and a slip surface that extends through the Aqueduct. The latter two represent the potential range of slip surfaces that could impact the integrity of the Aqueduct.

A minimum FS of 1.5 was targeted for slip surfaces at the abutments or Aqueduct. Modelling during the preliminary design indicated that the depth of granular fill around the abutments needed to be increased to improve soil strength. Also, it was identified that wingwalls were necessary to reduce loading near the top of the channel. These changes were incorporated into Dillon's design drawings and were included in the detailed design analysis. Table 02 presents the results of the modelling.

Table 02 – Stability Analysis Results

Slip Surface	Abutment (1)		Through Aqueduct	
Location	North Side	South Side	North Side	South Side
Along Centre Line	1.51	1.72	1.62	1.72
Outside of Wingwall	1.72	1.81	1.78	1.81

Notes:
(1) – Also represents the critical (lowest FS) slip surface

As shown in Table 02, the FS at the abutments and through the Aqueduct are above the design target of a minimum FS of 1.5. Model outputs showing the stability analysis are presented in Appendix B.

5.0 Stress and Settlement Analysis

A stress-deformation analysis was completed to evaluate the stresses that may be imposed on the Aqueduct structure and associated settlements as a result of bridge construction. The cross-section geometry used in the analysis was taken through the centre of the approach fill on both the north and south sides where the maximum fill height occurs. The stress analysis was completed using a stress-deformation finite element model (Sigma/W) from the GeoStudio 2007 software package (Geo-Slope International Inc.). Deformations were modelled using linear elastic and elastic-plastic constitutive soil models.

Soil properties used in the analysis were based off measured values or were assumed based on typical values used for similar soil types. A sensitivity analysis was completed with a range of values for the Young's modulus of the alluvial silts and clays and lacustrine silty clay to determine a range of potential settlements and stresses. Table 03 presents the soil units and the parameters used in the stress-deformation analysis.

Table 03 – Soil Properties for Stress-Deformation Analysis

Soil Unit	Unit Weight (kN/m^3)	Young's Modulus (kPa)	Poisson's Ratio
Peat	14	200	0.4
Alluvial Silts and Clays	20.5	5,000 - 15,000	0.4
Silty Clay	19	1,200 - 5,000	0.4
Clay Fill	19	5,000	0.4
Embankment Fill	21	40,000	0.3
Silt Till	19	100,000	0.3

5.1 Stress Analysis

The Aqueduct structure was modelled as a rigid member (no displacement allowed). The model assumes 1.2 m of clay backfill at the Aqueduct base with peat backfill to surface based on previous investigations at Mile 92.99 (UMA, 1994). The estimated increase in stress in both the horizontal (x-direction) and vertical (y-direction) direction were then determined at various locations (nodes) along the outside surface of the structure as shown on Figures 01 and summarized in Table 04. An example model analysis is included in Appendix B.

Figure 01 – Nodes on Aqueduct from Stress Analysis

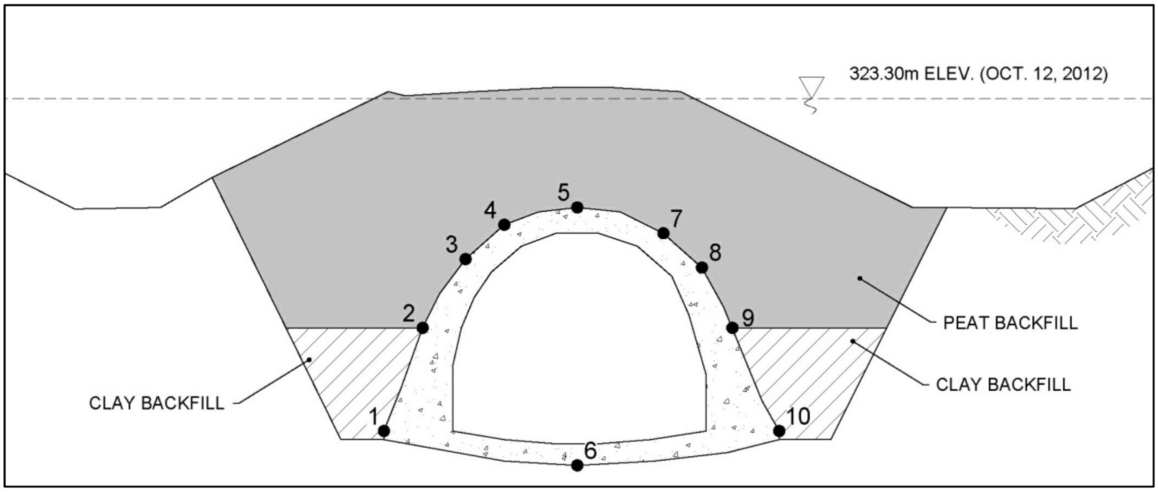


Table 04 –Stress Analysis Results

Node	Aqueduct Boundary Condition			
	X-Effective Stress (kPa)		Y-Effective Stress (kPa)	
	Total	Change	Total	Change
1	42	12	25	5.3
2	11	3	5.2	<1
3	3.8	<1	4.7	<1
4	4.4	<1	6.5	<1
5	4.6	<1	6.9	<1
6	12	<1	18	<1
7	2.8	<1	5.9	<1
8	2.4	<1	2.7	<1
9	11	5.8	3.8	1.2
10	34	11	18	5.1

From Table 04, the maximum total stresses in the horizontal and vertical directions are 42 and 25 kPa, respectively. These values also correspond to the maximum changes (increase) from existing stresses of 12 kPa and 5.3 kPa in the horizontal and vertical directions, respectively. Overall the maximum horizontal and vertical stress increases occur at the outside edges of the base of the structure (nodes 1, 6 and 10). If the estimated stresses are greater than what can be tolerated by the structure, a more rigorous analysis should be carried out during detailed design. Additionally, options to reduce the loading from proposed fills, such as lightweight fill or increasing the setback distance of the abutments could be investigated.

5.2 Settlement Analysis

Consolidation settlement of the soils beneath the approach fills can be expected although it will take a number of years for the settlement to occur due the fine-grained nature of the soils on site. The largest settlement magnitudes will be immediately beneath the maximum fill heights and will dissipate with increasing distance away from the fill. Settlement of the approach fills can likely be accommodated in the bridge design, however, any associated settlement of the soil beneath the Aqueduct must be within an acceptable range for the structure. In this regard, the stress-deformation analysis was used to predict the settlements under the north and south abutments and under the centre of the Aqueduct. The results of the analysis are summarized in Table 05.

Table 05 – Estimated Settlements at Aqueduct and Abutment

Location	Estimated Settlement (mm)
Under Aqueduct	6-10
North Abutment	50-90
South Abutment	40-75

In the event these magnitudes of settlement at the abutment locations cannot be accommodated by regular maintenance (e.g. gravelling or asphalt overlays at the bridge approaches), techniques to accelerate consolidation settlement such as preloading or the installation of vertical drains may be considered. If the estimated settlements of the Aqueduct are greater than what can be tolerated by the structure, options to reduce the loading from proposed fills, such as lightweight fill or increasing the setback distance of the abutments should be investigated.

The longitudinal settlement profile can be projected along the aqueduct alignment assuming 0 mm settlement perpendicular with the edges of the proposed embankment (i.e. where the embankment reaches existing ground) and be the maximum settlement of 10 mm coinciding with the centreline of the bridge alignment.

6.0 Foundation Recommendations

Based on our understanding of the proposed development, the sub-surface conditions encountered during drilling and discussions with Dillon, rock socketed steel pipe piles founded in bedrock are the preferred foundation type for the site. Design and construction recommendations are provided in the following sections and include axial (compression and uplift) pile capacities and parameters for lateral pile analysis.

6.1 Limit States Design (CHBDC)

Limit states design requires consideration of distinct loading scenarios comparing the structural loads to the foundation bearing capacity using resistance and load factors that are based on probabilistic reliability criteria. Two general design scenarios are evaluated corresponding to the serviceability and ultimate capacity requirements.

The **Ultimate Limit State (ULS)** is concerned with ensuring that the maximum structural loads do not exceed the nominal (ultimate) capacity of the foundation units. The ULS foundation bearing capacity is obtained by multiplying the nominal (ultimate) bearing capacity by a resistance factor (reduction factor), which is then compared to the factored (increased) structural loads. The ULS bearing capacity must be greater or equal to the maximum factored load. Table 06 summarizes the resistance factors that can be used for the design of foundations as per the CHBDC depending upon the method of analysis and verification testing completed during construction. The CHBDC also requires that the degree of understanding of site and soil conditions (which can be classified as either low, typical or high) be assessed in the selection of the resistance factors. Since driven pile refusal is anticipated to occur on bedrock (which is known to be sloping in the area) based on the two test holes completed at the abutment locations and given our experience with the proposed pile types in similar geological conditions, we consider the current level of understanding at the site to be typical. CHBDC also requires that the resistance factor be modified by a consequence factor which ranges from 0.9 for high consequence structures to 1.15 for low consequence structures. The structures for this project are interpreted to be of typical consequence based on the CHBDC guidelines and as such the consequence factor is 1.0.

The **Service Limit State (SLS)** is concerned with limiting deformation or settlement of the foundation under service loading conditions such that the integrity of the structure will not be impacted. The SLS should generally be analysed by calculating the settlement resulting from applied service loads and comparing this to the settlement tolerance of the structure. However, the settlement tolerance of the structure is typically not defined at the preliminary design stage. As such, SLS bearing capacities (or unit resistances) provided are developed on the basis of limiting settlement to approximately 25 mm or less. A more detailed settlement analysis should be conducted to refine the estimated settlement and/or adjust the SLS vertical bearing resistance if a more stringent settlement tolerance is required.

Table 06. ULS Resistance Factors for Foundations (CHBDC 2014)

Description	Degree of Understanding of Soil Conditions	
	Typical	High
Deep foundations in compression based on static analysis	0.40	0.45
Deep foundations in compression based on dynamic testing	0.50	0.55
Deep foundations in tension based on static analysis	0.30	0.40

6.2 Rock Socketed Pipe Piles

Rock socketed, open-ended steel pipe piles end bearing in the amphibolite bedrock are considered appropriate for this site. The axial compressive capacity of steel piles will be controlled by the Structural Limit State (based on the strength of steel used) provided that the piles are driven to refusal on bedrock. The factored geotechnical ULS capacity of the driven steel piles can be calculated based on $0.9\Phi f_y A_p$ (f_y is the yield stress of the pile material, A_p is the cross-sectional area of the pile section and Φ is the resistance factor from Table 06). Based on the understanding of soil conditions and method of analysis a resistance factor of 0.40 is appropriate for compression. The pile head settlement under unfactored service loads can be calculated based on 5 mm or less of pile tip displacement plus elastic shortening of the pile.

Steel piles driven to refusal will derive their uplift resistance in skin friction within overburden deposits. For the purposes of uplift resistance calculations, a factored unit ULS uplift capacity of 9 kPa should be used for soils above bedrock, based on a resistance factor of 0.30.

Additional Pipe Pile Recommendations

1. Piles should be advanced into sound, intact, unweathered bedrock a minimum of 0.3 m or two socket diameters. Given the known presence of sloping bedrock in the area and observed rubble zones near the bedrock surface, the acceptance of embedment depths less than two socket diameters should be confirmed during pile installation by on-site TREK personnel.
2. The contractor should be prepared to advance through boulders, cobbles and into sound bedrock.
3. Care must be taken to ensure that the piles are seated securely on the base of the socket and that the pile is centered in the socket.
4. Where lateral resistance is required, piles should be grouted to ground surface prior to removing casing to ensure compliance with surrounding soils along the entire pile length. TREK can provide additional recommendations to address lateral loads if needed.
5. Inspection of all rock-socketed piles should be performed by TREK personnel to confirm that the pile installation has been completed according to the design.

6.3 Lateral Pile Capacity

For design of pile foundations, the soil response (subgrade reaction) to lateral loads can be modeled in a simplified manner that assumes the soil around a pile can be simulated by a series of horizontal springs. The soil behaviour can be estimated using an equivalent spring constant referred to as the lateral subgrade reaction modulus (K_s) as provided in Table 07. The majority of lateral resistance will typically be offered by the upper 5 m to 10 m of soil, depending on the relative stiffness of the pile and soil units. Void spaces surrounding piles due to pre-boring activities should be in-filled with lean-mix concrete to ensure compliance with the surrounding soil. If in-filling is not completed, the depth of the pre-bore should be neglected from lateral pile resistance calculations.

Table 07. Recommended Values for Lateral Subgrade Reaction Modulus (K_s)

Soil Layer	Approximate Elevation (m, asl)	K_s (kN/m^3)
Surface to depth of frost or depth of prebore	Surface to X (1)	0
Alluvial Soils	X to 317	3,100/d (2)
Silty Clay	317 – 301	2,000/d (2)
Sand and Silt Tills	301 – 297	4,500z/d (2)(3)

Notes:

(1) X = depth of frost (2.4 m) or depth of prebore, whichever is greater
(2) d = pile diameter
(3) z = depth of pile

The values provided in Table 07 should be used at the appropriate depth for the portion of the pile in the corresponding soil type. The contact elevations for the soils are provided on the test hole logs. If peat soils are encountered and not removed, the value of subgrade reaction modulus should be taken as zero within these layers. It should be understood that using the lateral subgrade reaction modulus assumes a linear response to lateral loading and therefore is only appropriate under the following conditions:

- maximum pile deflections are small (less than 1% of the pile diameter),
- loading is static (no cycling), and
- pile material behavior is linear-elastic.

If one or more of these conditions are not met, a more rigorous analysis that includes non-linear behavior of the piles and surrounding soil is required.

6.4 Foundation Inspection Requirements

In accordance with Section *4.2.2.3 Field Review* of the NBCC (2010), the designer or other suitably qualified person shall carry out a field review on:

1. a continuous basis during:
    - i. the construction of all deep foundation units, and
    - ii. during the placement of engineered fills.
2. on an as-required basis for the construction of shallow foundation units and in excavating, dewatering and other related works.

In consideration of the above and relative to this particular project, the embedment of pipe piles must be confirmed by qualified geotechnical personnel for embedment less than 2 socket diameters. TREK is familiar with the geotechnical conditions and the basis for the foundation recommendations and can provide any design modifications deemed to be necessary should altered subsurface conditions be encountered.

6.5 Ad-freezing Effects

Concrete piles, pile caps, grade beams, and buried walls subjected to freezing conditions should be designed to resist ad-freeze and uplift forces related to frost action acting along the vertical face of the member within the depth of frost penetration (2.4 m). In this regard, concrete piles, pile caps, grade beams, and walls may be subject to an ad-freeze bond stress of 65 kPa within the depth of frost penetration. Steel piles may be subject to an ad-freeze bond stress of 100 kPa within the depth of frost penetration.

Ad-freeze forces will be resisted by structural dead loads and uplift resistance provided by the length of the pile below the depth of frost penetration. The following design recommendations apply to piles subject to ad-freeze forces:

1. A load factor (α) of 1.2 may be used in the calculation of ad-freezing forces.
2. A reduction factor of 0.8 may be used in calculation of the geotechnical resistance for the factored ULS condition with an ultimate (nominal) resistance of 30 kPa. Resistance to ad-freezing within the depth of frost penetration (2.4 m) should be neglected. Structural dead loads should be added to the resistance.
3. The calculated geotechnical resistance plus the structural dead loads must be greater than the factored ad-freezing forces.
4. Measures such as rigid polystyrene insulation could be considered to reduce frost penetration depths and thereby ad-freezing and uplift forces.
5. Replacement of existing soils around piles and abutments with non-frost susceptible soils such sand and gravel with minimal fines could be considered to minimize ad-freeze forces.

6.6 Foundation Concrete

All foundation concrete should be designed by a qualified structural engineer for the anticipated axial (compression and uplift), lateral, and bending loads from the structure. Based on local experience gathered through previous work in the area, the degree of exposure for concrete subjected to sulphate attack is classified as severe according to Table 3, CSA A23.1-14 (Concrete Materials and Methods of Concrete Construction). Accordingly, all concrete in contact with the native soil should be made with high sulphate-resistant cement (HS or HSb). Furthermore, the concrete should have a minimum specified 56-day compressive strength of 32 MPa and have a maximum water to cement ratio of 0.45 in accordance with Table 2, CSA A23.1-14 for concrete with severe sulphate exposure (S2). Concrete that may be exposed to freezing and thawing should be adequately air entrained to improve freeze-thaw durability in accordance with Table 4, CSA A23.1-14.

7.0 Roadways and Approach Fills

The pavement structure for access road areas should be constructed in accordance with the Manitoba Infrastructure (MI) specifications. Granular materials should be in accordance with MI Standard Construction Specification No.900 (Granular Base Course) and compacted in accordance with the recommendations below. Based on the results of the sub-surface investigation and observations during the site visits, sub-grade soils along proposed roadways and approaches consist largely of organic and peat soils. Given the amorphous nature and depth of the peats encountered, they should be removed in their entirety and replaced with granular fill. Additional recommendations for the roadways and approach fills are provided below.

1. Peats, organics, silt and any other deleterious material should be stripped such that the sub-grade consists of native firm silty clay or clay and silt.
2. Excavation should be completed with an excavator equipped with a smooth-bladed bucket and operating from the edge of the excavation in order to minimize disturbance to the exposed sub-grade.
3. After excavation, the sub-grade should be inspected by TREK personnel to identify unsuitable deleterious material. The sub-grade should also be proof-rolled with a fully loaded tandem axle truck to detect soft areas. Soft and /or deleterious areas should be repaired as per directions provided by TREK. This will likely consist of excavating an additional 150 to 300 mm and placing a non-woven geotextile on the sub-grade and backfilling with an MI Class ‘C’ sub-base.
4. Fill required to raise grades should consists of a well graded granular fill in accordance with MI Standard Construction Specification No.520 (Granular Fill).
5. The sub-grade should be protected from freezing, drying, inundation with water or disturbance. If any of these conditions occur the sub-grade should be scarified, moisture conditioned as appropriate, and re-compacted to a minimum of 95% of the SPMDD.
6. A high strength, woven geotextile should be placed in accordance with the manufacturers recommendations on the prepared subgrade prior to placement of granular fill.
7. The granular sub-base (MI Class ‘C’) and base (MI Class ‘A’) materials should be placed in lifts not exceeding 150 mm and compacted to 98% and 100% SPMDD, respectively.

8.0 Excavations

All temporary excavations must be carried out in compliance with the appropriate regulation(s) under the Manitoba Workplace Safety and Health Act. Any open-cut excavations greater than 3 m deep must be designed and sealed by a professional engineer and should be reviewed by the geotechnical engineer of record (TREK). Furthermore, maintaining the stability of the excavation slopes for the duration of construction should be the responsibility of the contractor. Based on the observed sloughing and seepage during the sub-surface investigation, flatter slopes than 1H:1V may be required.

The excavation should be kept free of water at all times and surface water should be diverted away from the excavation. Given the relatively high groundwater level (0.3 m to 1.5 m depth) observed at the site and the nature of the soils that will be encountered during excavation, dewatering of the excavation for foundation construction will likely be required. Dewatering may be achieved through over excavation and directing water to a sump area with subsequent pumping. The dewatering plan should be discussed with the excavating contractor prior to construction. Stockpiles of excavated material should not be permitted near the edge of an open excavation.

9.0 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 and laboratory testing). 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.

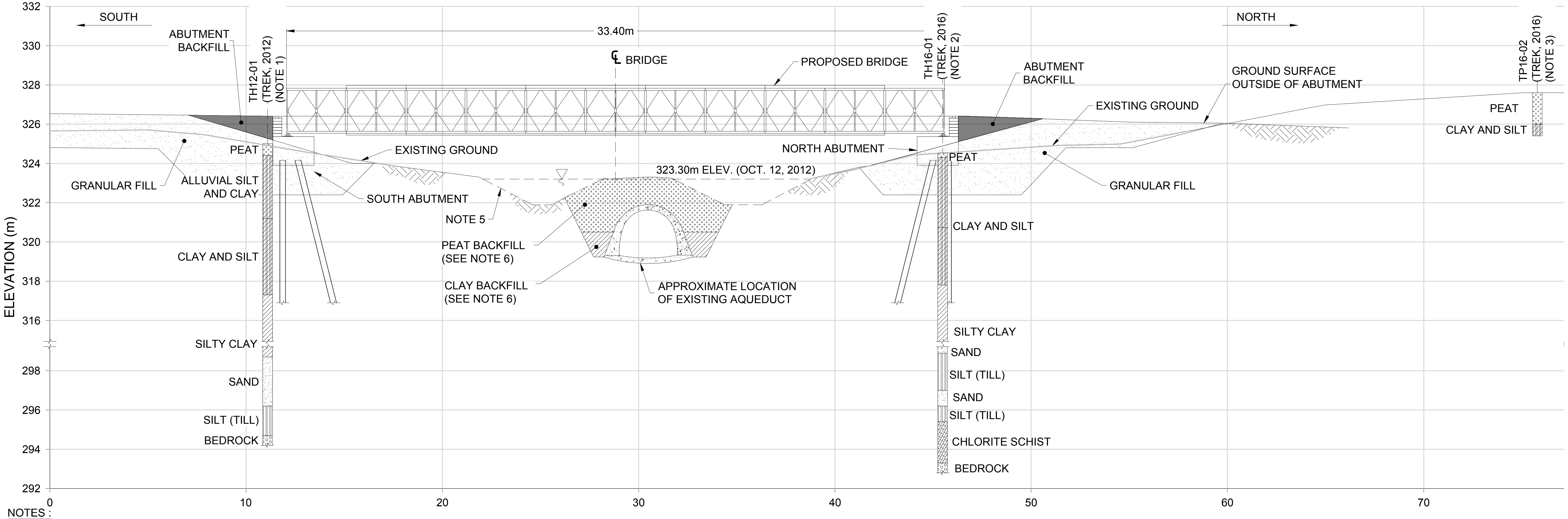
All information provided in this report is subject to our standard terms and conditions for engineering services, a copy of which is provided to each of our clients with the original scope of work or standard engineering services agreement. If these conditions are not attached, and you are not already 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 Dillon Consulting Ltd. (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.

Drawings

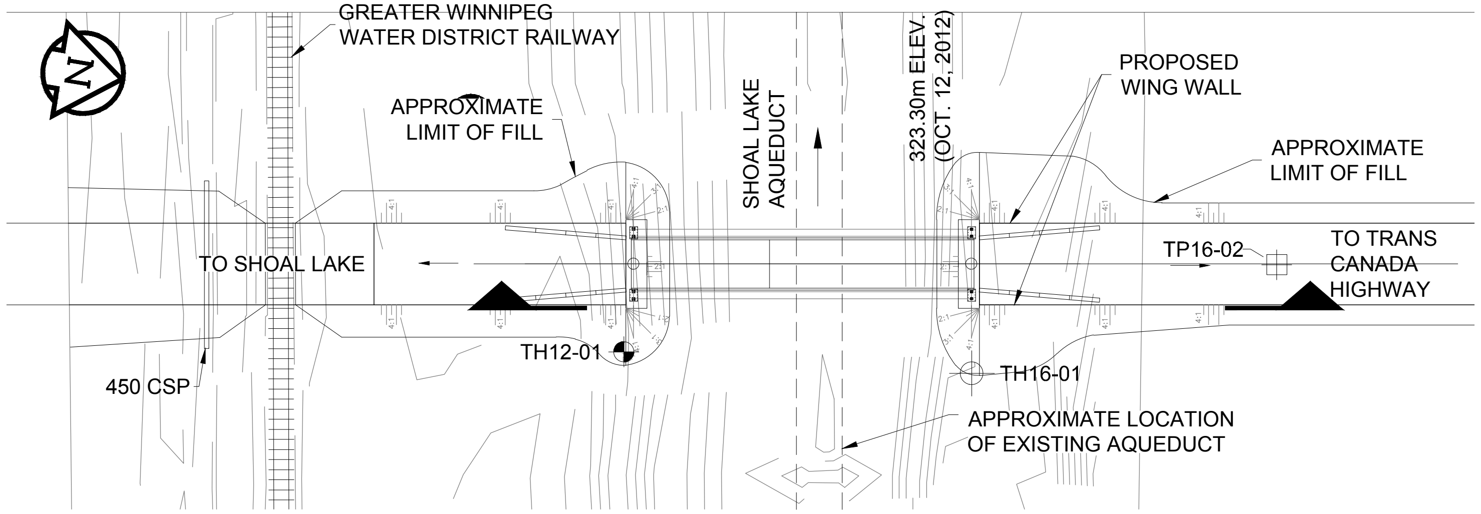
0022 039 01
Dillon Consulting Ltd.
Mile 93 Aqueduct Bridge Detailed Design

Tabloid (279mm x 432mm)



NOTES :
1. TH12-01 OFFSET 4.3m EAST OF CROSS-SECTION.
2. TH16-01 OFFSET 6.5m EAST OF CROSS-SECTION.
3. TP16-02 AT CENTERLINE OF BRIDGE.
4. CROSS-SECTION GEOMETRY BASED OFF OF DILLON JANUARY 2017 SURVEY.
5. CHANNEL GEOMETRY BELOW WATER LEVEL NOT SURVEYED.
6. EXTENTS OF BACKFILL ARE APPROXIMATE.

LOCATION PLAN
SCALE : N.T.S.



SITE PLAN
SCALE : 1:750

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

0 2 4 6 8m
SCALE : 1:200 (279mm x 432mm)

LEGEND :
- TEST HOLE (TREK, 2012)
- TEST PIT (TREK, 2016)
- TEST HOLE (TREK, 2016)

FILE NAME: Fig.001 2018-01-09 Test Hole Locaiton Plan & Stratigraphic Cross Section

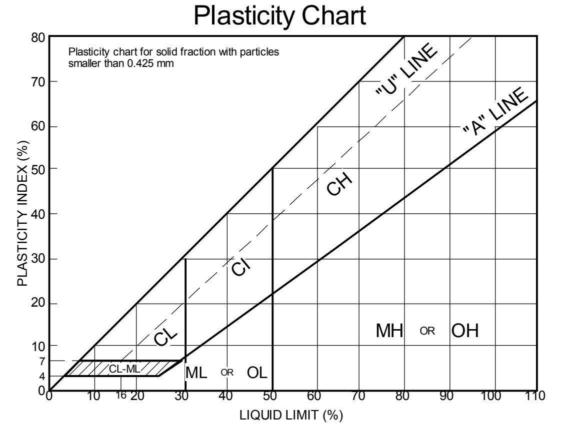
Drawing 01
Test Hole Location Plan and Stratigraphic Cross Section

Test Hole Logs

EXPLANATION OF FIELD AND LABORATORY TESTING

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.
2. Descriptions on these test hole logs apply only at the specific test hole locations and at the time the test holes were drilled. Variability of soil and groundwater conditions may exist between test hole locations.
3. When the following classification terms are used in this report or test hole logs, the primary and secondary soil fractions may be visually estimated.

Major Divisions			USCS Classi-fication	Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than 4.75 mm)	Clean gravel (Little or no fines)	GW	●	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent...... GW, GP, SW, SP More than 12 percent...... GM, GC, SM, SC 6 to 12 percent...... Borderline case4s requiring dual symbols*	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	○	Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	◌	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			GC	▨	Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than 4.75 mm)	Clean sands (Little or no fines)	SW	⁘	Well-graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	░	Poorly-graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	▥	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			SC	▨	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7	
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 50)		ML	▥	Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity Chart 		
			CL	▨	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	☰	Organic silts and organic silty clays of low plasticity			
	Silts and Clays (Liquid limit greater than 50)		MH	▮	Inorganic silts, micaceous or distomaceous fine sandy or silty soils, organic silts			
			CH	▰	Inorganic clays of high plasticity, fat clays			
			OH	≋	Organic clays of medium to high plasticity, organic silts			
	Highly Organic Soils		Pt	⁂	Peat and other highly organic soils	Von Post Classification Limit	Strong colour or odour, and often fibrous texture	

Material		Particle Size mm	Particle Size ASTM Sieve sizes
Sand	Coarse	2.00 to 4.75	#10 to #4
	Medium	0.425 to 2.00	#40 to #10
	Fine	0.075 to 0.425	#200 to #40
Silt or Clay		< 0.075	< #200

Material		Particle Size mm	Particle Size ASTM Sieve Sizes
Boulders		> 300	> 12 in.
Cobbles		75 to 300	3 in. to 12 in.
Gravel	Coarse	19 to 75	3/4 in. to 3 in.
	Fine	4.75 to 19	#4 to 3/4 in.

* Borderline classifications used for soils possessing characteristics of two groups are designated by combinations of groups symbols. For example; GW-GC, well-graded gravel-sand mixture with clay binder.

Other Symbol Types

■	Asphalt	▧	Bedrock (undifferentiated)	○	Cobbles
░	Concrete	⊞	Limestone Bedrock	●	Boulders and Cobbles
▩	Fill	☰	Cemented Shale	◌	Silt Till
		▱	Non-Cemented Shale	▨	Clay Till

EXPLANATION OF FIELD AND LABORATORY TESTING

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)
PL - Plastic Limit (%)
PI - Plasticity Index (%)
MC - Moisture Content (%)
SPT - Standard Penetration Test
RQD - Rock Quality Designation
Qu - Unconfined Compression
Su - Undrained Shear Strength
VW - Vibrating Wire Piezometer
SI - Slope Inclinometer

▽ Water Level at Time of Drilling

▼ Water Level at End of Drilling

⧨ Water Level After Drilling as Indicated on Test Hole Logs

FRACTION OF SECONDARY SOIL CONSTITUENTS ARE BASED ON THE FOLLOWING TERMINOLOGY

TERM	EXAMPLES	PERCENTAGE
and	and CLAY	35 to 50 percent
"y" or "ey"	clayey, silty	20 to 35 percent
some	some silt	10 to 20 percent
trace	trace gravel	1 to 10 percent

TERMS DESCRIBING CONSISTENCY OR COMPACTION CONDITION

The Standard Penetration Test blow count (N) of a non-cohesive soil can be related to compactness condition as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very loose	< 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	> 50

The Standard Penetration Test blow count (N) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very soft	< 2
Soft	2 to 4
Firm	4 to 8
Stiff	8 to 15
Very stiff	15 to 30
Hard	> 30

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

Descriptive Terms	Undrained Shear Strength (kPa)
Very soft	< 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	> 200

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH12-01

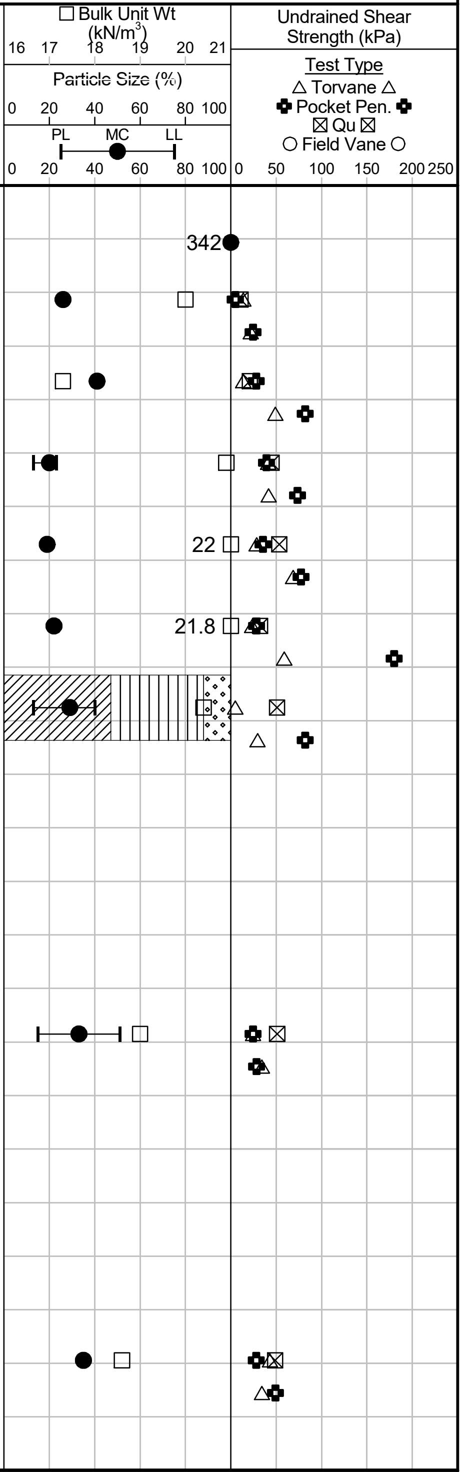
1 of 3

Client: Dillon Consulting
Project Number: 0022 005 01
Project Name: Falcon River Diversion and Shoal Lake Aqueduct Bridges
Location: UTM 15 N-5499351, E-334334 (SLA-Mile 93)
Contractor: Paddock Drilling Ltd.
Ground Elevation: 325.06 m
Method: 170 mm Hollow Stem Auger, Acker SS3 Track Mount
Date Drilled: 2012 March 27 - 2012 March 28

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

Elevation (m)	Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)
			PEAT - fibrous, fine, dark brown, wet, (von post H3)	Grab (G)	G01	
324.5			SILT - trace clay, trace sand - light grey - moist, very soft - intermediate plasticity	Shelby Tube (T)	T02	
323.4			CLAY - silty - grey, moist, soft, intermediate plasticity	Shelby Tube (T)	T03	
322.8			SILT - some clay, trace oxidation - light brown - moist to wet, soft to firm - low plasticity	Shelby Tube (T)	T04 T05	
321.3			CLAY and SILT - some sand, trace gravel, trace oxidation - light brown - moist - firm to stiff, intermediate plasticity	Shelby Tube (T)	T06 T07	
317.4			CLAY - silty, trace gravel (<10 mm diam.), trace fine to medium sand - grey - moist, firm to stiff - high plasticity	Shelby Tube (T)	T08 T09	



Depth (m): 1 2 3 4 5 6 7 8 9 10 11

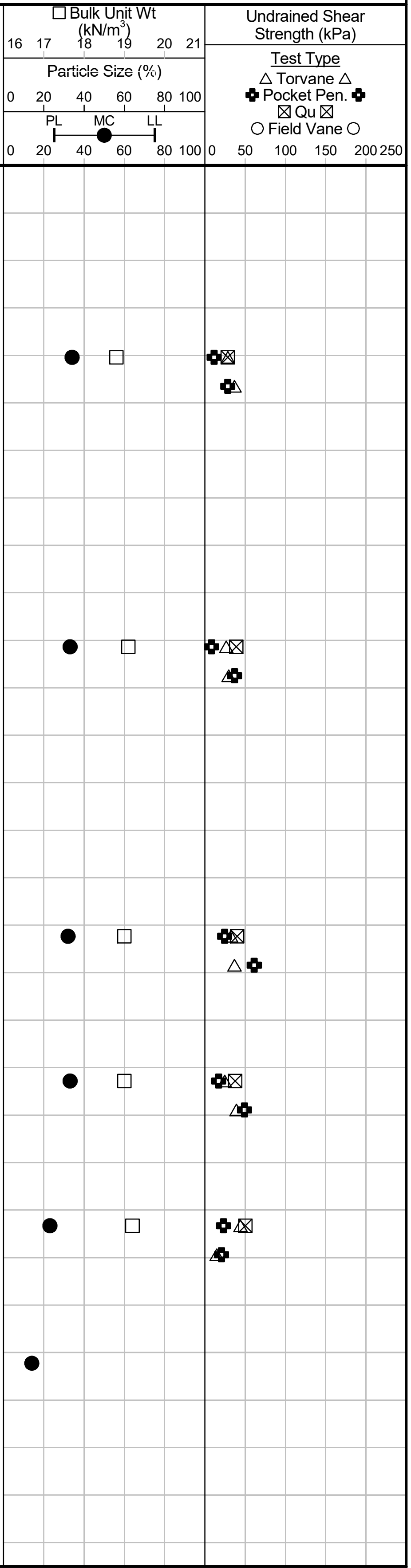
Logged By: Tom Hildahl **Reviewed By:** Brent Hay **Project Engineer:** Ken Skaftfeld

Test Hole TH12-01

2 of 3

Sub-Surface Log

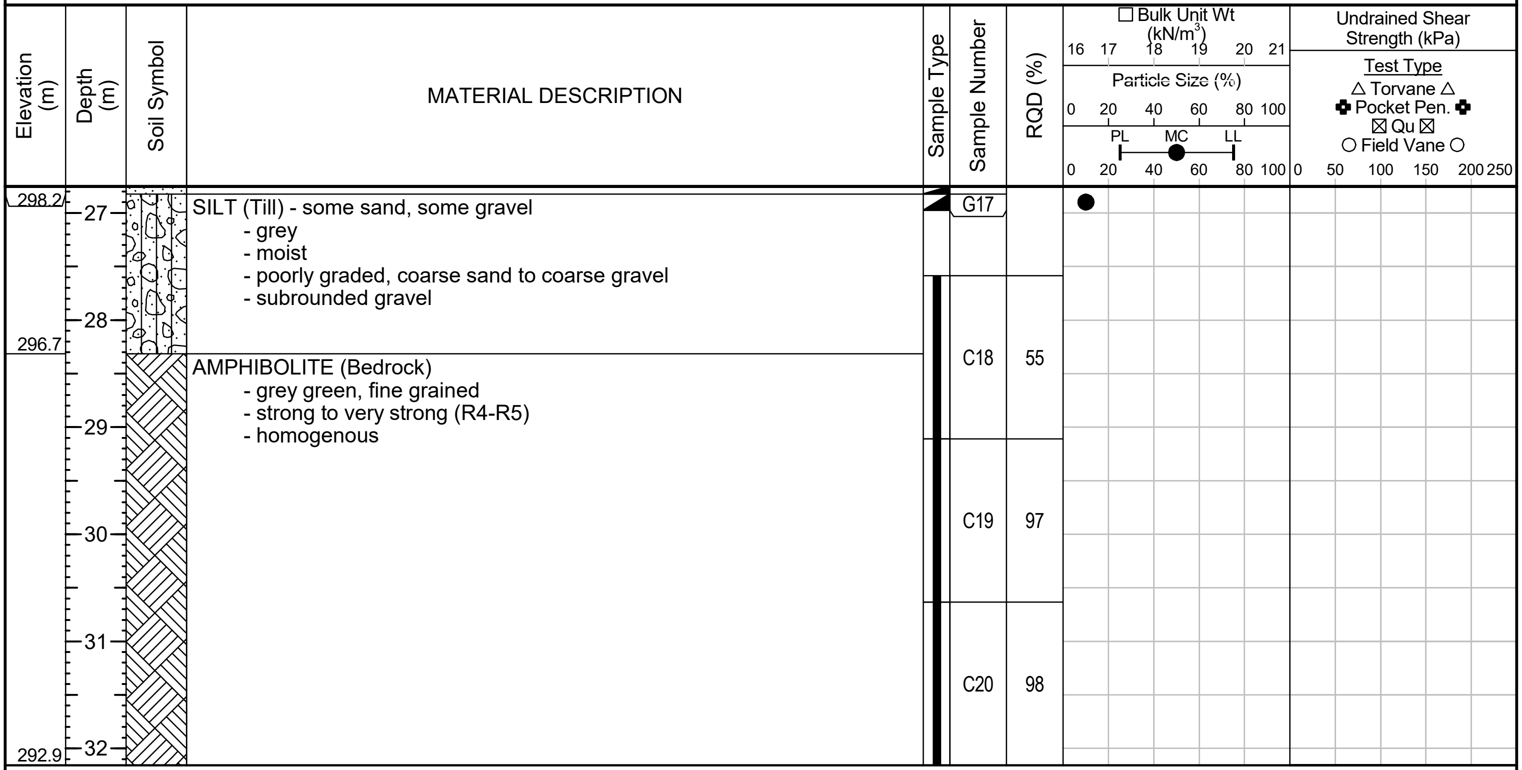
Elevation (m)	Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)
			-soft to firm, trace silt inclusions (<5mm diam.) below 10.7m		T10	
					T11	
					T12	
					T13	
					T14	
300.7			SAND - some gravel, trace to some cobbles - grey - poorly graded, coarse sand to coarse gravel - subrounded gravel		SB15	
			-brown below 26.2 m -cored through 150 mm cobble below from 26.4 m		G16	



Logged By: Tom Hildahl **Reviewed By:** Brent Hay **Project Engineer:** Ken Skaftfeld

Sub-Surface Log

Test Hole TH12-01



Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Number	RQD (%)
298.2		SILT (Till) - some sand, some gravel - grey - moist - poorly graded, coarse sand to coarse gravel - subrounded gravel	G17	
296.7		AMPHIBOLITE (Bedrock) - grey green, fine grained - strong to very strong (R4-R5) - homogenous	C18	55
			C19	97
			C20	98
292.9				

END OF HOLE AT 32.2 m IN AMPHIBOLITE

Notes:

1) Water level was 0.9 m below ground surface during drilling.
2) Sloughing observed at 3.1 m below ground surface during drilling.
3) Drilling method switched to NQ coring below 26.4 m.
4) Upper contact with bedrock is strongly weathered, fractured, and crumbly.

Logged By: Tom Hildahl **Reviewed By:** Brent Hay **Project Engineer:** Ken Skaftfeld

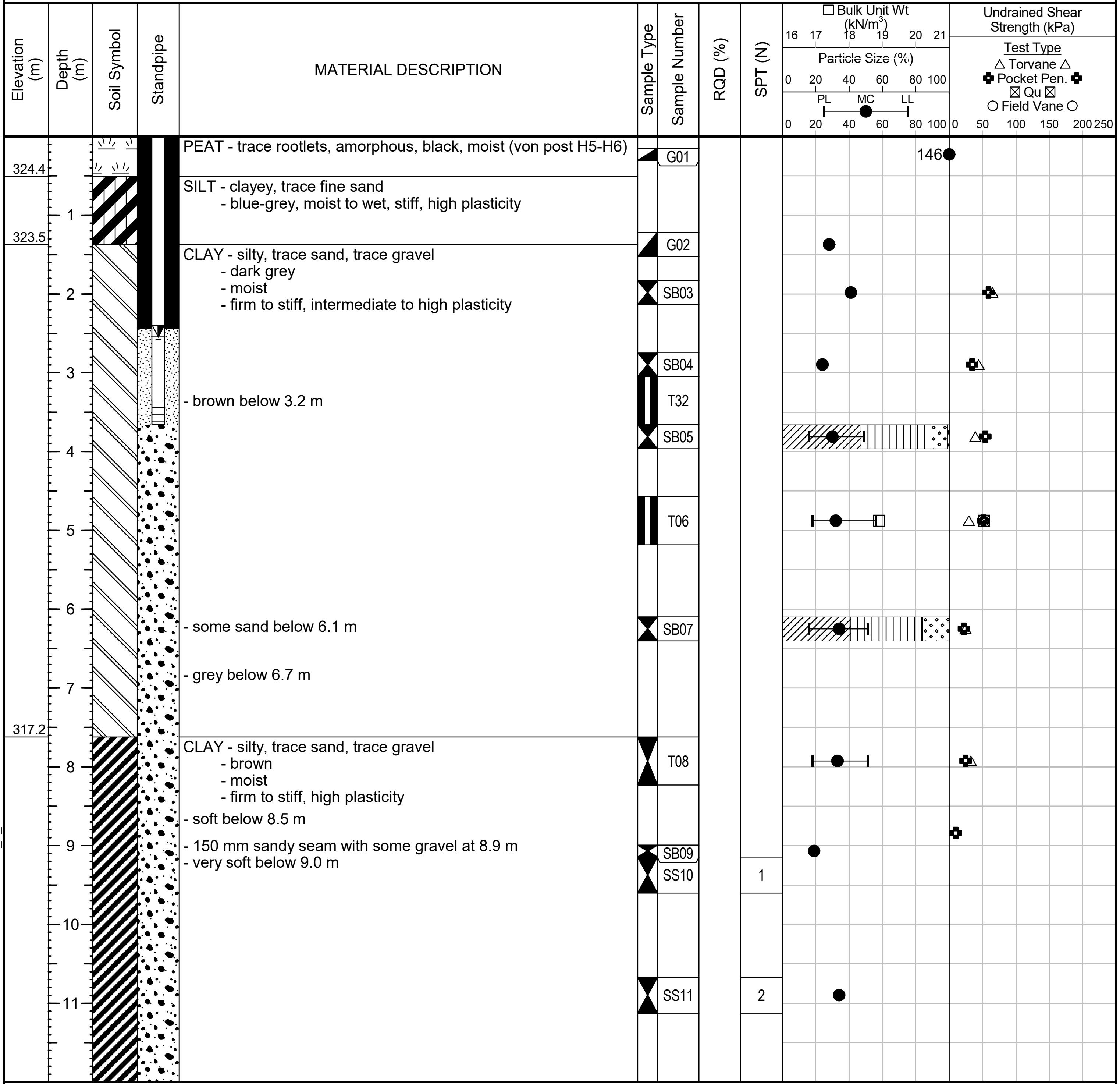
Sub-Surface Log

Client: Dillon Consulting Ltd
Project Name: Mile 93 Aqueduct Bridge
Contractor: Maple Leaf Drilling Ltd.
Method: 170 mm Hollow Stem Auger, B37X Track Mount
Project Number: 0022 039 00
Location: 5499388 m N, 334332 m E, Zone 15 UTM
Ground Elevation: 324.86 m
Date Drilled: 2016 December 7 - 2016 December 10

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



PEAT - trace rootlets, amorphous, black, moist (von post H5-H6)

SILT - clayey, trace fine sand
- blue-grey, moist to wet, stiff, high plasticity

CLAY - silty, trace sand, trace gravel
- dark grey
- moist
- firm to stiff, intermediate to high plasticity

- brown below 3.2 m

- some sand below 6.1 m

- grey below 6.7 m

CLAY - silty, trace sand, trace gravel
- brown
- moist
- firm to stiff, high plasticity

- soft below 8.5 m

- 150 mm sandy seam with some gravel at 8.9 m
- very soft below 9.0 m

Sample Number	SPT (N)
G01	
G02	
SB03	
SB04	
T32	
SB05	
T06	
SB07	
T08	
SB09	
SS10	1
SS11	2

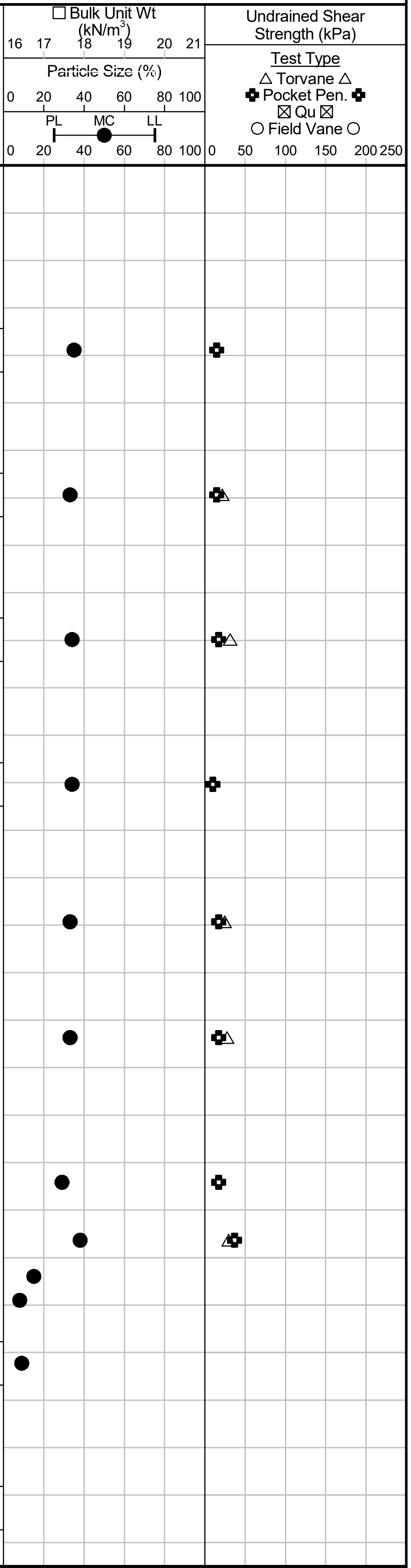
Logged By: Brent Hay **Reviewed By:** Ken Skaftfeld **Project Engineer:** Brent Hay

Sub-Surface Log

Test Hole TH16-01

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION
	13–23	CLAY - silty, trace sand, trace gravel - brown - moist - soft to firm, high plasticity
301.5		SAND - some gravel, trace clay, trace silt, dark grey, wet, compact, well graded fine sand to coarse gravel
300.9	24–25	SILT (TILL) - sandy, some gravel - dark grey - moist - dense
299.0	26	SAND - some gravel, trace clay, trace silt - dark grey, wet - very loose, well graded fine sand to corase gravel
298.2		

Sample Number	RQD (%)	SPT (N)
T12		
SS13		1
SS14		1
SS15		1
SS16		2
SB17		
SB18		
SB19		
SB20		
SB21		
SB22		
SS23		32
SS24		1



Logged By: Brent Hay **Reviewed By:** Ken Skaftfeld **Project Engineer:** Brent Hay

Sub-Surface Log

Test Hole TH16-01

☐ 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): 0 50 100 150 200 250

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

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Number	RQD (%)	SPT (N)
	27	SILT (TILL) - sandy, some gravel - dark grey, moist, dense			
297.4		CHLORITE SCHIST - light green to green - finely foliated - very soft to soft (R0-R1), rubbled	SS25		71 / 97mm
	28		C26		
	29 30		C27		
	31		C28a		
293.5		CHLORITE SCHIST with AMPHIBOLITE (Bedrock) transition			
293.3		AMPHIBOLITE (Bedrock) - grey green, fine grained - strong to very strong (R4-R5) - homogenous	C28b	83	
	32 33		C29	100	
291.2					

END OF HOLE AT 33.7 m in CHLORITE SCHIST

Notes:

1) Power auger refusal at 27.4 m in CHLORITE SCHIST.
2) Sloughing could not be observed due to drilling method.
3) Seepage observed into hollow stem augers at 3.0 m depth.
4) Standpipe piezometer SP16-01 installed 3 m west of test hole upon completion.

Logged By: Brent Hay **Reviewed By:** Ken Skaftfeld **Project Engineer:** Brent Hay

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TP16-02

1 of 1

Client: Dillon Consulting Ltd
Project Name: Mile 93 Aqueduct Bridge
Contractor: City of Winnipeg
Method: Hitachi 200 LC Excavator

Project Number: 0022 039 00
Location: 5499413 m N, 334318 m E, Zone 15 UTM
Ground Elevation: 325.68 m
Date Drilled: 2016 December 9 - 2016 December 9

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

Elevation (m)	Depth (m)	Soil Symbol	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 50 100 150 200 250
	▽		PEAT - trace rootlets, amorphous (von post H5-H6) - brown to black - wet						
				◢	G29			680●	
	1								
				◢	G30			720●	
324.1			SILT and CLAY - trace sand - grey, wet, firm, low plasticity						
323.5	2			◢	G31			●	

END OF HOLE AT 2.1 m in SILT AND CLAY
Notes:
1) Seepage observed from surface and throughout peat.
2) Caving of sidewall from surface to 2.1 m depth.
3) Water level at surface following completion.
4) Test hole backfilled with excavated material and tamped with bucket.

Logged By: Brent Hay **Reviewed By:** Ken Skaftfeld **Project Engineer:** Brent Hay

Appendix A

Soils Laboratory Testing

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. 0022 005 01
Client Dillion Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

Sample Date Mar 27, 2012
Test Date 3 to 6 of Apr, 2012
Technician Lee Boughton

Test Hole	TH12-01	TH12-01	TH12-01	TH12-01	TH12-01	TH12-01
Depth (m)	0.5 - 0.6	0.8 - 1.4	1.5 - 2.1	2.3 - 2.9	3.0 - 3.7	3.8 - 4.4
Sample #	G1	T2	T3	T4	T5	T6
Tare ID	Z52	N91	Z15	D5	N96	N102
Mass of tare	8.3	8.3	8.2	8.1	8.3	8.3
Mass wet + tare	162	499.2	389.1	553.2	468.4	410.3
Mass dry + tare	43.1	397.5	279.1	463.7	395.6	338.3
Mass water	118.9	101.7	110.0	89.5	72.8	72.0
Mass dry soil	34.8	389.2	270.9	455.6	387.3	330.0
Moisture %	341.7%	26.1%	40.6%	19.6%	18.8%	21.8%

Test Hole	TH12-01	TH12-01	TH12-01	TH12-01	TH12-01	TH12-01
Depth (m)	4.6 - 5.2	7.6 - 8.2	10.7 - 11.3	13.7 - 14.3	16.8 - 17.4	19.8 - 20.4
Sample #	T7	T8	T9	T10	T11	T12
Tare ID	N94	N93	N92	Z72	Z71	Z54
Mass of tare	8.3	8.3	8.3	8.4	8.3	8.2
Mass wet + tare	499.6	427.6	385.8	391.9	400.4	460.7
Mass dry + tare	388	323.3	288.9	294.2	303.2	350.1
Mass water	111.6	104.3	96.9	97.7	97.2	110.6
Mass dry soil	379.7	315.0	280.6	285.8	294.9	341.9
Moisture %	29.4%	33.1%	34.5%	34.2%	33.0%	32.3%

Test Hole	TH12-01	TH12-01	TH12-01	TH12-01		
Depth (m)	21.3 - 21.9	22.9 - 23.5	24.4 - 24.8	26.8 - 27.0		
Sample #	T13	T14	S15	G17		
Tare ID	Z65	N24	Z68	Z62		
Mass of tare	8.4	8.4	8.3	8.3		
Mass wet + tare	389.2	378.9	285.3	154.4		
Mass dry + tare	295.1	310.3	250.7	140.9		
Mass water	94.1	68.6	34.6	13.5		
Mass dry soil	286.7	301.9	242.4	132.6		
Moisture %	32.8%	22.7%	14.3%	10.2%		

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.	0022-039-00
Client	Dillion Consulting Ltd.
Project	Mile 93 Aqueduct Bridge
Sample Date	09-Dec-16
Test Date	14-Dec-16
Technician	SGBR

Test Pit	TH16-01	TH16-01	TH16-01	TH16-01	TH16-01	TH16-01
Depth (m)	0.2 - 0.3	1.2 - 1.5	1.8 - 2.1	2.7 - 3.0	3.7 - 4.0	6.1 - 6.4
Sample #	G01	G02	SB03	SB04	SB05	SB07
Tare ID	H60	F42	H80	N62	N57	AB47
Mass of tare	8.5	8.4	8.5	8.4	8.5	6.9
Mass wet + tare	382.8	607.3	394.4	292.3	441.9	453.0
Mass dry + tare	160.8	476.1	281.7	237.1	343.2	338.9
Mass water	222.0	131.2	112.7	55.2	98.7	114.1
Mass dry soil	152.3	467.7	273.2	228.7	334.7	332.0
Moisture %	145.8%	28.1%	41.3%	24.1%	29.5%	34.4%

Test Pit	TH16-01	TH16-01	TH16-01	TH16-01	TH16-01	TH16-01
Depth (m)	9.0 - 9.1	10.7 - 11.1	13.7 - 14.2	15.2 - 15.7	16.8 - 17.2	18.3 - 18.7
Sample #	SB09	SP11	SP13	SP14	SP15	SP16
Tare ID	Z31	K17	A102	E25	AC06	E24
Mass of tare	8.4	8.5	8.3	8.8	6.6	8.6
Mass wet + tare	401.8	355.7	385.7	313.2	390.9	342.3
Mass dry + tare	340.2	267.5	287.9	237.9	292.8	257.5
Mass water	61.6	88.2	97.8	75.3	98.1	84.8
Mass dry soil	331.8	259.0	279.6	229.1	286.2	248.9
Moisture %	18.6%	34.1%	35.0%	32.9%	34.3%	34.1%

Test Pit	TH16-01	TH16-01	TH16-01	TH16-01	TH16-01	TH16-01
Depth (m)	19.8 - 20.1	21.0 - 21.3	22.6 - 22.9	23.2 - 23.5	23.6 - 23.8	23.9 - 24.0
Sample #	SB17	SB18	SB19	SB20	SB21	SB22
Tare ID	H59	N76	Z83	C12	W41	D19
Mass of tare	8.5	8.5	8.4	8.4	8.5	8.6
Mass wet + tare	364.8	270.9	352.9	403.0	497.1	341.2
Mass dry + tare	277.5	205.6	275.0	293.7	432.3	316.9
Mass water	87.3	65.3	77.9	109.3	64.8	24.3
Mass dry soil	269.0	197.1	266.6	285.3	423.8	308.3
Moisture %	32.5%	33.1%	29.2%	38.3%	15.3%	7.9%

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. 0022-039-00
Client Dillion Consulting Ltd.
Project Mile 93 Aqueduct Bridge

Sample Date 09-Dec-16
Test Date 14-Dec-16
Technician SGBR

Test Pit	TH16-01	TH16-01	TH16-02	TH16-02	TH16-02	
Depth (m)	24.4 - 24.8	27.4 - 27.7	0.3 - 0.6	1.2 - 1.5	1.8 - 2.1	
Sample #	SB23	SP25	G29	G30	G31	
Tare ID	E47	N53	Z51	E62	F12	
Mass of tare	8.6	8.5	8.4	8.4	8.5	
Mass wet + tare	427.2	554.2	249.2	370.4	382.8	
Mass dry + tare	394.0	478.5	39.3	52.5	250.9	
Mass water	33.2	75.7	209.9	317.9	131.9	
Mass dry soil	385.4	470.0	30.9	44.1	242.4	
Moisture %	8.6%	16.1%	679.3%	720.9%	54.4%	

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

Atterberg Limits
ASTM D4318

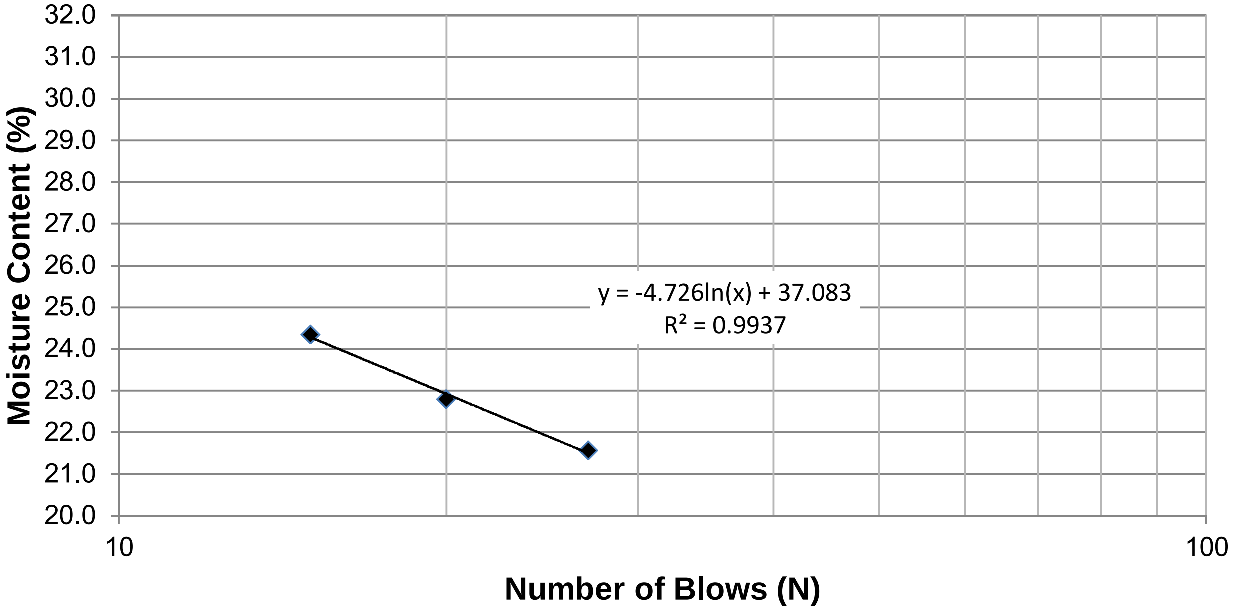
Project No. 0022 005 01
Client Dillion Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole TH12-01
Sample # T4
Depth (m) 2.3 - 2.9
Sample Date 27-Mar-12
Test Date 11-Apr-12
Technician Lee Boughton

Liquid Limit	21.9
Plastic Limit	13.0
Plasticity Index	8.9

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	27	20	15		
Mass Wet Soil + Tare (g)	28.317	26.949	27.198		
Mass Dry Soil + Tare (g)	25.789	24.544	24.627		
Mass Tare (g)	14.068	13.994	14.068		
Mass Water (g)	2.528	2.405	2.571		
Mass Dry Soil (g)	11.721	10.550	10.559		
Moisture Content (%)	21.568	22.796	24.349		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	19.973	19.813			
Mass Dry Soil + Tare (g)	19.290	19.140			
Mass Tare (g)	14.053	13.928			
Mass Water (g)	0.683	0.673			
Mass Dry Soil (g)	5.237	5.212			
Moisture Content (%)	13.042	12.913			

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

Atterberg Limits
ASTM D4318

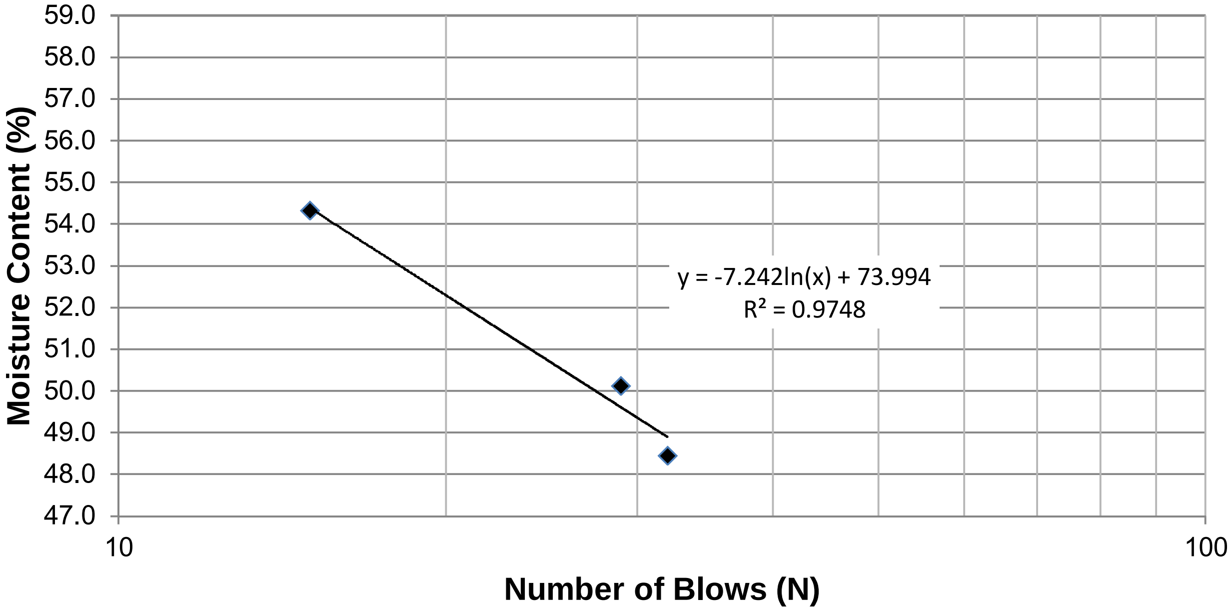
Project No.	0022 005 01
Client	Dillion Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole	TH12-01
Sample #	T8
Depth (m)	7.6 - 8.2
Sample Date	27-Mar-12
Test Date	11-Apr-12
Technician	Lee Boughton

Liquid Limit	50.7
Plastic Limit	15.1
Plasticity Index	35.5

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	32	29	15		
Mass Wet Soil + Tare (g)	27.454	26.295	27.887		
Mass Dry Soil + Tare (g)	23.076	22.209	22.978		
Mass Tare (g)	14.040	14.056	13.940		
Mass Water (g)	4.378	4.086	4.909		
Mass Dry Soil (g)	9.036	8.153	9.038		
Moisture Content (%)	48.451	50.117	54.315		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	20.120	20.051			
Mass Dry Soil + Tare (g)	19.339	19.294			
Mass Tare (g)	14.201	14.274			
Mass Water (g)	0.781	0.757			
Mass Dry Soil (g)	5.138	5.020			
Moisture Content (%)	15.200	15.080			

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

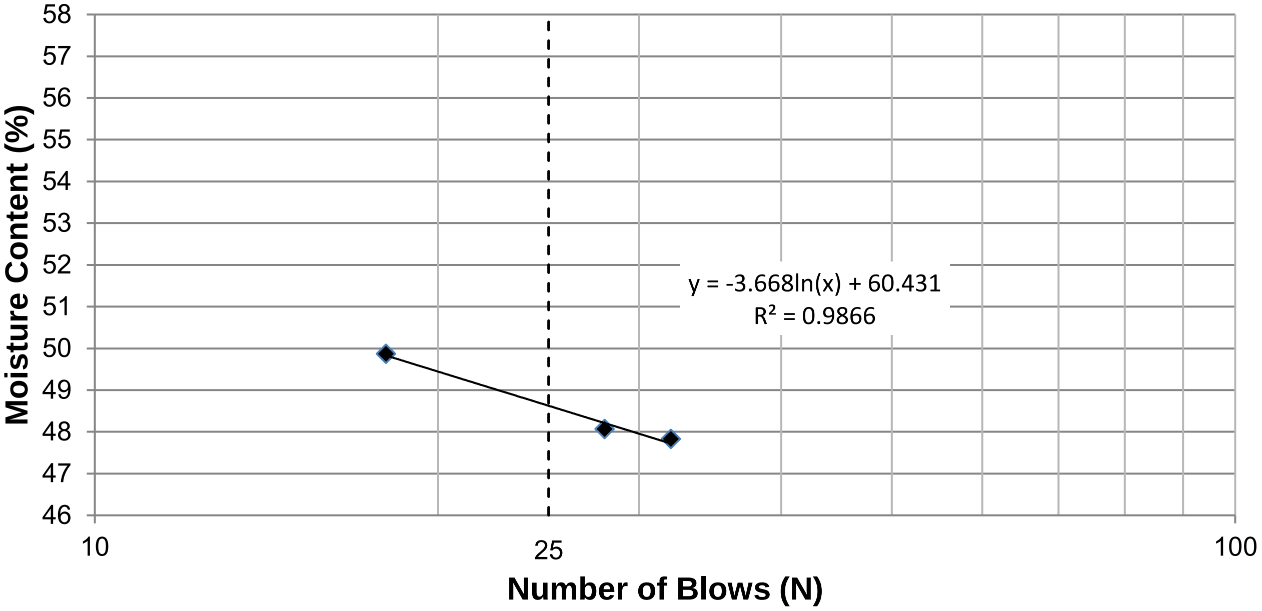
Atterberg Limits
ASTM D4318-10e1

Project No.	0022-039-00
Client	Dillon Consulting Ltd
Project	Mile 93 Aqueduct Bridge
Test Hole	TH16-01
Sample #	SB05
Depth (m)	3.7-4.0
Sample Date	09-Dec-16
Test Date	21-Dec-16
Technician	SGBR

Liquid Limit	49
Plastic Limit	16
Plasticity Index	33

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	18	28	32		
Mass Wet Soil + Tare (g)	29.991	34.405	35.405		
Mass Dry Soil + Tare (g)	24.718	27.839	28.521		
Mass Tare (g)	14.143	14.179	14.128		
Mass Water (g)	5.273	6.566	6.884		
Mass Dry Soil (g)	10.575	13.660	14.393		
Moisture Content (%)	49.863	48.067	47.829		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	20.412	20.640			
Mass Dry Soil + Tare (g)	19.595	19.710			
Mass Tare (g)	14.158	14.191			
Mass Water (g)	0.817	0.930			
Mass Dry Soil (g)	5.437	5.519			
Moisture Content (%)	15.027	16.851			

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

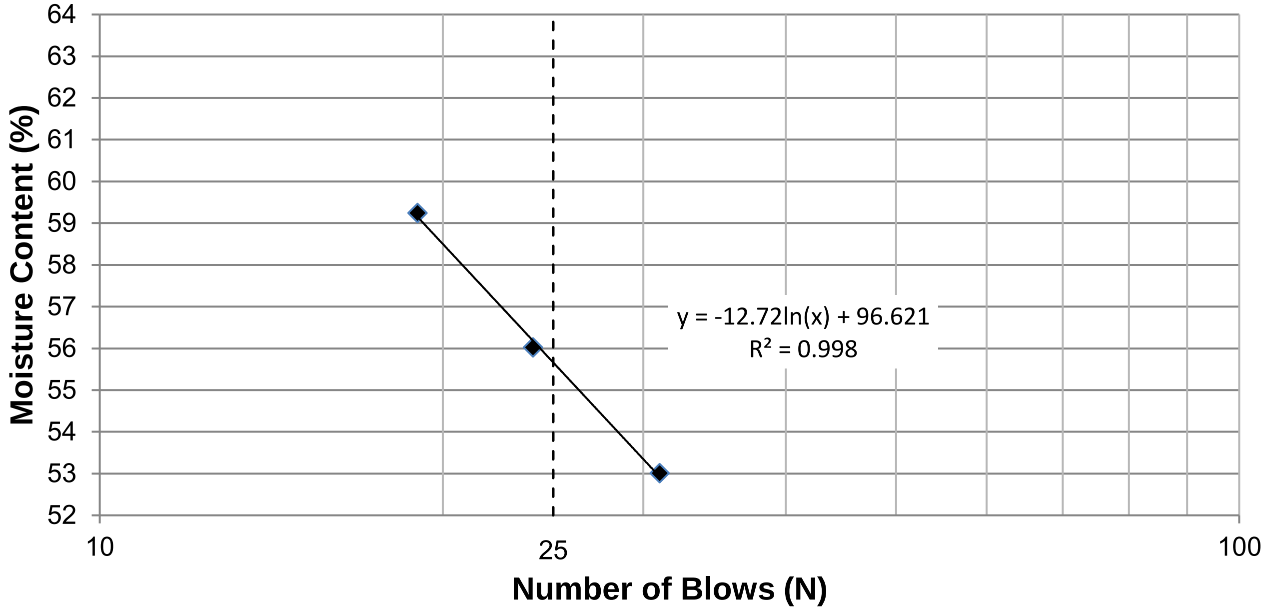
Atterberg Limits
ASTM D4318-10e1

Project No.	0022-039-00
Client	Dillon Consulting Ltd
Project	Mile 93 Aqueduct Bridge
Test Hole	TH16-01
Sample #	T06
Depth (m)	4.6-5.2
Sample Date	09-Dec-16
Test Date	21-Dec-16
Technician	SGBR

Liquid Limit	56
Plastic Limit	18
Plasticity Index	38

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	19	24	31		
Mass Wet Soil + Tare (g)	32.047	30.724	34.726		
Mass Dry Soil + Tare (g)	25.472	24.750	27.657		
Mass Tare (g)	14.373	14.086	14.320		
Mass Water (g)	6.575	5.974	7.069		
Mass Dry Soil (g)	11.099	10.664	13.337		
Moisture Content (%)	59.240	56.020	53.003		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	20.400	21.450			
Mass Dry Soil + Tare (g)	19.408	20.364			
Mass Tare (g)	13.768	14.167			
Mass Water (g)	0.992	1.086			
Mass Dry Soil (g)	5.640	6.197			
Moisture Content (%)	17.589	17.525			

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

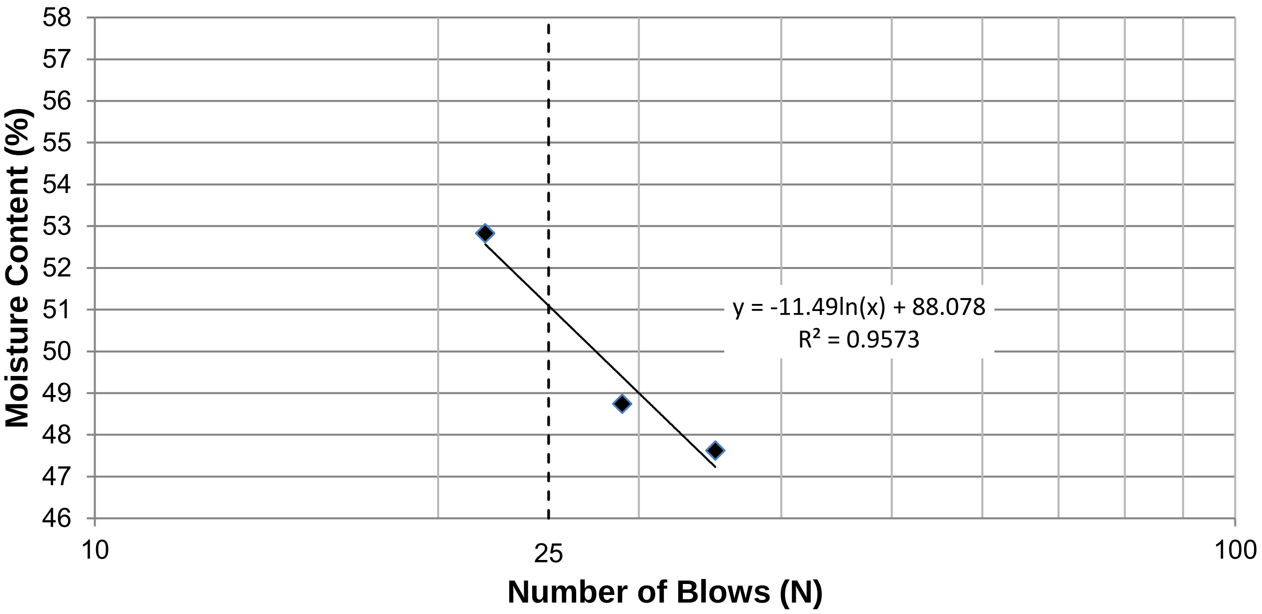
Atterberg Limits
ASTM D4318-10e1

Project No.	0022-039-00
Client	Dillon Consulting Ltd
Project	Mile 93 Aqueduct Bridge
Test Hole	TH16-01
Sample #	SB07
Depth (m)	6.1-6.4
Sample Date	09-Dec-16
Test Date	21-Dec-16
Technician	SGBR

Liquid Limit	51
Plastic Limit	16
Plasticity Index	35

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	22	29	35		
Mass Wet Soil + Tare (g)	29.063	30.802	29.583		
Mass Dry Soil + Tare (g)	23.868	25.313	24.630		
Mass Tare (g)	14.034	14.051	14.228		
Mass Water (g)	5.195	5.489	4.953		
Mass Dry Soil (g)	9.834	11.262	10.402		
Moisture Content (%)	52.827	48.739	47.616		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	20.068	22.027			
Mass Dry Soil + Tare (g)	19.201	21.010			
Mass Tare (g)	14.030	14.252			
Mass Water (g)	0.867	1.017			
Mass Dry Soil (g)	5.171	6.758			
Moisture Content (%)	16.767	15.049			

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

Atterberg Limits
ASTM D4318-10e1

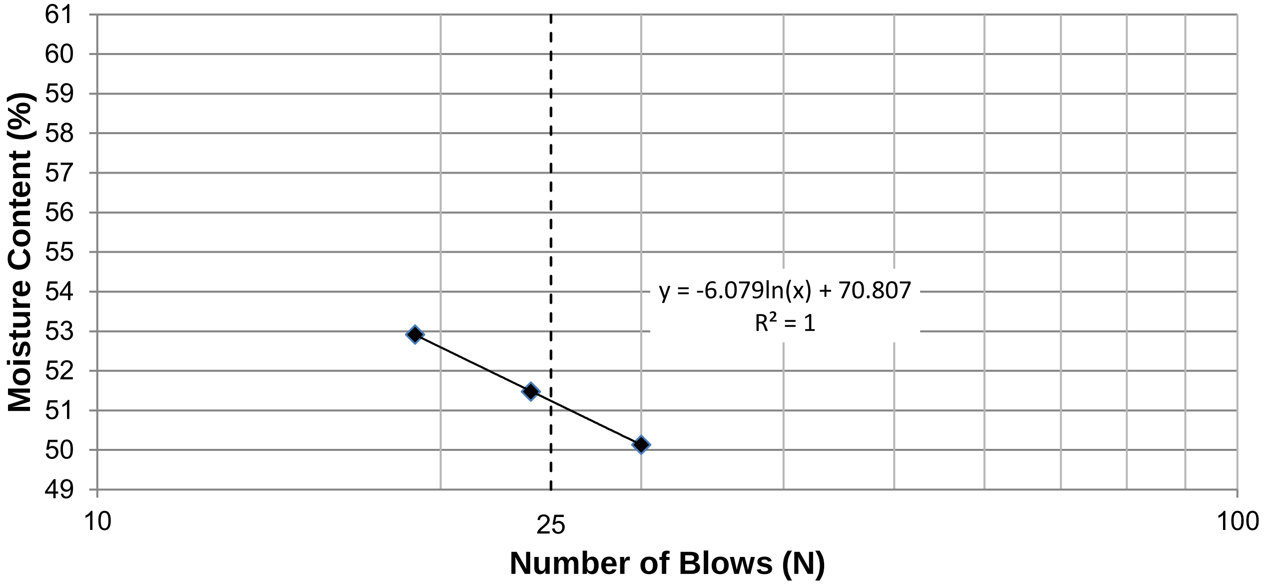
Project No.	0022-039-00
Client	Dillon Consulting Ltd
Project	Mile 93 Aqueduct Bridge

Test Hole	TH 16-01
Sample #	T08
Depth (m)	7.6-8.2
Sample Date	12-Dec-16
Test Date	16-Feb-17
Technician	SX

Liquid Limit	51
Plastic Limit	18
Plasticity Index	33

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	19	24	30		
Mass Wet Soil + Tare (g)	24.530	25.393	23.260		
Mass Dry Soil + Tare (g)	21.015	21.443	20.139		
Mass Tare (g)	14.372	13.770	13.914		
Mass Water (g)	3.515	3.950	3.121		
Mass Dry Soil (g)	6.643	7.673	6.225		
Moisture Content (%)	52.913	51.479	50.137		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	22.230	22.760			
Mass Dry Soil + Tare (g)	20.939	21.430			
Mass Tare (g)	13.933	14.154			
Mass Water (g)	1.291	1.330			
Mass Dry Soil (g)	7.006	7.276			
Moisture Content (%)	18.427	18.279			

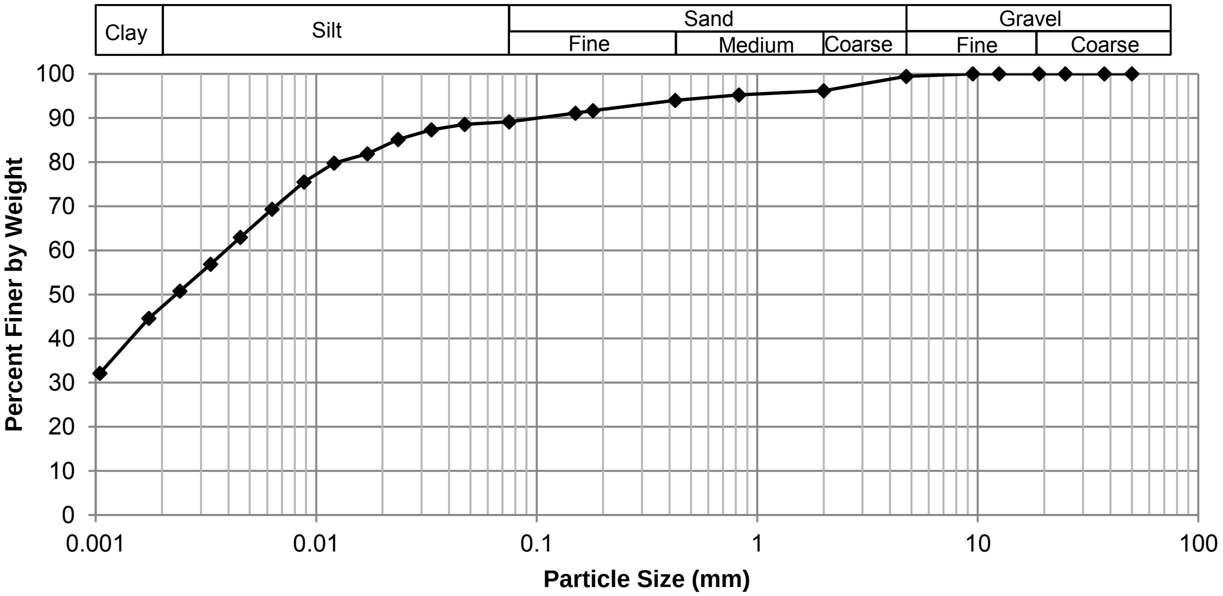
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Grain Size Analysis (Hydrometer Method)
ASTM D422

Project No.	0022-039
Client	Dillon Consulting Ltd
Project	Mile 93 Aqueduct Bridge
Test Hole	TH16-01
Sample #	SB05
Depth (m)	3.7 - 4.0
Sample Date	9-Dec-16
Test Date	21-Dec-16
Technician	MM

Gravel	0.6%
Sand	10.3%
Silt	42.1%
Clay	47.0%

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	99.41	0.0750	89.11
37.5	100.00	2.00	96.17	0.0471	88.54
25.0	100.00	0.825	95.24	0.0333	87.32
19.0	100.00	0.425	93.98	0.0236	85.18
12.5	100.00	0.180	91.68	0.0171	81.89
9.50	100.00	0.150	91.10	0.0121	79.75
4.75	99.41	0.075	89.11	0.0088	75.48
				0.0063	69.37
				0.0045	62.95
				0.0033	56.84
				0.0024	50.74
				0.0017	44.63
				0.0010	32.11

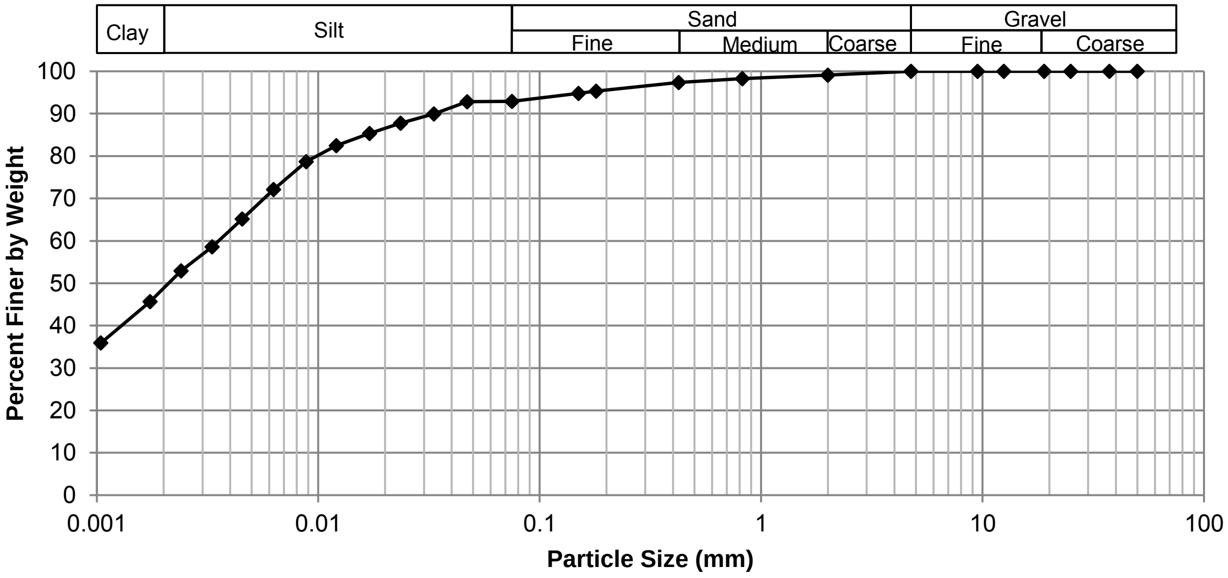
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Grain Size Analysis (Hydrometer Method)
ASTM D422

Project No.	0022-039
Client	Dillon Consulting Ltd
Project	Mile 93 Aqueduct Bridge
Test Hole	TH16-01
Sample #	SB07
Depth (m)	6.1 - 6.4
Sample Date	9-Dec-16
Test Date	21-Dec-16
Technician	MM

Gravel	0.0%
Sand	7.1%
Silt	44.5%
Clay	48.5%

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	92.93
37.5	100.00	2.00	99.09	0.0471	92.80
25.0	100.00	0.825	98.31	0.0333	89.97
19.0	100.00	0.425	97.33	0.0236	87.76
12.5	100.00	0.180	95.36	0.0171	85.31
9.50	100.00	0.150	94.83	0.0121	82.48
4.75	100.00	0.075	92.93	0.0088	78.71
				0.0063	72.10
				0.0045	65.18
				0.0033	58.57
				0.0024	52.90
				0.0017	45.67
				0.0010	35.91

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

Shelby Tube Visual

Project No.	0022-039-00
Client	Dillon Consulting
Project	Mile 93 Aqueduct Bridge
Test Hole	TH16-01
Sample #	T06
Depth (m)	4.6 - 5.2
Sample Date	09-Dec-16
Test Date	14-Dec-16
Technician	SGBR

Tube Extraction

Recovery (mm) 565

Bottom - 5.1 m **Top - 4.6 m**

Keep	PP TV Visual	QU Bulk	Moisture Content	Slough
230 mm	80 mm	150 mm	70 mm	35 mm

Visual Classification

Material	Clay
Composition	silty

trace sand, trace gravel (~<20mm ⌀)

trace precipitate (gypsum) (~<10mm ⌀)

Color	mottled brown
Moisture	moist
Consistency	soft
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.26
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	25.5

Pocket Penetrometer

Reading	**1**	1.50
	2	1.50
	3	1.25
	Average	1.42
Undrained Shear Strength (kPa)		69.5

Moisture Content

Tare ID	43
Mass tare (g)	371.9
Mass wet + tare (g)	1415.9
Mass dry + tare (g)	1160.7
Moisture %	32.4%

Unit Weight

Bulk Weight (g)		1201.9
		152.68
Length (mm)	**1**	152.57
	2	152.28
	3	152.00
	4	
Average Length (m)		0.152
Diam. (mm)	**1**	72.44
	2	72.32
	3	72.12
	4	71.86
Average Diameter (m)		0.072
Volume (m^3)		6.23E-04
Bulk Unit Weight (kN/m^3)		18.9
Bulk Unit Weight (pcf)		120.4
Dry Unit Weight (kN/m^3)		14.3
Dry Unit Weight (pcf)		91.0

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

Unconfined Compressive Strength

ASTM D2166

Project No. 0022-039-00
Client Dillon Consulting
Project Mile 93 Aqueduct Bridge

Test Hole TH16-01
Sample # T06
Depth (m) 4.6 - 5.2
Sample Date 9-Dec-16
Test Date 14-Dec-16
Technician SGBR

Unconfined Strength

	kPa	ksf
Max q_u	103.9	2.2
Max S_u	51.9	1.1

Specimen Data

Description Clay - silty, trace sand, trace gravel (~<20mm ⌀), trace precipitate (gypsum) (~<10mm ⌀), mottled brown , moist, soft, high plasticity

Length	152.3	(mm)	**Moisture %**	32%	
Diameter	72.2	(mm)	**Bulk Unit Wt.**	18.9	(kN/m^3)
L/D Ratio	2.1		**Dry Unit Wt.**	14.3	(kN/m^3)
Initial Area	0.00409	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.26	25.5	0.53
Vane Size		
m		

Pocket Penetrometer

	Reading	**Undrained Shear Strength**	
	tsf	**kPa**	**ksf**
	1.50	73.6	1.54
	1.50	73.6	1.54
	1.25	61.3	1.28
Average	**1.42**	**69.5**	**1.45**

Failure Geometry

Sketch:

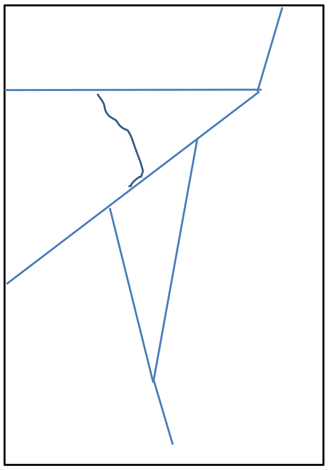


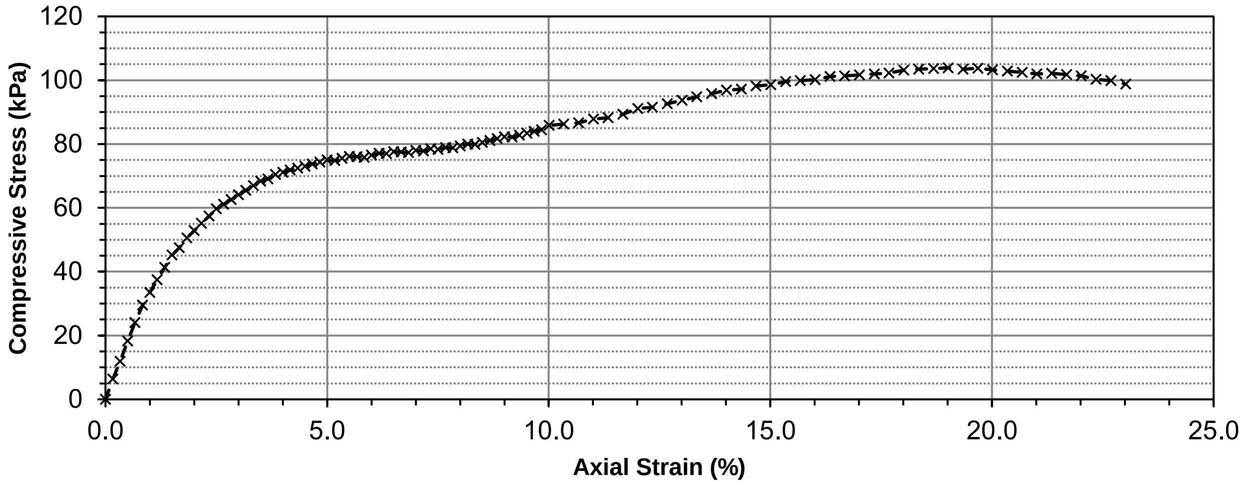
Photo:

Unconfined Compressive Strength

ASTM D2166

Project No. 0022-039-00
Client Dillon Consulting
Project Mile 93 Aqueduct Bridge

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	0.004092	0.0	0.00	0.00
10	8	0.2540	0.17	0.004099	26.2	6.38	3.19
20	15	0.5080	0.33	0.004106	49.1	11.96	5.98
30	23	0.7620	0.50	0.004113	75.3	18.32	9.16
40	30	1.0160	0.67	0.004120	98.9	24.01	12.01
50	37	1.2700	0.83	0.004127	122.0	29.56	14.78
60	42	1.5240	1.00	0.004134	138.5	33.50	16.75
70	47	1.7780	1.17	0.004141	155.0	37.43	18.71
80	52	2.0320	1.33	0.004148	171.4	41.33	20.67
90	57	2.2860	1.50	0.004155	187.9	45.23	22.62
100	60	2.5400	1.67	0.004162	197.8	47.53	23.76
110	64	2.7940	1.83	0.004169	211.0	50.62	25.31
120	67	3.0480	2.00	0.004176	220.9	52.90	26.45
130	70	3.3020	2.17	0.004183	230.8	55.17	27.58
140	73	3.5560	2.34	0.004190	240.7	57.44	28.72
150	76	3.8100	2.50	0.004197	250.6	59.70	29.85
160	78	4.0640	2.67	0.004205	257.2	61.16	30.58
170	80	4.3180	2.84	0.004212	263.8	62.63	31.31
180	82	4.5720	3.00	0.004219	270.4	64.08	32.04
190	84	4.8260	3.17	0.004226	276.9	65.53	32.76
200	86	5.0800	3.34	0.004234	283.5	66.97	33.48
210	88	5.3340	3.50	0.004241	290.2	68.42	34.21
220	89	5.5880	3.67	0.004248	293.4	69.07	34.54
230	91	5.8420	3.84	0.004256	300.0	70.50	35.25

Unconfined Compressive Strength

ASTM D2166

Project No. 0022-039-00
Client Dillon Consulting
Project Mile 93 Aqueduct Bridge

Unconfined Compression Test Data (cont'd)

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)
240	92	6.0960	4.0031	0.004263	303.3	71.15	35.58
250	93	6.3500	4.17	0.004271	306.6	71.80	35.90
260	94	6.6040	4.34	0.004278	309.9	72.44	36.22
270	95	6.8580	4.50	0.004285	313.2	73.08	36.54
280	96	7.1120	4.67	0.004293	316.5	73.73	36.87
290	97	7.3660	4.84	0.004300	319.8	74.37	37.19
300	98	7.6200	5.00	0.004308	323.1	75.00	37.50
310	98	7.8740	5.17	0.004316	323.1	74.87	37.44
320	99	8.1280	5.34	0.004323	326.4	75.50	37.75
330	100	8.3820	5.50	0.004331	329.7	76.13	38.06
340	100	8.6360	5.67	0.004338	329.7	75.99	38.00
350	100	8.8900	5.84	0.004346	329.7	75.86	37.93
360	101	9.1440	6.00	0.004354	333.1	76.50	38.25
370	102	9.3980	6.17	0.004362	336.4	77.13	38.57
380	102	9.6520	6.34	0.004369	336.4	76.99	38.50
390	103	9.9060	6.50	0.004377	339.8	77.63	38.81
400	103	10.1600	6.67	0.004385	339.8	77.49	38.75
410	103	10.4140	6.84	0.004393	339.8	77.35	38.68
420	104	10.6680	7.01	0.004401	343.2	77.98	38.99
430	104	10.9220	7.17	0.004409	343.2	77.84	38.92
440	105	11.1760	7.34	0.004417	346.6	78.47	39.23
450	105	11.4300	7.51	0.004425	346.6	78.33	39.16
460	106	11.6840	7.67	0.004433	349.9	78.94	39.47
470	106	11.9380	7.84	0.004441	349.9	78.80	39.40
480	107	12.1920	8.01	0.004449	353.3	79.41	39.71
490	108	12.4460	8.17	0.004457	356.7	80.03	40.01
500	108	12.7000	8.34	0.004465	356.7	79.88	39.94
510	109	12.9540	8.51	0.004473	360.0	80.48	40.24
520	110	13.2080	8.67	0.004481	363.4	81.09	40.55
530	111	13.4620	8.84	0.004489	366.8	81.70	40.85
540	112	13.7160	9.01	0.004498	370.1	82.30	41.15
550	112	13.9700	9.17	0.004506	370.1	82.15	41.07
560	113	14.2240	9.34	0.004514	373.5	82.73	41.37
570	114	14.4780	9.51	0.004522	376.9	83.33	41.67
580	115	14.7320	9.67	0.004531	380.2	83.92	41.96
590	116	14.9860	9.84	0.004539	383.6	84.50	42.25
600	118	15.2400	10.01	0.004548	390.3	85.83	42.92
620	119	15.7480	10.34	0.004564	393.7	86.25	43.12
640	120	16.2560	10.67	0.004582	397.0	86.66	43.33
660	122	16.7640	11.01	0.004599	403.8	87.81	43.90
680	123	17.2720	11.34	0.004616	407.1	88.20	44.10
700	125	17.7800	11.68	0.004633	413.9	89.33	44.67
720	128	18.2880	12.01	0.004651	424.0	91.16	45.58
740	129	18.7960	12.34	0.004669	427.4	91.54	45.77
760	131	19.3040	12.68	0.004687	434.1	92.63	46.31

Project No. 0022-039-00
Client Dillon Consulting
Project Mile 93 Aqueduct Bridge

780	133	19.8120	13.01	0.004705	440.8	93.70	46.85
800	135	20.3200	13.34	0.004723	447.6	94.77	47.39
820	137	20.8280	13.68	0.004741	454.3	95.83	47.91
840	139	21.3360	14.01	0.004759	461.1	96.88	48.44
860	140	21.8440	14.34	0.004778	464.4	97.20	48.60
880	142	22.3520	14.68	0.004796	471.2	98.23	49.11
900	143	22.8600	15.01	0.004815	474.5	98.55	49.27
920	145	23.3680	15.35	0.004834	481.3	99.55	49.78
940	146	23.8760	15.68	0.004853	484.6	99.85	49.93
960	147	24.3840	16.01	0.004873	488.0	100.14	50.07
980	149	24.8920	16.35	0.004892	494.7	101.13	50.56
1000	150	25.4000	16.68	0.004912	498.1	101.40	50.70
1020	151	25.9080	17.01	0.004931	501.4	101.68	50.84
1040	152	26.4160	17.35	0.004951	504.8	101.96	50.98
1060	153	26.9240	17.68	0.004971	508.2	102.23	51.11
1080	155	27.4320	18.01	0.004992	514.9	103.16	51.58
1100	156	27.9400	18.35	0.005012	518.3	103.41	51.71
1120	157	28.4480	18.68	0.005033	521.6	103.65	51.83
1140	158	28.9560	19.01	0.005053	525.0	103.90	51.95
1160	158	29.4640	19.35	0.005074	525.0	103.47	51.73
1180	159	29.9720	19.68	0.005095	528.4	103.70	51.85
1200	159	30.4800	20.02	0.005117	528.4	103.27	51.64
1220	159	30.9880	20.35	0.005138	528.4	102.84	51.42
1240	159	31.4960	20.68	0.005160	528.4	102.41	51.21
1260	159	32.0040	21.02	0.005181	528.4	101.98	50.99
1280	160	32.5120	21.35	0.005203	531.8	102.20	51.10
1300	160	33.0200	21.68	0.005226	531.8	101.77	50.88
1320	160	33.5280	22.02	0.005248	531.8	101.33	50.67
1340	159	34.0360	22.35	0.005270	528.4	100.26	50.13
1360	159	34.5440	22.68	0.005293	528.4	99.83	49.91
1380	158	35.0520	23.02	0.005316	525.0	98.76	49.38

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

Unconfined Compressive Strength

ASTM D2166

Project No.	0022 005 01
Client	Dillon Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole	TH12-01
Sample #	T2
Depth (m)	0.8 - 1.4
Sample Date	27-Mar-12
Test Date	03-Apr-12
Technician	Lee Boughton

Unconfined Strength

	kPa	**ksf**
Max q_u	21.1	0.4
Max S_u	10.6	0.2

Specimen Data

Description SILT - some clay, light grey, moist, very soft, intermediate plasticity, homogeneous

Length	152.2	(mm)	**Moisture %**	26.1%	
Diameter	71.6	(mm)	**Bulk Unit Wt.**	20.0	(kN/m^3)
L/D Ratio	2.1		**Dry Unit Wt.**	15.9	(kN/m^3)
Initial Area	0.00403	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.14	13.7	0.29

Pocket Penetrometer

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.10	4.9	0.10
0.10	4.9	0.10
0.10	4.9	0.10
Average	**4.9**	**0.10**

Failure Geometry

Sketch:

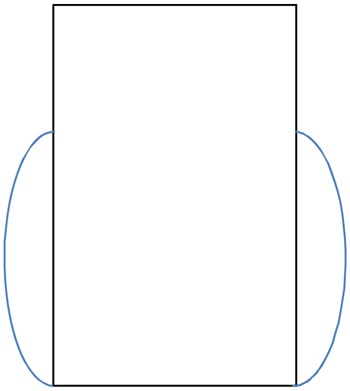
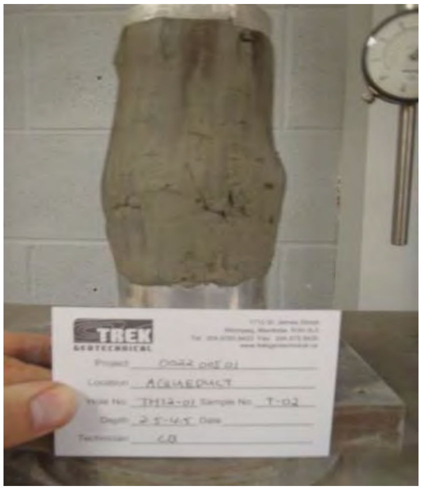


Photo:



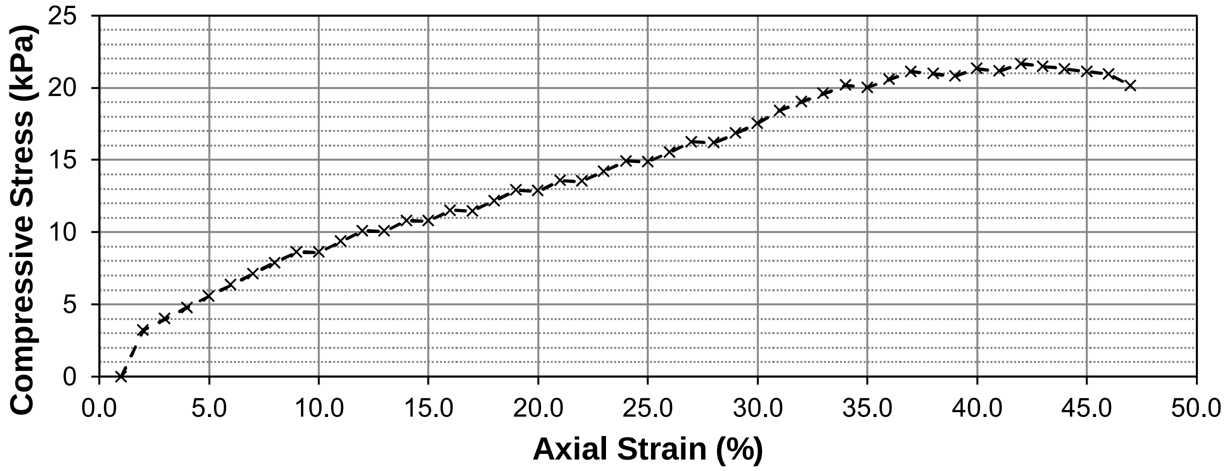
Notes: Buldge failure

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	0.004025	0.0	0.00	0.00
20	4	0.5080	0.33	0.004039	13.0	3.21	1.61
40	5	1.0160	0.67	0.004052	16.2	4.00	2.00
60	6	1.5240	1.00	0.004066	19.5	4.79	2.39
80	7	2.0320	1.33	0.004080	22.7	5.57	2.78
100	8	2.5400	1.67	0.004094	26.0	6.34	3.17
120	9	3.0480	2.00	0.004108	29.2	7.11	3.56
140	10	3.5560	2.34	0.004122	32.5	7.88	3.94
160	11	4.0640	2.67	0.004136	35.7	8.64	4.32
180	11	4.5720	3.00	0.004150	35.7	8.61	4.30
200	12	5.0800	3.34	0.004164	39.0	9.36	4.68
220	13	5.5880	3.67	0.004179	42.2	10.11	5.05
240	13	6.0960	4.00	0.004193	42.2	10.07	5.04
260	14	6.6040	4.34	0.004208	45.5	10.81	5.41
280	14	7.1120	4.67	0.004223	45.5	10.77	5.39
300	15	7.6200	5.01	0.004237	48.8	11.51	5.75
320	15	8.1280	5.34	0.004252	48.8	11.46	5.73
340	16	8.6360	5.67	0.004267	52.0	12.19	6.09
360	17	9.1440	6.01	0.004283	55.3	12.91	6.45
380	17	9.6520	6.34	0.004298	55.3	12.86	6.43
400	18	10.1600	6.67	0.004313	58.5	13.57	6.79
420	18	10.6680	7.01	0.004329	58.5	13.52	6.76
440	19	11.1760	7.34	0.004344	61.8	14.22	7.11
460	20	11.6840	7.68	0.004360	65.1	14.92	7.46

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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)
480	20	12.1920	8.0092	0.004376	65.1	14.87	7.43
500	21	12.7000	8.34	0.004392	68.3	15.56	7.78
520	22	13.2080	8.68	0.004408	71.6	16.24	8.12
540	22	13.7160	9.01	0.004424	71.6	16.18	8.09
560	23	14.2240	9.34	0.004440	74.9	16.86	8.43
580	24	14.7320	9.68	0.004457	78.1	17.53	8.76
600	25	15.2400	10.01	0.004473	82.4	18.43	9.21
640	26	16.2560	10.68	0.004507	85.7	19.02	9.51
680	27	17.2720	11.35	0.004540	89.0	19.60	9.80
720	28	18.2880	12.01	0.004575	92.3	20.18	10.09
760	28	19.3040	12.68	0.004610	92.3	20.02	10.01
800	29	20.3200	13.35	0.004645	95.6	20.58	10.29
840	30	21.3360	14.02	0.004681	98.9	21.13	10.57
880	30	22.3520	14.68	0.004718	98.9	20.97	10.48
920	30	23.3680	15.35	0.004755	98.9	20.80	10.40
960	31	24.3840	16.02	0.004793	102.2	21.33	10.66
1000	31	25.4000	16.69	0.004831	102.2	21.16	10.58
1040	32	26.4160	17.35	0.004870	105.5	21.66	10.83
1080	32	27.4320	18.02	0.004910	105.5	21.49	10.74
1120	32	28.4480	18.69	0.004950	105.5	21.31	10.66
1160	32	29.4640	19.36	0.004991	105.5	21.14	10.57
1200	32	30.4800	20.02	0.005033	105.5	20.96	10.48
1240	31	31.4960	20.69	0.005075	102.2	20.14	10.07

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

Unconfined Compressive Strength

ASTM D2166

Project No.	0022 005 01
Client	Dillon Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole	TH12-01
Sample #	T3
Depth (m)	1.5 - 2.1
Sample Date	27-Mar-12
Test Date	03-Apr-12
Technician	Lee Boughton

Unconfined Strength

	kPa	**ksf**
Max q_u	41.9	0.9
Max S_u	20.9	0.4

Specimen Data

Description CLAY - silty, silt inclusions (<15 mm diam.), grey, moist, soft, intermediate plasticity, blocky

Length	148.2	(mm)
Diameter	72.8	(mm)
L/D Ratio	2.0	
Initial Area	0.00416	(m^2)
Load Rate	1.00	(%/min)

Moisture %	40.6%	
Bulk Unit Wt.	17.3	(kN/m^3)
Dry Unit Wt.	12.3	(kN/m^3)
Liquid Limit	-	
Plastic Limit	-	
Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.14	13.7	0.29

Pocket Penetrometer

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.60	29.4	0.61
0.50	24.5	0.51
0.60	29.4	0.61
Average	**27.8**	**0.58**

Failure Geometry

Sketch:

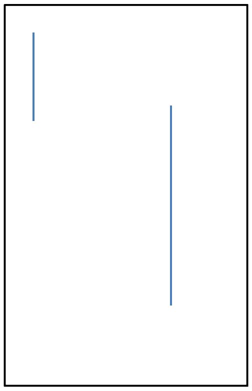


Photo:

TREK GEOTECHNICAL
Project 0022 005 01
Location AQUEDUCT
Hole No. TH12-01 Sample No. T-03
Depth 5-7 Date
Technician LB

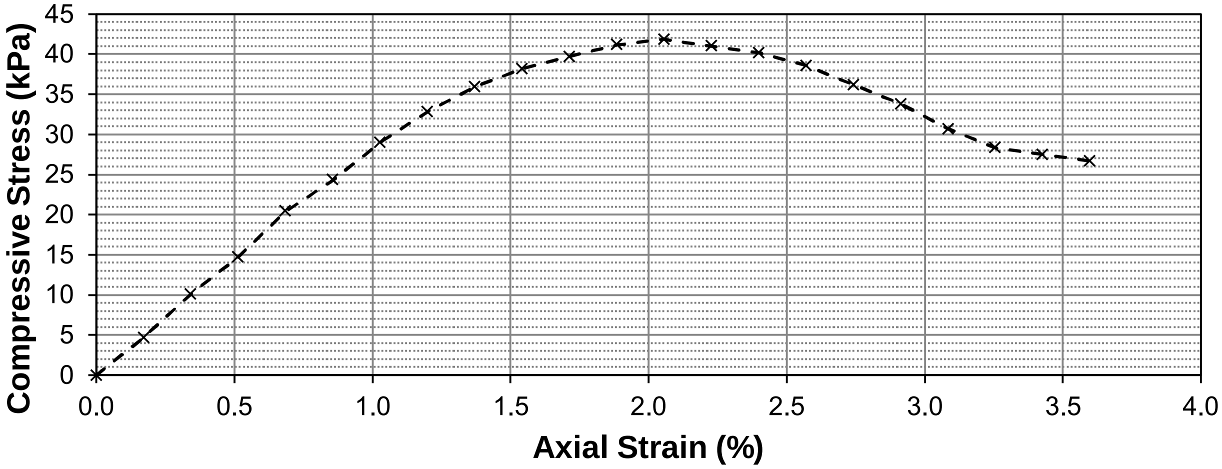
Notes: Columnar failure

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	0.004163	0.0	0.00	0.00
10	6	0.2540	0.17	0.004170	19.5	4.67	2.33
20	13	0.5080	0.34	0.004178	42.2	10.11	5.06
30	19	0.7620	0.51	0.004185	61.8	14.77	7.38
40	26	1.0160	0.69	0.004192	85.7	20.45	10.22
50	31	1.2700	0.86	0.004199	102.2	24.34	12.17
60	37	1.5240	1.03	0.004207	122.0	29.00	14.50
70	42	1.7780	1.20	0.004214	138.5	32.86	16.43
80	46	2.0320	1.37	0.004221	151.7	35.93	17.97
90	49	2.2860	1.54	0.004229	161.6	38.21	19.10
100	51	2.5400	1.71	0.004236	168.1	39.69	19.85
110	53	2.7940	1.88	0.004243	174.7	41.18	20.59
120	54	3.0480	2.06	0.004251	178.0	41.88	20.94
130	53	3.3020	2.23	0.004258	174.7	41.03	20.52
140	52	3.5560	2.40	0.004266	171.4	40.19	20.09
150	50	3.8100	2.57	0.004273	164.9	38.58	19.29
160	47	4.0640	2.74	0.004281	155.0	36.20	18.10
170	44	4.3180	2.91	0.004288	145.1	33.83	16.91
180	40	4.5720	3.08	0.004296	131.9	30.70	15.35
190	37	4.8260	3.26	0.004303	122.0	28.34	14.17
200	36	5.0800	3.43	0.004311	118.7	27.53	13.76
210	35	5.3340	3.60	0.004319	115.4	26.72	13.36

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

Unconfined Compressive Strength
ASTM D2166

Project No.	0022 005 01
Client	Dillon Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole	TH12-01
Sample #	T4
Depth (m)	2.3 - 2.9
Sample Date	27-Mar-12
Test Date	03-Apr-12
Technician	Lee Boughton

Unconfined Strength

	kPa	ksf
Max q_u	90.0	1.9
Max S_u	45.0	0.9

Specimen Data

Description SILT - some clay, trace oxidation, light brown, moist to wet, firm, low plasticity, homogeneous

Length	133.4	(mm)
Diameter	72.2	(mm)
L/D Ratio	1.8	
Initial Area	0.00409	(m^2)
Load Rate	1.00	(%/min)

Moisture %	19.6%	
Bulk Unit Wt.	20.9	(kN/m^3)
Dry Unit Wt.	17.5	(kN/m^3)
Liquid Limit	21.9	
Plastic Limit	13.0	
Plasticity Index	8.9	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.42	41.2	0.86

Pocket Penetrometer

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
1.00	49.0	1.02
0.60	29.4	0.61
0.80	39.2	0.82
Average	**39.2**	**0.82**

Failure Geometry

Sketch:

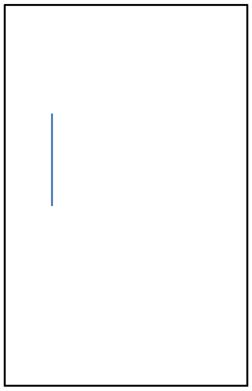


Photo:

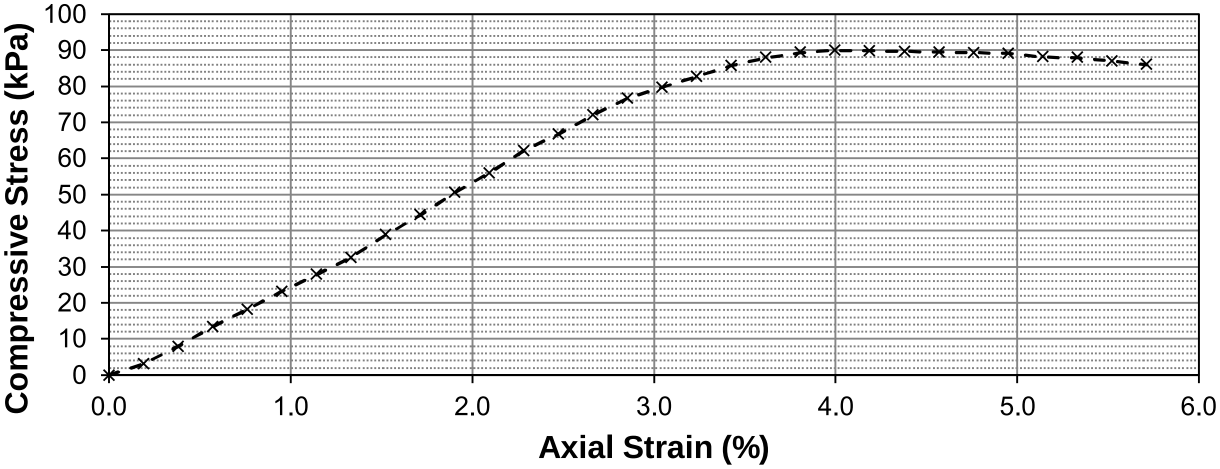
Notes: Columnar failure

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	0.004092	0.0	0.00	0.00
10	4	0.2540	0.19	0.004100	13.0	3.16	1.58
20	10	0.5080	0.38	0.004108	32.5	7.91	3.95
30	17	0.7620	0.57	0.004116	55.3	13.43	6.71
40	23	1.0160	0.76	0.004124	74.9	18.15	9.08
50	29	1.2700	0.95	0.004132	95.6	23.14	11.57
60	35	1.5240	1.14	0.004140	115.4	27.87	13.94
70	41	1.7780	1.33	0.004148	135.2	32.59	16.30
80	49	2.0320	1.52	0.004156	161.6	38.88	19.44
90	56	2.2860	1.71	0.004164	184.6	44.35	22.17
100	64	2.5400	1.90	0.004172	211.0	50.58	25.29
110	71	2.7940	2.09	0.004180	234.1	56.01	28.00
120	79	3.0480	2.28	0.004188	260.4	62.19	31.09
130	85	3.3020	2.48	0.004196	280.2	66.78	33.39
140	92	3.5560	2.67	0.004205	303.3	72.14	36.07
150	98	3.8100	2.86	0.004213	323.1	76.70	38.35
160	102	4.0640	3.05	0.004221	336.4	79.70	39.85
170	106	4.3180	3.24	0.004229	349.9	82.73	41.37
180	110	4.5720	3.43	0.004238	363.4	85.75	42.87
190	113	4.8260	3.62	0.004246	373.5	87.96	43.98
200	115	5.0800	3.81	0.004254	380.2	89.37	44.69
210	116	5.3340	4.00	0.004263	383.6	89.98	44.99
220	116	5.5880	4.19	0.004271	383.6	89.80	44.90
230	116	5.8420	4.38	0.004280	383.6	89.62	44.81

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	116	6.0960	4.5695	0.004288	383.6	89.44	44.72
250	116	6.3500	4.76	0.004297	383.6	89.26	44.63
260	116	6.6040	4.95	0.004306	383.6	89.09	44.54
270	115	6.8580	5.14	0.004314	380.2	88.13	44.07
280	115	7.1120	5.33	0.004323	380.2	87.96	43.98
290	114	7.3660	5.52	0.004332	376.9	87.00	43.50
300	113	7.6200	5.71	0.004340	373.5	86.05	43.02

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

Unconfined Compressive Strength

ASTM D2166

Project No.	0022 005 01
Client	Dillon Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole	TH12-01
Sample #	T5
Depth (m)	3.0 - 3.7
Sample Date	27-Mar-12
Test Date	03-Apr-12
Technician	Lee Boughton

Unconfined Strength

	kPa	ksf
Max q_u	106.8	2.2
Max S_u	53.4	1.1

Specimen Data

Description SILT - clayey, trace gravel (<15 mm diam.), trace silt inclusions (<5 mm diam.), trace oxidation, light brown, moist, firm, low plasticity, homogeneous

Length	120.8	(mm)	**Moisture %**	18.8%	
Diameter	71.5	(mm)	**Bulk Unit Wt.**	21.7	(kN/m^3)
L/D Ratio	1.7		**Dry Unit Wt.**	18.2	(kN/m^3)
Initial Area	0.00402	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.29	28.4	0.59

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
Average	**35.1**	**0.73**

Failure Geometry

Sketch:

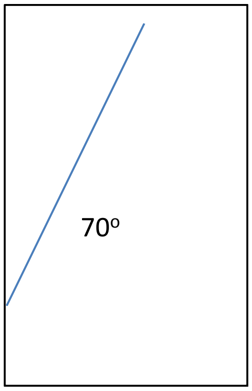


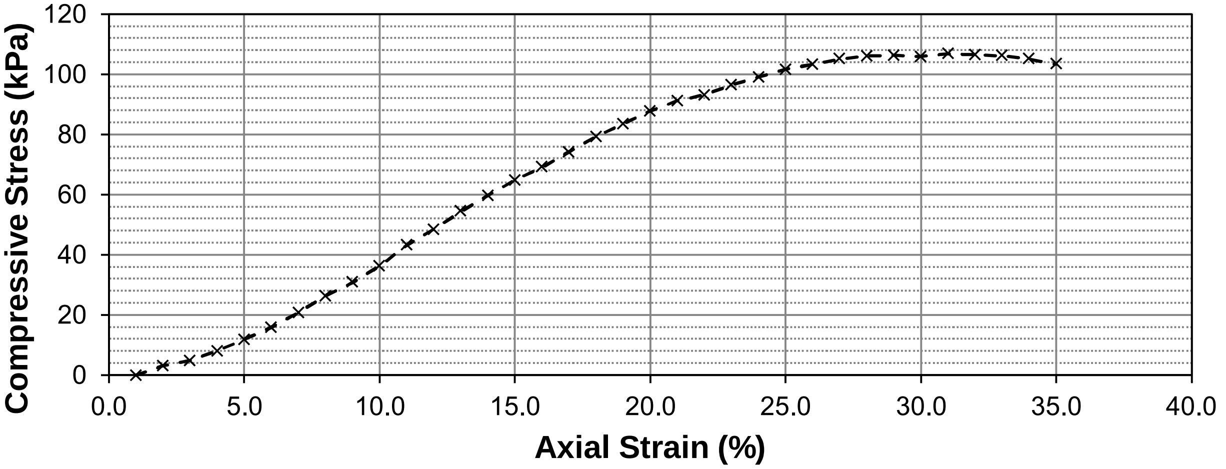
Photo:

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	0.004019	0.0	0.00	0.00
20	4	0.5080	0.42	0.004036	13.0	3.21	1.61
40	6	1.0160	0.84	0.004053	19.5	4.80	2.40
60	10	1.5240	1.26	0.004071	32.5	7.98	3.99
80	15	2.0320	1.68	0.004088	48.8	11.93	5.96
100	20	2.5400	2.10	0.004106	65.1	15.85	7.92
120	26	3.0480	2.52	0.004123	85.7	20.79	10.39
140	33	3.5560	2.94	0.004141	108.8	26.27	13.14
160	39	4.0640	3.37	0.004159	128.6	30.92	15.46
180	46	4.5720	3.79	0.004178	151.7	36.31	18.15
200	55	5.0800	4.21	0.004196	181.4	43.22	21.61
220	62	5.5880	4.63	0.004214	204.4	48.50	24.25
240	70	6.0960	5.05	0.004233	230.8	54.52	27.26
260	77	6.6040	5.47	0.004252	253.9	59.71	29.85
280	84	7.1120	5.89	0.004271	276.9	64.84	32.42
300	90	7.6200	6.31	0.004290	296.7	69.17	34.58
320	97	8.1280	6.73	0.004309	319.8	74.22	37.11
340	104	8.6360	7.15	0.004329	343.2	79.28	39.64
360	110	9.1440	7.57	0.004349	363.4	83.56	41.78
380	116	9.6520	7.99	0.004369	383.6	87.80	43.90
400	121	10.1600	8.41	0.004389	400.4	91.24	45.62
420	124	10.6680	8.83	0.004409	410.5	93.11	46.56
440	129	11.1760	9.25	0.004429	427.4	96.49	48.25
460	133	11.6840	9.68	0.004450	440.8	99.06	49.53

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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)
480	137	12.1920	10.0963	0.004471	454.3	101.62	50.81
500	140	12.7000	10.52	0.004492	464.4	103.39	51.69
520	143	13.2080	10.94	0.004513	474.5	105.15	52.57
540	145	13.7160	11.36	0.004534	481.3	106.13	53.07
560	146	14.2240	11.78	0.004556	484.6	106.37	53.19
580	146	14.7320	12.20	0.004578	484.6	105.87	52.93
600	148	15.2400	12.62	0.004600	491.4	106.82	53.41
640	149	16.2560	13.46	0.004645	494.7	106.52	53.26
680	150	17.2720	14.30	0.004690	498.1	106.19	53.10
720	150	18.2880	15.14	0.004737	498.1	105.15	52.58
760	149	19.3040	15.99	0.004784	494.7	103.41	51.71

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

Unconfined Compressive Strength

ASTM D2166

Project No.	0022 005 01
Client	Dillon Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole	TH12-01
Sample #	T6
Depth (m)	3.8 - 4.4
Sample Date	27-Mar-12
Test Date	03-Apr-12
Technician	Lee Boughton

Unconfined Strength

	kPa	ksf
Max q_u	64.7	1.4
Max S_u	32.3	0.7

Specimen Data

Description CLAY - silty, trace gravel (<15 mm diam.), trace organics (rootlets), mottled light brown and light grey, moist, firm, intermediate plasticity, homogeneous

Length	140.8	(mm)	**Moisture %**	21.8%	
Diameter	72.2	(mm)	**Bulk Unit Wt.**	20.5	(kN/m^3)
L/D Ratio	2.0		**Dry Unit Wt.**	16.9	(kN/m^3)
Initial Area	0.00409	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.24	23.5	0.49

Pocket Penetrometer

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.40	19.6	0.41
0.60	29.4	0.61
0.75	36.8	0.77
Average	**28.6**	**0.60**

Failure Geometry

Sketch:

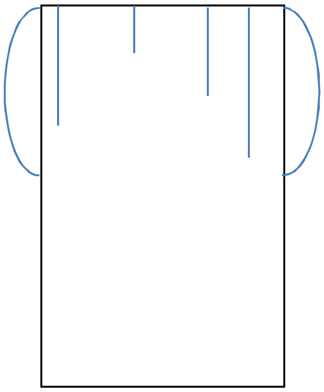
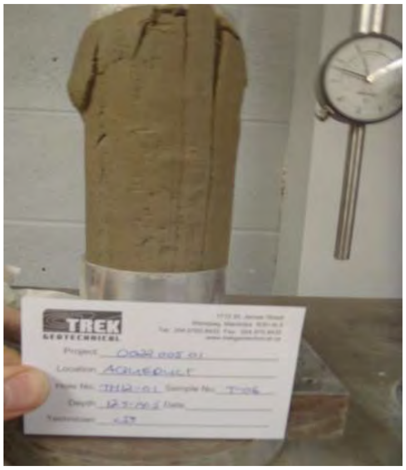


Photo:



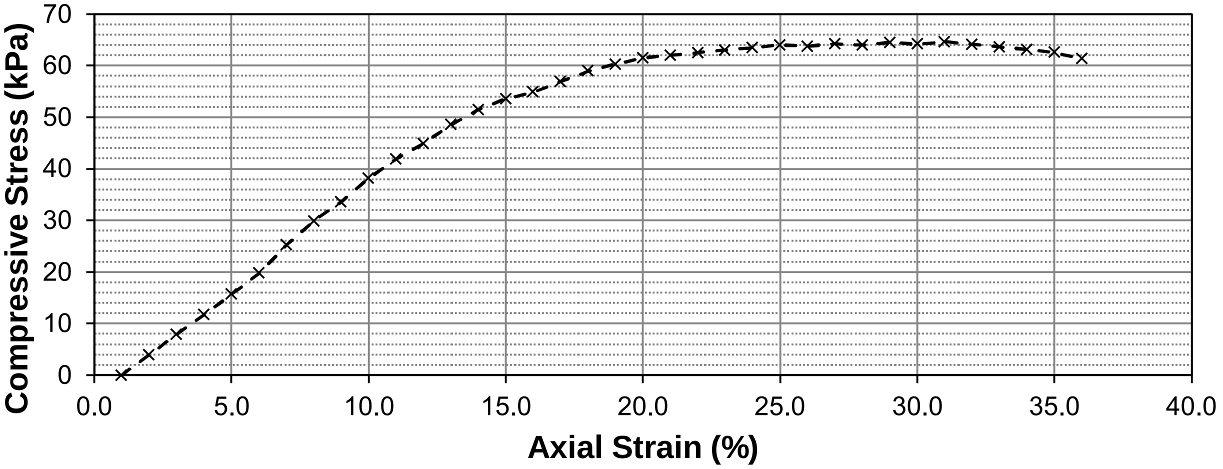
Notes: Columnar buldge failure

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	0.004092	0.0	0.00	0.00
20	5	0.5080	0.36	0.004107	16.2	3.95	1.97
40	10	1.0160	0.72	0.004122	32.5	7.88	3.94
60	15	1.5240	1.08	0.004137	48.8	11.78	5.89
80	20	2.0320	1.44	0.004152	65.1	15.67	7.83
100	25	2.5400	1.80	0.004168	82.4	19.78	9.89
120	32	3.0480	2.17	0.004183	105.5	25.22	12.61
140	38	3.5560	2.53	0.004199	125.3	29.85	14.92
160	43	4.0640	2.89	0.004214	141.8	33.64	16.82
180	49	4.5720	3.25	0.004230	161.6	38.20	19.10
200	54	5.0800	3.61	0.004246	178.0	41.93	20.96
220	58	5.5880	3.97	0.004262	191.2	44.87	22.44
240	63	6.0960	4.33	0.004278	207.7	48.56	24.28
260	67	6.6040	4.69	0.004294	220.9	51.44	25.72
280	70	7.1120	5.05	0.004310	230.8	53.54	26.77
300	72	7.6200	5.41	0.004327	237.4	54.87	27.43
320	75	8.1280	5.77	0.004343	247.3	56.93	28.47
340	78	8.6360	6.13	0.004360	257.2	58.98	29.49
360	80	9.1440	6.50	0.004377	263.8	60.27	30.13
380	82	9.6520	6.86	0.004394	270.4	61.53	30.77
400	83	10.1600	7.22	0.004411	273.7	62.04	31.02
420	84	10.6680	7.58	0.004428	276.9	62.54	31.27
440	85	11.1760	7.94	0.004445	280.2	63.04	31.52
460	86	11.6840	8.30	0.004463	283.5	63.53	31.77

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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)
480	87	12.1920	8.6608	0.004481	286.8	64.02	32.01
500	87	12.7000	9.02	0.004498	286.8	63.76	31.88
520	88	13.2080	9.38	0.004516	290.2	64.25	32.12
540	88	13.7160	9.74	0.004534	290.2	63.99	32.00
560	89	14.2240	10.10	0.004552	293.4	64.46	32.23
580	89	14.7320	10.47	0.004571	293.4	64.20	32.10
600	90	15.2400	10.83	0.004589	296.7	64.66	32.33
640	90	16.2560	11.55	0.004627	296.7	64.14	32.07
680	90	17.2720	12.27	0.004665	296.7	63.61	31.81
720	90	18.2880	12.99	0.004703	296.7	63.09	31.54
760	90	19.3040	13.71	0.004743	296.7	62.57	31.28
800	89	20.3200	14.43	0.004783	293.4	61.35	30.68

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

Unconfined Compressive Strength

ASTM D2166

Project No.	0022 005 01
Client	Dillon Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole	TH12-01
Sample #	T7
Depth (m)	4.6 - 5.2
Sample Date	27-Mar-12
Test Date	04-Apr-12
Technician	Lee Boughton

Unconfined Strength

	kPa	ksf
Max q_u	101.8	2.1
Max S_u	50.9	1.1

Specimen Data

Description SILT - clayey, trace gravel (<8 mm diam.), trace oxidation, light brown, moist to wet, firm, low plasticity, homogeneous

Length	145.3	(mm)	**Moisture %**	29.4%	
Diameter	72.4	(mm)	**Bulk Unit Wt.**	20.4	(kN/m^3)
L/D Ratio	2.0		**Dry Unit Wt.**	15.8	(kN/m^3)
Initial Area	0.00411	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.05	4.9	0.10

Pocket Penetrometer

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
Average		

Failure Geometry

Sketch:

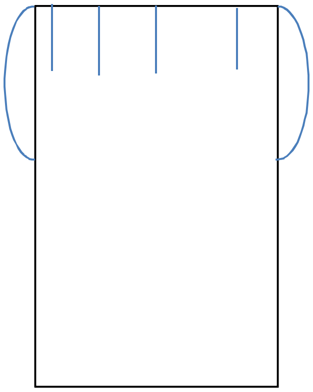


Photo:

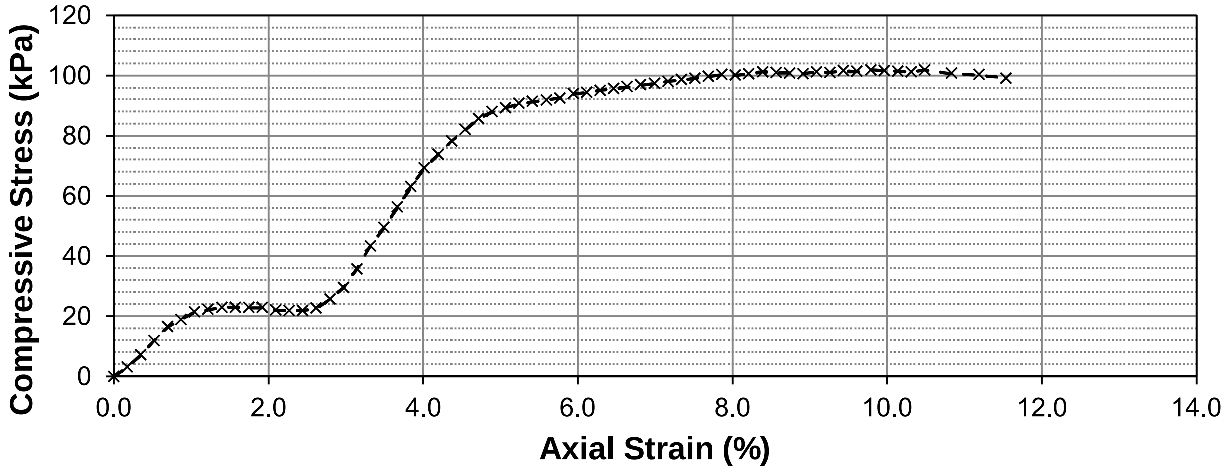
Notes: Columnar buldge failure

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	0.004113	0.0	0.00	0.00
10	4	0.2540	0.17	0.004121	13.0	3.15	1.57
20	9	0.5080	0.35	0.004128	29.2	7.08	3.54
30	15	0.7620	0.52	0.004135	48.8	11.79	5.89
40	21	1.0160	0.70	0.004142	68.3	16.49	8.25
50	24	1.2700	0.87	0.004150	78.1	18.83	9.41
60	27	1.5240	1.05	0.004157	89.0	21.41	10.71
70	28	1.7780	1.22	0.004164	92.3	22.16	11.08
80	29	2.0320	1.40	0.004172	95.6	22.91	11.46
90	29	2.2860	1.57	0.004179	95.6	22.87	11.44
100	29	2.5400	1.75	0.004187	95.6	22.83	11.42
110	29	2.7940	1.92	0.004194	95.6	22.79	11.40
120	28	3.0480	2.10	0.004202	92.3	21.97	10.98
130	28	3.3020	2.27	0.004209	92.3	21.93	10.96
140	28	3.5560	2.45	0.004217	92.3	21.89	10.94
150	29	3.8100	2.62	0.004224	95.6	22.63	11.31
160	33	4.0640	2.80	0.004232	108.8	25.71	12.86
170	38	4.3180	2.97	0.004239	125.3	29.56	14.78
180	46	4.5720	3.15	0.004247	151.7	35.71	17.86
190	56	4.8260	3.32	0.004255	184.6	43.40	21.70
200	64	5.0800	3.50	0.004263	211.0	49.51	24.75
210	73	5.3340	3.67	0.004270	240.7	56.37	28.18
220	82	5.5880	3.85	0.004278	270.4	63.20	31.60
230	90	5.8420	4.02	0.004286	296.7	69.24	34.62

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	96	6.0960	4.1960	0.004294	316.5	73.72	36.86
250	102	6.3500	4.37	0.004301	336.4	78.21	39.11
260	107	6.6040	4.55	0.004309	353.3	81.98	40.99
270	112	6.8580	4.72	0.004317	370.1	85.73	42.87
280	115	7.1120	4.90	0.004325	380.2	87.91	43.96
290	117	7.3660	5.07	0.004333	387.0	89.30	44.65
300	119	7.6200	5.25	0.004341	393.7	90.68	45.34
310	120	7.8740	5.42	0.004349	397.0	91.29	45.65
320	121	8.1280	5.59	0.004357	400.4	91.90	45.95
330	122	8.3820	5.77	0.004365	403.8	92.50	46.25
340	124	8.6360	5.94	0.004373	410.5	93.87	46.93
350	125	8.8900	6.12	0.004382	413.9	94.47	47.23
360	126	9.1440	6.29	0.004390	417.2	95.05	47.52
370	127	9.3980	6.47	0.004398	420.6	95.64	47.82
380	128	9.6520	6.64	0.004406	424.0	96.23	48.11
390	129	9.9060	6.82	0.004414	427.4	96.81	48.41
400	130	10.1600	6.99	0.004423	430.7	97.39	48.69
410	131	10.4140	7.17	0.004431	434.1	97.97	48.98
420	132	10.6680	7.34	0.004439	437.5	98.54	49.27
430	133	10.9220	7.52	0.004448	440.8	99.11	49.55
440	134	11.1760	7.69	0.004456	444.2	99.68	49.84
450	135	11.4300	7.87	0.004465	447.6	100.25	50.12
460	135	11.6840	8.04	0.004473	447.6	100.06	50.03
470	136	11.9380	8.22	0.004482	451.0	100.62	50.31
480	137	12.1920	8.39	0.004490	454.3	101.17	50.59
490	137	12.4460	8.57	0.004499	454.3	100.98	50.49
500	137	12.7000	8.74	0.004507	454.3	100.79	50.39
510	137	12.9540	8.92	0.004516	454.3	100.59	50.30
520	138	13.2080	9.09	0.004525	457.7	101.15	50.57
530	138	13.4620	9.27	0.004534	457.7	100.95	50.48
540	139	13.7160	9.44	0.004542	461.1	101.50	50.75
550	139	13.9700	9.62	0.004551	461.1	101.31	50.65
560	140	14.2240	9.79	0.004560	464.4	101.84	50.92
570	140	14.4780	9.97	0.004569	464.4	101.65	50.82
580	140	14.7320	10.14	0.004578	464.4	101.45	50.72
590	140	14.9860	10.32	0.004587	464.4	101.25	50.63
600	141	15.2400	10.49	0.004596	467.8	101.79	50.89
620	140	15.7480	10.84	0.004614	464.4	100.66	50.33
640	140	16.2560	11.19	0.004632	464.4	100.26	50.13
660	139	16.7640	11.54	0.004650	461.0582	99.15	49.58

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

Unconfined Compressive Strength

ASTM D2166

Project No.	0022 005 01
Client	Dillon Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole	TH12-01
Sample #	T8
Depth (m)	7.6 - 8.2
Sample Date	27-Mar-12
Test Date	04-Apr-12
Technician	Lee Boughton

Unconfined Strength

	kPa	ksf
Max q_u	102.2	2.1
Max S_u	51.1	1.1

Specimen Data

Description CLAY - silty, trace gravel (<8 mm diam.), trace sand (fine and medium grained), grey, moist, firm, high plasticity, homogeneous

Length	152.2	(mm)
Diameter	72.6	(mm)
L/D Ratio	2.1	
Initial Area	0.00414	(m^2)
Load Rate	1.00	(%/min)

Moisture %	33.1%	
Bulk Unit Wt.	19.0	(kN/m^3)
Dry Unit Wt.	14.2	(kN/m^3)
Liquid Limit	50.7	
Plastic Limit	15.1	
Plasticity Index	35.6	

Undrained Shear Strength Tests

Torvane

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

Pocket Penetrometer

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.50	24.5	0.51
0.50	24.5	0.51
0.50	24.5	0.51
Average	**24.5**	**0.51**

Failure Geometry

Sketch:

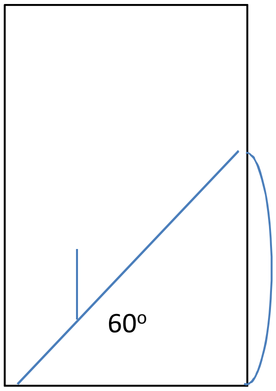


Photo:

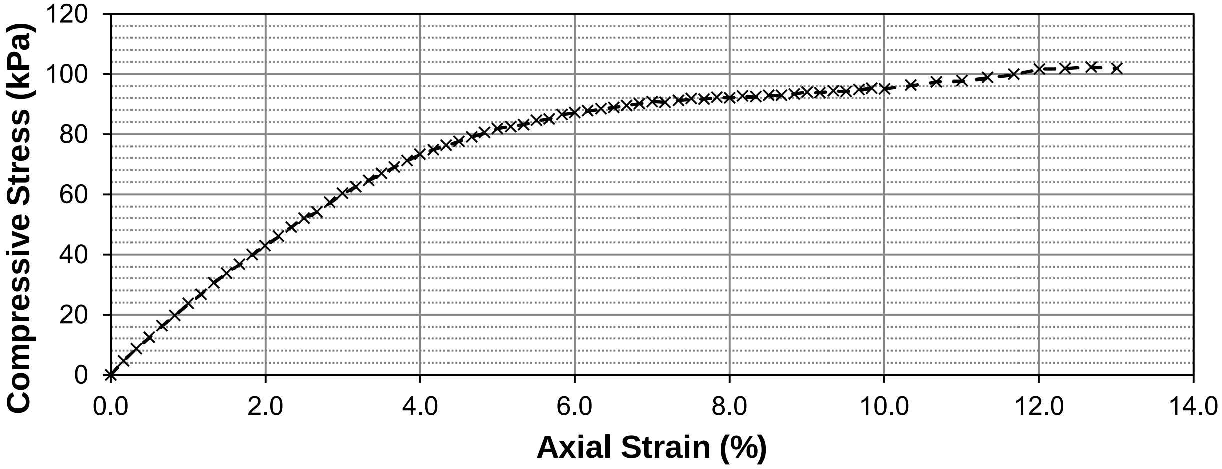
Unconfined Compressive Strength

ASTM D2166

Project No.	0022 005 01
Client	Dillon Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

---

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	0.004139	0.0	0.00	0.00
10	6	0.2540	0.17	0.004146	19.5	4.70	2.35
20	11	0.5080	0.33	0.004153	35.7	8.60	4.30
30	16	0.7620	0.50	0.004160	52.0	12.50	6.25
40	21	1.0160	0.67	0.004167	68.3	16.40	8.20
50	25	1.2700	0.83	0.004174	82.4	19.75	9.87
60	30	1.5240	1.00	0.004181	98.9	23.66	11.83
70	34	1.7780	1.17	0.004188	112.1	26.76	13.38
80	39	2.0320	1.33	0.004195	128.6	30.65	15.33
90	43	2.2860	1.50	0.004202	141.8	33.73	16.87
100	47	2.5400	1.67	0.004210	155.0	36.81	18.41
110	51	2.7940	1.84	0.004217	168.1	39.87	19.94
120	55	3.0480	2.00	0.004224	181.4	42.93	21.47
130	59	3.3020	2.17	0.004231	194.5	45.97	22.99
140	63	3.5560	2.34	0.004238	207.7	49.01	24.51
150	67	3.8100	2.50	0.004246	220.9	52.03	26.01
160	70	4.0640	2.67	0.004253	230.8	54.26	27.13
170	74	4.3180	2.84	0.004260	244.0	57.27	28.64
180	78	4.5720	3.00	0.004268	257.2	60.26	30.13
190	81	4.8260	3.17	0.004275	267.1	62.47	31.24
200	84	5.0800	3.34	0.004282	276.9	64.67	32.34
210	87	5.3340	3.50	0.004290	286.8	66.86	33.43
220	90	5.5880	3.67	0.004297	296.7	69.06	34.53
230	93	5.8420	3.84	0.004305	306.6	71.23	35.62

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	96	6.0960	4.0045	0.004312	316.5	73.41	36.70
250	98	6.3500	4.17	0.004320	323.1	74.80	37.40
260	100	6.6040	4.34	0.004327	329.7	76.20	38.10
270	102	6.8580	4.51	0.004335	336.4	77.61	38.81
280	104	7.1120	4.67	0.004342	343.2	79.03	39.52
290	106	7.3660	4.84	0.004350	349.9	80.44	40.22
300	108	7.6200	5.01	0.004357	356.7	81.85	40.92
310	109	7.8740	5.17	0.004365	360.0	82.47	41.24
320	110	8.1280	5.34	0.004373	363.4	83.10	41.55
330	112	8.3820	5.51	0.004381	370.1	84.50	42.25
340	113	8.6360	5.67	0.004388	373.5	85.11	42.55
350	115	8.8900	5.84	0.004396	380.2	86.49	43.25
360	116	9.1440	6.01	0.004404	383.6	87.10	43.55
370	117	9.3980	6.17	0.004412	387.0	87.71	43.85
380	118	9.6520	6.34	0.004420	390.3	88.32	44.16
390	119	9.9060	6.51	0.004427	393.7	88.91	44.46
400	120	10.1600	6.67	0.004435	397.0	89.52	44.76
410	121	10.4140	6.84	0.004443	400.4	90.12	45.06
420	122	10.6680	7.01	0.004451	403.8	90.72	45.36
430	122	10.9220	7.17	0.004459	403.8	90.55	45.28
440	123	11.1760	7.34	0.004467	407.1	91.14	45.57
450	124	11.4300	7.51	0.004475	410.5	91.73	45.86
460	124	11.6840	7.68	0.004483	410.5	91.56	45.78
470	125	11.9380	7.84	0.004492	413.9	92.15	46.08
480	125	12.1920	8.01	0.004500	413.9	91.98	45.99
490	126	12.4460	8.18	0.004508	417.2	92.56	46.28
500	126	12.7000	8.34	0.004516	417.2	92.39	46.19
510	127	12.9540	8.51	0.004524	420.6	92.97	46.48
520	127	13.2080	8.68	0.004533	420.6	92.80	46.40
530	128	13.4620	8.84	0.004541	424.0	93.37	46.69
540	129	13.7160	9.01	0.004549	427.4	93.95	46.97
550	129	13.9700	9.18	0.004558	427.4	93.77	46.89
560	130	14.2240	9.34	0.004566	430.7	94.33	47.17
570	130	14.4780	9.51	0.004574	430.7	94.16	47.08
580	131	14.7320	9.68	0.004583	434.1	94.72	47.36
590	132	14.9860	9.84	0.004591	437.5	95.28	47.64
600	132	15.2400	10.01	0.004600	437.5	95.11	47.55
620	134	15.7480	10.34	0.004617	444.2	96.21	48.10
640	136	16.2560	10.68	0.004634	451.0	97.31	48.66
660	137	16.7640	11.01	0.004652	454.2969	97.66	48.83
680	139	17.2720	11.35	0.004669	461.0582	98.75	49.37
700	141	17.7800	11.68	0.004687	467.7750	99.81	49.90
720	144	18.2880	12.01	0.004705	477.8724	101.58	50.79
740	145	18.7960	12.35	0.004722	481.2531	101.91	50.95

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

Unconfined Compressive Strength

ASTM D2166

Project No.	0022 005 01
Client	Dillon Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole	TH12-01
Sample #	T9
Depth (m)	10.7 - 11.3
Sample Date	27-Mar-12
Test Date	04-Apr-12
Technician	Lee Boughton

Unconfined Strength

	kPa	**ksf**
Max q_u	97.3	2.0
Max S_u	48.7	1.0

Specimen Data

Description CLAY - silty, trace gravel (<10 mm diam.), trace silt inclusions (<5 mm diam.), grey, moist, firm, high plasticity, homogeneous

Length	151.8	(mm)	**Moisture %**	34.5%	
Diameter	72.4	(mm)	**Bulk Unit Wt.**	18.6	(kN/m^3)
L/D Ratio	2.1		**Dry Unit Wt.**	13.8	(kN/m^3)
Initial Area	0.00411	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.44	43.2	0.90

Pocket Penetrometer

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.60	29.4	0.61
0.50	24.5	0.51
0.60	29.4	0.61
Average	**27.8**	**0.58**

Failure Geometry

Sketch:

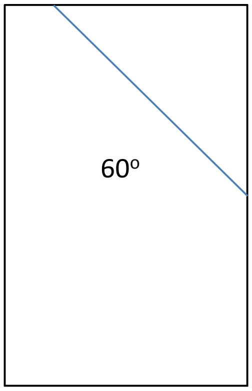


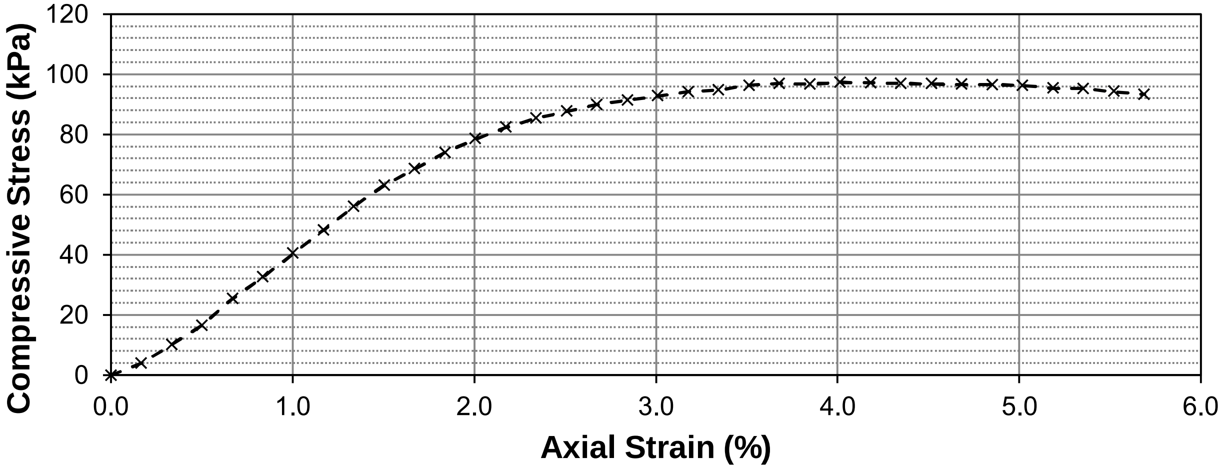
Photo:

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	0.004115	0.0	0.00	0.00
10	5	0.2540	0.17	0.004121	16.2	3.94	1.97
20	13	0.5080	0.33	0.004128	42.2	10.23	5.12
30	21	0.7620	0.50	0.004135	68.3	16.52	8.26
40	32	1.0160	0.67	0.004142	105.5	25.47	12.74
50	41	1.2700	0.84	0.004149	135.2	32.58	16.29
60	51	1.5240	1.00	0.004156	168.1	40.45	20.23
70	61	1.7780	1.17	0.004163	201.1	48.30	24.15
80	71	2.0320	1.34	0.004170	234.1	56.14	28.07
90	80	2.2860	1.51	0.004178	263.8	63.14	31.57
100	87	2.5400	1.67	0.004185	286.8	68.54	34.27
110	94	2.7940	1.84	0.004192	309.9	73.93	36.97
120	100	3.0480	2.01	0.004199	329.7	78.52	39.26
130	105	3.3020	2.18	0.004206	346.6	82.40	41.20
140	109	3.5560	2.34	0.004213	360.0	85.44	42.72
150	112	3.8100	2.51	0.004221	370.1	87.70	43.85
160	115	4.0640	2.68	0.004228	380.2	89.94	44.97
170	117	4.3180	2.84	0.004235	387.0	91.37	45.68
180	119	4.5720	3.01	0.004242	393.7	92.79	46.40
190	121	4.8260	3.18	0.004250	400.4	94.23	47.11
200	122	5.0800	3.35	0.004257	403.8	94.86	47.43
210	124	5.3340	3.51	0.004264	410.5	96.27	48.13
220	125	5.5880	3.68	0.004272	413.9	96.89	48.45
230	125	5.8420	3.85	0.004279	413.9	96.72	48.36

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	126	6.0960	4.0155	0.004287	417.2	97.33	48.67
250	126	6.3500	4.18	0.004294	417.2	97.16	48.58
260	126	6.6040	4.35	0.004302	417.2	96.99	48.50
270	126	6.8580	4.52	0.004309	417.2	96.82	48.41
280	126	7.1120	4.68	0.004317	417.2	96.66	48.33
290	126	7.3660	4.85	0.004324	417.2	96.49	48.24
300	126	7.6200	5.02	0.004332	417.2	96.32	48.16
310	125	7.8740	5.19	0.004340	413.9	95.38	47.69
320	125	8.1280	5.35	0.004347	413.9	95.21	47.60
330	124	8.3820	5.52	0.004355	410.5	94.26	47.13
340	123	8.6360	5.69	0.004363	407.1	93.32	46.66

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

Unconfined Compressive Strength
ASTM D2166

Project No.	0022 005 01
Client	Dillon Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole	TH12-01
Sample #	T10
Depth (m)	13.7 - 14.3
Sample Date	27-Mar-12
Test Date	05-Apr-12
Technician	Lee Boughton

Unconfined Strength

	kPa	ksf
Max q_u	56.8	1.2
Max S_u	28.4	0.6

Specimen Data

Description CLAY - silty, trace gravel (<3%)(<8 mm diam.), trace sand (<3%)(fine grained), trace silt inclusions (<3%)(<4 mm diam.), grey, moist, soft, high plasticity, homogeneous

Length	151.5	(mm)	**Moisture %**	34.2%	
Diameter	72.5	(mm)	**Bulk Unit Wt.**	18.8	(kN/m^3)
L/D Ratio	2.1		**Dry Unit Wt.**	14.0	(kN/m^3)
Initial Area	0.00412	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.29	28.4	0.59

Pocket Penetrometer

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.25	12.3	0.26
0.20	9.8	0.20
0.25	12.3	0.26
Average	**11.4**	**0.24**

Failure Geometry

Sketch:

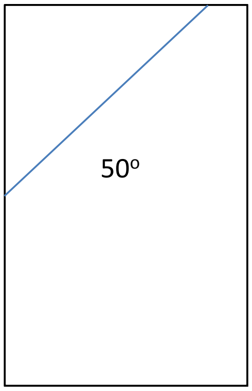


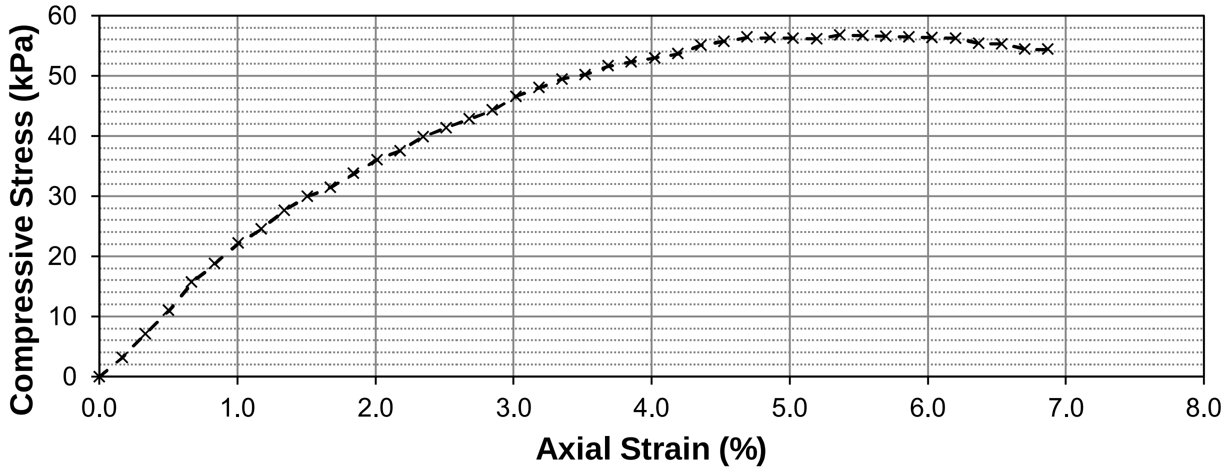
Photo:

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	0.004123	0.0	0.00	0.00
10	4	0.2540	0.17	0.004130	13.0	3.14	1.57
20	9	0.5080	0.34	0.004137	29.2	7.06	3.53
30	14	0.7620	0.50	0.004144	45.5	10.98	5.49
40	20	1.0160	0.67	0.004151	65.1	15.67	7.84
50	24	1.2700	0.84	0.004158	78.1	18.79	9.39
60	28	1.5240	1.01	0.004165	92.3	22.16	11.08
70	31	1.7780	1.17	0.004172	102.2	24.50	12.25
80	35	2.0320	1.34	0.004179	115.4	27.61	13.81
90	38	2.2860	1.51	0.004186	125.3	29.93	14.97
100	40	2.5400	1.68	0.004193	131.9	31.45	15.73
110	43	2.7940	1.84	0.004200	141.8	33.75	16.88
120	46	3.0480	2.01	0.004207	151.7	36.05	18.03
130	48	3.3020	2.18	0.004215	158.3	37.55	18.78
140	51	3.5560	2.35	0.004222	168.1	39.83	19.91
150	53	3.8100	2.51	0.004229	174.7	41.31	20.66
160	55	4.0640	2.68	0.004236	181.4	42.81	21.40
170	57	4.3180	2.85	0.004244	187.9	44.29	22.14
180	60	4.5720	3.02	0.004251	197.8	46.53	23.27
190	62	4.8260	3.18	0.004258	204.4	48.00	24.00
200	64	5.0800	3.35	0.004266	211.0	49.47	24.73
210	65	5.3340	3.52	0.004273	214.3	50.15	25.08
220	67	5.5880	3.69	0.004281	220.9	51.60	25.80
230	68	5.8420	3.86	0.004288	224.2	52.28	26.14

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	69	6.0960	4.0227	0.004296	227.5	52.96	26.48
250	70	6.3500	4.19	0.004303	230.8	53.63	26.81
260	72	6.6040	4.36	0.004311	237.4	55.07	27.54
270	73	6.8580	4.53	0.004318	240.7	55.74	27.87
280	74	7.1120	4.69	0.004326	244.0	56.40	28.20
290	74	7.3660	4.86	0.004333	244.0	56.30	28.15
300	74	7.6200	5.03	0.004341	244.0	56.20	28.10
310	74	7.8740	5.20	0.004349	244.0	56.10	28.05
320	75	8.1280	5.36	0.004357	247.3	56.76	28.38
330	75	8.3820	5.53	0.004364	247.3	56.66	28.33
340	75	8.6360	5.70	0.004372	247.3	56.56	28.28
350	75	8.8900	5.87	0.004380	247.3	56.46	28.23
360	75	9.1440	6.03	0.004388	247.3	56.36	28.18
370	75	9.3980	6.20	0.004395	247.3	56.26	28.13
380	74	9.6520	6.37	0.004403	244.0	55.41	27.70
390	74	9.9060	6.54	0.004411	244.0	55.31	27.66
400	73	10.1600	6.70	0.004419	240.7	54.47	27.23
410	73	10.4140	6.87	0.004427	240.7	54.37	27.18

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

Unconfined Compressive Strength

ASTM D2166

Project No.	0022 005 01
Client	Dillon Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole	TH12-01
Sample #	T11
Depth (m)	16.8 - 17.4
Sample Date	27-Mar-12
Test Date	05-Apr-12
Technician	Lee Boughton

Unconfined Strength

	kPa	ksf
Max q_u	78.0	1.6
Max S_u	39.0	0.8

Specimen Data

Description CLAY - silty, trace gravel (<10 mm diam.), grey, moist, soft, high plasticity, homogeneous

Length	151.9	(mm)
Diameter	72.1	(mm)
L/D Ratio	2.1	
Initial Area	0.00409	(m^2)
Load Rate	1.00	(%/min)

Moisture %	33.0%	
Bulk Unit Wt.	19.1	(kN/m^3)
Dry Unit Wt.	14.3	(kN/m^3)
Liquid Limit	-	
Plastic Limit	-	
Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.27	26.5	0.55

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.20	9.8	0.20
0.10	4.9	0.10
0.20	9.8	0.20
Average	**8.2**	**0.17**

Failure Geometry

Sketch:

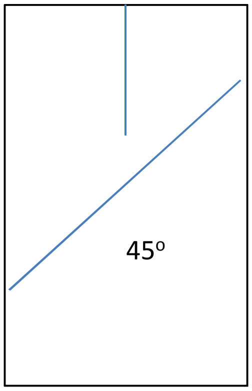
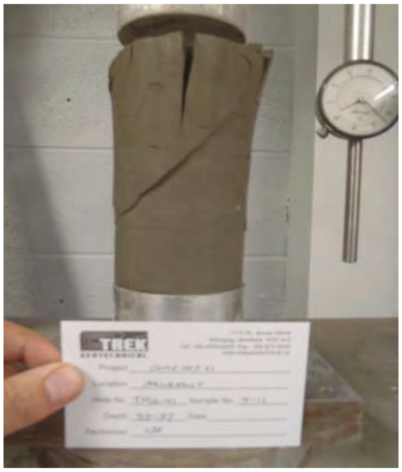


Photo:

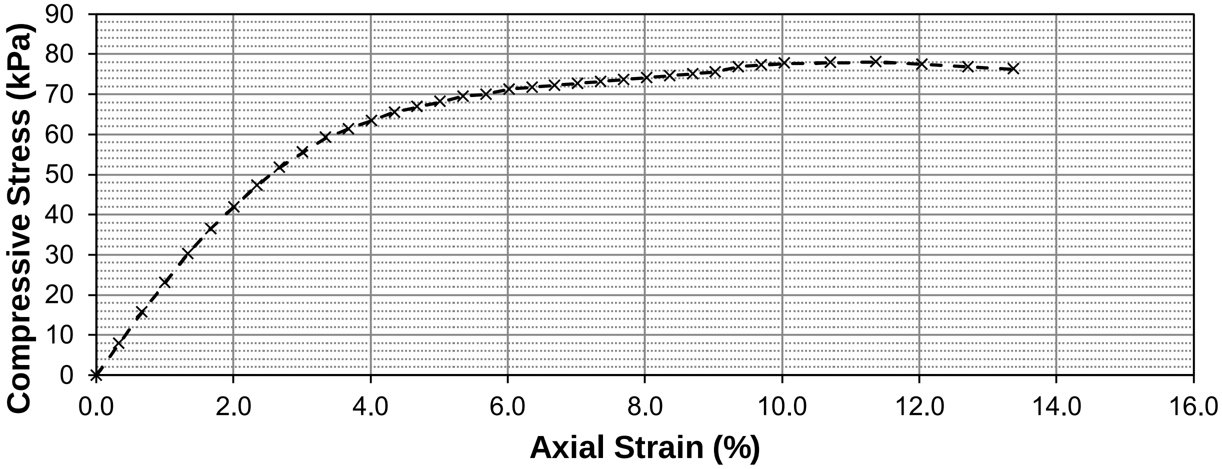


Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	0.004088	0.0	0.00	0.00
20	10	0.5080	0.33	0.004102	32.5	7.92	3.96
40	20	1.0160	0.67	0.004115	65.1	15.81	7.90
60	29	1.5240	1.00	0.004129	95.6	23.15	11.57
80	38	2.0320	1.34	0.004143	125.3	30.24	15.12
100	46	2.5400	1.67	0.004157	151.7	36.48	18.24
120	53	3.0480	2.01	0.004172	174.7	41.88	20.94
140	60	3.5560	2.34	0.004186	197.8	47.26	23.63
160	66	4.0640	2.68	0.004200	217.6	51.81	25.90
180	71	4.5720	3.01	0.004215	234.1	55.54	27.77
200	76	5.0800	3.34	0.004229	250.6	59.24	29.62
220	79	5.5880	3.68	0.004244	260.4	61.37	30.68
240	82	6.0960	4.01	0.004259	270.4	63.48	31.74
260	85	6.6040	4.35	0.004274	280.2	65.57	32.79
280	87	7.1120	4.68	0.004289	286.8	66.88	33.44
300	89	7.6200	5.02	0.004304	293.4	68.18	34.09
320	91	8.1280	5.35	0.004319	300.0	69.47	34.73
340	92	8.6360	5.69	0.004334	303.3	69.98	34.99
360	94	9.1440	6.02	0.004350	309.9	71.25	35.62
380	95	9.6520	6.36	0.004365	313.2	71.75	35.87
400	96	10.1600	6.69	0.004381	316.5	72.25	36.13
420	97	10.6680	7.02	0.004397	319.8	72.74	36.37
440	98	11.1760	7.36	0.004413	323.1	73.23	36.61
460	99	11.6840	7.69	0.004429	326.4	73.70	36.85

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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)
480	100	12.1920	8.0277	0.004445	329.7	74.18	37.09
500	101	12.7000	8.36	0.004461	333.1	74.67	37.33
520	102	13.2080	8.70	0.004477	336.4	75.14	37.57
540	103	13.7160	9.03	0.004494	339.8	75.62	37.81
560	105	14.2240	9.37	0.004510	346.6	76.84	38.42
580	106	14.7320	9.70	0.004527	349.9	77.29	38.65
600	107	15.2400	10.03	0.004544	353.3	77.75	38.87
640	108	16.2560	10.70	0.004578	356.7	77.91	38.95
680	109	17.2720	11.37	0.004612	360.0	78.05	39.02
720	109	18.2880	12.04	0.004648	360.0	77.46	38.73
760	109	19.3040	12.71	0.004683	360.0	76.87	38.43
800	109	20.3200	13.38	0.004719	360.0	76.28	38.14

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

Unconfined Compressive Strength

ASTM D2166

Project No.	0022 005 01
Client	Dillon Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole	TH12-01
Sample #	T12
Depth (m)	19.8 - 20.4
Sample Date	27-Mar-12
Test Date	05-Apr-12
Technician	Lee Boughton

Unconfined Strength

	kPa	ksf
Max q_u	80.0	1.7
Max S_u	40.0	0.8

Specimen Data

Description CLAY - silty, trace gravel (<15 mm diam.), grey, moist, firm, high plasticity, homogeneous

Length	150.0	(mm)
Diameter	72.3	(mm)
L/D Ratio	2.1	
Initial Area	0.00410	(m^2)
Load Rate	1.00	(%/min)

Moisture %	32.3%	
Bulk Unit Wt.	19.0	(kN/m^3)
Dry Unit Wt.	14.4	(kN/m^3)
Liquid Limit	-	
Plastic Limit	-	
Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.33	32.4	0.68

Pocket Penetrometer

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.60	29.4	0.61
0.50	24.5	0.51
0.40	19.6	0.41
Average	**24.5**	**0.51**

Failure Geometry

Sketch:

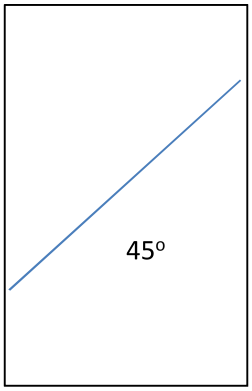


Photo:

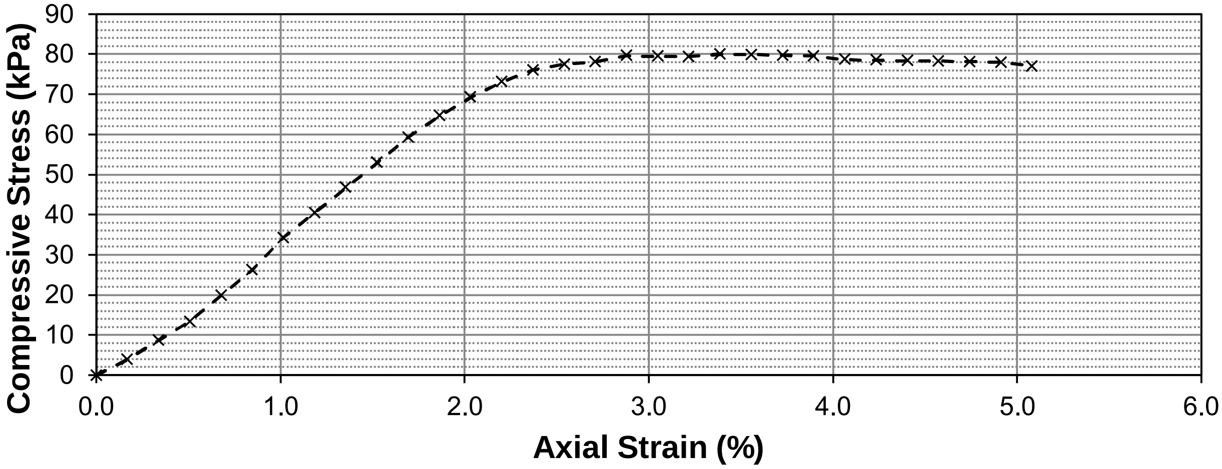
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	0.004102	0.0	0.00	0.00
10	5	0.2540	0.17	0.004109	16.2	3.95	1.97
20	11	0.5080	0.34	0.004116	35.7	8.68	4.34
30	17	0.7620	0.51	0.004123	55.3	13.40	6.70
40	25	1.0160	0.68	0.004130	82.4	19.96	9.98
50	33	1.2700	0.85	0.004137	108.8	26.30	13.15
60	43	1.5240	1.02	0.004145	141.8	34.21	17.10
70	51	1.7780	1.19	0.004152	168.1	40.50	20.25
80	59	2.0320	1.36	0.004159	194.5	46.77	23.39
90	67	2.2860	1.52	0.004166	220.9	53.03	26.51
100	75	2.5400	1.69	0.004173	247.3	59.26	29.63
110	82	2.7940	1.86	0.004180	270.4	64.68	32.34
120	88	3.0480	2.03	0.004187	290.2	69.29	34.65
130	93	3.3020	2.20	0.004195	306.6	73.10	36.55
140	97	3.5560	2.37	0.004202	319.8	76.11	38.06
150	99	3.8100	2.54	0.004209	326.4	77.54	38.77
160	100	4.0640	2.71	0.004217	329.7	78.19	39.10
170	102	4.3180	2.88	0.004224	336.4	79.64	39.82
180	102	4.5720	3.05	0.004231	336.4	79.51	39.75
190	102	4.8260	3.22	0.004239	336.4	79.37	39.68
200	103	5.0800	3.39	0.004246	339.8	80.02	40.01
210	103	5.3340	3.56	0.004254	339.8	79.88	39.94
220	103	5.5880	3.73	0.004261	339.8	79.74	39.87
230	103	5.8420	3.90	0.004269	339.8	79.60	39.80

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	102	6.0960	4.0652	0.004276	336.4	78.67	39.34
250	102	6.3500	4.23	0.004284	336.4	78.53	39.27
260	102	6.6040	4.40	0.004291	336.4	78.39	39.20
270	102	6.8580	4.57	0.004299	336.4	78.26	39.13
280	102	7.1120	4.74	0.004307	336.4	78.12	39.06
290	102	7.3660	4.91	0.004314	336.4	77.98	38.99
300	101	7.6200	5.08	0.004322	333.1	77.07	38.53

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

Unconfined Compressive Strength

ASTM D2166

Project No.	0022 005 01
Client	Dillon Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole	TH12-01
Sample #	T13
Depth (m)	21.3 - 21.9
Sample Date	27-Mar-12
Test Date	05-Apr-12
Technician	Lee Boughton

Unconfined Strength

	kPa	ksf
Max q_u	74.8	1.6
Max S_u	37.4	0.8

Specimen Data

Description CLAY - silty, trace gravel (<25 mm diam.), grey, moist, firm, high plasticity, homogeneous

Length	150.1	(mm)
Diameter	72.5	(mm)
L/D Ratio	2.1	
Initial Area	0.00413	(m^2)
Load Rate	1.00	(%/min)

Moisture %	32.8%	
Bulk Unit Wt.	19.0	(kN/m^3)
Dry Unit Wt.	14.3	(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

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.40	19.6	0.41
0.40	19.6	0.41
0.25	12.3	0.26
Average	**17.2**	**0.36**

Failure Geometry

Sketch:

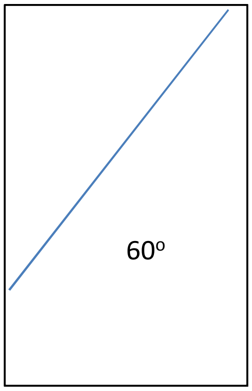


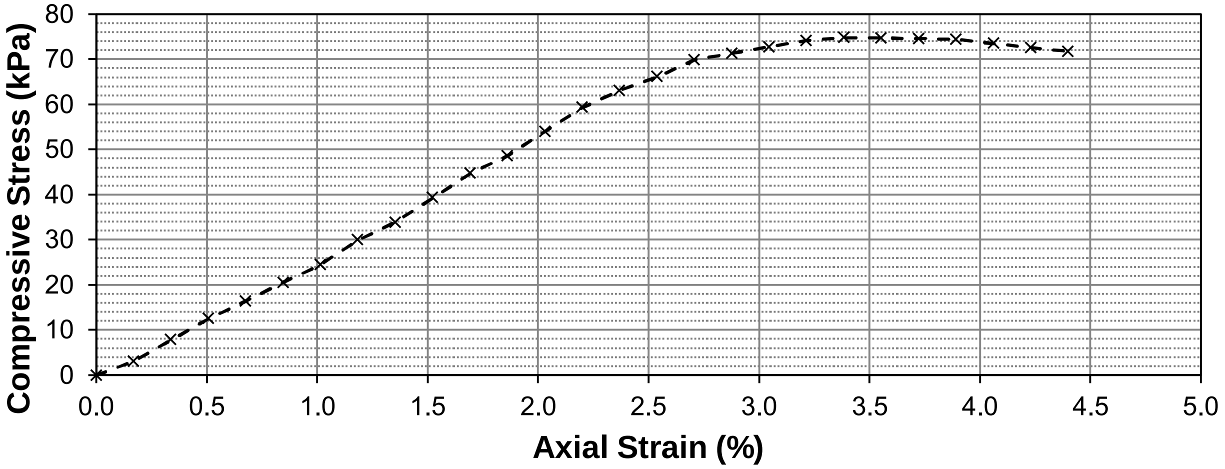
Photo:

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	0.004131	0.0	0.00	0.00
10	4	0.2540	0.17	0.004138	13.0	3.14	1.57
20	10	0.5080	0.34	0.004145	32.5	7.83	3.92
30	16	0.7620	0.51	0.004152	52.0	12.53	6.26
40	21	1.0160	0.68	0.004159	68.3	16.43	8.21
50	26	1.2700	0.85	0.004166	85.7	20.58	10.29
60	31	1.5240	1.02	0.004173	102.2	24.49	12.25
70	38	1.7780	1.18	0.004180	125.3	29.98	14.99
80	43	2.0320	1.35	0.004187	141.8	33.85	16.93
90	50	2.2860	1.52	0.004195	164.9	39.30	19.65
100	57	2.5400	1.69	0.004202	187.9	44.73	22.36
110	62	2.7940	1.86	0.004209	204.4	48.56	24.28
120	69	3.0480	2.03	0.004216	227.5	53.95	26.98
130	76	3.3020	2.20	0.004224	250.6	59.32	29.66
140	81	3.5560	2.37	0.004231	267.1	63.12	31.56
150	85	3.8100	2.54	0.004238	280.2	66.12	33.06
160	90	4.0640	2.71	0.004246	296.7	69.89	34.95
170	92	4.3180	2.88	0.004253	303.3	71.32	35.66
180	94	4.5720	3.05	0.004261	309.9	72.74	36.37
190	96	4.8260	3.22	0.004268	316.5	74.16	37.08
200	97	5.0800	3.38	0.004276	319.8	74.80	37.40
210	97	5.3340	3.55	0.004283	319.8	74.67	37.34
220	97	5.5880	3.72	0.004291	319.8	74.54	37.27
230	97	5.8420	3.89	0.004298	319.8	74.41	37.21

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	96	6.0960	4.0611	0.004306	316.5	73.52	36.76
250	95	6.3500	4.23	0.004313	313.2	72.61	36.31
260	94	6.6040	4.40	0.004321	309.9	71.72	35.86

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

Unconfined Compressive Strength

ASTM D2166

Project No.	0022 005 01
Client	Dillon Consulting
Project	Falcon River Diversion and Shoal Lake Aqueduct Bridges

Test Hole	TH12-01
Sample #	T14
Depth (m)	22.9 - 23.5
Sample Date	27-Mar-12
Test Date	06-Apr-12
Technician	Lee Boughton

Unconfined Strength

	kPa	**ksf**
Max q_u	100.6	2.1
Max S_u	50.3	1.1

Specimen Data

Description CLAY - silty, trace sand (<3%)(fine and medium grained), trace silt inclusions (<5 mm diam.), grey, moist, firm, high plasticity, homogeneous

Length	149.5	(mm)	**Moisture %**	22.7%	
Diameter	72.5	(mm)	**Bulk Unit Wt.**	19.2	(kN/m^3)
L/D Ratio	2.1		**Dry Unit Wt.**	15.6	(kN/m^3)
Initial Area	0.00413	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.45	44.1	0.92

Pocket Penetrometer

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.50	24.5	0.51
0.40	19.6	0.41
0.50	24.5	0.51
Average	**22.9**	**0.48**

Failure Geometry

Sketch:

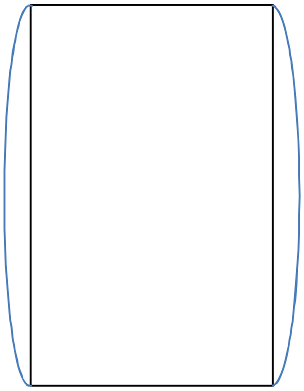


Photo:

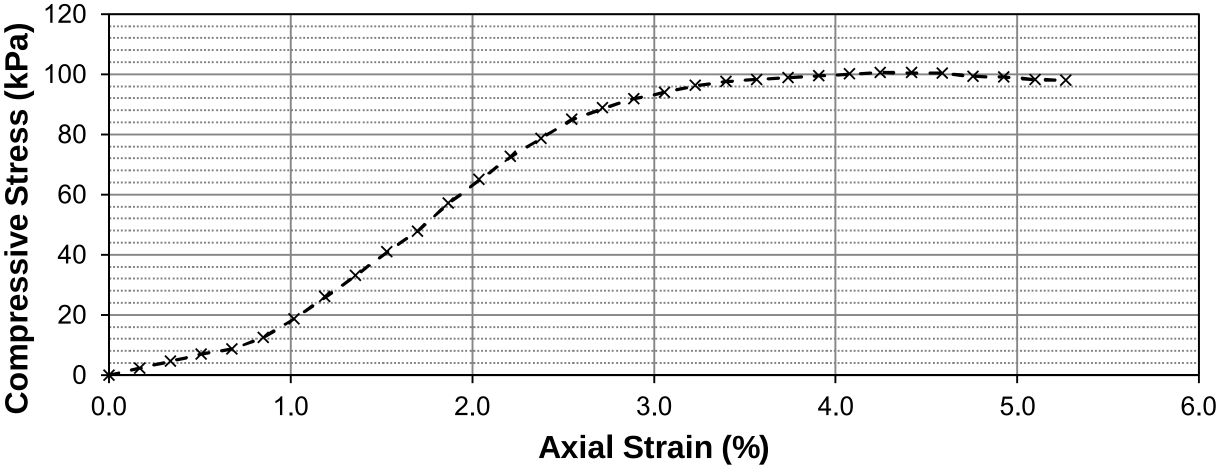
Notes: Buldge failure

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	0.004130	0.0	0.00	0.00
10	3	0.2540	0.17	0.004137	9.7	2.35	1.18
20	6	0.5080	0.34	0.004144	19.5	4.70	2.35
30	9	0.7620	0.51	0.004151	29.2	7.04	3.52
40	11	1.0160	0.68	0.004159	35.7	8.59	4.30
50	16	1.2700	0.85	0.004166	52.0	12.49	6.24
60	24	1.5240	1.02	0.004173	78.1	18.72	9.36
70	33	1.7780	1.19	0.004180	108.8	26.03	13.01
80	42	2.0320	1.36	0.004187	138.5	33.07	16.54
90	52	2.2860	1.53	0.004194	171.4	40.87	20.44
100	61	2.5400	1.70	0.004202	201.1	47.86	23.93
110	73	2.7940	1.87	0.004209	240.7	57.19	28.59
120	83	3.0480	2.04	0.004216	273.7	64.91	32.45
130	93	3.3020	2.21	0.004224	306.6	72.60	36.30
140	101	3.5560	2.38	0.004231	333.1	78.73	39.36
150	109	3.8100	2.55	0.004238	360.0	84.94	42.47
160	114	4.0640	2.72	0.004246	376.9	88.76	44.38
170	118	4.3180	2.89	0.004253	390.3	91.78	45.89
180	121	4.5720	3.06	0.004261	400.4	93.99	46.99
190	124	4.8260	3.23	0.004268	410.5	96.19	48.09
200	126	5.0800	3.40	0.004276	417.2	97.59	48.79
210	127	5.3340	3.57	0.004283	420.6	98.21	49.10
220	128	5.5880	3.74	0.004291	424.0	98.82	49.41
230	129	5.8420	3.91	0.004298	427.4	99.43	49.72

Unconfined Compressive Strength

ASTM D2166

Project No. 0022 005 01
Client Dillon Consulting
Project Falcon River Diversion and Shoal Lake Aqueduct Bridges

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	130	6.0960	4.0782	0.004306	430.7	100.03	50.02
250	131	6.3500	4.25	0.004313	434.1	100.64	50.32
260	131	6.6040	4.42	0.004321	434.1	100.46	50.23
270	131	6.8580	4.59	0.004329	434.1	100.28	50.14
280	130	7.1120	4.76	0.004337	430.7	99.32	49.66
290	130	7.3660	4.93	0.004344	430.7	99.15	49.57
300	129	7.6200	5.10	0.004352	427.4	98.20	49.10
310	129	7.8740	5.27	0.004360	427.4	98.03	49.01

Appendix B

Stability and Stress-Deformation Model Outputs

Tabloid (279mm x 432mm)

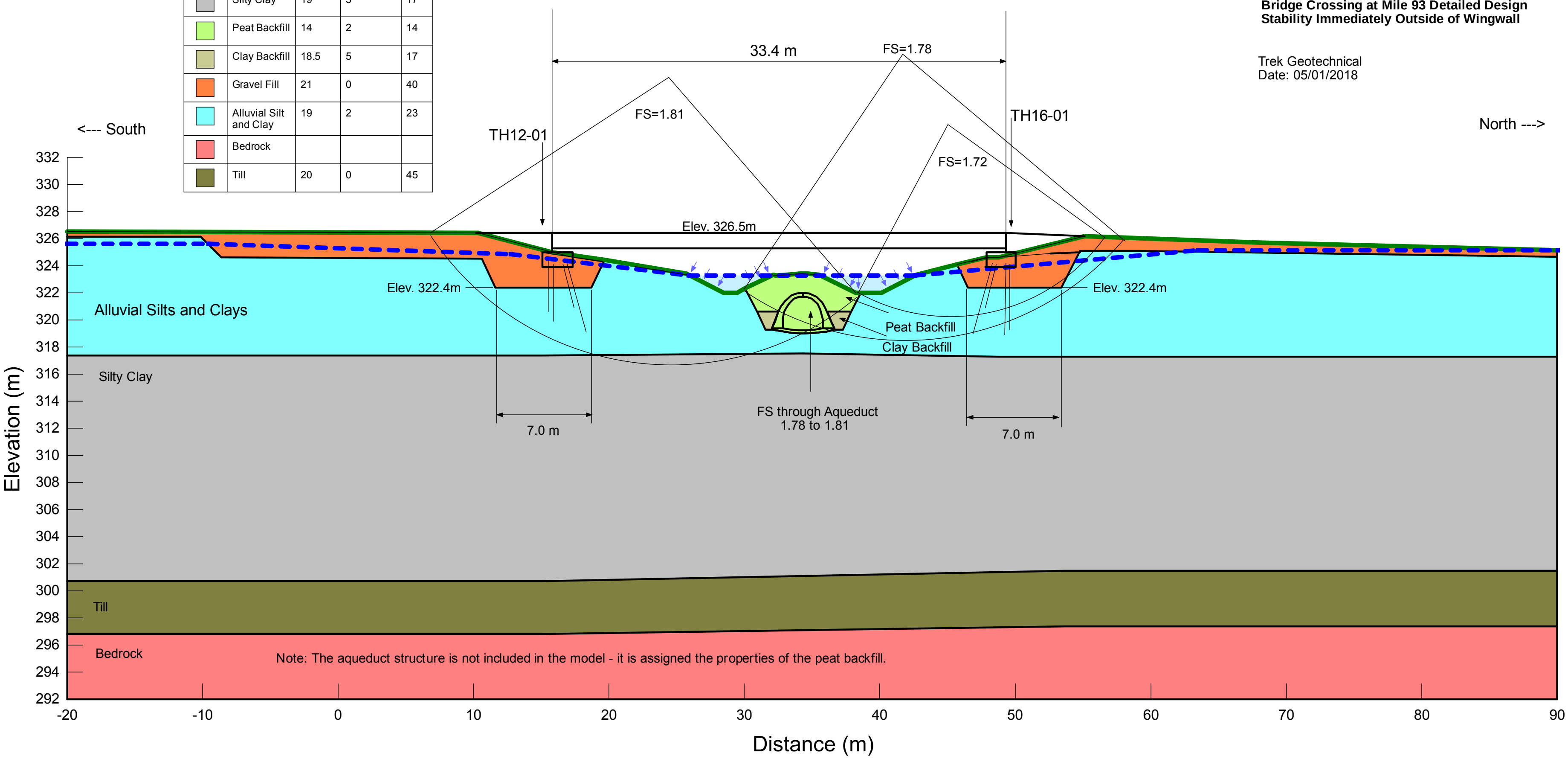
SAVED: 05/01/2018 10:56:54 AM

SCALE: 1:476 (279mm x 432mm)

0022 033 00

Dillon Consulting Ltd.

Shoal Lake Aqueduct - Bridge Crossing at Mile 93 Detailed De



Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
⬜	Silty Clay	19	5	17
🟩	Peat Backfill	14	2	14
🟨	Clay Backfill	18.5	5	17
🟧	Gravel Fill	21	0	40
🟦	Alluvial Silt and Clay	19	2	23
🟥	Bedrock			
🟫	Till	20	0	45

0022 039 00
Dillon Consulting Ltd.
Shoal Lake Aqueduct
Bridge Crossing at Mile 93 Detailed Design
Stability Immediately Outside of Wingwall

Trek Geotechnical
Date: 05/01/2018

Note: The aqueduct structure is not included in the model - it is assigned the properties of the peat backfill.

FILE PATH: Z:\Projects\0022 Dillon Consulting Ltd\0022 039 00 Mile 93 Aqueduct Bridge Detailed Design\2 Design\2.7 Modelling\SlopeW\0022 039 00 M004.gsz

Model M004

33m Span Accrow Bridge - Stability Immediately Outside of Wingwall

TREK GEOTECHNICAL

0022 033 00

Dillon Consulting Ltd.

Shoal Lake Aqueduct - Bridge Crossing at Mile 93 Detailed Design

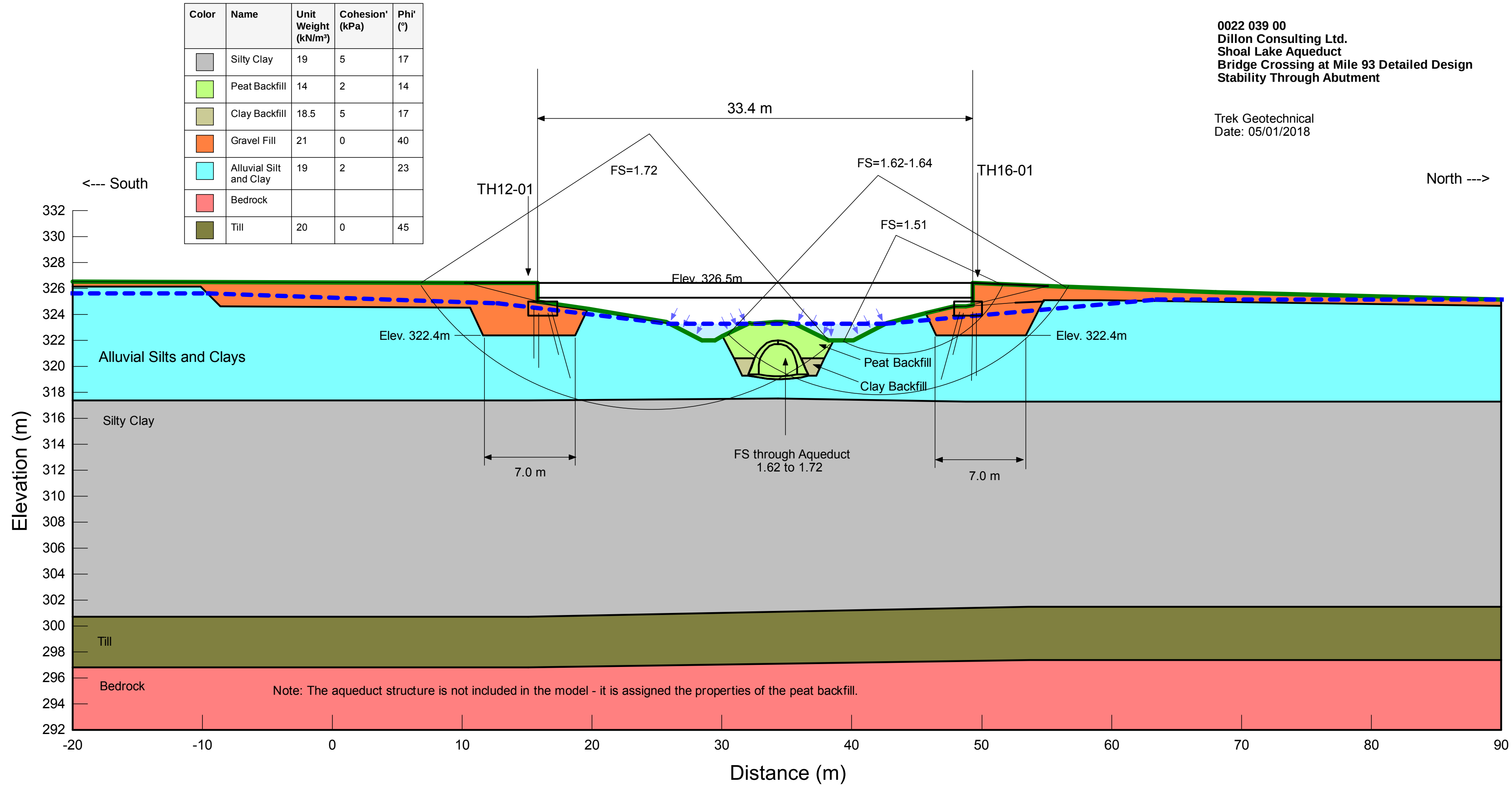
Tabloid (279mm x 432mm)

SAVED: 05/01/2018 11:08:54 AM

SCALE: 1:476 (279mm x 432mm)

0022 039 00
Dillon Consulting Ltd.
Shoal Lake Aqueduct
Bridge Crossing at Mile 93 Detailed Design
Stability Through Abutment

Trek Geotechnical
Date: 05/01/2018



Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
⬜	Silty Clay	19	5	17
🟩	Peat Backfill	14	2	14
🟨	Clay Backfill	18.5	5	17
🟧	Gravel Fill	21	0	40
🟦	Alluvial Silt and Clay	19	2	23
🟥	Bedrock			
🟫	Till	20	0	45

Note: The aqueduct structure is not included in the model - it is assigned the properties of the peat backfill.

FILE PATH: Z:\Projects\0022 Dillon Consulting Ltd\0022 039 00 Mile 93 Aqueduct Bridge Detailed Design\2 Design\2.7 Modelling\SlopeW\0022 039 00 M005.gsz

Model M005

33m Span Accrow Bridge - Stability Through Centreline

TREK GEOTECHNICAL

0022 033 00
Dillon Consulting Ltd.
Shoal Lake Aqueduct - Bridge Crossing at Mile 93 Detailed Design

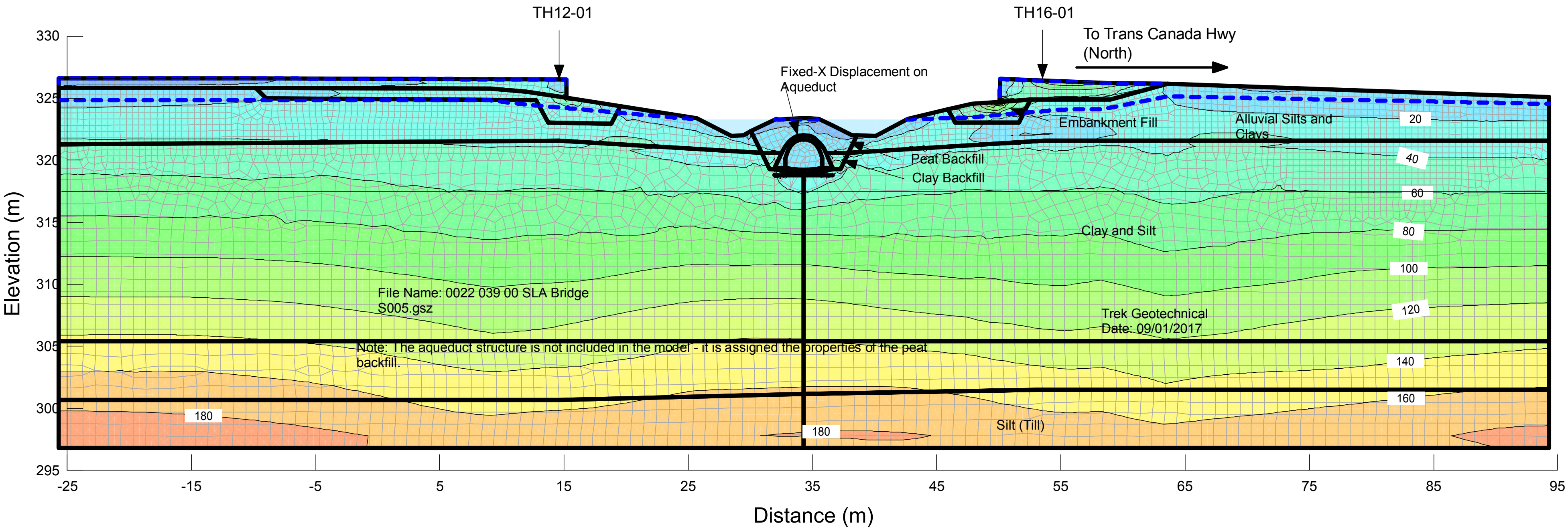
Tabloid (279mm x 432mm)

SAVED: 09/01/2017 2:43:43 PM

SCALE: 1:488.36364 (279mm x 432mm)

Color	Name	Model	Effective Young's Modulus (E') (kPa)	Poisson's Ratio	Unit Weight (kN/m³)
⬜	Clay and Silt (1)	Elastic-Plastic (Effective)	1,200	0.4	19
🟩	Peat Backfill	Linear Elastic (Effective)	200	0.4	14
🟨	Clay Backfill	Linear Elastic (Effective)	5,000	0.4	19
🟧	Embankment Fill	Linear Elastic (Effective)	40,000	0.3	21
🟦	Alluvial Silts and Clays	Linear Elastic (Effective)	15,000	0.4	20.5
🟫	Silt (Till)	Linear Elastic (Effective)	100,000	0.4	19
⬛	Clay and Silt (2)	Elastic-Plastic (Effective)	4,000	0.4	19

Type: X-Effective Stress kPa
Starting Contour Value: -20kPa
Increment by: 20kPa



File Name: 0022 039 00 SLA Bridge S005.gsz

Trek Geotechnical
Date: 09/01/2017

Note: The aqueduct structure is not included in the model - it is assigned the properties of the peat backfill.

FILE PATH: Z:\Projects\0022 Dillon Consulting Ltd\0022 039 00 Mile 93 Aqueduct Bridge Detailed Design\2 Design\2.7 Modelling\SigmaW\0022 039 00 SLA Bridge S005.gsz

Model S005
Stress Deformation Analysis