May 2014

CHERRY LANE SLOPE MOVEMENT, SASKATOON, SK

Geotechnical Investigation and Evaluation of Conceptual Remedial Options

Submitted to:
City of Saskatoon
Infrastructure Services
222 - 3rd Avenue North
Saskatoon, SK S7K 0J5

Attention: Mr. Andrew Hildebrandt

City of Saskatoon

The City of Saskatoon is making available for your information a general study of parts of the east riverbank area conducted in 1985 by the Meewasin Valley Authority and the City of Saskatoon, as well as studies conducted for the City of Saskatoon in 2012 and 2013 for parts of the area between 11th Street East and Saskatchewan Crescent.

These reports are provided as a courtesy only. There have been significant changes in ground water levels as well as actual slope failures in recent years; therefore, the information contained in all studies must be regarded with caution and with the assistance of external experts. The City makes no representation that these reports reflect the current condition of the area.

Report Number: 11-1362-0057/5100

Distribution:

2 Copies - City of Saskatoon, Saskatoon, SK
2 Copies - Golder Associates Ltd., Saskatoon, SK

REPORT

Golder Associates

Executive Summary

Golder Associates Ltd. was retained by the City of Saskatoon to conduct a geotechnical investigation and evaluation of conceptual remedial options for the slope instability located in the area of Cherry Lane (back alley), the 200 to 300 blocks between the 11th Street East and the Saskatchewan Crescent East, Saskatoon (the Site).

Two slope failures recently occurred in this area, affecting approximately a 120 metre long section of Cherry Lane and the backyards of several houses and buildings. The first failure (referred to as the West Failure) occurred on June 20, 2012. The second failure (referred to as the East Failure) occurred sometime between June 20 and June 24, 2013. The West Failure impacted a slope area approximately 70 metre section of Cherry Lane and 40 metres from the head scarp to the toe; it was most pronounced in the backyards of 229, 231, 233/235 and 237/239 11th Street East, through Cherry Lane, and into the backyard of 222 Saskatchewan Crescent East. The West Failure resulted in the disruption and interference with the Electrical Utility Services, requiring repairs and adjustment, and disruption of the geometry and stability of the public right-of-way land, requiring closure of Cherry Lane. The East Failure affected a slope area approximately 30 metre section of Cherry Lane and 45 metres from the head scarp to the toe; it was most pronounced in the backyard of 303, 305 and 307 11th Street East, through Cherry Lane, and into the backyard of 306 Saskatchewan Crescent East. The West Failure and East Failure were separated by two residential houses/apartment building, 241 11th Street East and 230 Saskatchewan Crescent East. No obvious cracking or slope movement was observed in this slope section between the two failure areas to date (May 2014).

Soil investigation and instrumentation installation were carried out to determine stratigraphy, location of the failure plane, rate of landslide movement and groundwater conditions; which are required for the development of conceptual remedial option. Monitoring of slope movements has been conducted since the West Failure occurred. The slope failures along Cherry Lane are most likely a result of a combination of the geology of the area along the riverbank, the heavy and prolonged precipitation in the spring of 2012 and 2013 that resulted in increased groundwater levels, and changes to the geometry as a result of landscaping of the slope.

The following conceptual remedial options have been evaluated for the Site:

- Option 1: Do nothing option;
- Option 2: Installation of a sub-drainage system;
- Option 3: Slope flattening with the installation of a sub-drainage system; and
- Option 4: Modification of shear zone with installation of a sub-drainage system.

As this Site poses a high risk to the public, infrastructure, and property in the area; a minimum slope factor of safety of 1.5 is recommended as the criteria for the evaluation of conceptual remedial options.

Based on the results of the option evaluation, Option 4 is recommended as a potential remedial option for the Site. The conceptual Option 4 involves the shear zone modification along Cherry Lane and the installation of a sub-drainage system (one section along 11th Street East and another along Cherry Lane). The approximate extent of the conceptual shear zone modification area is approximately 120 metres long and 4 to 13 metres wide. The construction cost estimate for this Option is in the range of 10 to 20 million dollars. While the conceptual cost of this option is estimated to be higher than the other three options, this option will result in the least disturbance to the surrounding properties (e.g., the majority of the remedial work can be confined to the area surrounding Cherry Lane), and can achieve the recommended minimum factor of safety of 1.5 for the remedial slope.

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APPENDICES

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by the City of Saskatoon (the City) to conduct a geotechnical investigation and evaluation of conceptual remedial options for the slope instability located in the area of Cherry Lane (back alley), the 200 to 300 blocks between the 11th Street East and the Saskatchewan Crescent East, Saskatoon (the Site).

Two slope failures recently occurred in this area, affecting approximately a 120 metre (m) long section of Cherry Lane and the backyards of several houses and buildings. The first failure (referred to as the West Failure) occurred on June 20, 2012. The second failure (referred to as the East Failure) occurred sometime between June 20 and June 24, 2013. Site location, locations of the slope failures and civic addresses of residential properties are shown in Figure 1.

The West Failure impacted a slope area approximately 70 m section of Cherry Lane and 40 m from the head scarp to the toe; it was most pronounced in the backyards of 229, 231, 233/235 and 237/239 11th Street East, through Cherry lane, and into the backyard of 222 Saskatchewan Crescent East. The West Failure resulted in the disruption and interference with the Electrical Utility Services, requiring repairs and adjustment, and disruption of the geometry and stability of the public right-of-way (ROW) land, requiring closure of Cherry Lane. The East Failure affected a slope area approximately 30 m section of Cherry Lane and 45 m from the head scarp to the toe; it was most pronounced in the backyard of 303, 305 and 307 11th Street East, through Cherry Lane, and into the backyard of 306 Saskatchewan Crescent East. The West Failure and East Failure were separated by two residential houses/apartment building, 241 11th Street East and 230 Saskatchewan Crescent East. No obvious cracking or slope movement was observed in this slope section between the two failure areas.

This report presents a summary of field observations, the results of field investigation and monitoring program, assessment of slope stability conditions, and conceptual slope remediation options for the Site.

This report should be read in conjunction with “Information and Limitations of the Report”, included in Appendix A. The reader is specifically directed to this information as it is essential for the proper interpretation and usage of this report.

LEGEND

- - CRACK LOCATION (APPROXIMATE)
— TOE OF SLUMP (APPROXIMATE)
303 LOT NUMBER

REFERENCE

AERIAL PHOTOGRAPH PROVIDED BY CITY OF SASKATOON, MAY 15, 2011

10 0 10
SCALE 1:600 METRES

PROJECT
City of Saskatoon
CHERRY LANE
SLOPE INSTABILITY

TITLE

SITE LOCATION PLAN

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LM	08/05/14	SCALE AS SHOWN	REV.
CADD	BDS/JDS	08/05/14	**FIGURE: 1**	
CHECK	HV	08/05/14		
REVIEW	PGB	08/05/14		

G:\2011\1362\11-1362-0057 COS East Riverbank\Figures\Phase 5100 Cherry Lane Remediation\Task 7000\11-1362-0057 Site Loc Plan.dwg 5/2/2014 9:31 AM

2.0 OBJECTIVE AND SCOPE OF WORK

The objective of this work was to develop a conceptual remediation plan for the Site (i.e., the West Failure, the East Failure, and the section of Cherry Lane between the two existing failures).

The scope of work for this study, as presented in our work plan dated July 12, 2013 includes:

- project management and meetings;
- geotechnical information review and compilation;
- structural engineering support;
- installation of survey control network and topographic survey;
- development of soil investigation program and monitoring system;
- soil investigation and instrumentation installation;
- soil laboratory testing;
- field monitoring;
- geotechnical analysis;
- development and evaluation of conceptual remediation options; and
- preparation of this engineering report.

Site reconnaissance, slope movement monitoring, and meetings with the City began when the slope movement occurred in June 2012, as part of the emergency response to the slope movement. Prior to July 2013, site reconnaissance and monitoring conducted by Golder was restricted to a portion of the Site owned by the City (i.e., Cherry Lane). Recent site reconnaissance and monitoring have been conducted for the entire Site, which is partially-owned by the City and partially-owned properties of private landowners. These tasks have been continued to date (May 2014); the results of our field observations and monitoring program have been provided to the City following each monitoring visit.

3.0 BACKGROUND

3.1 Riverbank Instability History

The topography of Saskatoon is a generally level plain of low relief dissected by the valley of the South Saskatchewan River. The South Saskatchewan River within Saskatoon runs through glacial till underlying surficial stratified deposits (SSD) of lacustrine clays, silts, and sands. The river is a discharge receptor for many of the aquifer systems in this geographic region. Slope instability along the east riverbank in the City has been an ongoing problem since 1913 (Clifton et al. 1981). Clifton et al. (1981), Clifton (1985), Eckel et al. (2002) and Golder (2008a) provide a detailed review of the geology, hydrogeology, historical slope instability activities and remedial works for the east river bank.

There is an increasing level of slope instability along the riverbank in recent years. High annual precipitation and heavy and prolonged precipitation events occurring in the last few years have increased piezometric levels in soils and contributed to slope instability.

3.2 Historical Slope Stability Condition of the Site

Riverbank instability occurs as a result of shear failure within the soil mass. Slope stability conditions depend on the site stratigraphy, soil materials, slope geometry, groundwater conditions and time. Most of the slope failures occur as shear within the lacustrine clay of the SSD at the contact with the till. The stability of a slope can be negatively affected by a number of activities (Clifton 1985), including: i) adding weight to the slope (such as fills on the slope and snow dumps); ii) increase in the elevation of the water table (resulting from lawn watering, leaking water mains, sewers and storm water lines, surface runoff directed towards the slope, blockage of the zone of seepage by placed fill, and the reduction in evapotranspiration through removal of vegetation, covering the slope with a membrane, or covering the slope with gravel); iii) excavation of the slope face (e.g., for road cuts and basement excavations); iv) removing natural vegetation (e.g., mature trees that tend to stabilize the slope); v) erosion of toe of the slope; and vi) vibrations (e.g., pile driving and explosives).

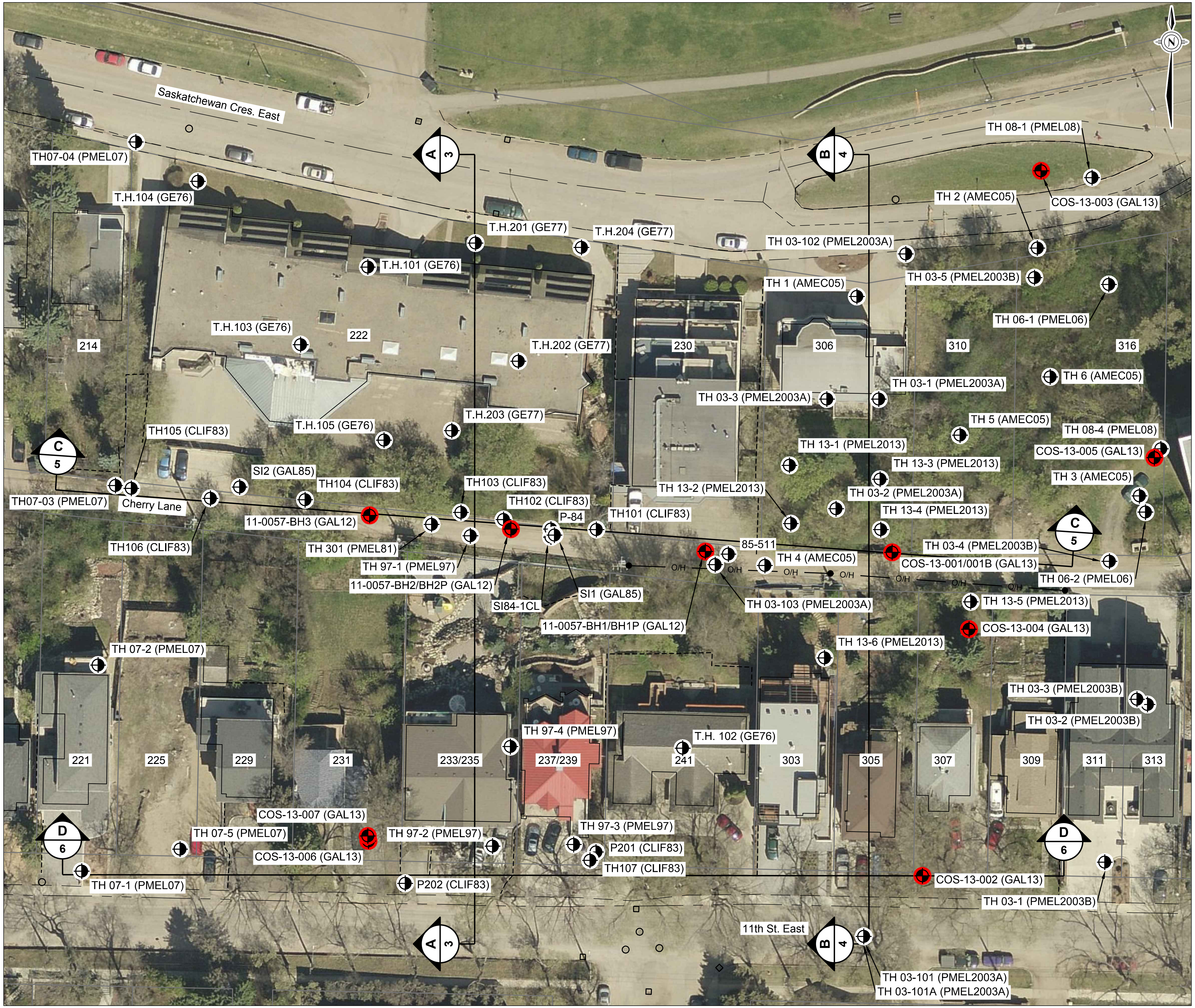
P. Machibroda Engineering Ltd. (PMEL) (1997) suggested the following primary mechanisms contributing to instability:

- prolonged periods of precipitation and/or spring snowmelt resulting in induced surface infiltration;
- toe erosion at the lower reach of the riverbank; and
- influences from upslope or down slope development including site grading, groundwater discharge or recharge and/or building development.

Clifton (1985) highlights the Cherry Lane area as an area where “existing landslides potentially threaten structures or improvements placed on or near the top of the slopes” and states that “the effects of movement can be seen on several parcels of private property and on several structures”. The report also states that new improvements would require detailed slope stability analysis with particular consideration to sites that “lie on a landform, such as the old head scarps landward from Cherry Lane, where shear strain, however slow, can be expected”.

Following the findings of the Clifton (1985) report, an agreement between Meewasin Valley Authority (MVA) and the City was signed on October 7, 1985 (City of Saskatoon 1985). This agreement outlined the responsibilities of each party in monitoring 17 inclinometers mentioned in the agreement, as well as any additional instrumentation that may be installed pursuant to the agreement. The 17 inclinometers that form the basis of the monitoring program were installed in 1984 and 1985. This agreement recommended monitoring the inclinometers in the spring and fall of each year, with more frequent monitoring during unusually heavy precipitation periods, and at locations where large displacements were observed.

Two inclinometers, designated as SI84-1CL and 85-511 with locations presented on Figure 2 were installed and monitored in Cherry Lane. However Inclinometer SI84-1CL was blocked in 2004 and inclinometer 85-511 was bent in 2006. Inclinometer SI-84 ICL recorded approximately 20 millimetres (mm) of total movement for the period from November 1992 to October 2001. Inclinometer 85-511 recorded approximately 32 mm of total movement for the period from August 1985 to October 2005.



REFERENCES

- GE76 - GROUND ENGINEERING LTD. APR. 9, 1976. GEOTECHNICAL INVESTIGATION 216, 218 AND 220 SASKATCHEWAN CRESCENT
- GE77 - GROUND ENGINEERING LTD. JULY 4, 1977. GEOTECHNICAL SITE INVESTIGATION PROPOSED HOUSING COMPLEX, SASKATCHEWAN CRESCENT
- PMEL81 - P. MACHIBRODA ENGINEERING LTD. JUNE 17, 1981. GEOTECHNICAL INVESTIGATION PROPOSED APARTMENT BUILDING SASKATCHEWAN CRESCENT, SASKATOON, SASKATCHEWAN
- CLIF83 - CLIFTON ASSOCIATES LTD. AUG. 17, 1983. GEOTECHNICAL STUDIES PROPOSED PARK TERRACE CONDOMINIUMS 222 SASKATCHEWAN CRESCENT EAST SASKATOON, SK.
- GAL85 - GOLDER ASSOCIATES LTD. MAY 1985. PROGRESS REPORT NO. 1 SLOPE MONITORING PROGRAM, PARK TERRACE CONDOMINIUMS, 222 SASKATCHEWAN CRESCENT EAST, SASKATOON, SASKATCHEWAN
- PMEL97 - P. MACHIBRODA ENGINEERING LTD. SEPT. 15, 1997. GEOTECHNICAL INVESTIGATION AND SLOPE STABILITY STUDY PROPOSED RESIDENTIAL DEVELOPMENT, 237-11TH STREET EAST, SASKATOON, SASKATCHEWAN
- PMEL03A - P. MACHIBRODA ENGINEERING LTD. SEPTEMBER 11, 2003. GEOTECHNICAL INVESTIGATION AND SLOPE STABILITY STUDY PROPOSED GARAGE, 306 SASKATCHEWAN CRESCENT EAST, SASKATOON, SASKATCHEWAN, PMEL FILE NO. S03-4869
- PMEL03B - P. MACHIBRODA ENGINEERING LTD. OCTOBER 31, 2003. GEOTECHNICAL INVESTIGATION AND SLOPE STABILITY STUDY PROPOSED RESIDENCE, 313-11TH STREET EAST, SASKATOON, SASKATCHEWAN, PMEL FILE NO. S03-4925
- AMEC05 - AMEC EARTH & ENVIRONMENTAL. JULY 27, 2005. REVISED SLOPE STABILITY ASSESSMENT PROPOSED CONDOMINIUM DEVELOPMENT, 316 SASKATCHEWAN CRESCENT, SASKATOON, SASKATCHEWAN
- PMEL06 - P. MACHIBRODA ENGINEERING LTD. JULY 14, 2006. GEOTECHNICAL INVESTIGATION AND SLOPE STABILITY STUDY PROPOSED CONDOMINIUM 316 - SASKATCHEWAN CRESCENT EAST, SASKATOON, SK
- PMEL07 - P. MACHIBRODA ENGINEERING LTD. JUNE 12, 2007. GEOTECHNICAL INVESTIGATION AND SLOPE STABILITY STUDY PROPOSED RESIDENCES, 221 & 225 - 11TH STREET EAST, SASKATOON, SK
- PMEL08 - P. MACHIBRODA ENGINEERING LTD. JULY 8, 2008. PROPOSED COMMERCIAL/RESIDENTIAL DEVELOPMENT 328 SASKATCHEWAN CRESCENT EAST, SASKATOON, SK
- GAL12 - GOLDER ASSOCIATES LTD. MAY 2013. ASSESSMENT OF SLOPE INSTABILITY AT 200 BLOCK, 11TH STREET EAST.
- PMEL13 - P. MACHIBRODA ENGINEERING LTD. JULY 18, 2013. SLOPE INSTABILITY 230/306 SASKATCHEWAN CRESCENT SASKATOON, SK. DRAWING NO S13-8517-1 TO 7

LEGEND

⊕	BOREHOLE LOCATION (OTHERS)
⊕	BOREHOLE LOCATION (GOLDER)
⊕	2013 & 2012 BOREHOLES LOCATION (GOLDER)
●	POWER POLE
□	CATCH BASIN
○	MANHOLE
— O/H —	OVERHEAD POWER LINE
303	LOT NUMBER

REFERENCE

AERIAL PHOTOGRAPH PROVIDED BY CITY OF SASKATOON, MAY 15, 2011
CITY OF SASKATOON DATUM

10 0 10
SCALE 1:600 METRES

PROJECT

City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

TITLE

BOREHOLE AND CROSS SECTION LOCATION PLAN

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LM	08/05/14	SCALE AS SHOWN	REV. 0
CADD	JDS	08/05/14	FIGURE: 2	
CHECK	HV	08/05/14		
REVIEW	PGB	08/05/14		

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As part of the City's site reconnaissance program for the east riverbank; site reconnaissance for Cherry Lane was conducted yearly by Golder since 2006. The 2012 site reconnaissance was conducted on April 26, 2012. As noted during these inspections, deflected curbs and fences, drops in the pavement and tension cracks were present; however, no noticeable slope movement was observed at the time of inspection.

The City noted that during surveys and inspections in 2012, there was no evidence of leaking water mains, storm drains or sewers in the vicinity of the study area.

3.3 Aerial Photos

Aerial photos covering the City area, including the Site were taken in 1939, 1958, 1961, 1970, 1974, 1977, 1987, 1997, 2001, 2006 and 2011 and are included Appendix B. The site is located in a meander bend of the South Saskatchewan River, where river erosion may affect the stability of the slope. Rotary Park and the fill area immediately north of Saskatchewan Crescent East were constructed in the 1960s. Apartment building 328 on Saskatchewan Crescent East was constructed before a portion of the river immediately north of Saskatchewan Crescent East (now Rotary Park) was filled in in the 1960s. Apartment buildings 222 and 230 on Saskatchewan Crescent East were constructed before 1987. Construction of 233/235 and 237/239 11th Street East and some landscaping work was completed before 2001. The landscaping in the backyards of 233/235 and 237/239 11th Street East was completed before 2006. Construction of 303 11th Street East and landscaping of this property was completed before 2011.

3.4 Previous Geotechnical Studies

A large amount of background information is available on the geology, hydrogeology, slope conditions and soil properties for the east riverbank within the City in general and at the Site. General background information related to slope stability assessment for the east riverbank includes various geologic and hydrogeologic data published in the physical environment of Saskatoon (Christiansen 1968, 1970, 1979, Sauer 1975, Haug et al. 1977, Clifton et al. 1981); riverbank instability study reports prepared for the MVA and the City (Clifton 1985, Golder 2008a, 2013a); and riverbank site reconnaissance and monitoring reports (Eckel et al. 2002, Golder 2013b, AMEC 2005a to 2010, 2013).

Available geotechnical information and documents for the area surrounding the Cherry Lane slope movement include geotechnical and riverbank assessment reports and aerial imagery provided by the City, the MVA and local landowners for the 200 to 300 block of 11th Street East and the 200 to 300 block of Saskatchewan Crescent East in Saskatoon. Table 1 shows a summary of the site specific reports for the Site. These reports were mainly prepared for residential development at various times.

Table 1: Summary of Historical Reports Reviewed

Title (Abbreviation)	Author	Year	Location
Geotechnical Investigation 216, 218 and 220 Saskatchewan Crescent (GE76)	Ground Engineering Ltd.	Apr. 9, 1976	222 Saskatchewan Crescent East
Geotechnical Site Investigation Proposed Housing Complex, Saskatchewan Crescent (GE77)	Ground Engineering Ltd.	Jul. 4, 1977	222 Saskatchewan Crescent East
Geotechnical Investigation Proposed Apartment Building Saskatchewan Crescent, Saskatoon, Saskatchewan (PMEL81)	P. Machibroda Engineering Ltd.	Jun. 17, 1981	222 Saskatchewan Crescent East
Geotechnical Studies, Proposed Park Terrace Condominiums 222 Saskatchewan Crescent East Saskatoon, SK (CLIF83)	Clifton Associates Ltd.	Aug. 17, 1983	222 Saskatchewan Crescent East
Progress Report No. 1 Slope Monitoring Program, Park Terrace Condominiums, 222 Saskatchewan Crescent East, Saskatoon, Saskatchewan (GAL85)	Golder Associates Ltd.	May 1985	222 Saskatchewan Crescent East
Slope Instability Study, South Saskatchewan River Bank Saskatoon, Saskatchewan (CLIF85)	Clifton Associates Ltd.	Dec. 23, 1985	East Riverbank
Feasibility of Horizontal Drains for Slope Stabilization East Bank – South Saskatoon, Saskatchewan (GAL89)	Golder Associates Ltd.	Apr. 1989	East Riverbank
Geotechnical Investigation and Slope Stability Study, Proposed Residential Development, 237-11th Street East, Saskatoon, Saskatchewan (PMEL97)	P. Machibroda Engineering Ltd.	Sept. 15, 1997	237 – 11th Street East
Geotechnical Investigation and Slope Stability Study, Proposed Garage, 306 Saskatchewan Crescent East, Saskatoon, Saskatchewan, PMEL File No. S03-4869 (PMEL03A)	P. Machibroda Engineering Ltd.	Sept. 11, 2003	306 Saskatchewan Crescent East
Geotechnical Investigation and Slope Stability Study, Proposed Residence, 313-11th Street East, Saskatoon, Saskatchewan, PMEL File No. S03-4925 (PMEL03B)	P. Machibroda Engineering Ltd.	Oct. 31, 2003	313 – 11th Street East
Revised Slope Stability Assessment, Proposed Condominium Development, 316 Saskatchewan Crescent, Saskatoon, Saskatchewan (AMEC05)	AMEC Earth & Environmental	Jul. 27, 2005	316 Saskatchewan Crescent East
Geotechnical Investigation, Proposed Idylwyld Lift Station Saskatoon, Saskatchewan (GAL06)	Golder Associates Ltd.	Feb. 2006	East of Sid Buckwold Bridge
Geotechnical Investigation and Slope Stability Study, Proposed Condominium 316 - Saskatchewan Crescent East, Saskatoon, SK (PMEL06)	P. Machibroda Engineering Ltd.	Jul. 14, 2006	316 Saskatchewan Crescent East
Geotechnical Investigation and Slope Stability Study, Proposed Residences, 221 & 225 - 11th Street East, Saskatoon, SK (PMEL07)	P. Machibroda Engineering Ltd.	Jun. 12, 2007	221 and 225 – 11th Street East
Proposed Commercial/Residential Development, 328 Saskatchewan Crescent East, Saskatoon, SK (PMEL08)	P. Machibroda Engineering Ltd.	Jul. 8, 2008	328 Saskatchewan Crescent East
Storm Sewer Preservation, East River Bank Slope Stabilization, City of Saskatoon File No. PW 8250-4/IS 7821-3 (GAL08)	Golder Associates Ltd.	Jul. 28, 2008	East Riverbank
Supplementary Comments and Visual Review and Groundwater Monitoring Results, Proposed Condominium 316-Saskatchewan Crescent East Saskatoon, Saskatchewan, PMEL File No. S09-5722.1 (PMEL09)	P. Machibroda Engineering Ltd.	Nov. 16, 2009	316 Saskatchewan Crescent East
Assessment of Slope Instability at 200 to 300 block, 11th Street East (GAL12)	Golder Associates Ltd.	May 2013a	200 to 300 block, 11th Street East

In addition to the geotechnical reports listed above, Golder also reviewed building permit information provided by the City for 222 and 230 Saskatchewan Crescent East and 229, 233-236, 239, 241, and 303 – 11th Street East.

3.5 Summary of Existing Foundation Plans

Foundation plans provided to the City as part of the building permit process were reviewed to determine the type and depths of foundation for those buildings located near the Cherry Lane slope failure, and are summarized in Table 2. It is not known if the installed foundations match the proposed building plans provided for review.

Table 2: Summary of Building Foundations in Building Permits

Location	Foundation Type	Foundation Size
222 Saskatchewan Crescent East	cast-in-place concrete piles	23 – 305 mm diameter, 6 m long 88 – 406 mm diameter, 6 m to 14 m long 20 – 600 mm diameter, 10 m to 14 m long
	battered concrete piles	5 – 406 mm diameter, 8 m to 10 m long
230 Saskatchewan Crescent East	cast-in-place concrete piles	2 – 500 mm diameter, 7.6 m long 25 – 406 mm diameter, 6.1 m to 7.9 m long 17 – 406 mm diameter, 3.0 m to 5.8 m long 8 – 406 mm diameter, 0.6 m to 2.7 m long
306 Saskatchewan Crescent East	cast-in-place concrete piles	2 – 254 mm diameter, 3.0 m deep (garage) 1 – 203 mm diameter, 3.0 m deep (garage)
	concrete footings	610 mm square, 203 mm thick and 1,372 mm square, 229 mm thick, step down (ground floor)
229 – 11th Street East	cast-in-place concrete piles	10 – 305 mm diameter, 6.1 m long
	concrete footings	610 mm square, 203 mm thick, step down, minimum 1.2 m deep
231 – 11th Street East	Demolished	N/A
233/235 – 11th Street East	cast-in-place concrete piles	5 – 305 mm diameter, 6.1 m long 15 – 406 mm diameter, 6.1 m to 9.1 m long 15 – 406 mm diameter, 10.7 m to 13.7 m long
237/239 – 11th Street East	cast-in-place concrete piles	1 – 305 mm diameter, 6.1 m long 17 – 406 mm diameter, 7.6 m to 9.1 m long 14 – 406 mm diameter, 10.7 m to 12.2 m long
241 – 11th Street East	concrete footings	610 mm strip, 305 mm thick
303 – 11th Street East	cast-in-place concrete piles	44 – 305 mm diameter, 4.9 m to 5.8 m long 8 – 406 mm diameter, 5.8 m to 7.0 m long
305 – 11th Street East	cast-in-place concrete piles	8 – 305 mm diameter, 3.7 m long (rear addition)
307 – 11th Street East	cast-in-place concrete piles	10 – 254 mm diameter, 6.1 m long (back porch) 1 – 203 mm diameter, 2.4 m long (2nd floor addition)
	concrete footings	610 mm square, 305 mm thick (front veranda)

mm = millimetre; m = metre

Buildings located along Saskatchewan Crescent East are founded on piles and/or strip footings. Foundation elevations of the buildings at 222 and 306 Saskatchewan Crescent East appeared to be below the till/clay contact (i.e., shear zone) and likely have an insignificant effect on the slope movement. The retaining wall and foundation system of 230 Saskatchewan Crescent East, which extended further upslope, appears to have a positive effect to the stability of the upper slope south of this building. However, it is unknown to what degree this retaining wall and foundation system can sustain slope movement.

3.6 Precipitation Data and Changes in Groundwater Table

Groundwater levels in the SSD, especially in the clay layer overlying till, have a significant influence on slope stability at the Site. Increases in groundwater elevation decrease the stability of the slope. In general, groundwater levels vary in response to the amount of water available at the ground surface and the amount of discharge or recharge potential of the soil profile, which are dependent on the variation of precipitation.

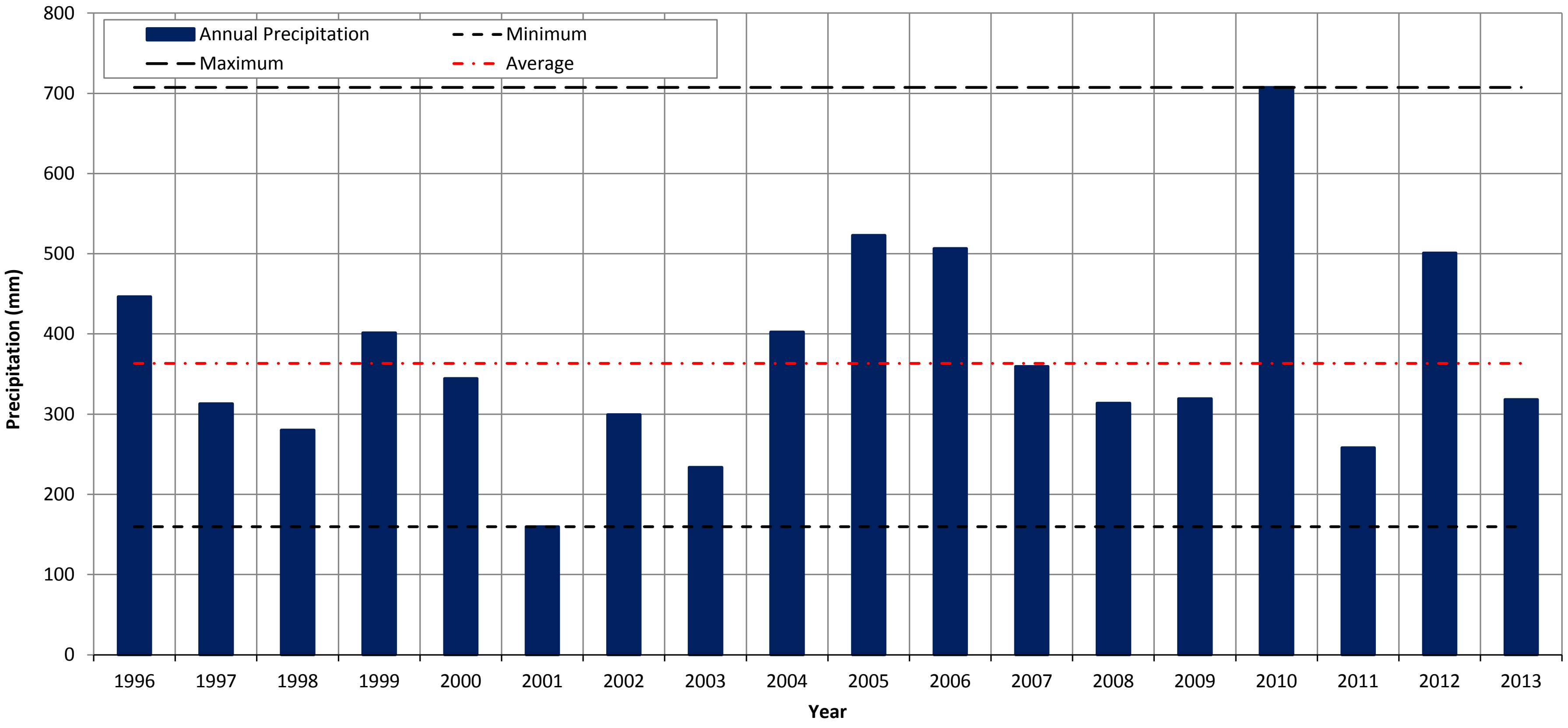
The 105 year daily total precipitation record for Saskatoon was analysed by Golder to determine the climatic conditions that may have influenced slope stability at the Site. The record was based on observations from the Environment Canada Reference Climate Station (EC 2013) for the years 1908 to 2007 and the Saskatchewan Research Council Climate Reference Station (SRC-CRS) (SRC 2013) from 2008 to present.

Saskatoon has experienced a wet cycle over the past ten years. Following a severe drought from 1997-2003, precipitation was above average between 2004 and 2006 (Figure 3) with 2005 and 2006 being the fourth and fifth wettest years on record, respectively. Although precipitation was below average between 2007 and 2009, the wettest year on record occurred in 2010 when 708 mm fell, almost double the historic average. High precipitation in 2010 created the antecedent conditions that led to flooding throughout the Prairie Provinces during 2011.

Although low through the winter of 2011-2012, precipitation was above normal during the spring and summer of 2012, particularly May and June (Figure 4). Several rain events between 10 and 25 mm led to a total precipitation of 129.8 mm in May 2012, making it the third wettest year observed between 1908 and 2012 and more than three times the median value of 31.5 mm: 69.6 mm of rain fell in the first week of May with 61.2 mm concentrated on May 5 and 6, 2012. On May 22 and 23, 2012, 33.6 mm of rain fell.

Rainfall in June 2012 was 104.4 mm, making it almost twice the median June precipitation of 54.6 mm (Figure 4). Sustained daily rainfall between June 9 and June 19, 2012 amounted to 81mm with 47.6 mm concentrated on June 9 and 10, 2012 (Figure 5). An additional 18.6 mm fell between June 24 and June 27, 2012.

The 2012-2013 winter snowpack leading up to the spring runoff was high. Cumulative winter precipitation from November 1, 2012 to March 4, 2013 exceeded 200% of average in Saskatoon (WSA 2013). There was below normal precipitation during April and May of 2013 (Figure 5). However, total June precipitation was approximately twice the median with 131.4 mm total precipitation of which 101.6 mm fell between June 13, 2013 and June 23, 2013 (Figure 6).



PROJECT

City of Saskatoon

CHERRY LANE SLOPE INSTABILITY

TITLE

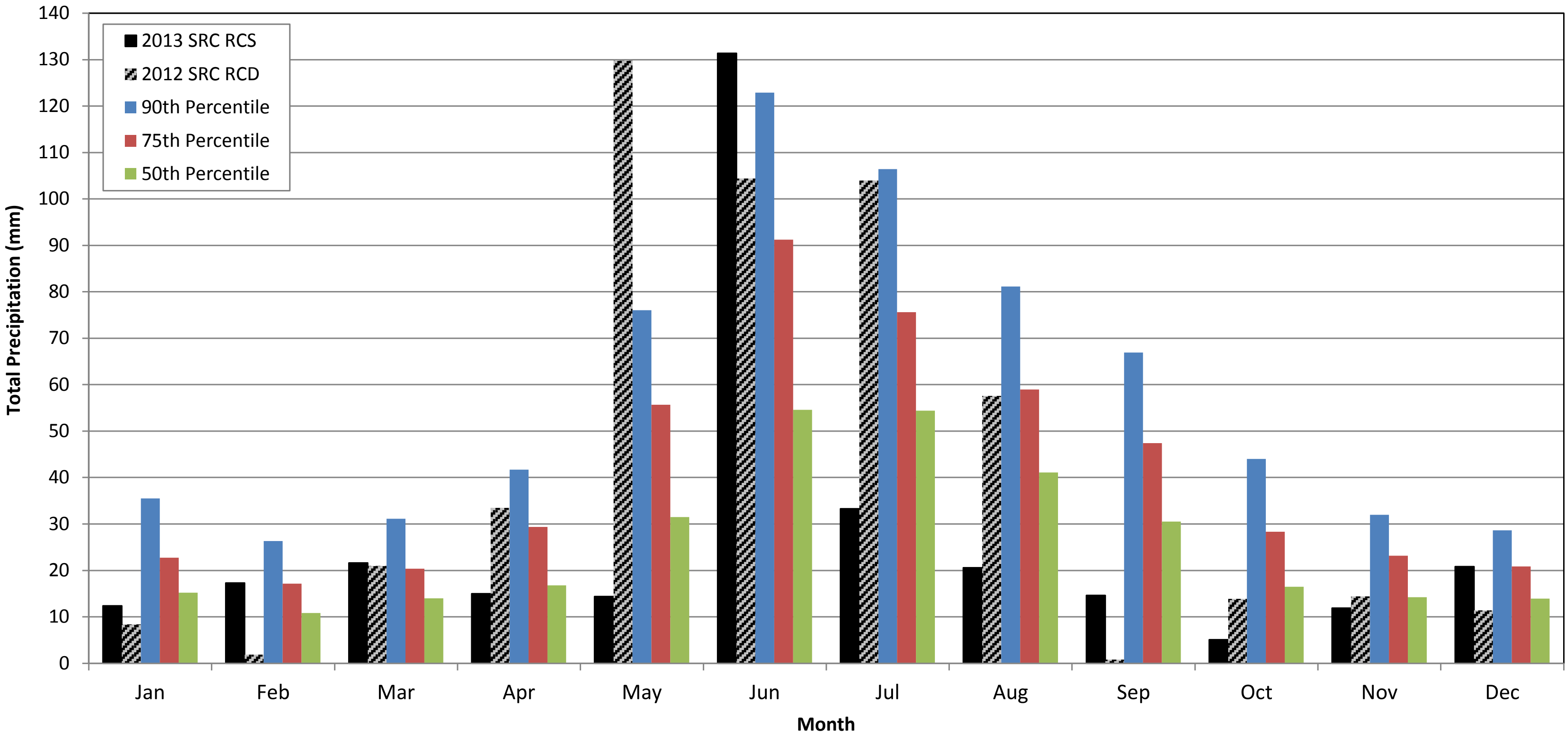
SASKATOON AREA ANNUAL PRECIPITATION (1996 - 2013)

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057	
DESIGN	LNM	08/05/14
CADD		
CHECK	PGB	08/05/14
REVIEW	HQV	08/05/14

FILE No.
SCALE N/A
REV.

FIGURE: 3



PROJECT

City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

TITLE

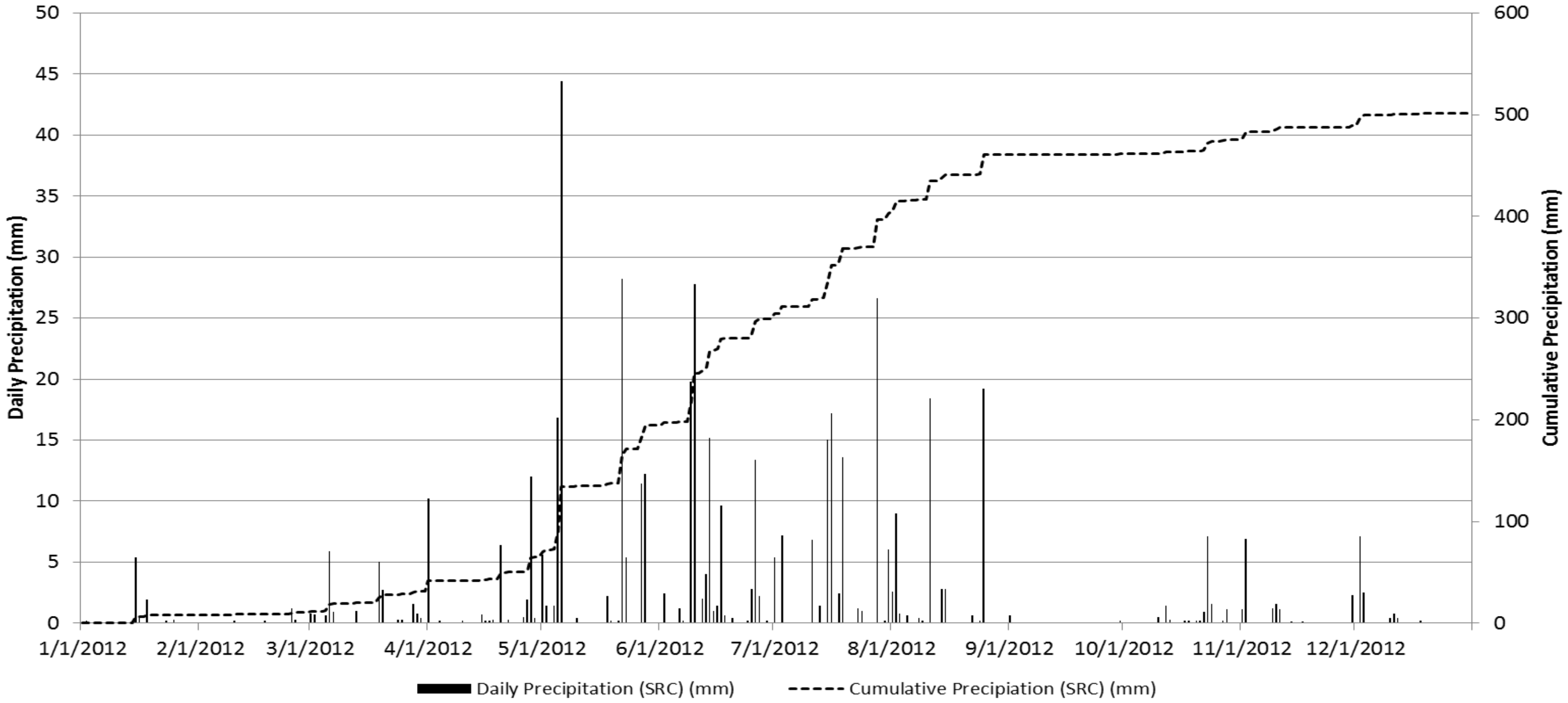
SASKATOON AREA TOTAL PRECIPITATION (1908 - 2013)

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057	
DESIGN	LNM	08/05/14
CADD		
CHECK	PGB	08/05/14
REVIEW	HQV	08/05/14

FILE No.
SCALE N/A
REV.

FIGURE: 4



PROJECT

City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

TITLE

SASKATOON AREA DAILY AND CUMULATIVE PRECIPITATION (2012)

Golder Associates
Saskatoon, Saskatchewan

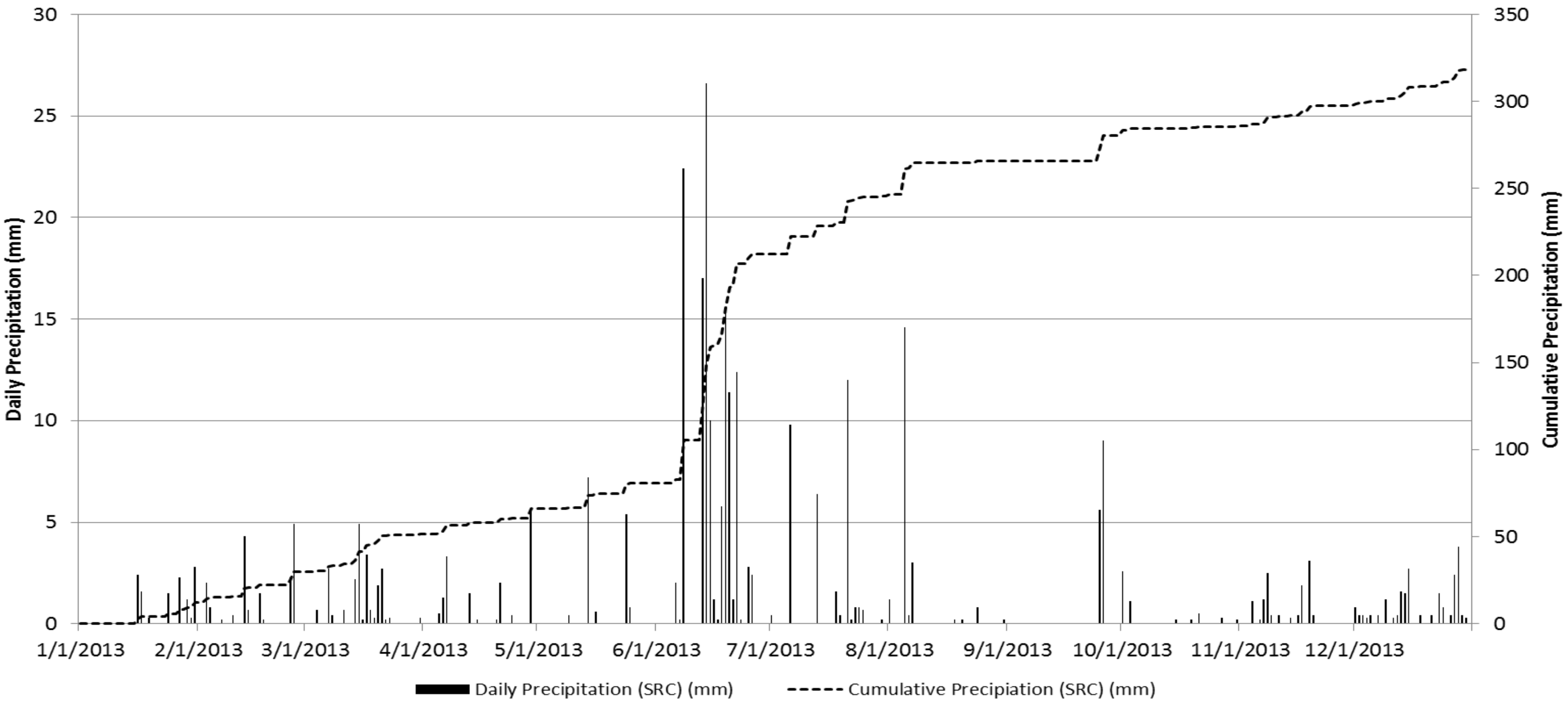
PROJECT	11-1362-0057	
DESIGN	LNM	08/05/14
CADD		
CHECK	PGB	08/05/14
REVIEW	HQV	08/05/14

FILE No.

SCALE N/A

REV.

FIGURE: 5



PROJECT

City of Saskatoon

CHERRY LANE SLOPE INSTABILITY

TITLE

SASKATOON AREA DAILY AND CUMULATIVE PRECIPITATION (2013)

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057	
DESIGN	LNM	08/05/14
CADD		
CHECK	PGB	08/05/14
REVIEW	HQV	08/05/14

FILE No.

SCALE N/A

REV.

FIGURE: 6

4.0 SITE RECONNAISSANCE

Visual inspection of the Site has been conducted yearly since 2006; more frequent inspection was conducted after the West Slide Failure in June 2012. Observations during the inspections are presented in Golder (2008a, 2008b, 2009, 2010, 2011, 2013a, 2013b). A summary of key observations and events from visual monitoring across the site has been broken down into a timeline, as follows. Photographs taken during the inspections are presented in Appendix C:

- 2006 to June 20, 2012

  The site had experienced deformation and some movement prior to the West Failure event on June 20, 2012. During the annual site reconnaissance conducted by Golder, active land development (e.g., new house/building construction and landscaping work) was noted; deflected curbs and fences, drops in pavement and tension cracks were observed, as shown in Photos C.1, C.2, and C.3. However, no noticeable slope failure was observed. The toe of the upper slope, along Cherry Lane, prior to the West Failure event is shown in Photo C.4.

- June 21, 2012

  Golder was notified by the City that a slope failure (i.e., the West Failure) had occurred at Cherry Lane. During the site inspection conducted by Golder and the City, the following observations were noted:

  - The failure was predominately in the backyards of 229, 231, 233/235 and 237/239 - 11th Street East, through Cherry Lane, and into the backyard of 222 Saskatchewan Crescent East.
  - The head scarp of the slide crossed through the backyard of 233/235 - 11th Street East (Photo C.5).
  - The toe of the slide crossed through the lane into the backyard of 222 Saskatchewan Crescent East (Photos C.6 and C.7).
  - There was cracking behind and displacement of the bricks along the retaining wall in the backyard of 237/239 - 11th Street East (Photos C.8 and C.9).
  - There was tension cracking along the lane, behind 237/239 - 11th Street East (Photo C.10).
  - There was cracking along the head scarp of the East Failure location (behind 303 and 305 - 11th Street East, Photo C.11).

- After June 21, 2012

  Subsequent to the West Failure, the following activities and observations were made in the summer of 2012. Field inspection and slope monitoring was restricted to portion of the Site owned by the City (i.e., Cherry Lane).

  - The SaskEnergy gas line that runs along Cherry Lane was shut off and relocated to reduce the public safety hazard.
  - Subsequent to the West Failure event, Golder initiated a slope monitoring program along the lane. The monitoring program included the installation of slope movement and groundwater monitoring equipment.

  - Homeowners affected by the slide were advised to seek independent geotechnical advice on their residences.
  - Golder continued to conduct visual inspections approximately every other day throughout July 2012. The frequency of site inspections decreased as the rate of slope movement decreased in the fall and winter seasons.
  - No significant slope movement was recorded east of 230 Saskatchewan Crescent East along Cherry Lane in 2012.

- June 24, 2013

  Golder was notified by the City that a second slide had occurred at Cherry Lane (i.e., the East Failure); predominantly in the backyards of 303 and 305 - 11th Street East, through Cherry Lane, and into the backyard of 306 Saskatchewan Crescent East. During the site inspection conducted by Golder and the City, the following observations were noted:

  - The head scarp of the slide crossed though the backyards of 303 and 305 - 11th Street East; the ground surface had dropped approximately 0.6 m to 0.9 m (Photos C.12 and C.13).
  - The toe of the slide was located in the backyard of 306 Saskatchewan Crescent East (Photo C.14).
  - There was severe cracking along the lane behind 305 - 11th Street East; the ground surface had dropped approximately 0.5 m (Photo C.15).
  - There was tension cracking along the lane behind 303 - 11th Street East (Photo C.16).
  - Damage to the retaining wall in the backyard of 237/239 - 11th Street East, in the West Slide area, was also noted to be more extensive during the site inspection on June 24, 2013, compared to the observations noted on June 4 and 20, 2013 (Photos C.17, C.18, and C.19).

- July to August 2013

  Site reconnaissance and monitoring had been conducted for the entire Site. Subsequent to the East Failure, the following activities and observations were made in the summer of 2013.

  - Golder conducted daily site inspections for the remainder of June 2013 and the majority of July 2013. Additional slope movement and groundwater monitoring equipment was installed in July and August 2013.
  - Homeowners affected by the slide were advised to seek independent geotechnical advice on their residences.
  - Cracking along Cherry Lane, between 303 and 305 - 11th Street East and 306 Saskatchewan Crescent East became more severe in the weeks following the East Failure. The drop in the pavement observed behind 305 - 11th Street East increased to approximately 0.5 m by June 4, 2013 (Photo C.20).
  - On July 5 and 6, 2013, the City's Public Works was on site to seal tension cracking along the lane and re-grade the section of Cherry Lane behind 305 - 11th Street East (Photo C.21). That night there was a rainfall event that continued into the following morning. That afternoon (July 6, 2013), Golder and the City were notified by the owners of 306 Saskatchewan Crescent East that runoff was flowing from the

parking lot of the apartment building at 328 Saskatchewan Crescent East, along the lane and into the backyard of 306 Saskatchewan Crescent East. The runoff was causing erosion along the lane (Photo C.22) and washing the cold patch material that had been used to re-grade the section of the lane behind 305 - 11th Street East into the backyard of 306 Saskatchewan Crescent East. The City subsequently re-graded the eroded area and constructed a soil berm along the north edge of the lane, adjacent to the backyard of 306 Saskatchewan Crescent East (Photo C.23).

- July 7, 2013

  During the site inspection the following observations were noted:

  - A trench was being excavated, by one of the residents, along the east side of the concrete retaining wall between 230 and 306 Saskatchewan Crescent East (Photo C.24). The retaining wall had been flexing and cracking under the loading of the adjacent soil on the lower slope (Photo C.25 and C.26).
  - New tension cracks had appeared along the section of lane that had been re-graded, behind 305-11th Street East (Photo C.27). The City's Public Works returned to site to re-grade the lane and seal tension cracks again on July 12 and 21, 2013.

- July 12, 2013

  The City implemented a voluntary evacuation notice due to the accelerated rate of movement that was observed at that time.

- July 17, 2013

  It was noted that the trench that had been excavated along the east side of the concrete retaining wall between 230 and 306 Saskatchewan Crescent East had been partially backfilled with soil (Photo C.28).

- August 18, 2013

  The City Public Works constructed an asphalt berm on the north edge of Cherry Lane, between 303 and 305 - 11th Street East and 306 Saskatchewan Crescent East. A V-shaped berm was installed on the lane, behind 311 - 11th Street East to capture runoff from the parking lot of 328 - 11th Street East and direct the water to a 200 mm diameter pipe on the surface of the lane (Photo C.29).

- Fall 2013

  The frequency of site inspections decreased as slope movement decreased in the fall and winter seasons.

5.0 TOPOGRAPHIC SURVEY, GEOTECHNICAL INVESTIGATION AND INSTRUMENTATION INSTALLATION

5.1 Topographic Survey

Topographic survey was conducted for the West Failure by the City and Golder in 2012 (Golder 2013a) after the West Failure occurred, and then for the entire Site (including 219 to 313 – 11th Street East, 212 to 316 Saskatchewan Crescent East, and Cherry Lane) by Meridian Surveys Ltd. of Saskatoon during the period from July 16 to July 25, 2013, after the East Slide occurred. The survey included the property outlines, roads and landslide features surrounding Cherry Lane. An additional survey of installed instrumentation was completed on September 4, 2013. The surface feature elevations in 2013 were tied to the City Benchmark D1-008 (Orthometric Elevation 499.033 masl), located at the southwest abutment of the Broadway Bridge. The survey is referenced to the NAD 83 Universal Transverse Mercator coordinate system. Figure 7 shows the plan view of the survey area contours and survey features completed in 2013. Locations and co-ordinates of control points and Bench Mark used by Meridian Survey are shown in Appendix D.

5.2 Geotechnical Investigation and Instrumentation Installation

Geotechnical investigation and instrumentation installation for the slope failure study of the Site were completed in 2012 for the West Failure, and in 2013 for both the West Failure and East Failure area. The site investigation was conducted, to supplement the historical site investigation programs, to provide information for assessing soil stratigraphy, soil properties, groundwater, and slope stability conditions for the Site.

A representative of Golder was on site during the field investigation to monitor the borehole drilling, install instrumentation, and collect samples for further laboratory testing. Borehole locations were selected in advance of drilling to determine whether conflicts with utilities or site access existed. Boreholes were drilled through the pavement, surficial stratified deposits, and into glacial till to depths of up to 7.6 metres below ground surface (mbgs) during the 2012 drilling and up to 16.8 mbgs during the 2013 drilling.

Disturbed samples and Shelby Tube samples were collected from each borehole and returned to Golder’s Saskatoon Laboratory for further testing and analysis. Disturbed samples were collected from the auger flights at the intervals noted on the Record of Borehole sheets. Shelby tube samples were collected to provide undisturbed samples for further testing. Groundwater conditions at the time of drilling were noted and the boreholes were backfilled with a bentonite-cement grout mixture to ground surface upon the completion of drilling.

LEGEND

──	CONTOURS (MAJOR / MINOR)
303	LOT NUMBER

REFERENCE

CONTOURS PROVIDED BY MERIDIAN SURVEYS, AUGUST 2013
CONTOURS SHOWN AT 0.5m INTERVALS
AERIAL PHOTOGRAPH PROVIDED BY CITY OF SASKATOON, MAY 15, 2011

10 0 10
SCALE 1:600 METRES

PROJECT

City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

TITLE

TOPOGRAPHIC SURVEY PLAN (2013)

Golder Associates
Saskatoon, Saskatchewan

PROJECT		11-1362-0057	FILE No.	
DESIGN	LM	08/05/14	SCALE AS SHOWN	REV.
CADD	BDS/JDS	08/05/14	FIGURE: 7	
CHECK	HV	08/05/14		
REVIEW	PGB	08/05/14		

G:\2011\1362\11-1362-0057 COS East Riverbank\Figures\Phase 5100 Cherry Lane Remediation\Task 7000\11-1362-0057 Topographic Survey Plan.dwg 5/2/2014 10:14 AM

Downhole instrumentation included slope inclinometer to measure slope movement, and vibrating wire and/or standpipe piezometers to monitor pore water pressure. Vibrating wire piezometers were attached to the slope inclinometer casing or installed in a separate borehole, and the boreholes were backfilled with a bentonite-cement grout mixture to ground surface upon the completion of drilling. The standpipe piezometers installed by Golder consisted of a 50 mm (2 inch) polyvinyl chloride pipe with a 1.5 m (5 ft) slotted screen which were covered with commercial filter sand and then backfilled with a bentonite-cement grout mixture to ground surface. In general, a flush mount casing was installed over the piezometer/slope inclinometer location to protect it from damage. Borehole locations were located in the field by Golder in 2012 and by Meridian Surveys Ltd. in 2013.

A field log was prepared for the boreholes to record the description and relative position of the soil strata, the location of samples, and the instrumentation installation details, in addition to other drilling notes. The Record of Borehole sheets are included in Appendix E.

In addition, six boreholes were drilled and standpipe piezometers installed by PMEL in the area of the East Slide, these piezometers are designated as TH13-1 to TH13-6. A cone penetration test (CPT) was conducted by PMEL at TH13-1 location.

Table 3 provides a summary of installed downhole instrumentation, locations of boreholes are shown in Figure 2, and locations of installed instrumentation are shown in Figure 8. Borehole records and instrumentation installation details are provided in Appendix E.

A Health and Safety Plan was developed prior to the start of drilling activities. All workers involved in the field investigation conducted a daily field hazard level assessment and toolbox meeting prior to starting work in order to identify potential site hazards and to address health and safety concerns.

Table 3: Summary of Installed Downhole Instrumentation

Borehole No.	Slope Inclinometer	VW Piezometer	Standpipe Piezometer	Location	Date of Installation
11-0057-BH1	SI1	VW11192	---	behind 241-11th Street East on Cherry Lane	23-Jun-12
11-0057-BH2	SI2	VW11200	---	behind 233/235-11th Street East on Cherry Lane	23-Jun-12
11-0057-BH3	SI3	VW11984	---	behind 231-11th Street East on Cherry Lane	23-Jun-12
COS-13-001B	COS-13-001B	VW25927	---	behind 305-11th Street East on Cherry Lane	26-Jul-13
COS-13-002	COS-13-002	VW25400 VW25399	---	front yard of 307-11th Street East	25-Jul-13
COS-13-003	---	---	COS-13-003	Saskatchewan Crescent East	26-Jul-13
COS-13-004	COS-13-004	VW26020 VW25397	---	backyard of 307-11th Street East	19-Aug-13

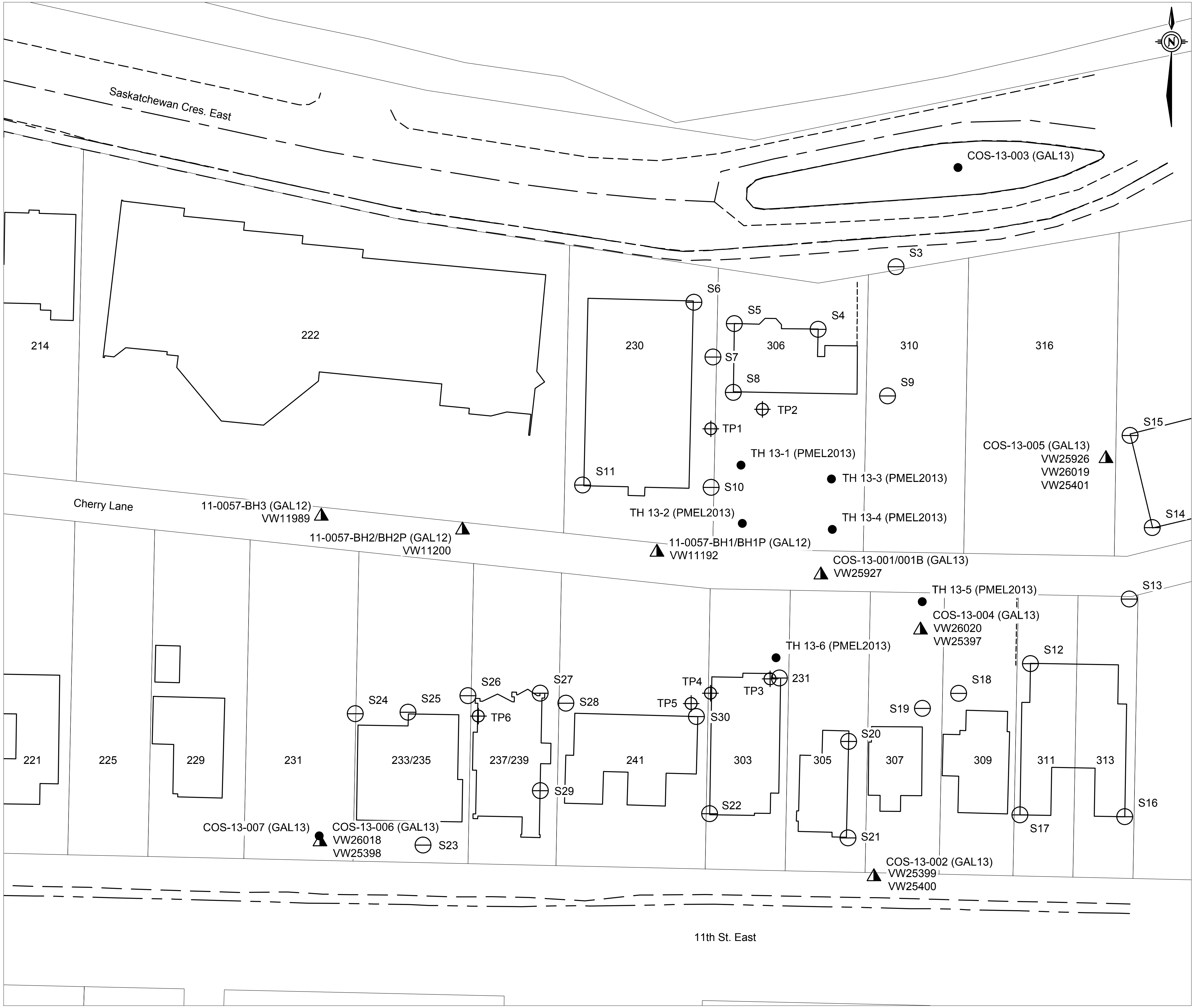
Table 3: Summary of Installed Downhole Instrumentation (continued)

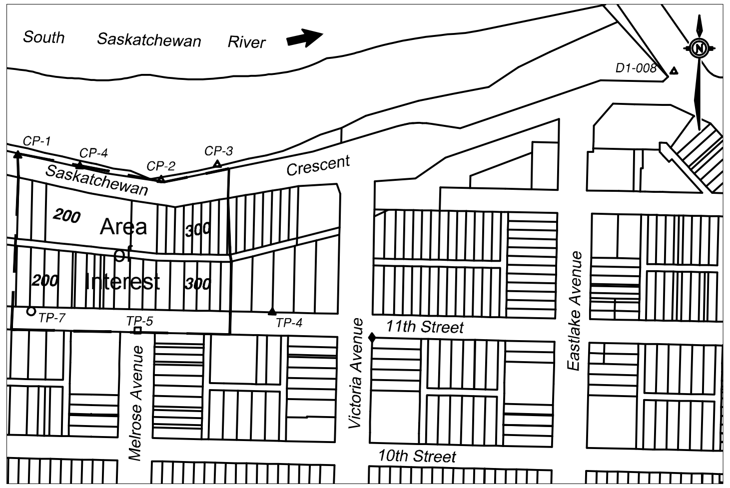
Borehole No.	Slope Inclinometer	VW Piezometer	Standpipe Piezometer	Location	Date of Installation
COS-13-005	COS-13-005	VW25926 VW26019 VW25401	---	empty lot 316 Saskatchewan Crescent East	20-Aug-13
COS-13-006	COS-13-006	VW26018 VW25398	---	empty lot 231-11th Street East	21-Aug-13
COS-13-007	---	---	COS-13-007	empty lot 231-11th Street East	21-Aug-13
TH 13-1	---	---	TH 13-1	backyard of 306 Saskatchewan Crescent East	17-Jul-13
TH 13-2	---	---	TH 13-2	backyard of 306 Saskatchewan Crescent East	17-Jul-13
TH 13-3	---	---	TH 13-3	backyard of 306 Saskatchewan Crescent East	17-Jul-13
TH 13-4	---	---	TH 13-4	backyard of 306 Saskatchewan Crescent East	17-Jul-13
TH 13-5	---	---	TH 13-5	backyard of 307-11th Street East	18-Jul-13
TH 13-6	---	---	TH 13-6	backyard of 30311th Street East	18-Jul-13

VW = vibrating wire

The 2012 soil investigation and instrumentation installation program was completed on June 23, 2012. Boreholes were drilled on Cherry Lane using Solid Stem Augers through the pavement, surficial stratified deposits, and into glacial till. The drilling was conducted by Paddock Drilling Ltd. with Acker MP-5 drill rig and monitored by Golder. The 2012 field program consisted of five (5) boreholes drilled to the depth ranging between 3.4 to 7.6 mbgs; three (3) slope inclinometers (in boreholes 11-0057-BH1, 11-0057-BH2 and 11-0057-BH3); and three (3) vibrating wire piezometers (in boreholes 11-0057-BH1P, 11-0057-BH2P and 11-0057-BH3).

The 2013 soil investigation and instrumentation installation program was completed using hollow and solid stem augers. The 2013 drilling program consisted of three phases: 1) on July 25 and 26, 2013 with a CME75 truck mounted drill rig operated by Boss Drilling Ltd. of Saskatoon, SK; 2) on August 19, 2013 with an MC4T track mounted drill rig operated by Mobile Augers and Research Ltd. of Saskatoon, SK; and 3) on August 20 and 21, 2013 with an M10 truck mounted drill rig operated by Mobile Augers and Research Ltd. of Saskatoon, SK. The 2013 field program conducted by Golder consisted of eight (8) boreholes drilled to depths ranging between 9.1 m and 16.8 m below ground surface (mbgs); five (5) slope inclinometer casings were installed to depths ranging between 7.5 and 15.5 mbgs (in boreholes COS-13-001B, COS-13-002, and COS-13-004 to COS-13-006); ten (10) vibrating wire piezometers installed to depths ranging between 5.7 mbgs and 16.1 mbgs (in boreholes COS-13-001B, COS-13-002, and COS-13-004 to COS-13-006); and two (2) standpipe piezometers installed to depths of 7.6 mbgs and 4.1 mbgs (in boreholes COS-13-003 and COS 13-007). Six standpipe piezometers installed by PMEL in the area of the East Failure are designated as TH13-1 to TH13-6.





CONTROL POINTS

COORDINATE TABLE NAD 83 (CSRS) UTM ZONE 13

POINT	NORTHING (m)	EASTING (m)	ORTHOMETRIC ELEVATION (m) HTv2.0	DESCRIPTION
CP-1	5,775,701.84	385,897.84	477.97	24" REBAR WITH PLASTIC CAP
CP-2	5,775,680.32	386,022.25	478.99	24" REBAR WITH PLASTIC CAP
CP-3	5,775,693.72	386,071.10	479.49	24" REBAR WITH PLASTIC CAP
CP-4	5,775,692.40	385,951.67	477.95	GPS CONTROL POINT
TP-4	5,775,565.50	386,118.76	499.32	X IN CONCRETE
TP-5	5,775,549.79	386,001.87	498.05	X IN NORTH RIM CATCH BASIN
TP-7	5,775,566.48	385,909.52	491.32	X IN SOUTH RIM MANHOLE
TP-8	5,775,560.37	385,809.26	484.62	X IN WEST RIM MANHOLE
D1-008	5,775,775.85	386,467.62	499.033	CONTROL TABLET

LEGEND

⊖	SETTLEMENT POINT LOCATION
△	TELL-TALE CRACK LOCATION MONITOR
⊕	TILT PLATE LOCATION
▲	SI & VIBRATING WIRE PIEZOMETER LOCATION
●	STANDPIPE PIEZOMETER LOCATION
303	LOT NUMBER

REFERENCE

LOT LOCATIONS PROVIDED BY CITY OF SASKATOON
CITY OF SASKATOON DATUM

10 0 10
SCALE 1:600 METRES

PROJECT
City of Saskatoon
CHERRY LANE
SLOPE INSTABILITY

TITLE

INSTRUMENTATION LOCATION PLAN

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LM	08/05/14	SCALE AS SHOWN	REV. 0
CADD	JDS/BDS	08/05/14	FIGURE: 8	
CHECK	HV	08/05/14		
REVIEW	PGB	08/05/14		

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5.3 Summary of Installed Instrumentation

In addition to the downhole instrumentation (e.g., slope inclinometers, vibrating wire piezometers and standpipe piezometers) other instrumentation was also installed on the ground surface (e.g., survey pins) to monitor ground surface movement, and on the house/building structures (e.g., tilt plate, settlement points, and tell-tale crack monitors) to monitor potential tilt, vertical movement and cracks of the structures.

The following sections summarize the instrumentation installed by Golder to investigate and evaluate slope stability conditions near Cherry Lane. Monitoring data for the instrumentation is included in Appendix F of this report.

5.3.1 Slope Inclinometers

Slope inclinometers are used to determine the magnitude, rate, direction, depth, and type of slope movement. Inclinometer casings were installed in boreholes, in 2012 and 2013, at depths shown in Table 4 to serve as an access tube to guide an inclinometer probe down the borehole. Slope inclinometers were installed 3 m or more into the till (i.e., below the expected zone of movement). The 70 mm diameter glue and snap inclinometer casings were supplied by RST Instruments.

Table 4: Slope Inclinometer Casing Summary Table

Borehole No.	Date of Base Reading	Ground Elevation (masl)	Clay/Till Contact Elevation (masl)
11-0057-BH1P	25-Jun-12	488.25	484.64
11-0057-BH2P	25-Jun-12	485.87	483
11-0057-BH3	25-Jun-12	484.06	N/A
COS-13-001B	27-Jul-13	489.34	482.79
COS-13-002	30-Jul-13	498.48	484.46
COS-13-004	28-Aug-13	491.74	483.05
COS-13-005	28-Aug-13	494.48	482.14
COS-13-006	28-Aug-13	494.77	484.25

masl = metres above sea level

5.3.2 Piezometers

Both vibrating wire type and standpipe type piezometers were installed. Vibrating wire piezometers consist of a pressure transducer, which outputs a frequency signal, and an integral thermistor, which measures the temperature of the transducer and its surroundings. The frequency output and temperature reading are used to calculate piezometric levels in the soil. The installed vibrating wire piezometers were supplied by RST Instruments. The vibrating wire piezometers were equipped with data loggers programmed to record measurements every eight hours. The data was downloaded periodically to evaluate fluctuations in pore-water conditions with time.

Standpipe piezometers consist of slotted and solid sections of polyvinyl chloride (PVC) pipe, and were installed to monitor groundwater elevations within the area. The area around the section of slotted PVC pipe (the intake zone) was backfilled with sand, allowing pore-water to flow into the standpipe. The groundwater elevation near the intake zone was determined by measuring the water elevation in the standpipe.

Table 5 summarizes the piezometers installed near Cherry Lane by Golder in 2012 and 2013, including six standpipe piezometers installed by PMEL. The targeted piezometer completion depths were at the Clay/Till contact, in the SSD and in the Till. Locations of piezometers are shown in Figure 8.

Table 5: Piezometer Summary Table

Piezometer Serial No.	Borehole No.	Type	Ground Elevation (masl)	Clay/Till Contact Elevation (masl)	Tip Elevation (masl)	Water Level (Oct 30)	Material at Tip Elevation
VW11192	11-0057-BH1P	VW	488.25	484.64	485.05	485.98	Clay
VW11200	11-0057-BH2P	VW	485.87	483.0	483.43	483.84	Clay
VW11984	11-0057-BH3	VW	484.06	-	482.84	dry	Clay
VW25927	COS-13-001B	VW	489.34	482.79	483.53	485.91	Clay
VW25400	COS-13-002	VW	498.48	484.46	485.38	490.80	Clay
VW25399	COS-13-002	VW	498.48	484.46	482.33	490.12	Till
-	COS-13-003	Standpipe	480.34	-	471.20	473.65	Gravel
VW26020	COS-13-004	VW	491.74	483.05	483.38	486.86	Clay
VW25397	COS-13-004	VW	491.74	483.05	481.50	485.08	Till
VW25926	COS-13-005	VW	494.48	482.14	487.30	dry	Sand
VW26019	COS-13-005	VW	494.48	482.14	482.73	485.93	Clay
VW25401	COS-13-005	VW	494.48	482.14	479.68	484.30	Till
VW26018	COS-13-006	VW	494.77	484.25	484.56	dry	Clay
VW25398	COS-13-006	VW	494.77	484.25	481.51	dry	Till
-	COS-13-007	Standpipe	494.80	-	489.21	dry	Clay
-	TH 13-1	Standpipe	486.55	483.5	482.7	482.73	Till
-	TH 13-2	Standpipe	487.84	484.0	482.0	483.53	Till
-	TH 13-3	Standpipe	487.85	482.8	482.0	483.07	Clay/Till
-	TH 13-4	Standpipe	488.60	483.3	482.2	483.59	Sand and Gravel/Till
-	TH 13-5	Standpipe	491.39	484.2	482.5	484.79	Till
-	TH 13-6	Standpipe	492.73	484.4	484.1	489.83	Clay/Till

masl = metres above sea level

5.3.3 Survey Pins

Three series of pins; 100, 200 and 300 series, were installed for monitoring of ground movement (primarily downslope, horizontal movement) along Cherry Lane. The pins were intended to be surveyed at regular intervals with reference to a reference line and a stable reference mark on Remai Arts Centre building. Pins were replaced in series over time as old pins were damaged or covered over, and to improve the monitoring accuracy. Survey markers were installed for the 300 series of survey pins. Figure 9, Figure 10 and Figure 11 show the location of survey pins of 100 series, 200 series, and 300 series installed by Golder along Cherry Lane, respectively. Survey pins consisted of nails driven into the surface of Cherry Lane. Survey markers consisted of square topped steel pins driven into the surface of Cherry Lane.

10 0 10

SCALE 1:600 METRES

LEGEND

●	PIN LOCATION
303	LOT NUMBER

NOTE

PINS 100-142 INSTALLED JUNE 28, 2012.

REFERENCE

AERIAL PHOTOGRAPH PROVIDED BY CITY OF SASKATOON, MAY 15, 2011
CITY OF SASKATOON DATUM

PROJECT
City of Saskatoon
CHERRY LANE
SLOPE INSTABILITY

TITLE
CHERRY LANE SURVEY PIN LOCATION PLAN - 100 SERIES PINS (2012)

Golder Associates
Saskatoon, Saskatchewan

PROJECT		11-1362-0057	FILE No.	
DESIGN	LM	08/05/14	SCALE AS SHOWN	REV. 0
CADD	JDS	08/05/14		
CHECK	HV	08/05/14	FIGURE: 9	
REVIEW	PGB	08/05/14		

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LEGEND

●	PIN LOCATION
303	LOT NUMBER

NOTE

PINS 200-216 INSTALLED JUNE 4, 2013
PINS 217-228 INSTALLED JUNE 25, 2013

REFERENCE

AERIAL PHOTOGRAPH PROVIDED BY CITY OF SASKATOON, MAY 15, 2011
CITY OF SASKATOON DATUM

PROJECT

City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

TITLE

CHERRY LANE SURVEY PIN LOCATION PLAN - 200 SERIES PINS (2013)

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LM	08/05/14	SCALE AS SHOWN	REV. 0
CADD	JDS	08/05/14	FIGURE: 10	
CHECK	HV	08/05/14		
REVIEW	PGB	08/05/14		

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LEGEND

● PIN LOCATION

303 LOT NUMBER

NOTE

PINS INSTALLED SEPTEMBER 13, 2013

REFERENCE

AERIAL PHOTOGRAPH PROVIDED BY CITY OF SASKATOON, MAY 15, 2011
CITY OF SASKATOON DATUM

PROJECT

City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

TITLE

CHERRY LANE SURVEY PIN LOCATION PLAN - 300 SERIES PINS (2013)

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LM	08/05/14	SCALE AS SHOWN	REV. 0
CADD	BDS/JDS	08/05/14	FIGURE: 11	
CHECK	HV	08/05/14		
REVIEW	PGB	08/05/14		

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5.3.4 Tell-Tale Crack Monitors

Crack monitors were installed on selected retaining walls where there was an existing crack. The crack monitors consisted of two plates, which were installed to overlap for part of their length, and move relative to each other as a crack opened or closed. Standard Tell-Tale crack monitors were used on flat surfaces, to monitor movement across cracks in vertical and horizontal directions.

Crack monitors were installed at the following locations (Figure 8):

- north face of the retaining wall behind 306 Saskatchewan Crescent East;
- east face of the retaining wall between 230 and 306 Saskatchewan Crescent East; and
- west face of the retaining wall between 230 and 306 Saskatchewan Crescent East.

5.3.5 Tilt Plates

Stainless steel tilt plates were installed on selected external house foundations and retaining walls. Changes in the tilt of the structure were measured using a tilt meter, which allows the tilt of a structure to be monitored on a vertical plane. Measurements were taken periodically, and cover plates were placed on the tilt plates to protect them between readings.

Tilt plates were installed at the following locations (Figure 8):

- North-south retaining wall between 230 and 306 Saskatchewan Crescent East;
- East-west retaining wall at 306 Saskatchewan Crescent East;
- North side of house at 303 – 11th Street East;
- West side of house at 303 – 11th Street East;
- North side of house at 241 – 11th Street East; and
- West side of house at 237 – 11th Street East.

5.3.6 Settlement Points

Building settlement points were installed at selected locations to monitor long term vertical movement of the structure. The settlement points were monitored using precise leveling equipment. Point S14, installed in the southwest corner of 328 Saskatchewan Crescent East, is used as a local temporary bench mark for the settlement monitoring. Elevation of Point S14 has been referenced to the COS D1-008 benchmark elevation. The building settlement surveys are conducted by precise levelling method using Leica DN03 precise digital level equipment. Settlement points were installed at the locations shown on Figure 8.

6.0 TOPOGRAPHY AND STRATIGRAPHY

Borehole information from the various geotechnical reports listed in Section 3.3 was compiled to construct a physical model of the soils at the Site. The boreholes used to construct all cross-sections were obtained from many different studies, and have likely been located using various coordinate systems and survey datums. Efforts were made to reconcile the different elevation datums; however, there may still be some discrepancies in the elevation data due to the use of unknown or older elevation datums, or slope movement. Soil descriptions and laboratory test results were also reviewed and interpreted according to Golder's classification system to provide a more consistent classification of the soils. Two cross-sections, A-A' and B-B' were selected as representative cross-sections for the West Failure and East Failure, respectively. Stratigraphic cross-sections A-A' and B-B' are shown in Figure 12 and Figure 13, respectively. Soil stratigraphic conditions along Cherry Lane and 11th Street East are shown in Figure 14 (longitudinal stratigraphic section C-C') and Figure 15 (longitudinal stratigraphic section D-D'), respectively. Locations of cross sections and longitudinal sections are shown in Figure 2.

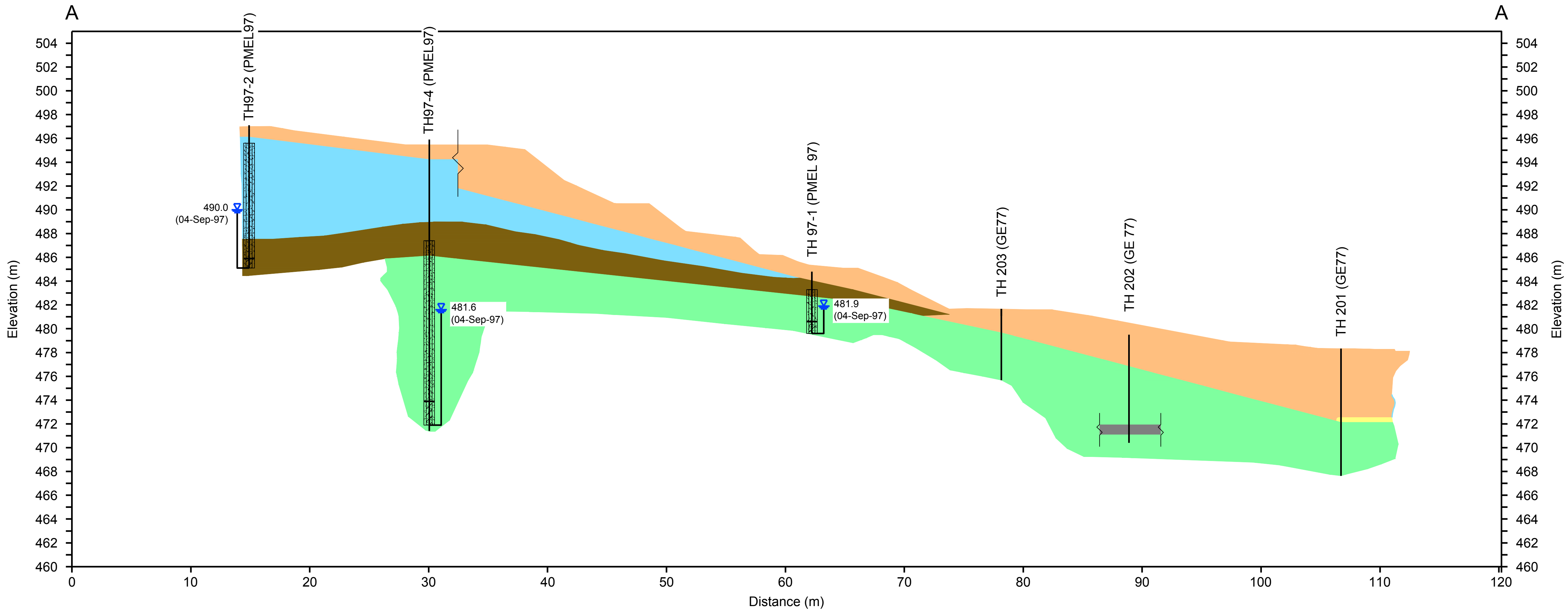
In general, the soil profile from 11th Street East to Saskatchewan Crescent East at this location consists of, in descending order: topsoil and/or fill, silty clay or clay of surficial stratified deposits (SSD), and glacial till. The ground elevation varies from approximately 496 m above sea level (masl) to 498 masl along 11th Street East, 481 to 486 masl along Cherry Lane and 474 to 479 masl along Saskatchewan Crescent East. The till/clay contact, at the failure area, is at elevation ranging from 482.8 to 484.6 masl. The silty clay and clay layer overlying till is up to 14 m thick. The topography of the area generally slopes downward to the northwest and the South Saskatchewan River. The river water elevation is at approximately 472 masl.

Topsoil thicknesses were generally less than 0.15 m at the borehole locations, and asphalt and fill up to 3 m deep were noted in various locations. The SSD at TH 97-3 location consist of less than 1 m of poorly graded sands and silty sands, less than 1 m of silt and clayey silt, 1 m to 2 m of poorly graded sands and silty sands, up to 2 m of silts and silty clay, and up to 5 m of highly plastic clay, in descending order.

The highly plastic clay unit is encountered above the till along the 11th Street East (Figure 14) and east portion of the Cherry Lane from TH101 (Figure 15). The contact between this highly plastic clay unit and till is at elevation approximately 485 masl along the 11th Street East, and at elevation approximately from 483 to 487 masl along the Cherry Lane. Extent of this highly plastic clay unit in the northwest portion of the West Failure was not known.

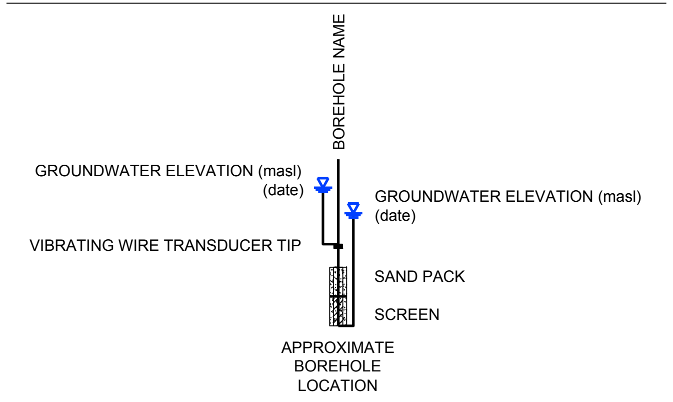
Much of the upper soil profile has been classified as fill in this report due to the unknown extent of slope modification and soil mixing caused by landscaping and slope movement. The layer thicknesses vary across the site, generally decreasing in thickness and daylighting in the lower slope between Cherry Lane and Saskatchewan Crescent East. The deposits of sand, silt and clay are present at the bottom of the slope, in addition to fill which was placed for landscaping and building construction.

The sand layers within the SSD were typically described as wet in the borehole logs reviewed. High sand content and layers of cobbles were noted in the silty clay till material at elevation approximately 467 masl below the SSD (at the TH 101 location).



A
2
CROSS SECTION A-A

LEGEND



STRATIGRAPHIC COLOUR LEGEND

🟧	UNDIFFERENTIATED FILL / SURFICIAL STRATIFIED DEPOSITS
🟨	SURFICIAL STRATIFIED DEPOSITS, SAND AND GRAVEL
🟦	SURFICIAL STRATIFIED DEPOSITS (SSD), SILT, SAND, CLAY
🟫	SURFICIAL STRATIFIED DEPOSITS (SSD), CLAY
🟩	TILL
⬛	GLACIAL SANDS AND GRAVELS
XXXX	COBBLE

REFERENCES

- GE77 - GROUND ENGINEERING LTD. JULY 4, 1977. GEOTECHNICAL SITE INVESTIGATION PROPOSED HOUSING COMPLEX, SASKATCHEWAN CRESCENT
- PMEL97 - P. MACHIBRODA ENGINEERING LTD. SEPT. 15, 1997. GEOTECHNICAL INVESTIGATION AND SLOPE STABILITY STUDY PROPOSED RESIDENTIAL DEVELOPMENT, 237-11TH STREET EAST, SASKATOON, SASKATCHEWAN

10 0 10
SCALE 1:400 METRES

PROJECT
City of Saskatoon
CHERRY LANE
SLOPE INSTABILITY

TITLE
CROSS SECTION A-A
(WEST FAILURE)

Golder Associates
Saskatoon, Saskatchewan

PROJECT		11-1362-0057	FILE No.	
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CADD	BDS/JDS	08/05/14	FIGURE: 12	
CHECK	HV	08/05/14		
REVIEW	PGB	08/05/14		

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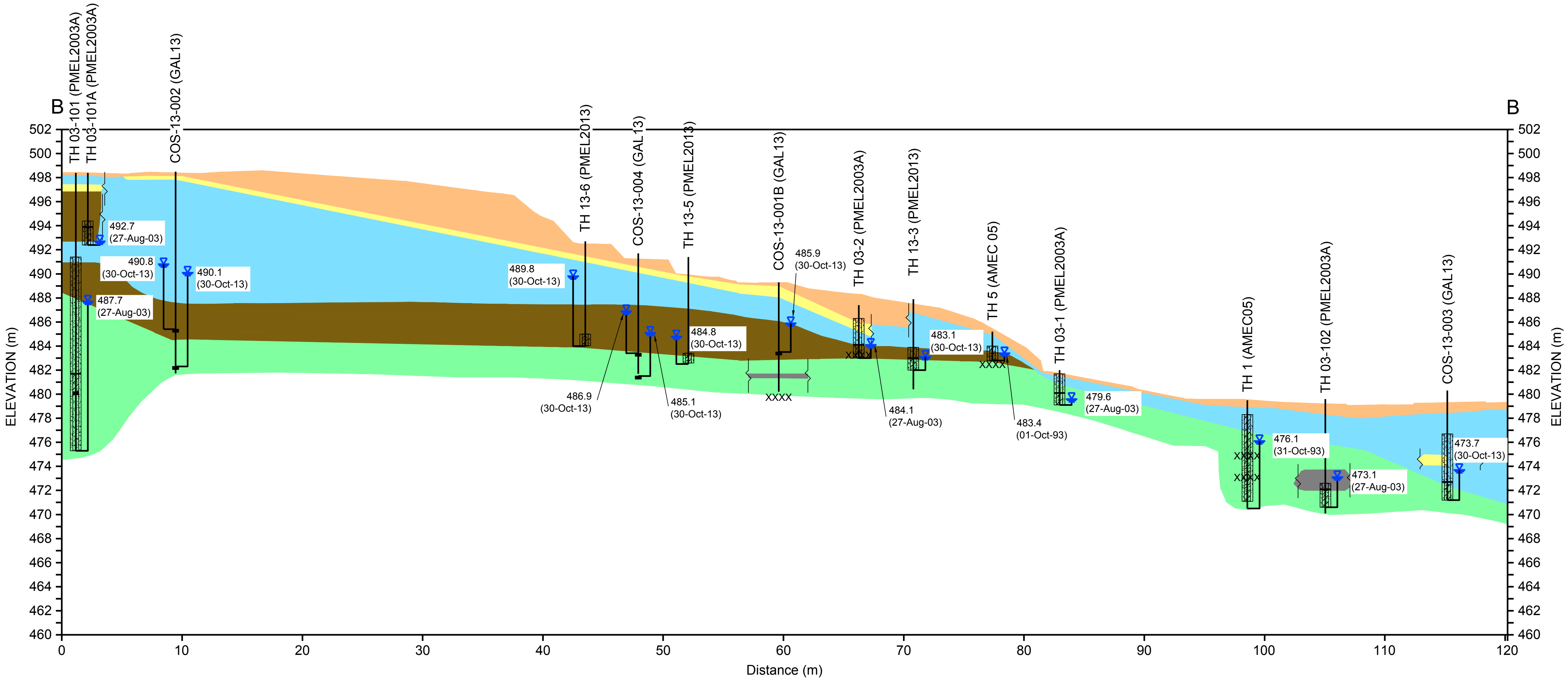

B
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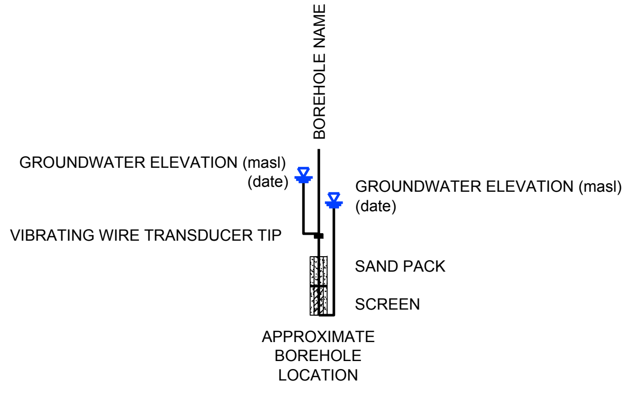
CROSS SECTION B-B

LEGEND



STRATIGRAPHIC COLOUR LEGEND

- 🟧 UNDIFFERENTIATED FILL / SURFICIAL STRATIFIED DEPOSITS
- 🟨 SURFICIAL STRATIFIED DEPOSITS, SAND AND GRAVEL
- 🟦 SURFICIAL STRATIFIED DEPOSITS (SSD), SILT, SAND, CLAY
- 🟫 SURFICIAL STRATIFIED DEPOSITS (SSD), CLAY
- 🟩 TILL
- ⬛ GLACIAL SANDS AND GRAVELS
- XXXX COBBLE

REFERENCES

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10 0 10
SCALE 1:400 METRES

PROJECT
City of Saskatoon
CHERRY LANE
SLOPE INSTABILITY

TITLE
CROSS SECTION B-B
(EAST FAILURE)

Golder Associates
Saskatoon, Saskatchewan

PROJECT		11-1362-0057
DESIGN	LM	08/05/14
CADD	BDS/JDS	08/05/14
CHECK	HV	08/05/14
REVIEW	PGB	08/05/14

FILE No.
SCALE AS SHOWN
REV. 0

FIGURE: 13

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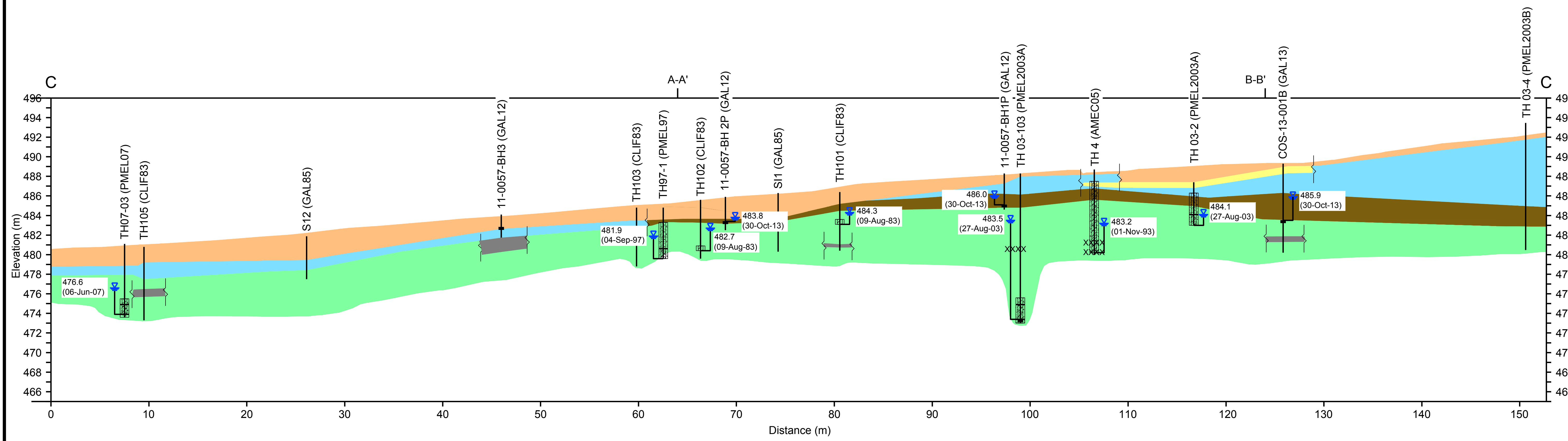
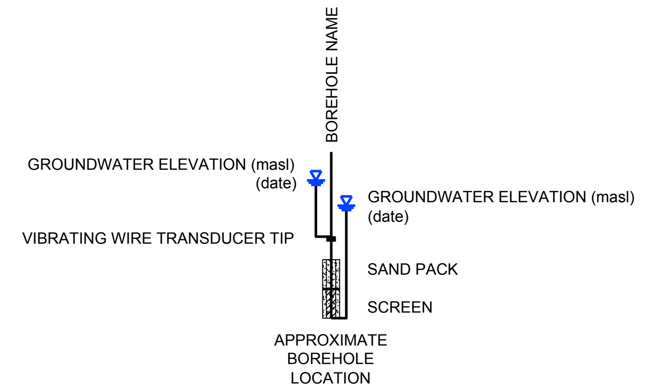


C 2 CROSS SECTION C-C

LEGEND



STRATIGRAPHIC COLOUR LEGEND

🟧	UNDIFFERENTIATED FILL / SURFICIAL STRATIFIED DEPOSITS
🟨	SURFICIAL STRATIFIED DEPOSITS, SAND AND GRAVEL
🟦	SURFICIAL STRATIFIED DEPOSITS (SSD), SILT, SAND, CLAY
🟫	SURFICIAL STRATIFIED DEPOSITS (SSD), CLAY
🟩	TILL
⬛	GLACIAL SANDS AND GRAVELS
XXXX	COBBLE

REFERENCES

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- GAL12 - GOLDER ASSOCIATES LTD. MAY 2013. ASSESSMENT OF SLOPE INSTABILITY AT 200 BLOCK, 11TH STREET EAST.

10 0 10
SCALE 1:400 METRES

PROJECT
City of Saskatoon
CHERRY LANE
SLOPE INSTABILITY

TITLE
LONGITUDINAL CROSS SECTION C-C
(ALONG CHERRY LANE)

Golder Associates
Saskatoon, Saskatchewan

PROJECT		11-1362-0057	FILE No.	
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CHECK	HV	08/05/14		
REVIEW	PGB	08/05/14		

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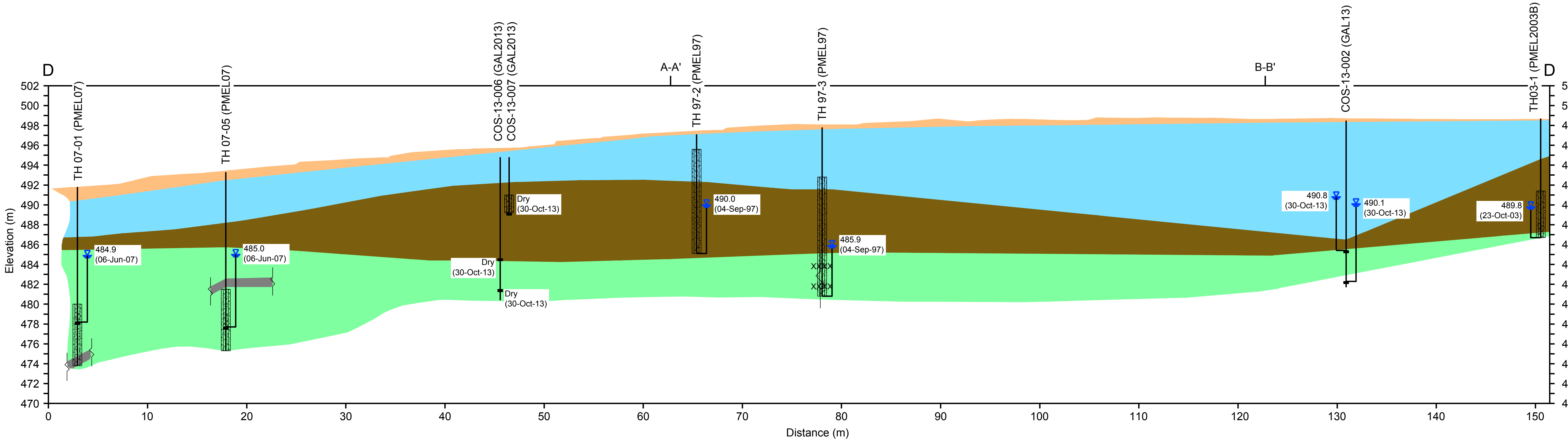

D
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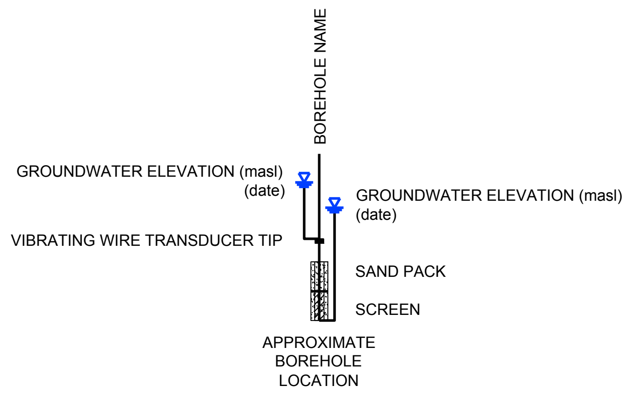
CROSS SECTION D-D

LEGEND



STRATIGRAPHIC COLOUR LEGEND

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🟨	SURFICIAL STRATIFIED DEPOSITS, SAND AND GRAVEL
🟦	SURFICIAL STRATIFIED DEPOSITS (SSD), SILT, SAND, CLAY
🟫	SURFICIAL STRATIFIED DEPOSITS (SSD), CLAY
🟩	TILL
⬛	GLACIAL SANDS AND GRAVELS
XXXX	COBBLE

REFERENCES

- PMEL97 - P. MACHIBRODA ENGINEERING LTD. SEPT. 15, 1997. GEOTECHNICAL INVESTIGATION AND SLOPE STABILITY STUDY PROPOSED RESIDENTIAL DEVELOPMENT, 237-11TH STREET EAST, SASKATOON, SASKATCHEWAN
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10 0 10
SCALE 1:400 METRES

PROJECT
City of Saskatoon
CHERRY LANE
SLOPE INSTABILITY

TITLE
LONGITUDINAL CROSS SECTION D-D
(ALONG 11TH STREET)

Golder Associates
Saskatoon, Saskatchewan

PROJECT		11-1362-0057
DESIGN	LM	08/05/14
CADD	BDS/JDS	08/05/14
CHECK	HV	08/05/14
REVIEW	PGB	08/05/14

FILE No.
SCALE AS SHOWN REV. 0

FIGURE: 15

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7.0 GROUNDWATER CONDITION

Groundwater levels in the surficial stratified deposits (SSD), particularly in the clay above the till, and in the intertill sand and gravel have significant influence on slope stability in the east riverbank geologic setting. High water levels in the soil can be expected immediately following spring thaw, following intensive irrigation, or after prolonged precipitation. The minimum water table condition is reached during winter when there is minimum recharge. Most slope instability occurs following spring thaw, or after periods of prolonged precipitation (Clifton 1985).

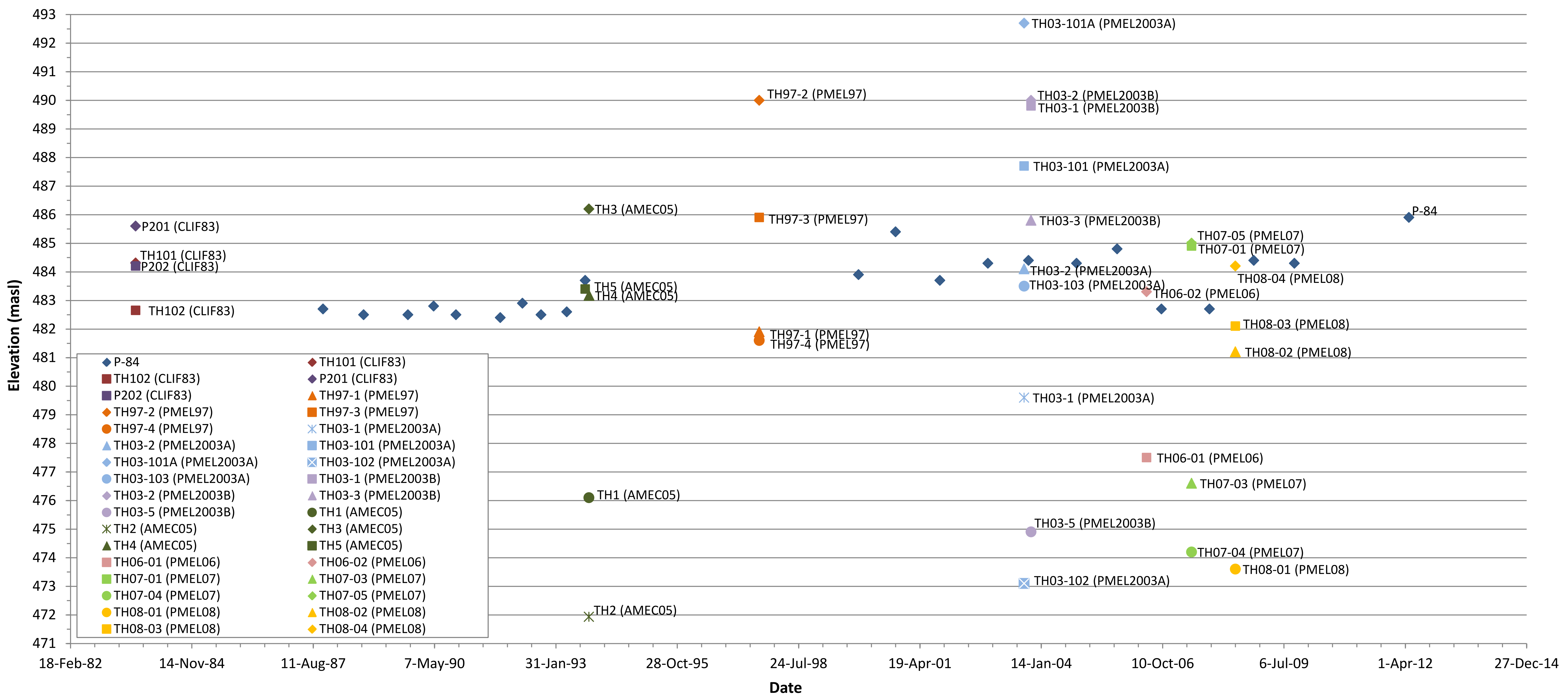
Hamilton and Tao (1977) reported the results of groundwater level measurements in SSD, spanning from six to fourteen years in three study areas in Saskatoon. Groundwater levels vary depending on annual weather cycles, the season of the year, and depending on rainfall and surface runoff conditions. It was reported that groundwater level rises of 6.1 m are reasonable, and 3.0 to 3.7 m might be considered average in clay soils for the typically semi-arid climatic conditions of Saskatoon. It was also reported that annual variation in groundwater levels can range from 0.6 m to more than 2.4 m, depending on many variables related to soil and weather conditions.

Historical groundwater levels (i.e., total head) in the area of Cherry Lane were compiled from data provided in the geotechnical reports reviewed and the East River Bank Monitoring Program reports provided by AMEC (2005b, 2009, 2013), PMEL (1994) and Ireland (2000) and are summarized in Figure 16. The groundwater table slopes downwards across the site from 11th Street to the river. Adjacent to 11th Street, the water table measured in September 1997 in TH07-2 was at about elevation 489.2, approximately 7 m below the ground surface. It should be noted that all groundwater elevations taken from the PMEL (1997) report have been converted from a local elevation presented in the report to be consistent with the surveyed elevations of the slope. It was noted that seepage was encountered during the August 5, 1997 investigation from sand layer at 490.3 masl in TH97-2, located in the front yard of 233/235 11th Street East.

With the exception of the data from piezometer P-84 (Figure 16), which was monitored on an annual basis from 1987 to 2012, there is insufficient data to interpret historical groundwater levels in this area. The highest groundwater elevation measured in P-84 was at 485.9 masl, or approximately 0.3 m below ground surface. It was recorded at this location in May 2012 prior to the occurrence of the West Failure. It should be noted that groundwater levels for this piezometer were generally monitored in fall or winter (October to December), when there is little recharge on ground surface and groundwater levels are expected to be at the lowest. High water table condition can be expected following spring thaw, or after heavy, prolonged precipitation during the summer.

During site walkovers immediately after the West Failure in 2012, water was observed in tension crack at the backyard of house 231 on June 21, 2012 which was approximately 0.5 mbgs. There was also seepage on the slope at the interface between Cherry Lane and Lot 231 immediately after the West Failure; the seepage was lessening since the West Failure occurred.

Groundwater levels recorded from the piezometers installed in 2012 and 2013 are presented and discussed in Section 9.2.



PROJECT

City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

TITLE

HISTORICAL GROUNDWATER LEVELS

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LNM	08/05/14	SCALE N/A	REV.
CADD			**FIGURE: 16**	
CHECK	HQV	08/05/14		
REVIEW	PGB	08/05/14		

8.0 LABORATORY TESTING

Laboratory tests conducted on representative soil samples included visual classification, water content, Atterberg limits, unit weight, specific gravity, grain size analysis, and direct shear tests. The test results are presented in Appendix G.

Table 6 presents the results of water content tests and Atterberg limit tests for the selected samples. The samples were obtained from the field investigation conducted in 2012 and 2013 along Cherry Lane. Grain size analysis was completed using both the mechanical method (for cohesionless soils) and the hydrometer method (for cohesive soils) for soil classification.

Table 7 presents the results of grain-size analysis. Specific gravity and dry density tests were completed to assess the volume and density relationships of the soil. Dry density tests were completed on select undisturbed samples, the results of which are shown in Table 8.

Direct Shear tests were completed on select undisturbed samples to provide additional material property information for slope stability modelling, the results of which are shown in Table 9.

The silty clay was medium plastic. Measured water contents varied from 23 percent (%) to 35%. Atterberg limit tests for three samples of silty clay indicated that the plastic limit varied from 13% to 25%, liquid limit varied from 31% to 49%, and plasticity index varied from 12% to 29%. Dry density values of 1,371 and 1,306 kilograms per cubic metre (kg/m^3) were determined for sample BH1P-1 and COS-13-005-9, respectively.

The clay was high plastic. Measured water contents varied from 25% to 36%. Atterberg limit tests for four samples of clay indicated that the plastic limit varied from 18% to 27%, liquid limit varied from 50% to 74%, and plasticity index varied from 29% to 50%. Dry density values determined for BH1P-3 and BH2P-2 were 1,405 kg/m^3 and 1,415 kg/m^3, respectively.

The glacial till consisted of a silty clay matrix with some sand and gravel. Measured water contents varied from 8% to 16%. Atterberg limits for sample BH2-5 indicated the till was low plasticity with a plastic limit of 12%, liquid limit of 18% and plasticity index of 6%.

Table 6: Atterberg Limit Test Results

Borehole	Material	Sample Number	Sample Elevation (masl)	Water Content (%)	Plastic Limit (%)	Liquid Limit (%)	Plastic Index
COS-13-005	Silty clay	005-5	488.9	23.2	20	49	29
COS-13-005	Silty clay	005-8	486.6	29.5	22	38	16
11-0057-BH1P	Silty clay	BH1P-1	486.4	34.6	21	43	22
11-0057-BH1	Silty clay	BH1-3	486.0	33.9	20	39	19
COS-13-006	Silty clay	006-10	486.0	29.5	13	41	28
COS-13-004	Silty clay	004-8	484.4	33.7	21	46	25
COS-13-005	Silty clay	005-12	483.5	28.7	21	33	12
11-0057-BH2	Silty Clay	BH2-4	483.3	30.4	25	48	23
COS-13-005	Silty clay	005-13	482.8	29.3	19	34	15
11-0057-BH3	Silty clay	BH3-2	482.7	24.3	17	31	14
COS-13-005	Silty clay	005-14	482.2	29.4	14	40	26
COS-13-005	Clayey sand	005-4	490.3	11.5	15	35	20
11-0057-BH3	Clayey sand	BH3-3	482.1	28.4	18	28	10
COS-13-005	Sandy, clayey silt	005-10	485.0	28.2	25	32	7
COS-13-006	Clay	006-3	492.9	25.3	22	65	43
COS-13-006	Clay	006-8	488.4	34.0	23	72	49
COS-13-004	Clay	004-5	487.2	33.6	24	74	50
11-0057-BH1P	Clay	BH1P-3	485.2	35.0	21	50	29
COS-13-002	Clay	002-17	485.2	32.7	21	69	48
COS-13-001	Clay	001-6	484.3	33.9	18	56	38
11-0057-BH1	Clay	BH1-5	484.7	36.3	22	62	40

Table 6: Atterberg Limit Test Results (continued)

Borehole	Material	Sample Number	Sample Elevation (masl)	Water Content (%)	Plastic Limit (%)	Liquid Limit (%)	Plastic Index
11-0057-BH2P	Clay	BH2P-2	483.4	34.5	27	72	45
11-0057-BH2	Clay	BH2-2	484.5	31.8	24	55	31
COS-13-003	Clay	003-5	475.4	32.3	19	57	38
11-0057-BH2	Till	BH2-5	482.4	12.9	12	18	6
COS-13-001B	Till	001B-3	482.4	11.0	11	23	12
COS-13-004	Till	004-11	481.8	10.8	12	19	7

masl = metres above sea level; % = percent

Table 7: Grain-size Analysis Results

Borehole	Material	Sample Number	Sample Elevation (masl)	Percent Sand (%)	Percent Silt (%)	Percent Clay (%)
COS-13-004	Silty clay	004-2	491.3	1	68	31
COS-13-002	Silty clay	002-13	488.6	12	69	17
COS-13-005	Silty clay	005-8	486.6	1	72	25
11-0057-BH1P	Silty clay	BH1P-1	486.4	3	69	28
COS-13-006	Silty clay	006-10	486.0	1	66	33
COS-13-005	Silty clay	005-12	483.5	7	74	19
COS-13-005	Silty sand	005-1	494.3	66	23	11
COS-13-006	Silty sand	006-13	482.5	59	31	10
COS-13-001	Silty sand	001-9	481.3	51	41	8
COS-13-005	Sandy, clayey silt	005-10	485.0	14	68	18
COS-13-005	Sandy, clayey silt	005-11	484.3	12	73	15
11-0057-BH3	Clayey sand	BH3-3	482.1	39	47	14

Table 7: Grain-size Analysis Results (continued)

Borehole	Material	Sample Number	Sample Elevation (masl)	Percent Sand (%)	Percent Silt (%)	Percent Clay (%)
11-0057-BH1P	Clay	BH1P-3	485.2	1	62	37
11-0057-BH1	Clay	BH1-5	484.7	3	62	35
COS-13-001	Clay	001-6	484.3	3	51	46
11-0057-BH2P	Clay	BH2P-2	483.4	1	47	52
COS-13-001B	Till	001B-3	482.4	44	36	18
COS-13-004	Till	004-11	481.8	49	36	12

masl = metres above sea level; % = percent

Table 8: Dry Density Test Results

Borehole	Material	Sample Number	Sample Elevation (masl)	Water Content (%)	Dry Density (kg/m^3)	Specific Gravity
11-0057-BH1P	Silty clay	BH1P-1	486.4	34.6	1,371	-
COS-13-004	Silty clay	004-7	485.8	30.1	1,699	2.61
COS-13-005	Silty clay	005-9	485.8	23.9	1,306	2.59
11-0057-BH1P	Clay	BH1P-3	485.2	35.0	1,405	-
COS-13-002	Clay	002-17	485.2	32.7	-	2.63
COS-13-001	Clay	001-6	484.3	33.9	-	2.63
11-0057-BH2P	Clay	BH2P-2	483.4	34.5	1,415	-
COS-13-001B	Till	001B-3	482.4	11.0	2,057	-

kg/m³ = kilogram per cubic metre; m = metre; % = percent

Table 9: Direct Shear Test Results

Borehole	Material	Sample Number	Sample Elevation (masl)	Peak		Residual	
				Friction Angle (°)	Cohesion (kPa)	Friction Angle (°)	Cohesion (kPa)
COS-13-004	Silty Clay	004-8	484.4	14.2	32	11.4	0
COS-13-005	Silty Clay	005-13	482.7	31.3	9	31.3	0
11-0057-BH2P	Clay	BH2P-2	483.4	23.7	18	22.0	0
11-0057-BH1P	Clay	BH1P-3	485.2	30.0	0	11.4	0
COS-13-001B	Clay	001B-1	483.8	26.6	12	21.7	0

mbgs = metres below ground surface; kPa = kiloPascal; ° = degrees; % = percent

9.0 INSTRUMENTATION MONITORING RESULTS

9.1 Slope Inclinometer Results

The monitoring results for the slope inclinometers are included in Appendix F. Location of historical inclinometers (i.e., SI84-1CL and SI85-511) are shown in Figure 2. Location of inclinometers installed by Golder in 2012 and 2013 are shown on Figure 8.

SI84-1CL: This inclinometer was blocked in 2004. A cumulative movement of 20 mm was recorded between November 2, 1992 and October 12, 2001, approximately 15 mm of which occurred for the period from October 31, 2000 to October 12, 2001.

SI85-511: This inclinometer was bent and not in service since 2006. Approximately 32 mm of cumulative movement was recorded for the period from August 1985 to October 2005. This inclinometer shows a zone of movement at approximately 2.5 mbgs.

11-0057-BH1: Less than 5 mm of cumulative movement was measured between June 25, 2012 and October 30, 2013.

11-0057-BH2: This inclinometer sheared off in June, 2013. A cumulative movement of 30 mm was recorded between June 25 and June 26, 2012. An approximate movement rate of 22 mm/day was recorded before it sheared off. This inclinometer shows a zone of movement at the clay/till interface at approximately elevation 483 masl (about 3.7 mbgs).

11-0057-BH3: Approximately 10 mm of cumulative movement was recorded between June 25, 2012 and October 30, 2013.

COS-13-001B: This inclinometer sheared off sometime between August and October, 2013. A cumulative movement of approximately 65 mm was recorded between July 27 and August 28, 2013. This inclinometer shows a consistent zone of movement at the clay/till interface at approximately elevation 482.8 masl (about 6.5 mbgs).

COS-13-002: Less than 5 mm of movement was recorded between July 30 and October 30, 2013.

COS-13-004: Less than 5 mm of movement was measured in the inclinometer installed in borehole COS-13-004 between August 28 and November 1, 2013.

COS-13-005: Less than 5 mm of movement was recorded between August 28 and October 30, 2013.

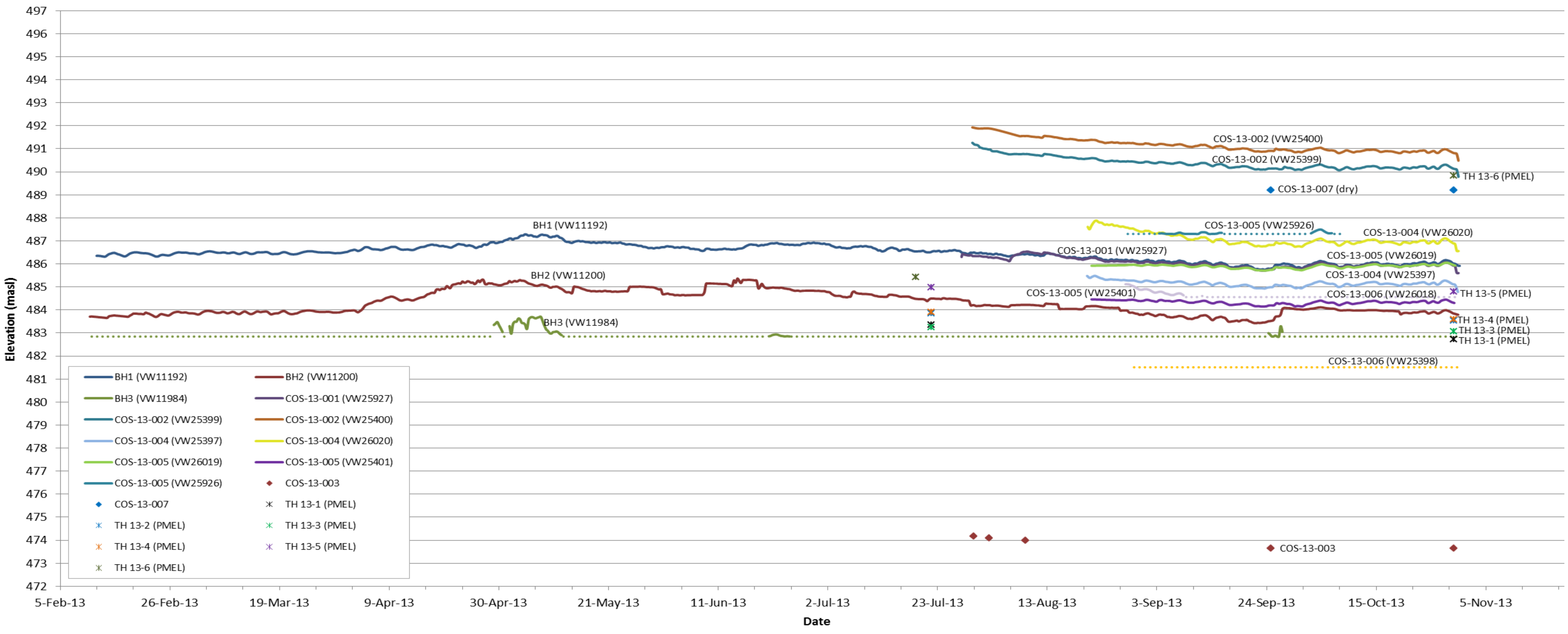
COS-13-006: Less than 5 mm of movement was recorded between August 28 and October 30, 2013.

9.2 Piezometers

The results of historical piezometer monitoring are presented and discussed in Section 7.0. Groundwater levels collected from the piezometers installed in 2012 and 2013 is included in Figure 17 for both types of piezometers (e.g., vibrating wire and standpipe). Piezometric levels recorded on October 30, 2013 are presented in Table 5, with the ground surface and till/clay contact elevation, and graphically presented in Figure 18, cross-sections A-A', B-B', and longitudinal sections C-C' and D-D'.

The vibrating wire piezometers installed in boreholes 11-1362-0057 BH1, BH2, and BH3 were installed during a period of high groundwater levels (June 2012); groundwater levels decreased approximately 0.5 m to 1.0 m during the fall and winter seasons. The trends in these vibrating wire piezometers throughout 2013 were as follows:

- Groundwater levels measured on October 30, 2013 show strong downward gradients at the piezometer nests, e.g., a gradient of 0.22 at COS-13-004, 0.53 at COS-13-005 and up to 0.95 at COS 13-004.
- Data collected from the vibrating wire piezometers revealed an increasing trend in groundwater levels starting around April 3, 2013 (at boreholes 11-1362-0057 BH1 and BH2).
- Measured annual variation in groundwater levels in 2013 was 0.86 m at 11-0057 BH3 and 1.93 m at 11-0057 BH2.
- The highest groundwater level recorded at borehole 11-1362-0057 BH1 was 487.3 masl (about 1.0 mbgs) on May 4, 2013.
- High groundwater levels recorded at borehole 11-1362-0057 BH2 were 485.3 masl (about 0.6 mbgs) and 485.4 masl (about 0.5 mbgs), recorded on April 27 and June 14, 2013, respectively.
- The highest groundwater level recorded in borehole 11-1362-0057 BH3 was 483.7 masl (about 0.4 mbgs) on May 8, 2013.
- Groundwater levels recorded at 11-0057 BH1 and BH2 started to decrease early in July 2013.



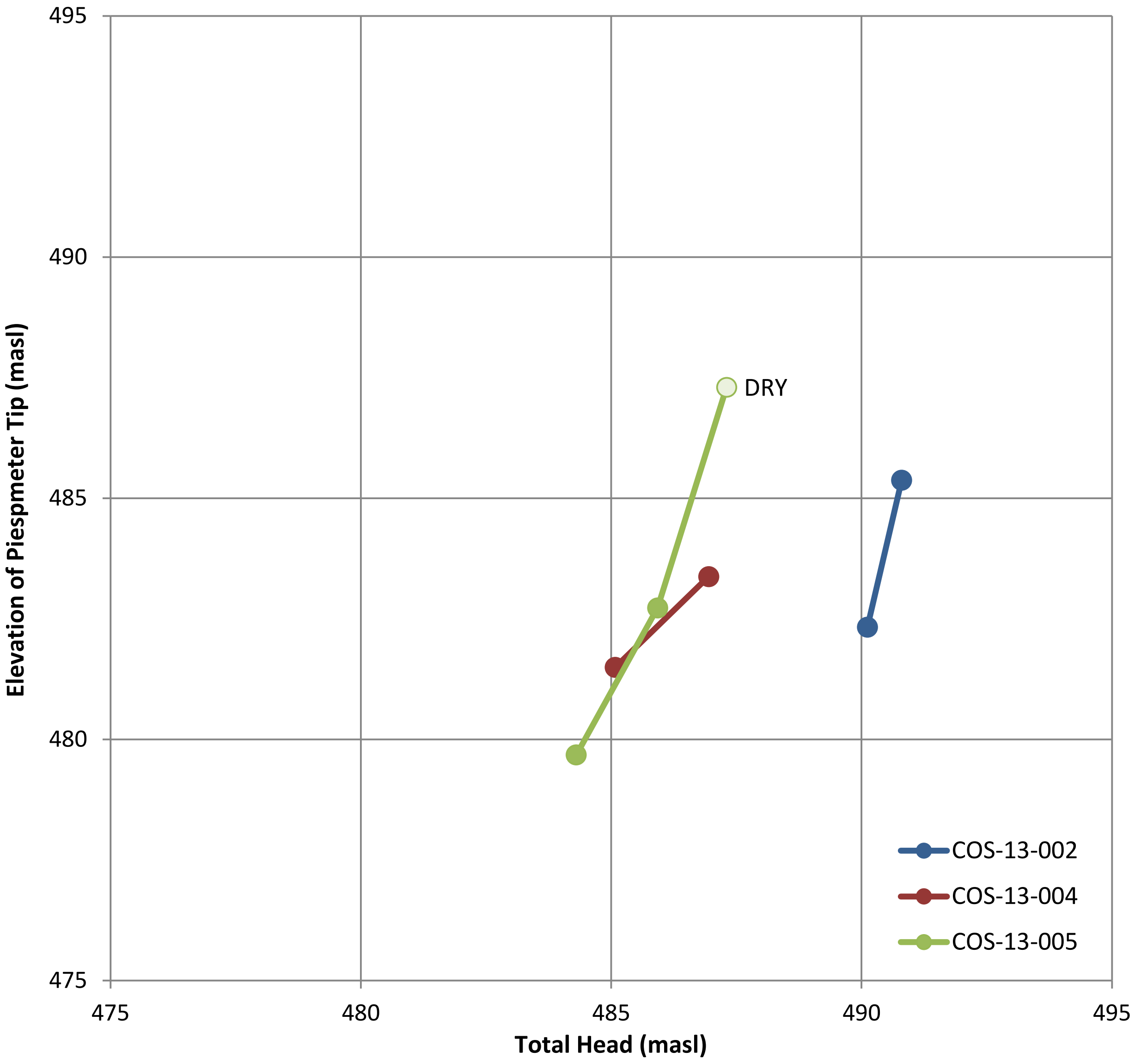
Notes:
1) Dashed lines indicate negative pore water pressures.
2) Piezometer TH13-1 to TH13-6 were installed by P.Machibroda Engineering Ltd. (PMEL) in July 2013.

PROJECT
City of Saskatoon
CHERRY LANE
SLOPE INSTABILITY

TITLE
MONITORED PIEZOMETERIC LEVELS
(2012-2013)

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LNM	08/05/14	SCALE N/A	REV.
CADD				
CHECK	PGB	08/05/14	**FIGURE: 17**	
REVIEW	HQV	08/05/14		



PROJECT

City of Saskatoon

CHERRY LANE SLOPE INSTABILITY

TITLE

TOTAL HEAD MEASURED ON OCTOBER 30, 2013

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LNM	08/05/14	SCALE N/A	REV.
CADD			**FIGURE: 18**	
CHECK	PGB	08/05/14		
REVIEW	HQV	08/05/14		

9.3 Survey Pin Monitoring

9.3.1 June 21 to June 28, 2012

A network of survey pins was installed within the West Failure area and monitored daily for the period from June 21 to June 28, 2012, immediately after the West Failure occurred using a Total Station. Figure 19 presents locations of the survey pins installed for this monitoring period and horizontal movement vectors for selected survey pins. The horizontal movement vectors were determined for the period from June 22 to June 24, 2012. A summary of the results of ground movement monitoring for this period is as follows:

- Cherry Lane behind 233-11th Street East (Pin 18 location) moved 260 mm down slope and pushed up 0.05 m for the monitoring period from June 22 to 28. The rate of movement reduced from 110 mm/day from June 22 to June 23, to approximately 27 mm/day from June 24 to June 28, 2012.
- Cherry Lane behind 237-11th Street East (Pin 34) moved 220 mm down slope and dropped 30 mm for the monitoring period from June 22 to 28.
- The toe of the failure in the backyard of 222 Saskatchewan Crescent East (Pin 31) moved 150 mm from June 22 to June 24, 2012.

9.3.2 June 28, 2012 to Jun 4, 2013 (100 series pins)

Survey Pins 100 to 142 (Figure 9) were installed on June 28, 2012, along Cherry Lane at approximately 5 m intervals, to monitor the slope movement along the lane using a survey line. This series of pins was surveyed from July 4, 2012 to June 4, 2013. Horizontal movement of this series of survey pins was monitored every third day from June 28 to August 2, 2012; the rate of movement then reduced, and the frequency of monitoring was reduced to weekly. Cumulative horizontal movements and rates of movement between June 28, 2012 and June 4, 2013 are shown in Figure 20 and Figure 21, respectively.

A summary of the results of ground movement monitoring for this series of survey pins is as follows:

- Monitoring results show that a 45 m section of Cherry Lane, from Pin 112 to Pin 125, was impacted. No significant movement was measured east of Pin 112 or west of Pin 125.
- Total horizontal movement of 115 mm was measured behind 233/235 – 11th Street East (Pin 120 location) from June 28 to September 13, 2012.
- Recorded rate of movement reduced significantly from 12 mm/day at the start of monitoring (June 28, 2012) to less than 1 mm/day in early September 2012. Less than 5 mm of movement was monitored between February 4 and June 4, 2013

9.3.3 June 28, 2012 to June 28, 2013 (100 series pins)

Figure 22 presents the results of GPS survey of the 100 series pins between June 28, 2012 and June 27, 2013 for the Cherry Lane at the East Failure. The results show 765 mm of horizontal movement for Pin 106, 555 mm for Pin 107, and 366 mm for Pin 108. Most of these movements occurred in June 2013 because less than 5 mm of movement was measured by line survey for this location up to June 4, 2013 (Figure 20).

PIN MOVEMENT (BETWEEN JUNE 22-24, 2012)	
PIN NUMBER	RECORDED MOVEMENT (mm)
PIN13	20
PIN14	70
PIN15	91
PIN16	81
PIN17	90
PIN18	150
PIN19	76
PIN21	73
PIN22	91
PIN23	30
PIN29	112
PIN30	41
PIN31	150
PIN32	81
PIN33	89
PIN34	100
PIN35	110
PIN37	36

LEGEND

→	PIN MOVEMENT VECTOR
- -	CRACK LOCATION
—	TOE OF SLUMP

REFERENCE

AERIAL PHOTOGRAPH PROVIDED BY CITY OF SASKATOON

0 50 100 150
MOVEMENT VECTOR SCALE (mm)

5 0 5
SCALE 1:200 METRES

PROJECT

City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

TITLE

MONITORING PIN LOCATION PLAN FOR THE PERIOD OF JUNE 22-24, 2012

Golder Associates
Saskatoon, Saskatchewan

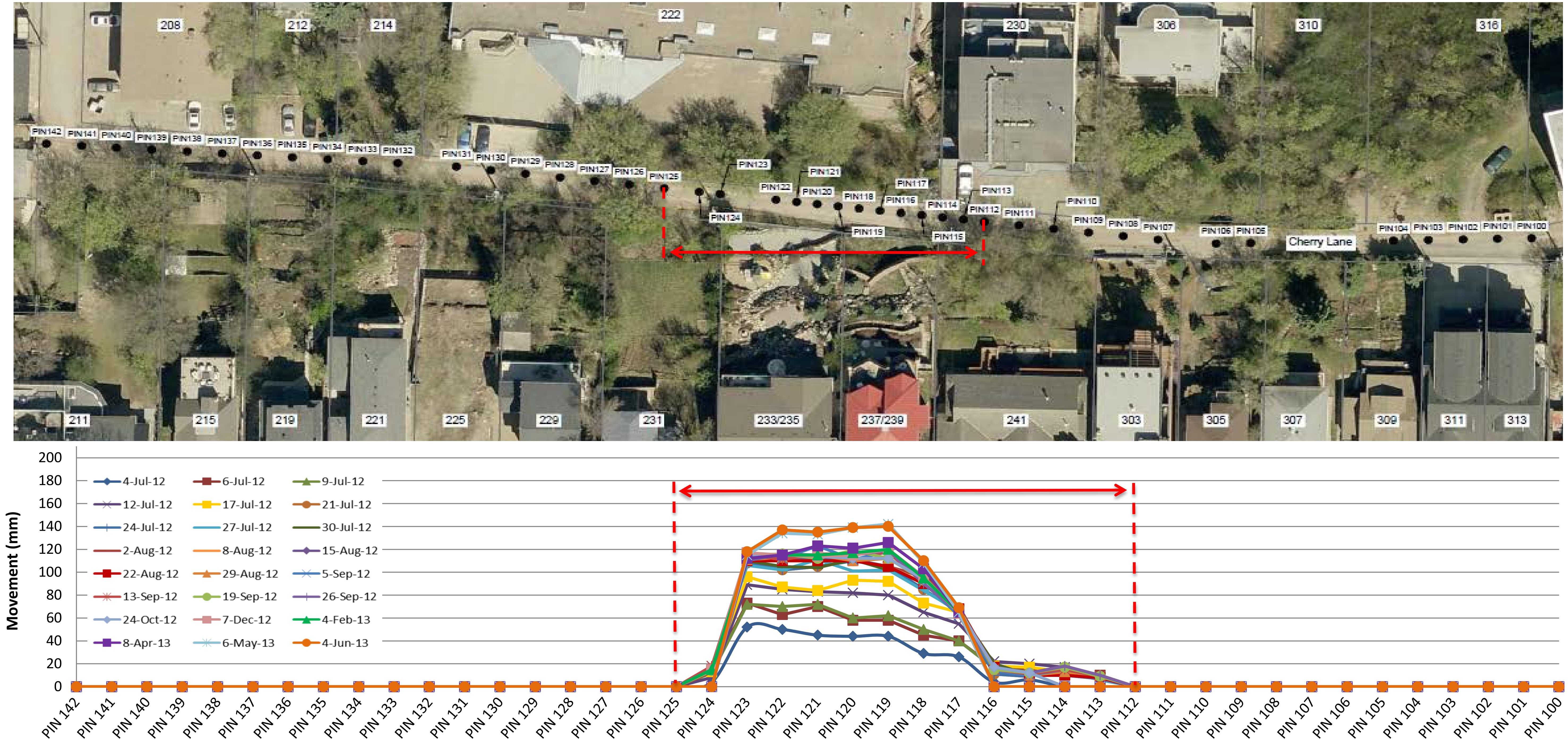
PROJECT		11-1362-0057
DESIGN		
CADD	JDS	02/05/14
CHECK		
REVIEW		

FILE No.

SCALE AS SHOWN REV.

FIGURE: 19

G:\2011\1362\11-1362-0057 COS East Riverbank\Figures\Phase 5100 Cherry Lane Remediation\Task 7000\11-1362-0057 Monitoring Pin Vectors.dwg 5/2/2014 2:38 PM



Notes:

1) Positive values indicate down slope movement.

2) Pins 100 to 142 were installed June 28, 2012.

PROJECT

City of Saskatoon

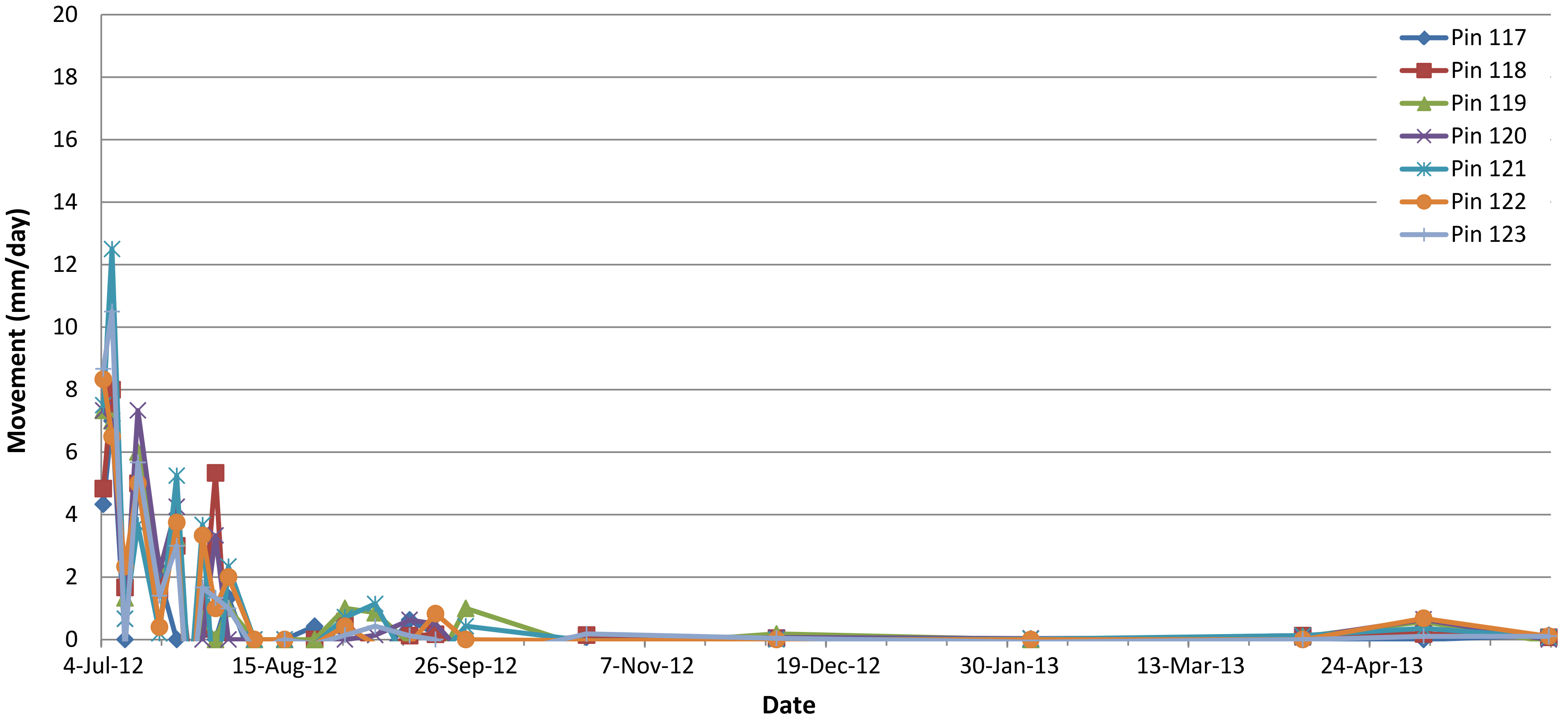
CHERRY LANE
SLOPE INSTABILITY

TITLE

HORIZONTAL SLOPE MOVEMENT,
100 SERIES PINS
(June 28, 2012 to June 4, 2013)

PROJECT	11-1362-0057		FILE No.
DESIGN	LNM	08/05/14	SCALE N/A REV.
CADD			
CHECK	HQV	08/05/14	**FIGURE: 20**
REVIEW	PGB	08/05/14	

Golder Associates
Saskatoon, Saskatchewan



Notes:

1) Positive values indicate down slope movement.

2) Pins 117 to 123 were installed June 28, 2012.

PROJECT

City of Saskatoon

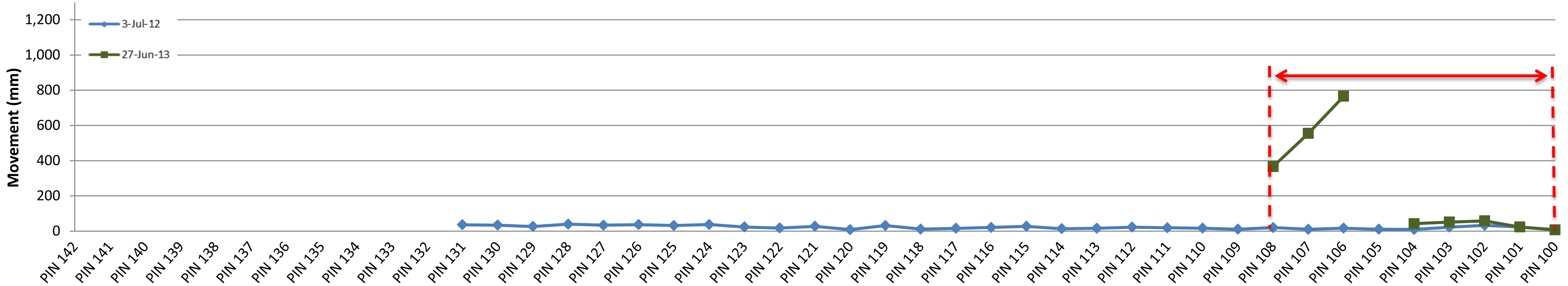
CHERRY LANE
SLOPE INSTABILITY

TITLE

RATE OF MOVEMENT vs TIME
FOR SELECTED 100 SERIES PINS

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LNM	08/05/14	SCALE N/A	REV.
CADD			**FIGURE: 21**	
CHECK	HQV	08/05/14		
REVIEW	PGB	08/05/14		



Notes:

1) Positive values indicate down slope movement.

2) Pins 100 to 142 were installed June 28, 2012.

PROJECT

City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

TITLE

HORIZONTAL SLOPE MOVEMENT,
100 SERIES PINS
(June 28, 2012 to June 27, 2013)

Golder Associates
Saskatoon, Saskatchewan

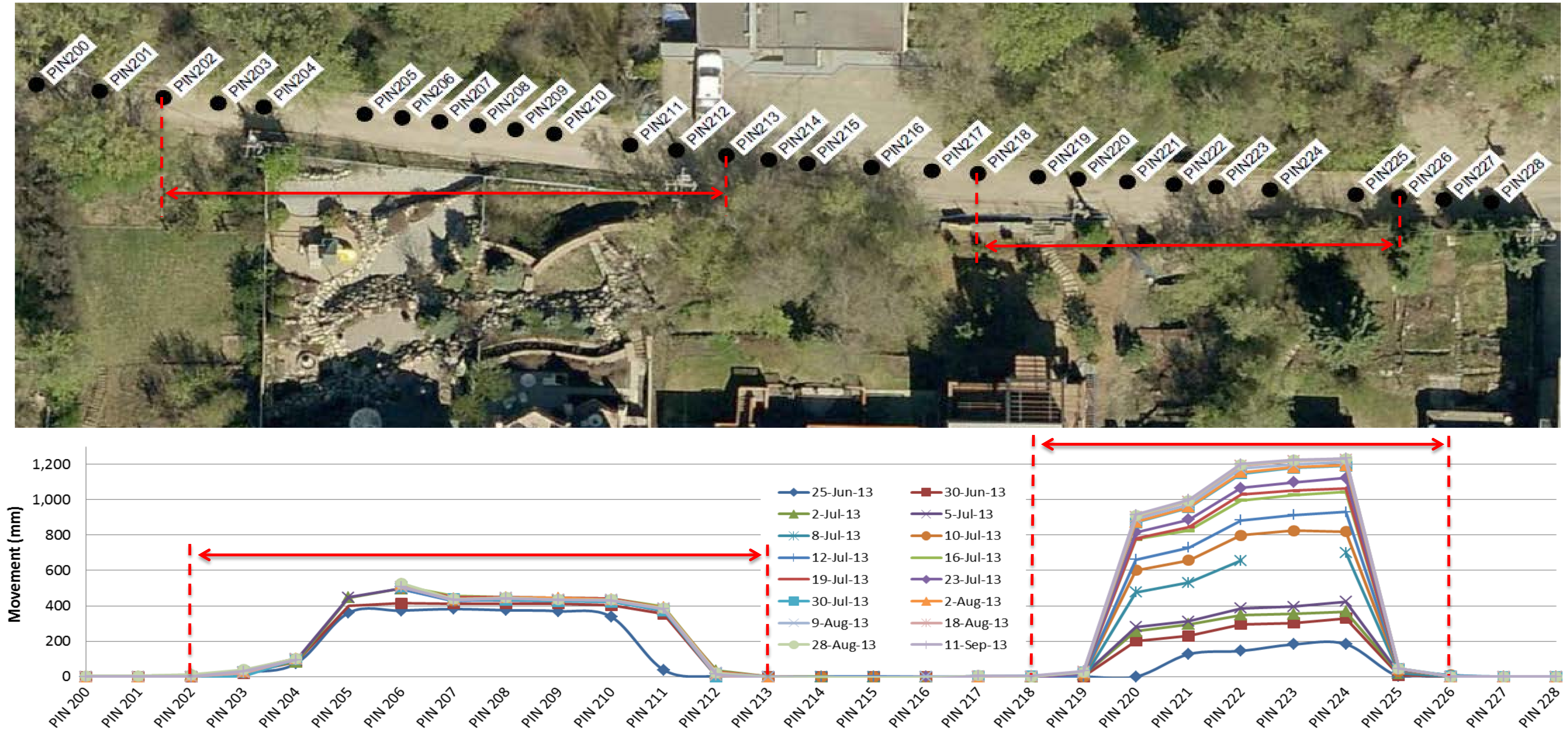
PROJECT	11-1362-0057		FILE No.	
DESIGN	LNM	08/05/14	SCALE N/A	REV.
CADD			**FIGURE: 22**	
CHECK	HQV	08/05/14		
REVIEW	PGB	08/05/14		

9.3.4 June 25, 2013 to September 11, 2013

The 100 series pins were replaced with Survey Pins 200 to 228 (Figure 10) to monitor horizontal slope movement along the Cherry Lane. This series of pins was surveyed from June 25 to September 11, 2013. Cumulative horizontal movements and rates of movement during this period are shown in Figure 23 and Figure 24, respectively. A summary of the ground movement monitoring for this series of survey pins is as follows:

- Monitoring results show that a 45 m section of Cherry Lane, from Pin 202 to Pin 213, was impacted within the West Failure area and a 35 m section of Cherry Lane, from Pin 218 to Pin 226, was impacted within the East Failure area.
- West Failure:
  - Rate of movement of approximately 1.8 mm/day was measured behind 233/235 and 237/239 - 11th Street East (Pin 205 to 210 locations) between June 4 and 25, 2013.
  - Rate of movement of approximately 63 mm/day was measured behind 237/239 - 11th Street East (Pin 211 location) between June 25 and 30, 2013; the rate of movement at this location decreased to approximately 13 mm/day, between June 30 and July 2, 2013.
  - Rate of movement of approximately 41 mm/day measured behind 233/235 - 11th Street East (Pin 206 location) between June 30 and July 2, 2013.
  - Movement between zero and 7.5 mm/day was measured within the West Failure area between July 2 and September 11, 2013; except for behind 233/235 - 11th Street East (Pin 207 location) where a rate of movement of 12.5 mm/day was measured between July 12 and 14, 2013.
- East Failure:
  - Rate of movement measured behind 303, 305, and 307 - 11th Street East (Pin 220 to 224 location) was approximately 50 mm/day to 75 mm/day between June 25 and 30, 2013; the rate of movement at this location decreased to approximately 8 mm/day to 33 mm/day between June 30 and July 5, 2013; rate of moment at this location then increased to approximately 13 mm/day to 92 mm/day between July 5 and 8, 2013.
  - Rate of moment behind 305 - 11th Street East (Pin 223) increased from approximately 13 mm/day, during the June 5 to 8, 2013 monitoring period, to 195 mm/day, during the June 8 to10, 2013 monitoring period.
  - Rate of movement generally decreased after July 10, 2013; movements between zero and 12 mm/day were measured after July 24, 2013.

The rate of movement for the 200 series of pins has been less than 5 mm since July 2013 at the West Failure and since August 2013 at the East Failure.



Notes:
1) Positive values indicate down slope movement.
2) Pins 200 to 216 were installed June 4, 2013.
3) Pins 217 to 228 were installed June 25, 2013.

PROJECT
City of Saskatoon
CHERRY LANE
SLOPE INSTABILITY

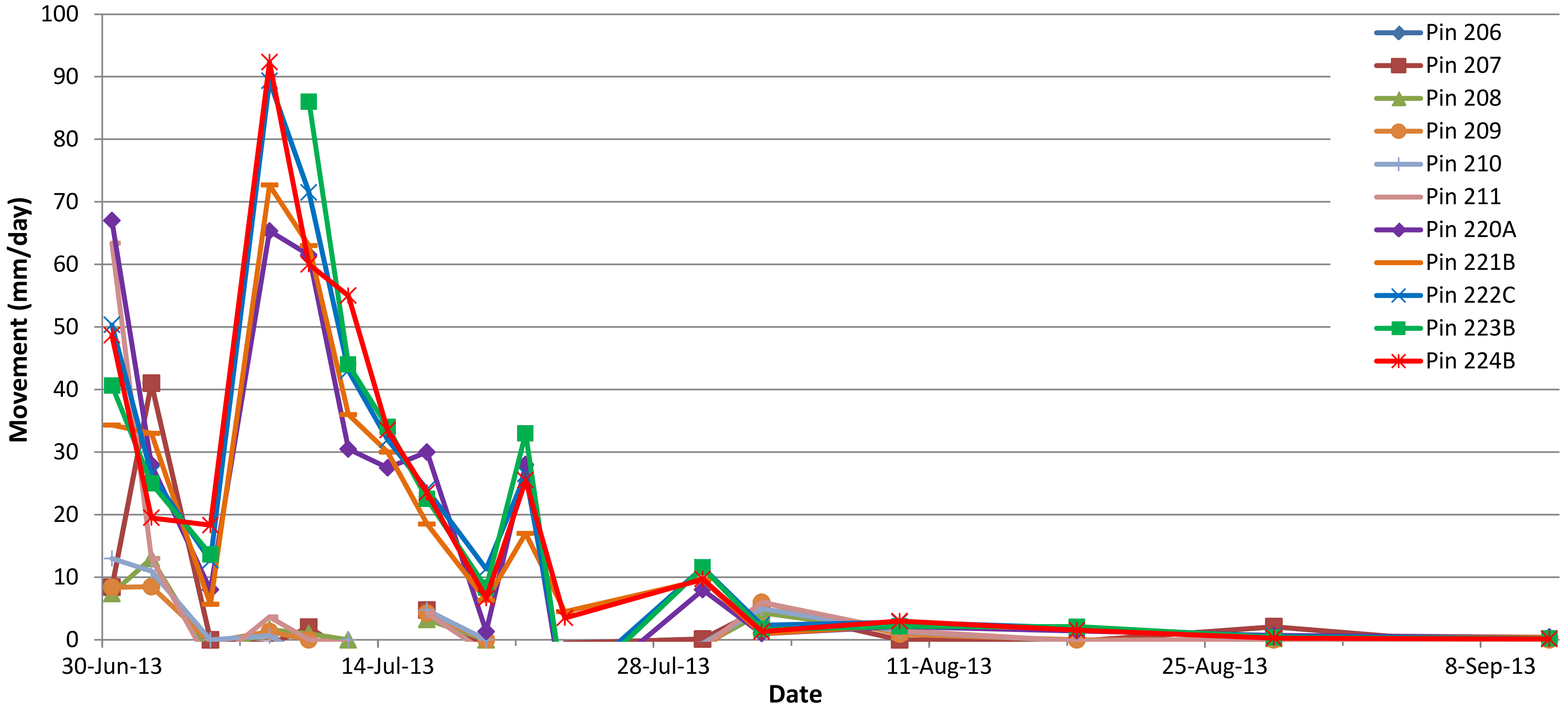
TITLE
HORIZONTAL SLOPE MOVEMENT, 200 SERIES PINS (June 25, 2013 to Sept. 11, 2013)

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057	
DESIGN	LNM	08/05/14
CADD		
CHECK	HQV	08/05/14
REVIEW	PGB	08/05/14

FILE No.
SCALE N/A REV.

FIGURE: 23



Notes:

1) Positive values indicate down slope movement.

2) Pins 206 to 211 were installed June 4, 2013.

PROJECT

City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

TITLE

RATE OF MOVEMENT vs TIME
FOR SELECTED 200 SERIES PINS

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LNM	08/05/14	SCALE N/A	REV.
CADD				
CHECK	HQV	08/05/14	**FIGURE: 24**	
REVIEW	PGB	08/05/14		

9.3.5 September 11, 2013 to October 31, 2013 (300 series pins)

More permanent survey markers, numbered 303 to 327 were installed on September 13, 2013 to monitor slope movement along Cherry Lane, and will continue to be monitored over time. Locations of these survey markers are shown in Figure 11. The 300 series pins were surveyed on September 16, September 25 and October 31, 2013. Less than 5 mm of movements, which are in a range of measurement accuracy, were measured between September 13 and October 31, 2013.

9.4 Monitoring of Structures

9.4.1 Tell-Tale Crack Monitors

Tell-tale cracks monitors were monitored approximately every 10 days from August 7 to October 30, 2013. No noticeable crack developments were noticed for this monitoring period. Photographs of the crack monitors are included in Appendix F.

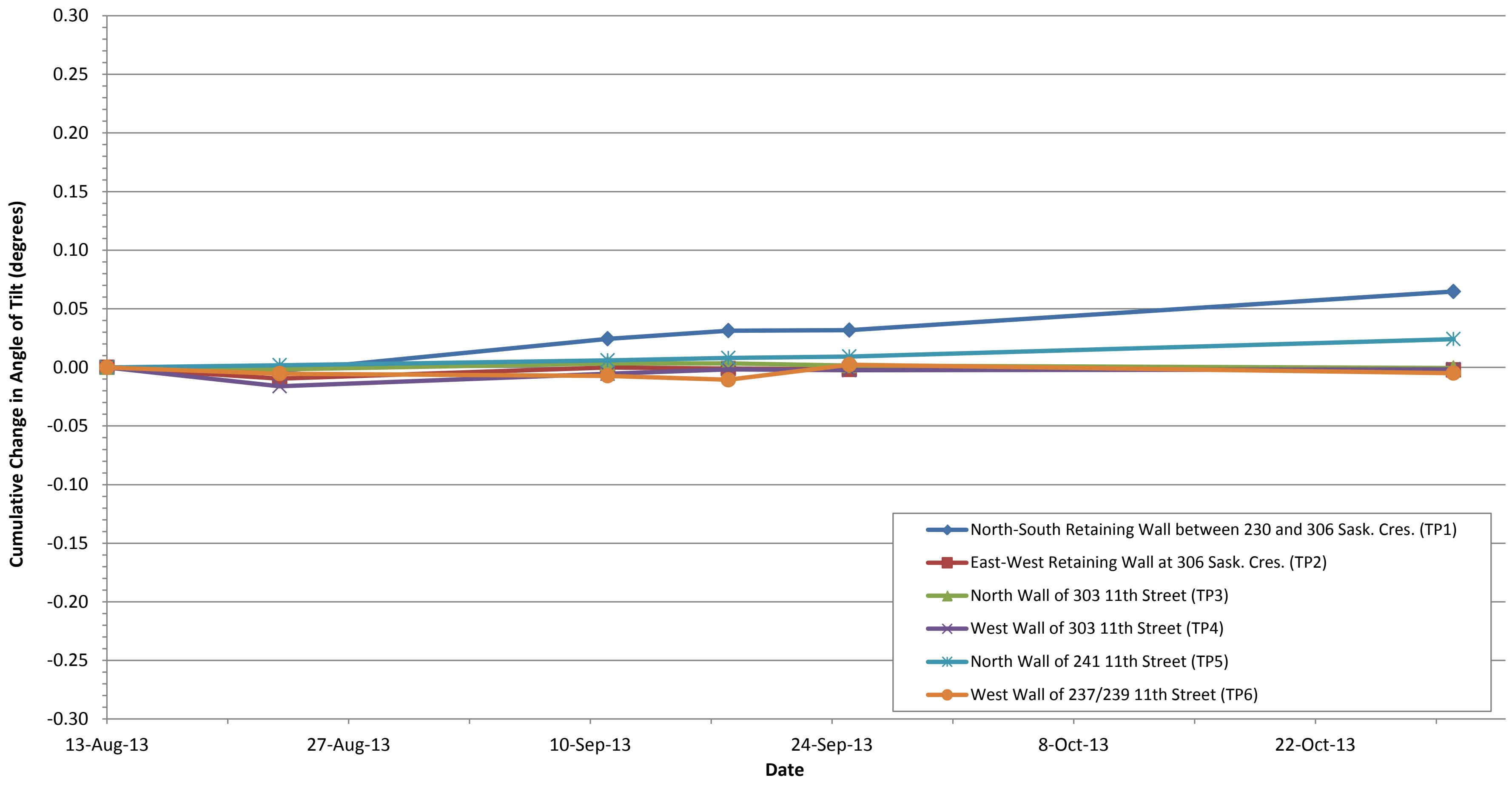
9.4.2 Tilt Plates

Tilt plates were monitored approximately every 10 days from August 13 to October 30, 2013. The results of tilt plate measurement are shown in Figure 25. During the monitoring period, a tilt of approximately 0.065 degrees towards the west direction was measured at the tilt plate located on the north-south retaining wall between 230 and 306 Saskatchewan Crescent East. The tilt plate located at 241 – 11th Street has measured a steady increase in tilt angle to 0.024 degrees; however total tilt is near the expected range of measurement accuracy and movement for this structure. Monitoring of the remaining tilt plates have measured variable results which were within the expected range of movement for most structures depending on time of day, weather and other factors.

A tilt plate was installed on the north side of the building at 1721 – 8th Street E. (Golder Associates Ltd.) to provide a check of the expected range of tilt of building due to climate and temperature changes. During the monitoring period, the angle of tilt at this location ranged from 0 to -0.009 degrees.

9.4.3 Settlement Points

Settlement Points were monitored on August 28 and 29, September 18, and November 28 and 29, 2013. The results of settlement monitoring from August 28 to November 29 are presented in Appendix F. The results of the settlement data analysis indicate that no noticeable differential settlement of the structures have been measured to date (November 2013).



Note: Positive changes in tilt indicate tilting toward the monitoring structure.

PROJECT
City of Saskatoon
CHERRY LANE
SLOPE INSTABILITY

TITLE
RESULTS OF TILT MONITORING

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LNM	08/05/14	SCALE N/A	REV.01
CADD			**FIGURE: 25**	
CHECK	PGB	08/05/14		
REVIEW	HQV	08/05/14		

10.0 SLOPE STABILITY ANALYSIS

10.1 General

Stability analyses of the Cherry Lane site were performed in order to identify failure mechanisms at the site and to evaluate conceptual remedial options.

The following information was used to model the riverbank slope at the Site:

- Ground surface topography was obtained from the topographic survey completed by Meridian in July 2013.
- Stratigraphy was inferred from review of available geotechnical reports and field investigations by Golder.
- Groundwater conditions were inferred from existing piezometric data.
- Geometry of the slip surface was inferred from observed landslide features, inclinometer data and site stratigraphy.
- Soil parameters used in this report were based on site specific laboratory test results, back-analysed values, or based on typical values reported in the literature.

10.2 Method of Analysis

The slope stability analysis was performed using the computer software SLOPE/W, marketed by Geo-Slope International Ltd. (2007). Two-dimensional analyses were conducted using the Morgenstern-Price limit equilibrium method.

10.3 Material Properties

Material properties for the slope stability analysis were selected based upon current and historical laboratory testing results for the Cherry Lane area and Saskatoon region. Table 10 shows the shear strength properties used for the slope stability analysis. Shear strength parameters for the shear zone are back-analyzed values. Effective cohesion value of 10 kiloPascals (kPa) was used for the silty clay, and clay materials to account for the contribution from soil suction to the unsaturated shear strength of these materials. Assumed material properties of fill or modified soils for several conceptual remediation options are also included, based on typical values.

Table 10: Shear Strength Parameters for the Preliminary Slope Stability Analysis

Material	Unit Weight (kN/m^3)	Effective Cohesion (kPa)	Effective Friction Angle (degrees)
Fill	19	5	22
Silty Clay	19	10	25
Clay	19	10	22
Shear Zone	19	0	12*
Till	impenetrable	-	-
Shear Zone Modification	20	0	30

*Back analysed value; kN/m^3 = kiloNewtons per cubic metre; kPa = kiloPascal

10.4 Uncertainty of Input Parameters

There is uncertainty in the input data (e.g., till/clay contact, soil properties and piezometric conditions) for the analysis. A sensitivity analysis, where the influence of variations in each input variable is isolated, can be conducted to evaluate the implications of uncertainty in the results. A probabilistic analysis can be used for assessing the reliability of the slope stability conditions. Sensitivity analysis and probabilistic analysis were not conducted at this stage of the study where a conceptual remediation is being developed. Further soil investigation and laboratory tests, sensitivity analysis and probabilistic analysis may be recommended for detailed design if one of the remediation options is to be constructed.

10.5 Recommended Factor of Safety

The stability condition of the slope is evaluated in terms of a calculated factor of safety, which is the ratio of the resisting forces/moments to the driving forces/moments. The factor of safety of a slope can be calculated in terms of all the forces and moments acting on the slope. Based on the limit equilibrium analysis, a computed factor of safety of 1.0 means the available resisting forces (e.g., the available shear strength of the soil along the sliding plane) have been mobilized and a condition of equilibrium exists and failure occurs. A computed factor of safety of greater than 1.0 means that the resisting forces are more than are required for a condition of limiting equilibrium and the slope is in a stable condition.

Determination of a minimum acceptable factor of safety (FS) for a slope stability model depends on several factors, including: i) the assumptions necessary to complete the analysis; ii) the reliability of the input data, particularly shear strength and pore-water pressure conditions; and iii) the consequence of failure. For the Cherry Lane area, potential changes in the slope geometry, additional structural loads and piezometric conditions can occur through unknown future development and landscaping work, therefore these potential unknown changes should be considered.

The consequence of failure (or risk) is an important factor to take into consideration when determining an acceptable factor of safety for design purposes. A lower factors of safety would be accepted on a slope where movement would result in little property damage or pose little hazard to public safety. A higher FS is typically required when risk to public safety and economic loss are involved.

Golder reviewed existing geotechnical reports for the site, the MVA policy (MVA 2004), and policies of other municipalities or government agencies that have high risk slope development. Existing geotechnical reports for the area specified a minimum FS of 1.3 to 1.5 depending on the site studied. In a slope instability study of the east riverbank conducted for MVA, Clifton (1985) recommended a desirable FS of 1.5 for slope improvement involving substantial risk of economic loss and some public safety considerations; and a minimum FS of 1.3 with monitoring was recommended. The MVA policy does not specify a minimum FS, with the caveat that any construction should not increase the instability of the slope, before or after construction.

As this Site poses a high risk to the people and structures on the 200 to 300 blocks of 11th Street East and Saskatchewan Crescent East, difficulties in maintaining a monitoring program in the residential properties, and uncertainty associated with future development, a FS of 1.5 is recommended for the design criteria for the Site under consideration.

10.6 Back-Analysis of Failure Slope

As the slope has already failed, a stability back-analysis can be conducted. The back-analysis method models the geometry, soil, and groundwater conditions at failure, indicated by a factor of safety (FS) of 1.0. Back-analysis is shown in Figure 26 for the West Failure and Figure 27 for the East Failure.

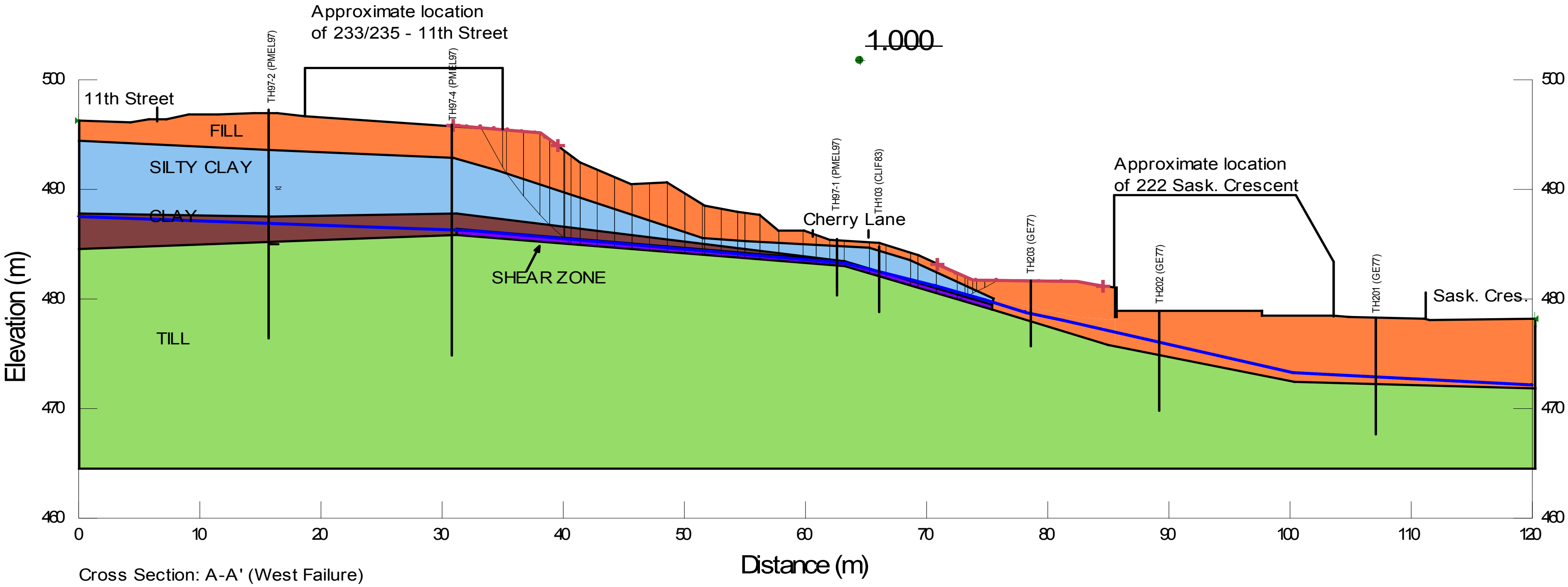
The condition modelled for back-analysis was for a time after the initial failure when the topography was surveyed, but when the slope was still actively moving. As such, groundwater levels shown in the model may be lower than those at the time of initial failure; but they are higher than those measured in the fall or winter months (Figure 17). Effective shear strength parameters of the clay at shear zone were expected to be near or at residual (i.e., having undergone movement).

Loading was not applied to any part of the slope within the stability analyses as it is understood that the houses within this area are founded on piles and therefore their associated vertical loads are distributed to a founding layer outside of the sliding mass. The retaining walls and large boulders present within the backyards of Lots 233/235 and 235/237 were modelled as soil within the stability analysis due to unknown geometries of these features. Retaining walls for the residences along Saskatchewan Crescent East were modelled as gravity walls and were based upon the geometry provided in the building permit plans. The slope stability analyses assume that the existing reinforced concrete wall and slab system of the basement structure of 222 Saskatchewan Crescent East (cross-section A-A’), and retaining wall behind 306 Saskatchewan Crescent East (cross-section B-B’) were impenetrable. To date, no noticeable movements were observed at these two structures. The resistance of these structures against landslide activity in the future is currently unknown.

The slip surface of the sliding soil mass is in surficial stratified deposits at the contact between the clay and the underlying till. Therefore, a composite slope failure along a slip surface at the interface between the clay and till was considered in the analyses.

Cross-sections A-A and B-B were selected as the primary section for analysis for the West Failure and East Failure, respectively. The location of the cross-sections is shown on Figure 2. Figure 12 and Figure 13 show the inferred stratigraphic soil profiles along each cross-section. Both the West Failure and East Failure were back-analysed to determine the residual (or large strain) shear strength parameters corresponding to failure or a FS of 1.0.

Name: Fill Unit Weight: 19 kN/m³ Cohesion: 5 kPa Phi: 22 °
Name: Silty Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 25 °
Name: Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 22 °
Name: Shear zone Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 12 °
Name: Till



Cross Section: A-A' (West Failure)
File Name: AA Back Analysis_v2.gsz

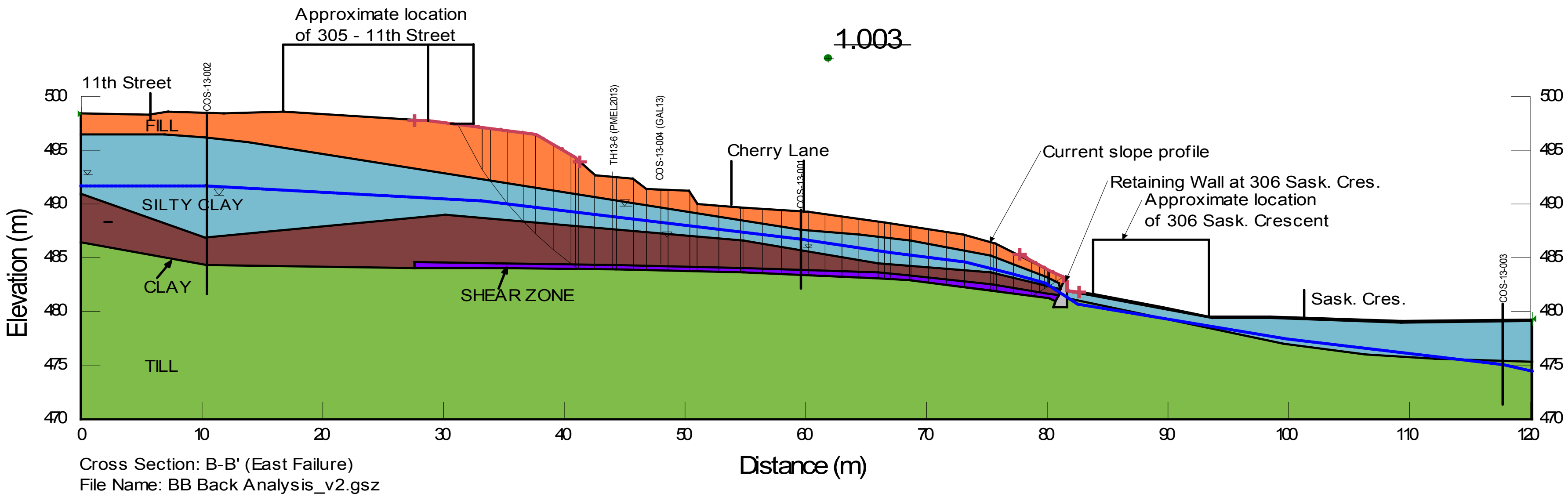
PROJECT
City of Saskatoon
**CHERRY LANE
SLOPE INSTABILITY**

TITLE
**BACK ANALYSIS - CROSS SECTION A-A'
WEST FAILURE**

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.		
DESIGN	LNM	08/05/14	SCALE	N/A	REV.
CADD			**FIGURE: 26**		
CHECK	HQV	08/05/14			
REVIEW	PGB	08/05/14			

Name: Fill Unit Weight: 19 kN/m³ Cohesion: 5 kPa Phi: 22 °
Name: Silty Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 25 °
Name: Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 22 °
Name: Shear zone Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 12 °
Name: Till
Name: Retaining wall



Cross Section: B-B' (East Failure)
File Name: BB Back Analysis_v2.gsz

PROJECT
City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

TITLE

BACK ANALYSIS - CROSS SECTION B-B'
EAST FAILURE

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.		
DESIGN	LNM	08/05/14	SCALE	N/A	REV.
CADD			**FIGURE: 27**		
CHECK	PGB	08/05/14			
REVIEW	HQV	08/05/14			

10.7 Conceptual Remedial Options

A number of conceptual remedial options were considered for the remediation of the slope, including:

- do nothing;
- installation of sub-drainage system to lower groundwater tables;
- re-grading of existing slope; and
- modification of the shear zone to increase shear strength.

It was understood that the primary focus of the slope remediation was to preserve existing residences along 11th Street East and Saskatchewan Crescent East, and maintain vehicle access along Cherry Lane. As discussed in Section 10.5, the required slope factor of safety for the conceptual remedial options was at least 1.5. Constructability and cost effectiveness were also considered in the process of evaluating conceptual remedial options.

Options evaluated are conceptual in nature, meaning specific design details such as detailed geometry, method of construction, sourcing and supply of materials, coordination of activities, etc. have not been considered.

Table 11 summarizes the calculated factor of safety (FS) for a number of conceptual remedial options, which is discussed in detail in the following sections.

Table 11: Calculated Factor of Safety for Remedial Options

Analysed Scenarios	Cross-section	Calculated FS	Figure
Back analysis	A-A’	1.00	26
	B-B’	1.00	27
Option 1: Do nothing, low groundwater table	A-A’	1.03	28
	B-B’	1.09	29
Option 1: Do nothing, high groundwater table	A-A’	0.89	30
	B-B’	0.87	31
Option 2: Installation of sub-drainage system	A-A’	1.03	32
	B-B’	1.26	33
Option 3: Site regrading with sub-drainage system	A-A’	1.51	34
	B-B’	1.50	35
Option 4: Shear zone modification with sub-drainage system	A-A’	1.51	37
	B-B’	1.51	38

FS = Factor of Safety

10.7.1 Option 1 – Do Nothing

The first remedial option considered was leaving the slope in its existing condition. Based on the slope stability analysis conducted, it is likely that the slope at the East and West Failure locations will continue to move, likely on a seasonal basis with higher rates of movement in the spring when groundwater levels in the area are high. Rates of movement are expected to be low in the winter months and in dry years where the groundwater table is at or near the contact surface between the glacial till and surficial stratified deposits. As noted in Sections 3.6 and 7.0, groundwater level fluctuations of up to 2 m during a year and up 6 m in the long term are measured.

Figure 28 and Figure 29 show the stability analyses for the do nothing option, with the piezometric levels approximately 1 m lower than those used on the back-analysis to represent slope instability conditions. The calculated factors of safety are 1.03 and 1.09 for cross-sections A-A' and B-B', respectively, for the case where nothing is done other than lowering the groundwater table.

Figure 30 and Figure 31 show the stability analyses for the do nothing option, with the piezometric level elevated approximately 1.5 m above those used in the back-analysis to represent slope instability. The calculated factor of safety is 0.89 for cross-section A-A' and 0.87 for cross-section B-B' when the raised groundwater level is used in the analysis. There is also a significant potential for additional sloughing of the material at the scarps of the failure areas, where there is up to 2 m of vertical drop. There is also a buildup of material at the toe and the slope has reached a flatter angle. Advancement of the failure toward 11th Street East will result in undermining of existing building foundations. Additionally, properties located below 11th Street East may experience damage from debris or additional soil loading as material collects at the toe of the sliding zone. It is expected that there will continue to be slope movement along Cherry Lane as the slope failure progresses, disrupting traffic access and power service along the lane.

10.7.2 Option 2 – Installation of Sub-Drainage System

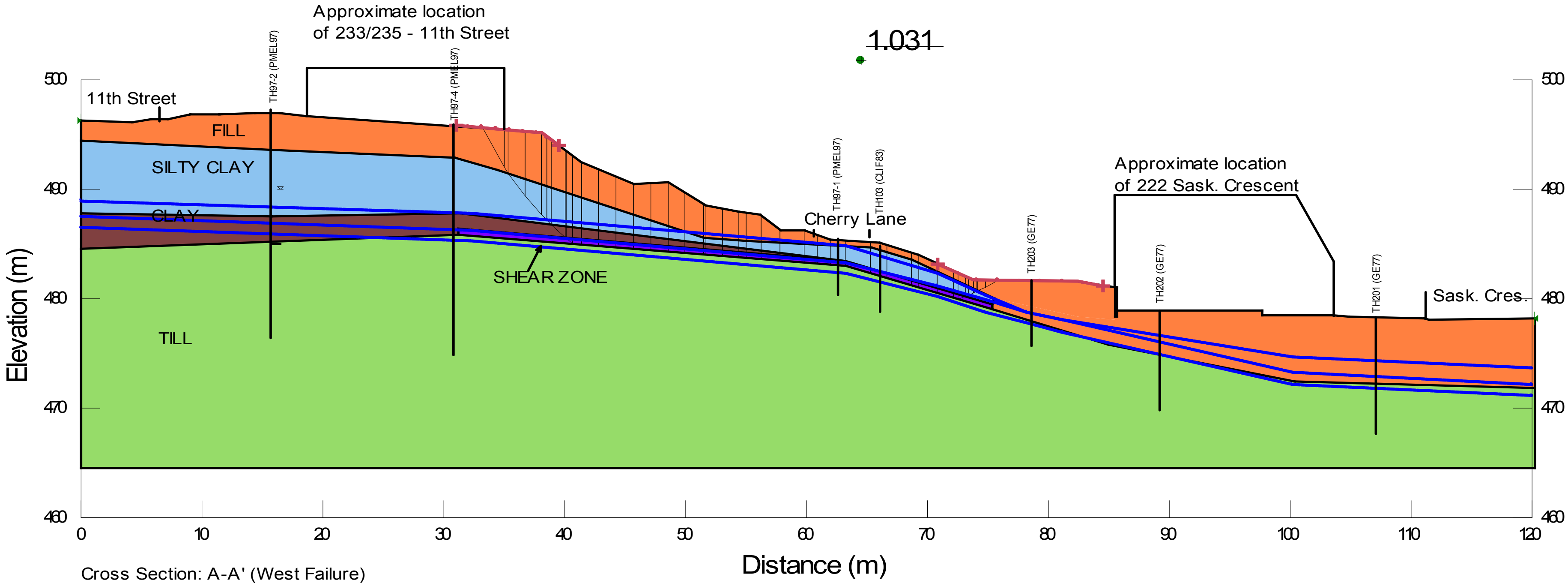
Pore-water pressures in surficial stratified deposits, especially in the highly plastic clay overlying the till, have significant influence on slope stability as indicated by the occurrence of the East and West Failures when groundwater levels were above average in both 2012 and 2013. Installation of sub-drainage system to lower groundwater levels and maintain it at low levels will result in an increase in the factor of safety of the slope and minimize the effect of seasonal and long term groundwater level variation.

Drainage systems installed in 11th Street East can be used to intercept groundwater prior to entering the slope, however the drains will not account for pore-water pressures that are generated from surface infiltration downslope of 11th Street East. A second or alternate drainage system could be installed along Cherry Lane to reduce the pore-water pressures near the middle of the slope. Drainage systems will have to be designed to reduce pore-water pressures over the entire area of potential slope instability to prevent mounding and increased instability between individual locations. Drainage systems would require regular maintenance to ensure that blockages do not occur, and to ensure that the system is effectively draining the slope.

For the slope stability analysis, groundwater conditions where drainage systems were installed along 11th Street East approximately 10 mbgs and along Cherry Lane between 3 mbgs and 8 mbgs were considered. Installation of drainage systems in both locations for the existing slope will be more effective than a single drainage system. For the West Failure (cross-section A-A'), the post-failure pore-water conditions along 11th Street East were already near the clay and till interface, resulting in marginal increase to FS when the level was lowered, however lowering the pore-water pressures along the East Failure (cross-section B-B') resulted in an approximate 20% increase in FS. It should be noted that this increase in slope FOS will not be achieved immediately after the sub-drainage system construction because pore-water pressure in clay slope may take several years to dissipate.

Figure 32 and Figure 33 show the stability analyses for this conceptual remedial option for the West Failure and East Failure, respectively. Installation of a drainage system in 11th Street East will require a minimum length of 135 m and a depth ranging between 8.6 m and 12.5 m. Installation of a drainage system in Cherry Lane will require a length of 135 m at a depth between 3.6 m and 8 m. Detailed design will refine the overall dimensions of this option.

Name: Fill Unit Weight: 19 kN/m³ Cohesion: 5 kPa Phi: 22 °
Name: Silty Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 25 °
Name: Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 22 °
Name: Shear zone Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 12 °
Name: Till



Cross Section: A-A' (West Failure)
File Name: AA Do Nothing Low WT_v2.gsz

PROJECT

City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

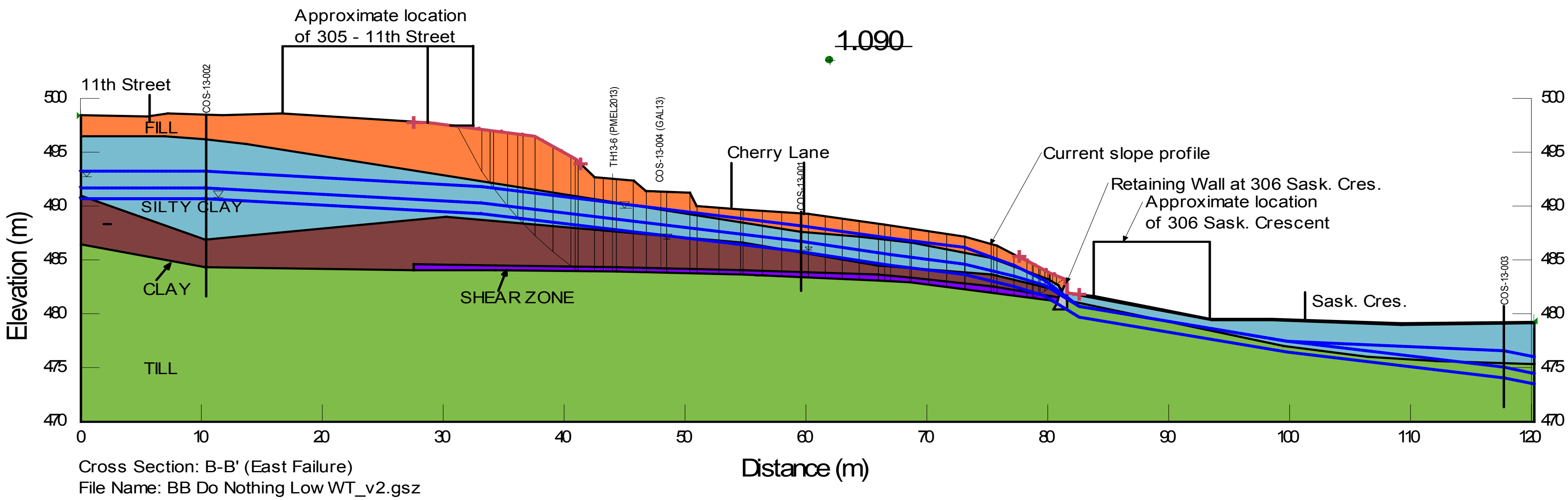
TITLE

SLOPE STABILITY ANALYSIS
CROSS SECTION A-A'
DO NOTHING OPTION WITH LOW WATER TABLE

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LNM	08/05/14	SCALE N/A	REV.
CADD				
CHECK	HQV	08/05/14	**FIGURE: 28**	
REVIEW	PGB	08/05/14		

Name: Fill Unit Weight: 19 kN/m³ Cohesion: 5 kPa Phi: 22 °
Name: Silty Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 25 °
Name: Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 22 °
Name: Shear zone Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 12 °
Name: Till
Name: Retaining wall



Cross Section: B-B' (East Failure)
File Name: BB Do Nothing Low WT_v2.gsz

PROJECT

City of Saskatoon

CHERRY LANE SLOPE INSTABILITY

TITLE

SLOPE STABILITY ANALYSIS
CROSS SECTION B-B'
DO NOTHING OPTION WITH LOW WATER TABLE

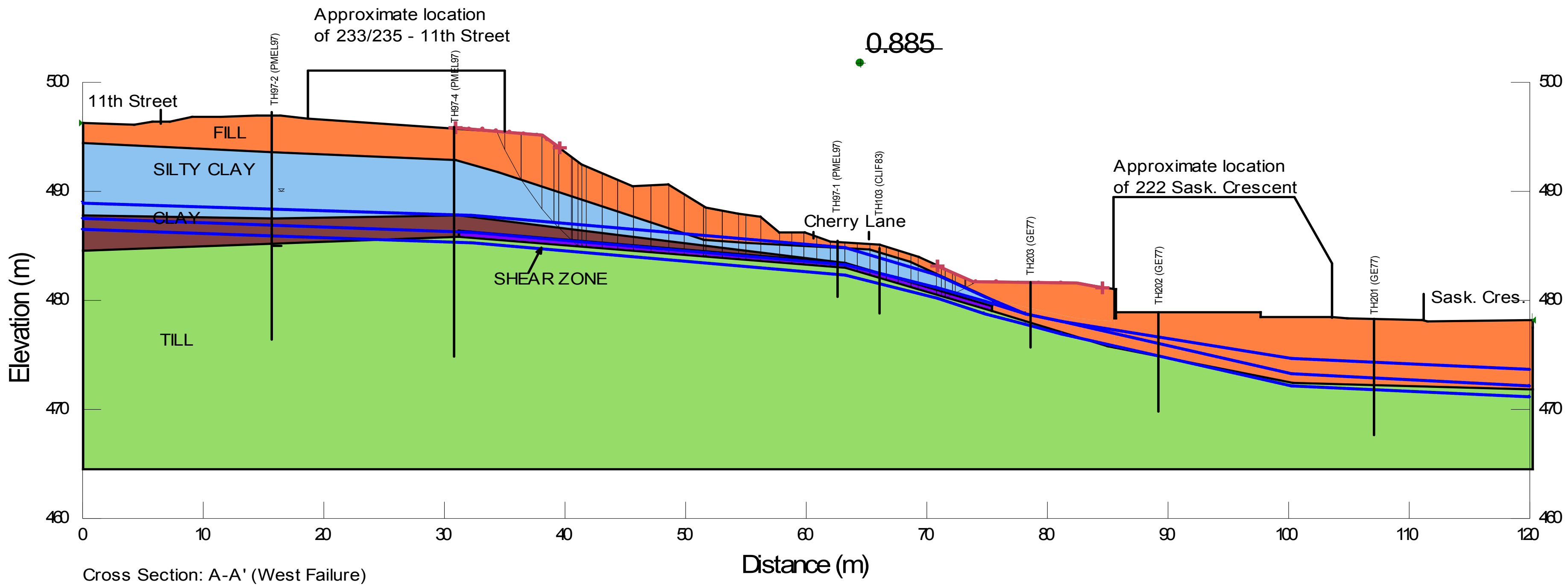
Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057	
DESIGN	LNM	08/05/14
CADD		
CHECK	PGB	08/05/14
REVIEW	HQV	08/05/14

FILE No.
SCALE N/A REV.

FIGURE: 29

Name: Fill Unit Weight: 19 kN/m³ Cohesion: 5 kPa Phi: 22 °
Name: Silty Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 25 °
Name: Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 22 °
Name: Shear zone Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 12 °
Name: Till



Cross Section: A-A' (West Failure)
File Name: AA Do Nothing HighWT_v2.gsz

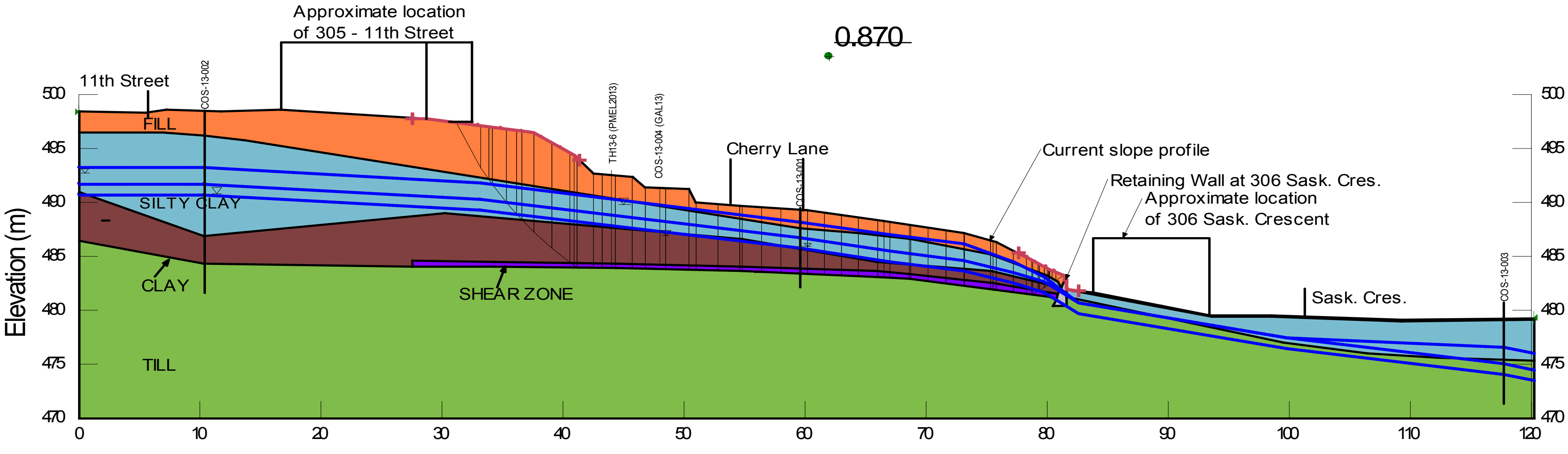
PROJECT
CHERRY LANE
SLOPE INSTABILITY

TITLE
SLOPE STABILITY ANALYSIS
CROSS SECTION A-A'
DO NOTHING OPTION WITH HIGH WATER TABLE

Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LNM	08/05/14	SCALE N/A	REV.
CADD				
CHECK	HQV	08/05/14	**FIGURE: 30**	
REVIEW	PGB	08/05/14		

Name: Fill Unit Weight: 19 kN/m³ Cohesion: 5 kPa Phi: 22 °
Name: Silty Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 25 °
Name: Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 22 °
Name: Shear zone Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 12 °
Name: Till
Name: Retaining wall



Cross Section: B-B' (East Failure)
File Name: BB Do Nothing HighWT_v2.gsz

PROJECT

City of Saskatoon

**CHERRY LANE
SLOPE INSTABILITY**

TITLE

**SLOPE STABILITY ANALYSIS
CROSS SECTION B-B'
DO NOTHING OPTION WITH HIGH WATER TABLE**

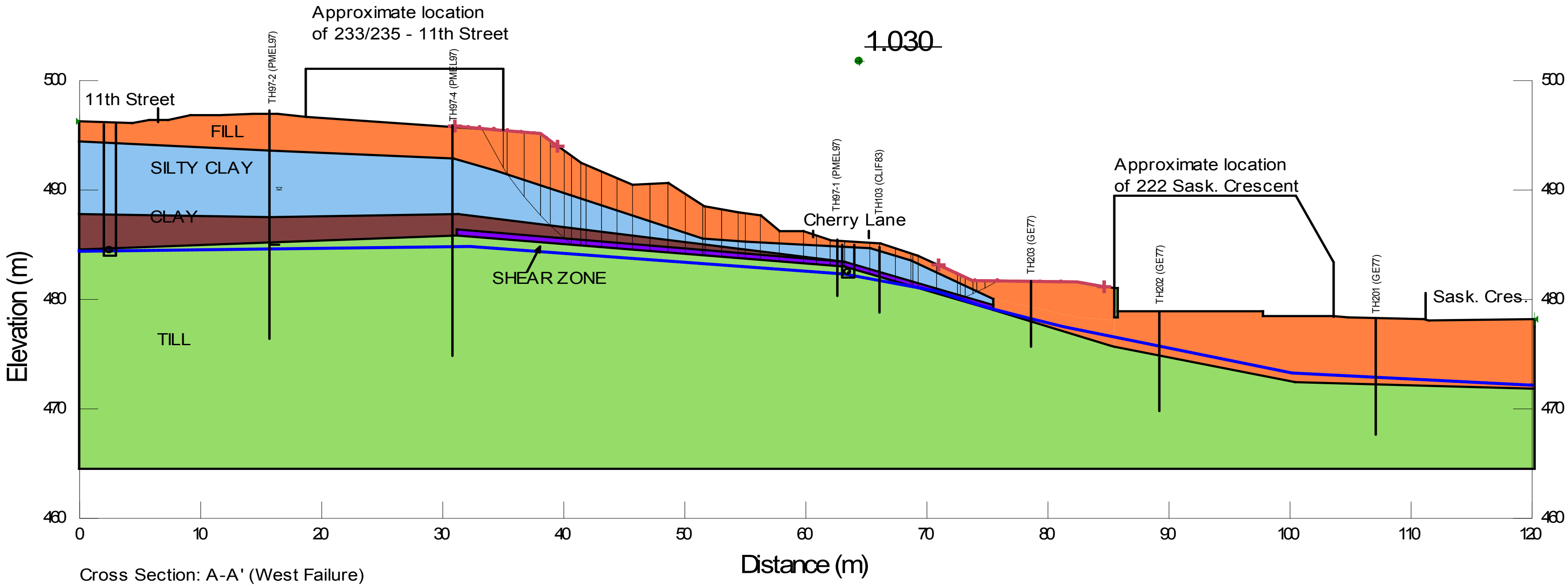
Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057	
DESIGN	LNM	08/05/14
CADD		
CHECK	PGB	08/05/14
REVIEW	HQV	08/05/14

FILE No.
SCALE N/A REV.

FIGURE: 31

Name: Fill Unit Weight: 19 kN/m³ Cohesion: 5 kPa Phi: 22 °
Name: Silty Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 25 °
Name: Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 22 °
Name: Shear zone Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 12 °
Name: Till



Cross Section: A-A' (West Failure)
File Name: AA SubDrainage System_v2.gsz

PROJECT

City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

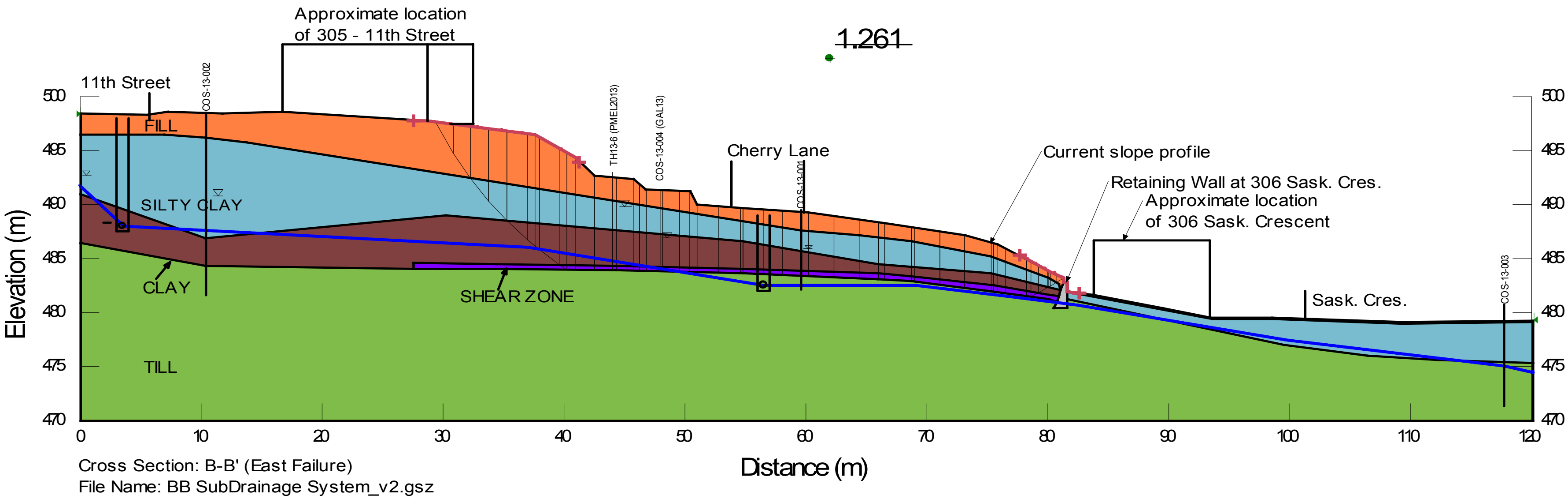
TITLE

SLOPE STABILITY ANALYSIS
CROSS SECTION A-A'
DRAINGAGE OPTION

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LNM	08/05/14	SCALE N/A	REV.
CADD				
CHECK	HQV	08/05/14	**FIGURE: 32**	
REVIEW	PGB	08/05/14		

Name: Fill Unit Weight: 19 kN/m³ Cohesion: 5 kPa Phi: 22 °
Name: Silty Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 25 °
Name: Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 22 °
Name: Shear zone Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 12 °
Name: Till
Name: Retaining wall



Cross Section: B-B' (East Failure)
File Name: BB SubDrainage System_v2.gsz

PROJECT

City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

TITLE

SLOPE STABILITY ANALYSIS
CROSS SECTION B-B'
DRAINAGE OPTION

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057	
DESIGN	LNM	08/05/14
CADD		
CHECK	PGB	08/05/14
REVIEW	HQV	08/05/14

FILE No.
SCALE N/A REV.

FIGURE: 33

Installation of a sub-drainage system would require disturbance to roadways (11th Street East and Cherry Lane) and underground utilities in the area, but would result in only localized disturbance to the residences in this area and pose little additional risk for slope instability during construction. Construction of the drainage outlet would require connection to the sewer system or construction of a new drainage outlet downslope.

10.7.3 Option 3 – Site Re-grading

Site re-grading (e.g., slope flattening) reduces material weight at the top of the slope and, in some cases, increases weight at the toe of the slope; therefore improves the slope stability condition.

Review of the upper slope topography shows that the current slope has an average slope of 2.5H:1V along cross-section A-A’ (West Failure), and 1.9H:1V along cross-section B-B’ (East Failure).

Slope stability analyses for cross-section A-A’ and B-B’ were conducted to determine the required level of slope flattening (conceptual slope geometry) of the site to obtain a minimum FS = 1.5, as shown in Table 12. It is assumed that installation of a drainage system along Cherry Lane will be required in conjunction with the slope re-grading in order to maintain pore-water pressures at or below the till contact.

Table 12: Average Slope Gradient for Conceptual Option 3 – Re-grading

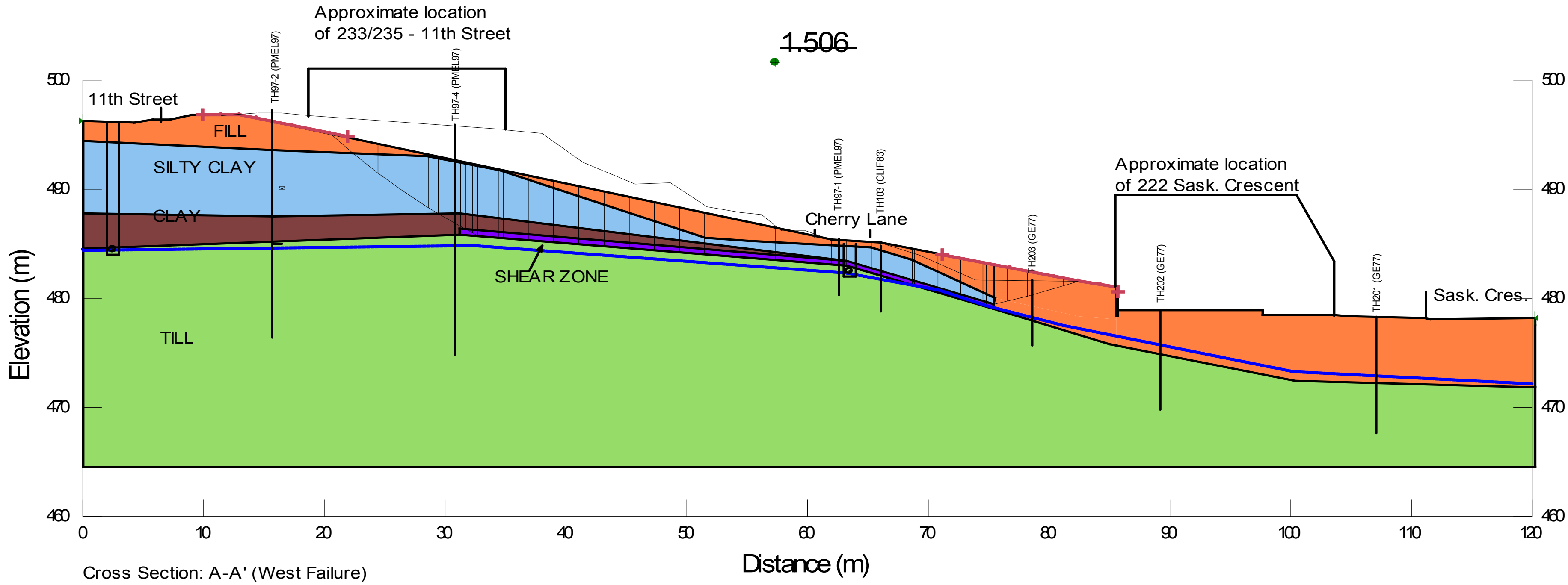
Cross Section	Average Slope Gradient	
	Upper Slope	Lower Slope
West Failure	4.4H:1V	4.8H:1V
East Failure	3.9H:1V	2.5H:1V

Figure 34 and Figure 35 show the stability analyses for this conceptual remedial slope flattening option. Figure 36 shows the plan view of the estimated extents of slope re-grading required to re-establish the slope to a minimum FS = 1.5. The approximate dimension of the conceptual slope re-grading is an area approximately 135 m long by 17 m to 67 m wide. Detailed design will refine the overall dimensions of this option.

Implementation of this option will cause significant disruption to residences along 11th Street East and Saskatchewan Crescent East, as well as the above ground power lines and landscaping in the area. Site access will be limited and large volumes of fill and debris will need to be hauled from site. Access to 11th Street East and Cherry Lane will be restricted during construction, but should not be affected in the long term.

Installation of a drainage system will be required along 11th Street East and Cherry Lane in order to maintain long term stability of the slope with this option.

Name: Fill Unit Weight: 19 kN/m³ Cohesion: 5 kPa Phi: 22 °
Name: Silty Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 25 °
Name: Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 22 °
Name: Shear zone Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 12 °
Name: Till



Cross Section: A-A' (West Failure)
File Name: AA Regrading_v2.gsz

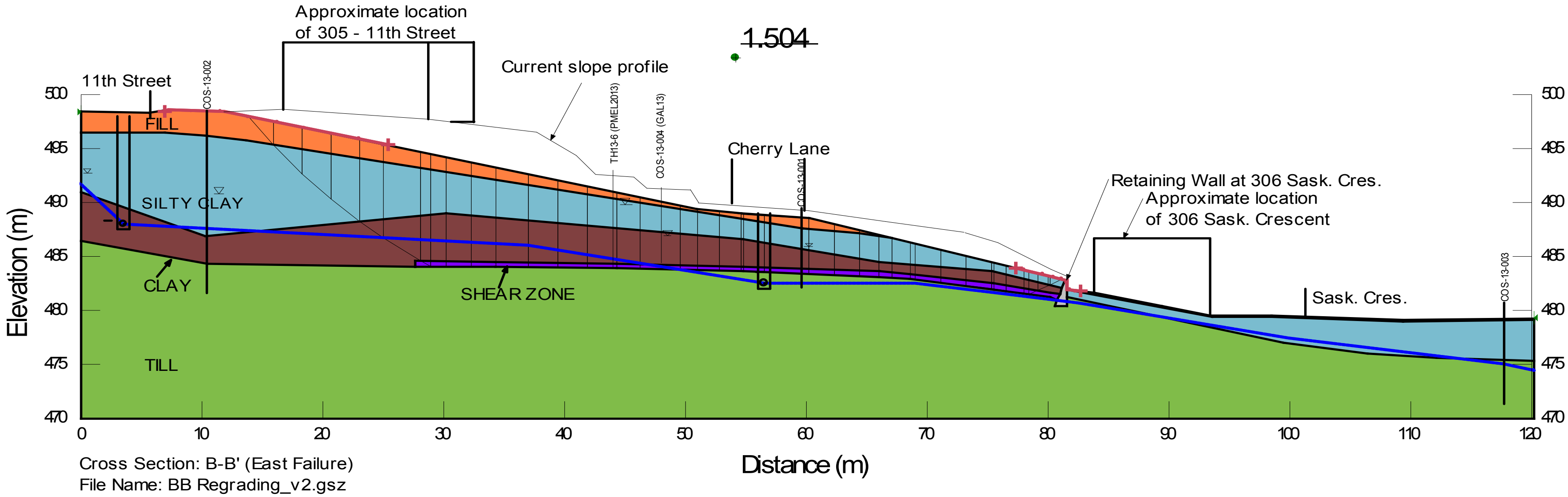
PROJECT
City of Saskatoon
CHERRY LANE SLOPE INSTABILITY

TITLE
SLOPE STABILITY ANALYSIS
CROSS SECTION A-A'
SITE REGRADING OPTION

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LNM	08/05/14	SCALE N/A	REV.
CADD				
CHECK	HQV	08/05/14	**FIGURE: 34**	
REVIEW	PGB	08/05/14		

Name: Fill   Unit Weight: 19 kN/m³   Cohesion: 5 kPa   Phi: 22 °
Name: Silty Clay   Unit Weight: 19 kN/m³   Cohesion: 10 kPa   Phi: 25 °
Name: Clay   Unit Weight: 19 kN/m³   Cohesion: 10 kPa   Phi: 22 °
Name: Shear zone   Unit Weight: 19 kN/m³   Cohesion: 0 kPa   Phi: 12 °
Name: Till
Name: Retaining wall



Cross Section: B-B' (East Failure)
File Name: BB Regrading_v2.gsz

PROJECT

City of Saskatoon

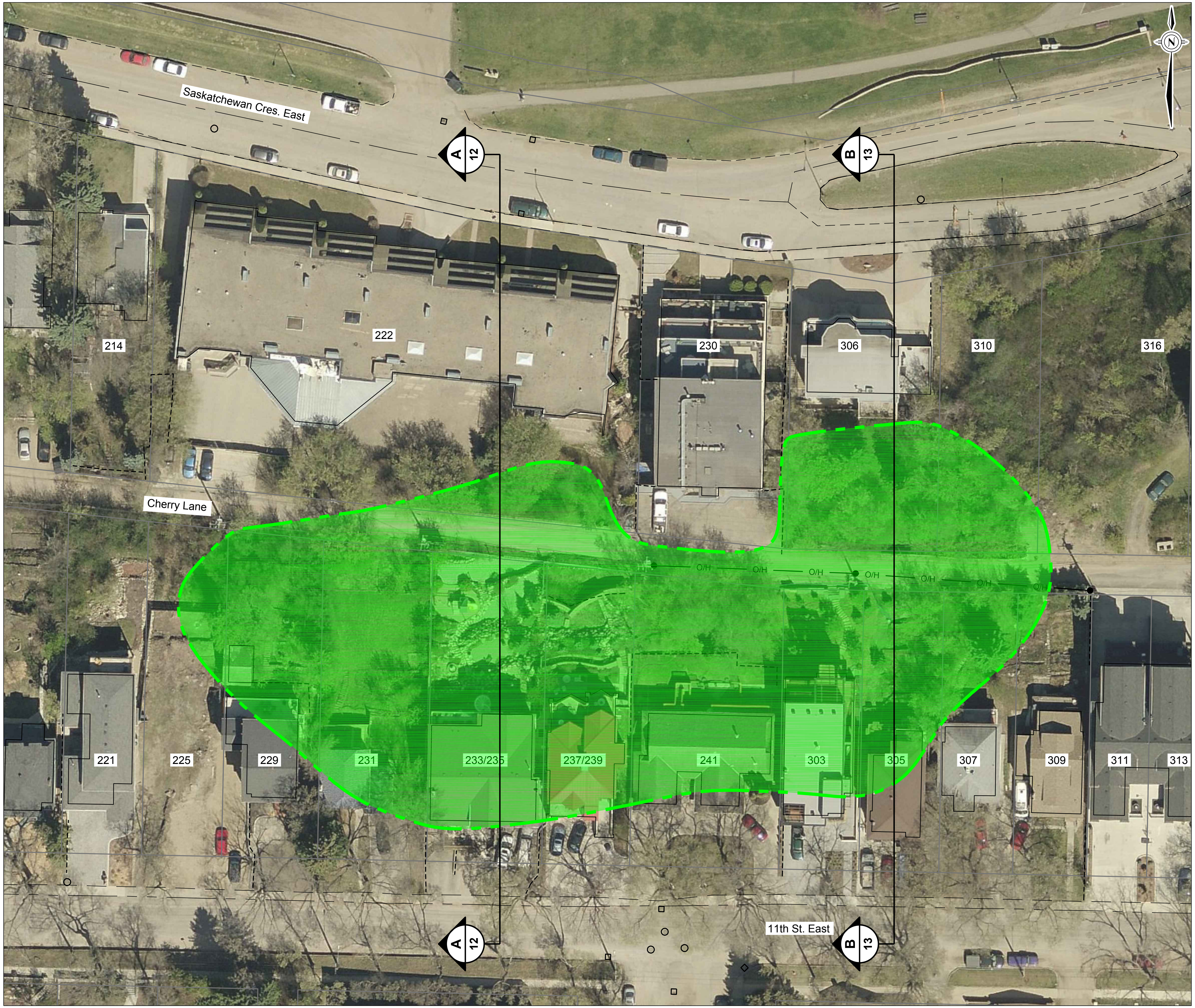
CHERRY LANE
SLOPE INSTABILITY

TITLE

SLOPE STABILITY ANALYSIS
CROSS SECTION B-B'
SITE REGRADING OPTION

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LNM	08/05/14	SCALE N/A	REV.
CADD			**FIGURE: 35**	
CHECK	PGB	08/05/14		
REVIEW	HQV	08/05/14		



LEGEND

- ● POWER POLE
- ◻ CATCH BASIN
- ○ MANHOLE
- — O/H — OVERHEAD POWER LINE
- 303 LOT NUMBER

REFERENCE

AERIAL PHOTOGRAPH PROVIDED BY CITY OF SASKATOON, MAY 15, 2011
CITY OF SASKATOON DATUM

10 0 10
SCALE 1:600 METRES

PROJECT

City of Saskatoon

CHERRY LANE
SLOPE INSTABILITY

TITLE

CONCEPTUAL AREA AFFECTED BY SITE RE-GRADING

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1326-0057	
DESIGN	LM	08/05/14
CADD	BDS/JDS	08/05/14
CHECK	HV	08/05/14
REVIEW	PGB	08/05/14

FILE No.

SCALE AS SHOWN REV. 0

FIGURE: 36

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10.7.4 Option 4 – Shear Zone Modification

Shear zone modification, such as the installation of shear key, stone column, concrete or steel piles, or using a cutter soil mixing (CSM) method, can be undertaken to improve the shear strength of the shear zone, thus improving slope stability conditions.

Slope stability analyses were conducted to evaluate the extent of the shear zone modification required to obtain a minimum FS = 1.5, as shown in Table 13. A material with an equivalent 30 degree effective friction angle and zero cohesion was assumed for the modified shear zone area. It is assumed that a dewatering system has been installed upslope of the shear zone modification in order to maintain the pore-water pressures at or below the till contact.

Table 13: Shear Zone Modification Dimensions for Conceptual Option 4

Cross Section	Shear Zone Dimensions		Comments
	Width (m)	Depth (mbgs)	
West Failure	13	7	Modification in Cherry Lane extending up and down slope
East Failure	4	7	Modification in Cherry Lane

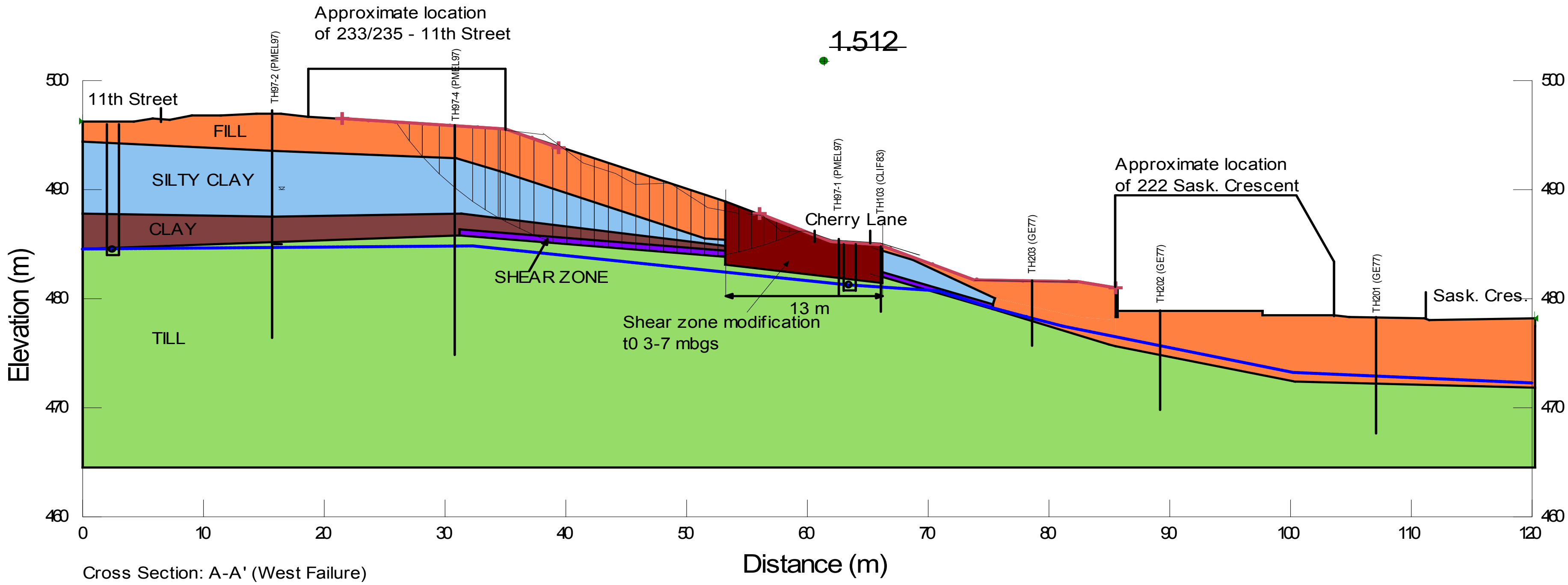
m = metre; mbgs = metres below ground surface

Figure 37 and Figure 38 show the stability analyses for this conceptual remedial option. Figure 39 shows the plan view of the estimated extent of shear zone modification required along Cherry Lane to achieve a minimum FS = 1.5. The approximate extent of the conceptual shear zone modification area is approximately 120 m long and 4 to 13 m wide. Detailed design will refine the overall dimensions of this option.

Implementation of this option will cause significant disruption to access and services along Cherry Lane, as well as the backyards of the residences along 11th Street East. Due to the unstable nature of this slope, the use of an open excavation method would not be acceptable. Construction methods where limited excavation is necessary would be required, such as stone columns, *in situ* cutter soil mixing, etc. Site access will be limited and large volumes of fill and debris will need to be hauled from site. Access to Cherry Lane will be restricted during construction.

Installation of a drainage system will be required along 11th Street East and Cherry Lane in order to maintain long term stability of the slope with this option.

Name: Fill Unit Weight: 19 kN/m³ Cohesion: 5 kPa Phi: 22 °
Name: Silty Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 25 °
Name: Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 22 °
Name: Shear zone Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 12 °
Name: Till
Name: Shear zone modification Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 °



Cross Section: A-A' (West Failure)
File Name: AA Shear Zone Modification_v2.gsz

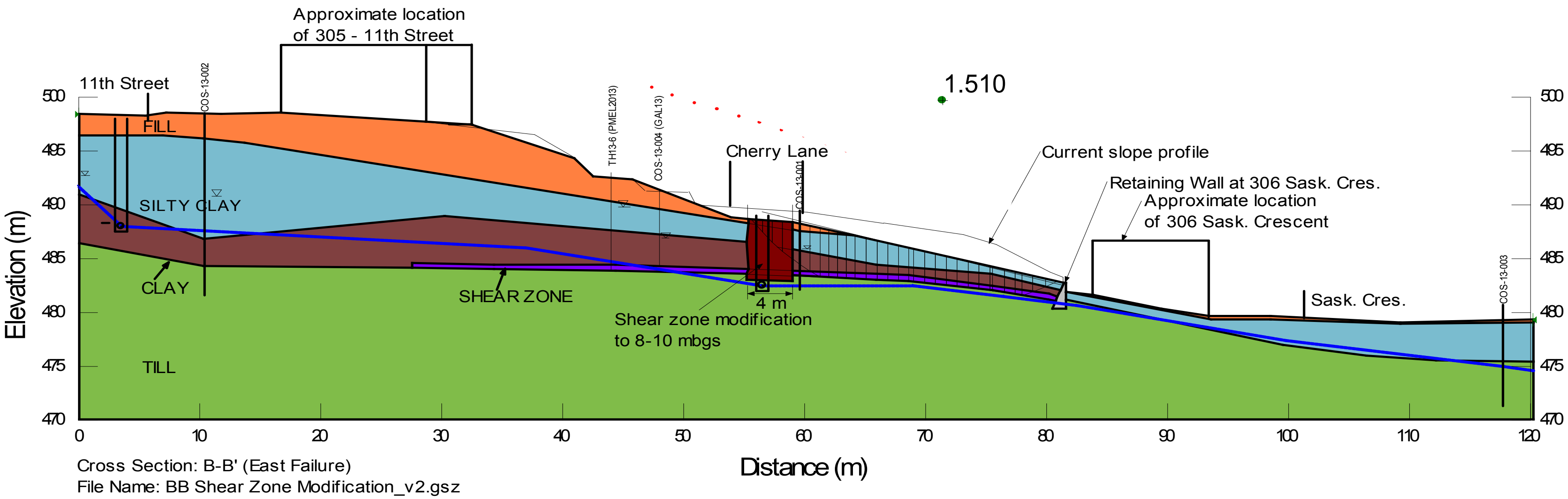
PROJECT
City of Saskatoon
CHERRY LANE SLOPE INSTABILITY

TITLE
SLOPE STABILITY ANALYSIS
CROSS SECTION A-A'
SHEAR ZONE MODIFICATION OPTION

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LNM	08/05/14	SCALE N/A	REV.
CADD			**FIGURE: 37**	
CHECK	HQV	08/05/14		
REVIEW	PGB	08/05/14		

Name: Fill Unit Weight: 19 kN/m³ Cohesion: 5 kPa Phi: 22 °
Name: Silty Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 25 °
Name: Clay Unit Weight: 19 kN/m³ Cohesion: 10 kPa Phi: 22 °
Name: Shear zone Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 12 °
Name: Till
Name: Shear zone modification Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Retaining wall



Cross Section: B-B' (East Failure)
File Name: BB Shear Zone Modification_v2.gsz

PROJECT
City of Saskatoon
CHERRY LANE
SLOPE INSTABILITY

TITLE
SLOPE STABILITY ANALYSIS
CROSS SECTION B-B'
SHEAR ZONE MODIFICATION OPTION

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1362-0057		FILE No.	
DESIGN	LNM	08/05/14	SCALE N/A	REV.
CADD			**FIGURE: 38**	
CHECK	PGB	08/05/14		
REVIEW	HQV	08/05/14		

LEGEND

●	POWER POLE
□	CATCH BASIN
○	MANHOLE
— O/H —	OVERHEAD POWER LINE
303	LOT NUMBER

REFERENCE
AERIAL PHOTOGRAPH PROVIDED BY CITY OF SASKATOON, MAY 15, 2011
CITY OF SASKATOON DATUM

10 0 10
SCALE 1:600 METRES

PROJECT
City of Saskatoon
CHERRY LANE
SLOPE INSTABILITY

TITLE
CONCEPTUAL AREA AFFECTED BY SHEAR ZONE MODIFICATION

Golder Associates
Saskatoon, Saskatchewan

PROJECT	11-1326-0057		FILE No.	
DESIGN	LM	08/05/14	SCALE AS SHOWN	REV. 0
CADD	BDS/JDS	08/05/14	**FIGURE: 39**	
CHECK	HV	08/05/14		
REVIEW	PGB	08/05/14		

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11.0 SUMMARY

The slope failures along Cherry Lane are most likely the result of a combination of the natural geology of the soils along the riverbank, the heavy and prolonged precipitation in the spring of 2012 and 2013 that resulted in increased groundwater levels, and changes to the geometry and landscaping of the slope. As such, this section of the riverbank is at a high risk of continuing slope failure. Action should be taken to reduce the risk to the public, infrastructure, and property in the area.

Conceptual slope remediation options were developed for the Site. Table 14 provides a summary of cost estimates, risks, and benefits associated with each of the conceptual options.

The conceptual cost estimate, shown in Table 14, was prepared by comparing the conceptual remedial options to similar projects conducted in and around the City of Saskatoon and scaling the costs to suit the estimated size and scope of the remedial option. A contingency of 50% has been added to the estimated costs to account for variations that will be generated from a more detailed analysis of the conceptual options. Similar projects include: shear key construction at Cosmopolitan Park in 2011, lightweight fill placement at 17th Street and Saskatchewan Crescent in 2013; and typical rates for CSM construction provided by Golder Construction. Costs associated with contractor mobilization, engineering design and support, and construction monitoring have been included. A more detailed breakdown of the costs for the conceptual estimates is provided in Appendix H.

It is recommended that shear zone modification with the installation of a sub-drainage system be considered as a remedial option for the properties affected by the slope movement at the Site. While the conceptual cost of the shear zone modification with drainage option is higher than the other options considered, this option will result in the least permanent disturbance to the surrounding properties, depending on the specific method of shear zone modification selected, and will achieve the required factor of safety for the remedial slope. Additionally, depending on the method selected, the majority of the remedial work can be confined to the area surrounding Cherry Lane, increasing accessibility for construction.

Table 14: Risk/Benefit Summary of Conceptual Remediation Options

Conceptual Remediation Option	Estimated Cost (a)	Benefit/Advantage	Risk/Disadvantage
Option 1 – Do nothing	<$500,000	■ Low cost	■ High risk of continued failure, additional sloughing of the material at the scarps of the failure areas, and for buildup of material at the toe until the slope has reached a flatter angle. ■ Failure likely to retrogress toward 11th Street East may affect building foundations along 11th Street East, and may cause movement of the structures. ■ Properties located below 11th Street East may experience damage from debris or additional soil loading as material collects at the toe of the failure. ■ Ongoing cracking and movement along Cherry Lane as the slope movement progress, disrupting traffic access and power service along the lane.
Option 2 – Installation of Sub- Drainage System	$4,500,000	■ The FS for the slope increases for the existing failure areas. ■ Decreasing and maintaining the pore-water pressures along the slope will decrease the risk of additional slope movement during high precipitation years. ■ Little additional risk for slope instability during construction. ■ Only localized disturbance to the residences in this area.	■ Does not improve the Factor of Safety for the slope to target 1.5. ■ It may take several years for the remediation to be effective because dissipation of pore-water pressure in clay takes time. ■ Installation of a drainage system will require disturbance to roadways (11th Street East and Cherry Lane) and underground utilities in the area. ■ Construction of the drainage outlet would require connection to the sewer system or construction of a new drainage outlet downslope which will affect properties along Saskatchewan Crescent East. ■ Cross drains connecting between 11th Street East and Cherry Lane may require some disturbance in the yards of the residences on the 200 to 300 block of 11th Street East. ■ Long term maintenance and monitoring of the drainage system is required.
Option 3- Slope Re-grading and Installation of Sub-Drainage System	$6,500,000	■ Target Factor of Safety of 1.5 for the slope in this area is achievable. ■ Reduced risk of shallow failures in the upper slope due to the flatter grade. ■ Decreasing and maintaining the pore-water pressures along the slope will decrease the risk of additional slope movement during high precipitation years. ■ Access to 11th Street East and Cherry Lane should not be affected in the long term.	■ Construction will cause significant disruption to residences along 11th Street East and Saskatchewan Crescent East, as well as the above ground power lines and landscaping in the area. ■ Site access will be limited and large volumes of fill and debris will need to be hauled from site. ■ Access to 11th Street East and Cherry Lane will be restricted during construction. ■ Installation of a drainage system will require disturbance to roadways (11th Street East and Cherry Lane) and underground utilities in the area. ■ Construction of the drainage outlet would require connection to the sewer system or construction of a new drainage outlet downslope which will affect properties along Saskatchewan Crescent East. ■ Cross drains connecting between 11th Street East and Cherry Lane may require some disturbance in the yards of the residences on the 200 to 300 block of 11th Street East. ■ Long term maintenance and monitoring of the drainage system is required.
Option 4 - Shear Zone Modification and Installation of Sub-Drainage System	$10,500,000	■ Target Factor of Safety of 1.5 for the slope in this area is achievable. ■ Majority of work can be confined to Cherry Lane, resulting in less disruption to residences along 11th Street East and Saskatchewan Crescent East. ■ Decreasing and maintaining the pore-water pressures along the slope will decrease the risk of additional slope movement during high precipitation years. ■ Access to 11th Street East and Cherry Lane should not be affected in the long term.	■ Construction will cause significant disruption to Cherry Lane and the backyards and power line along Cherry Lane. ■ Temporary slope stabilization methods will need to be installed above Cherry Lane to reduce the risk of instability during construction. ■ Access to 11th Street East and Cherry Lane will be restricted during construction. ■ Installation of a drainage system will require disturbance to roadways (11th Street East and Cherry Lane) and underground utilities in the area. ■ Construction of the drainage outlet would require connection to the sewer system or construction of a new drainage outlet downslope which will affect properties along Saskatchewan Crescent East. ■ Cross drains connecting between 11th Street East and Cherry Lane may require some disturbance in the yards of the residences on the 200 to 300 block of 11th Street East. ■ Long term maintenance and monitoring of the drainage system is required.

(a) Costs for alterations to existing properties, including removal of debris and landscaping, removal of structures, property purchase, and changes to existing utilities have not been considered in this estimate. Costs have been rounded to the nearest $500,000.

12.0 CLOSURE

The findings of this report are based upon the results of field and laboratory investigations conducted by Golder. If conditions encountered at the surface or at depth during construction appear to be different than indicated in the report, or if the stated assumptions are not consistent with design, this office should be notified for review and adjustment of recommendations, if necessary.

Soil conditions are, by nature, are highly variable across a construction site. The placement of fill and prior construction activities can contribute to variables in the near-surface conditions. A contingency should be included in any construction budget to allow for the possibility of variation of soil conditions that may result in modification of design and construction procedures.

This report was prepared for the City of Saskatoon for the proposed works described in the text. The data and recommendations should not be used for any other purpose, or by any other parties, without written consent from Golder Associates Ltd. The findings and recommendations of this report were prepared in accordance with generally accepted professional engineering principles and practice. No other warranty, expressed or implied, is given.

Report Signature Page

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Association of Professional Engineers & Geoscientists of Saskatchewan

CERTIFICATE OF AUTHORIZATION

Golder Associates Ltd.
Number C0230

Permission to Consult held by:

Discipline	Sk. Reg. No.	Signature
Geotechnical	12797	

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APPENDIX A

Information and Limitations of this Report

IMPORTANT INFORMATION AND LIMITATIONS
OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client can not rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT (cont'd)

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

APPENDIX B

Aerial Photographs

Figure B.1. Aerial Photograph, 1939

Figure B.2. Aerial Photograph, 1958

Figure B.3. Aerial Photograph, 1961

Figure B.4. Aerial Photograph, 1970

Figure B.5. Aerial Photograph, 1974

Figure B.6. Aerial Photograph, 1977

Figure B.7. Aerial Photograph, 1987

Figure B.8. Aerial Photograph, 1997

Figure B.9. Aerial Photograph, 2001

Figure B.10. Aerial Photograph, 2006

Figure B.11. Aerial Photograph, 2011

APPENDIX C

Field Inspection Photographs

Photo C.1. Looking East at Deflection of Curb and Fence Line along Cherry Lane (Nov 5, 2006)

Photo C.2. Looking East at Deflection of Curb and Fence Line along Cherry Lane (May 27, 2010)

Photo C.3. Looking East at Deflection of Curb and Fence Line along Cherry Lane (April 26, 2012)

Photo C.4. Looking West at Toe of Upper Slope (April 26, 2012)

Photo C.5. Headscarp in the Backyard of 233-235 11th St. E. (June 21, 2012)

Photo C.6. Bulging Toe of Slide on Cherry Lane (June 21, 2012)

Photo C.7. Bulging Toe of Slide below Cherry Lane (June 21, 2012)

Photo C.8. Cracking Behind Retaining Wall in Backyard of 237-239 11th St. E. (June 21, 2012)

Photo C.9. Retaining Wall in Backyard of 237-239 11th St. E. (June 21, 2012)

Photo C.10. Looking East at Tension Cracking along Cherry Lane (June 21, 2013)

Photo C.11. Cracking along Headscarp of East Failure (June 21, 2012)

Photo C.12. Looking East at Headscarp of East Failure in Backyard of 305 11th St. E.; Approx. 90 cm Drop (June 24, 2013)

Photo C.13. Headscarp of East Failure in Backyard of 303 11th St. E.; Approx. 60 cm Drop (June 24, 2013)

Photo C.14. Looking East at Bulging Toe of Slide above Retaining Wall behind 306 Sask. Cres. E. (June 24, 2013)

Photo C.15. Looking East at Severe Cracking across Cherry Lane, Pavement; Approx. 50 cm Drop (June 24, 2013)

Photo C.16. Looking East at Scarp & Tension Cracking on Cherry Lane (June 24, 2013)

Photo C.17. Retaining Wall in Backyard of 237-239 11th St. E. (June 4, 2013)

Photo C.18. Retaining Wall in Backyard of 237-239 11th St. E. (June 20, 2013)

Photo C.19. Retaining Wall in Backyard of 237-239 11th St. E. (June 24, 2013)

Photo C.20. Looking East at Drop in Pavement behind 305 11th St. E.; Approx 53 cm Drop (June 4, 2013)

Photo C.21. Looking East at Public Works Filling Cracks and Regrading Lane (June 5, 2013)

Photo C.22. Looking West at Erosion along Cherry Lane (June 6, 2013)

Photo C.23. Looking West at Berm Along North Edge of Cherry Lane, behind 306 Sask. Cres. E. (July 7, 2013)

Photo C.24. Looking Northeast at Trench being Excavated Adjacent to Wall between 230 & 306 Sask. Cres. E. (July 7, 2013)

Photo C.25. Looking Northeast at Concrete Retaining Wall between 230 & 306 Sask. Cres. E. (July 7, 2013)

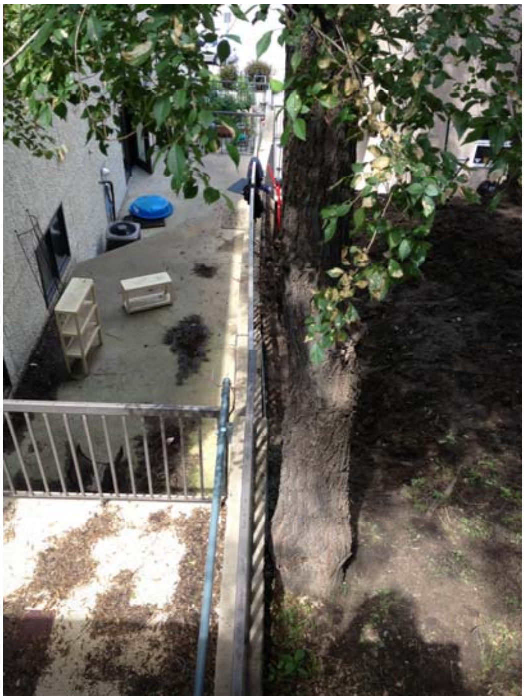


Photo C.26. Looking North at Concrete Retaining Wall between 230 & 306 Sask. Cres. E. (July 7, 2013)

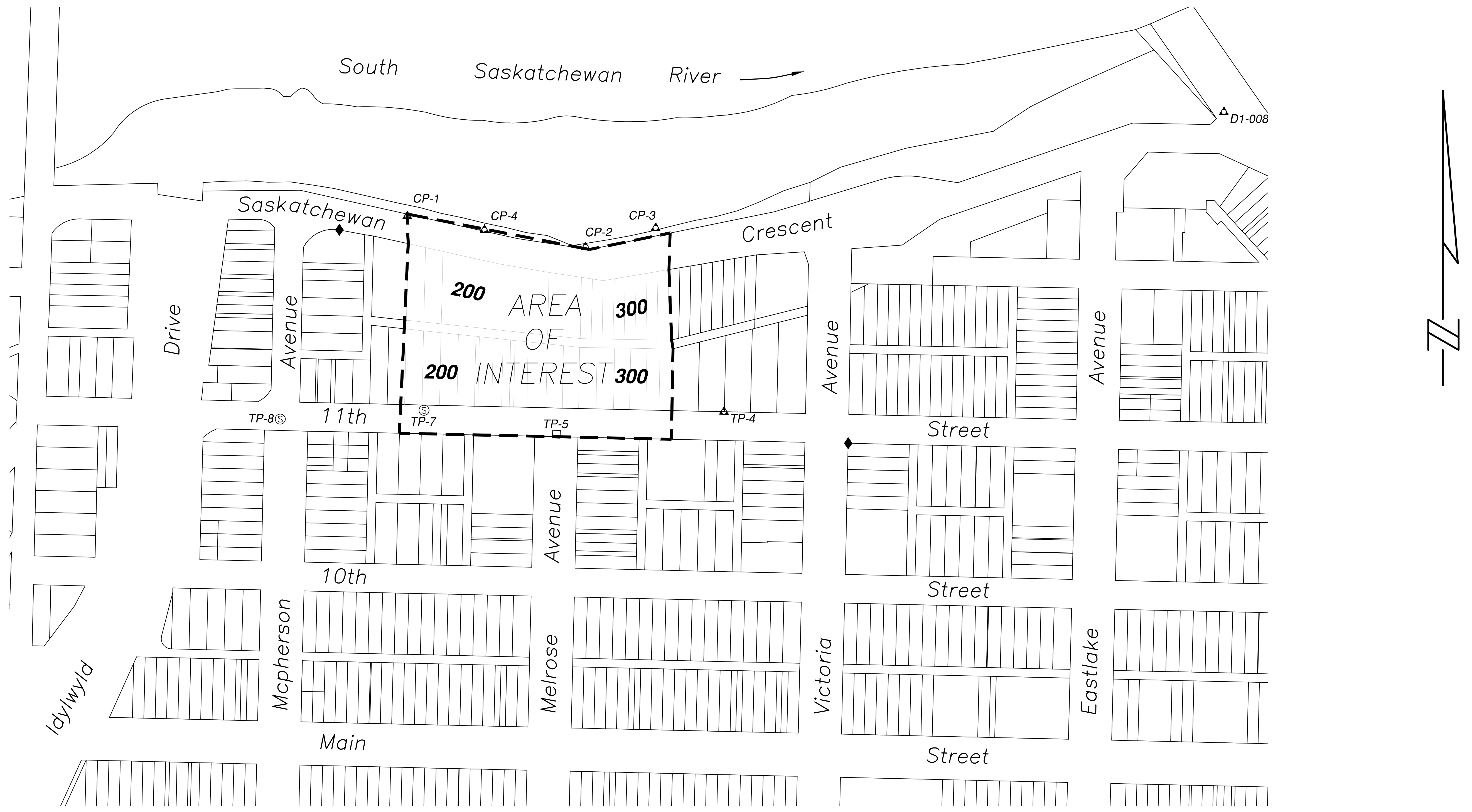
Phtoo C.27. Looking East at New Tension Craking Forming on Regraded Lane (July 7, 2013)

Photo C.28. Looking North at Partially Filled Trench (July 17, 2013)

Photo C.29. Looking East at Above Ground Drianage System Installed on Cherry Lane (September 18, 2013)

APPENDIX D

Topographic Survey Plan



KEYPLAN
Scale: 1:2500

CONTROL POINTS

NAD 83 (CSRS) UTM ZONE 13

POINT	NORTHING (m)	EASTING (m)	ORTHOMETRIC ELEVATION (m) HTv2.0	DESCRIPTION
CP–1	5,775,701.84	385,897.84	477.97	24" REBAR WITH PLASTIC CAP
CP–2	5,775,680.32	386,022.25	478.99	24" REBAR WITH PLASTIC CAP
CP–3	5,775,693.72	386,071.10	479.49	24" REBAR WITH PLASTIC CAP
CP–4	5,775,692.40	385,951.67	477.95	GPS CONTROL POINT
TP–4	5,775,565.50	386,118.76	499.32	X IN CONCRETE
TP–5	5,775,549.79	386,001.87	498.05	X IN NORTH RIM CATCH BASIN
TP–7	5,775,566.48	385,909.52	491.32	X IN SOUTH RIM MANHOLE
TP–8	5,775,560.37	385,809.26	484.62	X IN WEST RIM MANHOLE
D1–008	5,775,775.85	386,467.62	499.033	CONTROL TABLET

STAND PIPES (PIEZOMETERS) and SLOPE INDICATORS

NAD 83 (CSRS) UTM ZONE 13

POINT	NORTHING (m)	EASTING (m)	ORTHOMETRIC ELEVATION (m) HTv2.0	DESCRIPTION	GROUND ELEVATION (m)
44	5,775,674.76	386,061.60	480.88	COS–13–003 (SP)	480.343
102	5,775,620.13	386,037.21	489.00	PIEZOMETER (SP)	488.597
103	5,775,627.80	386,037.09	488.65	PIEZOMETER (SP)	487.852
104	5,775,626.17	386,029.80	487.78	PIEZOMETER (SP)	487.340
105	5,775,621.04	386,023.51	488.17	PIEZOMETER (SP)	487.843
110	5,775,629.91	386,023.30	487.32	PIEZOMETER (SP)	486.554
111	5,775,637.71	386,047.56	486.00	COS–13–005 (SP)	485.408
112	5,775,600.60	386,028.65	493.75	PIEZOMETER (SP)	492.734
117	5,775,609.14	386,050.90	492.39	PIEZOMETER (SP)	491.388
127	5,775,573.48	385,959.11	495.34	COS–13–007 (SP)	494.799

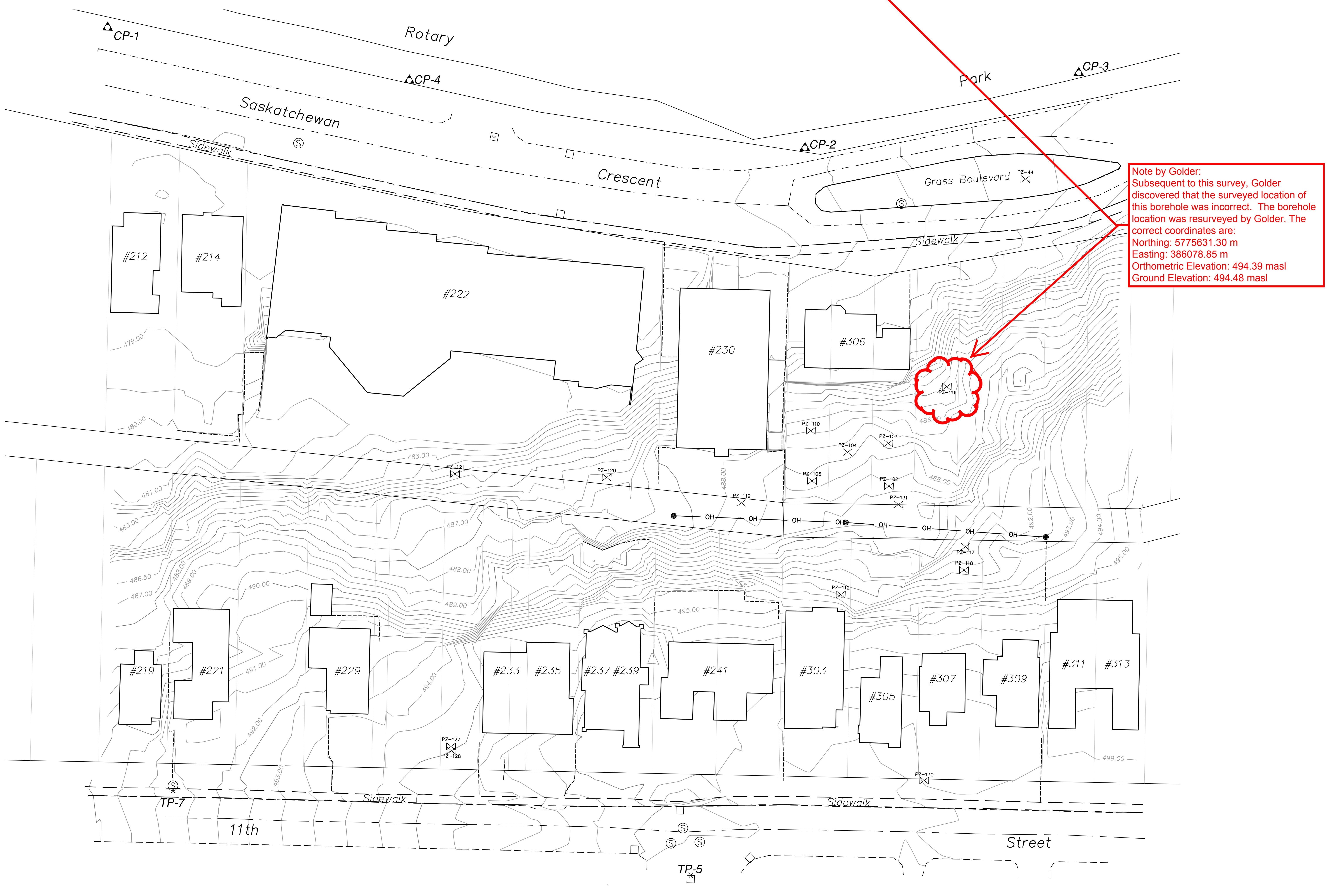
Elevations are to North Rim of PVC pipe and to typical ground beside said pipe.

STAND PIPES (PIEZOMETERS) and SLOPE INDICATORS

NAD 83 (CSRS) UTM ZONE 13

POINT	NORTHING (m)	EASTING (m)	ORTHOMETRIC ELEVATION (m) HTv2.0	DESCRIPTION	GROUND ELEVATION (m)
118	5,775,604.97	386,050.63	491.61	COS–13–004 (SI)	491.738
119	5,775,616.97	386,010.94	488.09	11–0057–BH1 (SI)	488.207
120*	5,775,621.52	385,986.89	486.16	11–0057–BH2 (SI)	486.157
121	5,775,622.14	385,959.83	483.97	11–0057–BH3 (SI)	484.035
128	5,775,572.72	385,959.21	494.62	COS–13–006 (SI)	494.767
130	5,775,567.41	386,043.54	498.37	COS–13–002 (SI)	498.483
131	5,775,616.67	386,038.94	489.23	COS–13–001 (SI)	489.339

* Could not locate PVC pipe in metal collar. Elevation to north rim of collar.



Note by Golder:
Subsequent to this survey, Golder discovered that the surveyed location of this borehole was incorrect. The borehole location was resurveyed by Golder. The correct coordinates are:
Northing: 5775631.30 m
Easting: 386078.85 m
Orthometric Elevation: 494.39 masl
Ground Elevation: 494.48 masl

LEGEND

- CONTROL POINTS ARE SHOWN THUS .... △
- STANDARD IRON POSTS ARE SHOWN THUS .... ◆
- PIEZOMETERS ARE SHOWN THUS .... PZ ⋈
- MANHOLES ARE SHOWN THUS .... Ⓢ
- CATCHBASINS ARE SHOWN THUS .... □
- BUILDINGS ARE SHOWN THUS .... ———————
- ℄ OF ROAD IS SHOWN THUS .... ——— — ———
- EDGE OF ASPHALT ROAD IS SHOWN THUS .... — — — — — — —
- EDGE OF SIDEWALK IS SHOWN THUS .... — —— —— —
- POWERLINES AND POWERPOLES ARE SHOWN THUS .... —●— OH —●
- RETAINING WALLS ARE SHOWN THUS .... - - - - - - - - - - - -

NOTES

- TOPOGRAPHIC SURVEY CONDUCTED TO PROVIDE THE OVERALL GEOMETRY OF THE SLOPE IN AREA OF INTEREST. SURVEY DOES NOT PURPORT TO ILLUSTRATE ALL SITE DETAIL. CERTAIN AREAS CONTAIN LESS TOPOGRAPHIC DETAIL DUE TO SCOPE LIMITATIONS OR SAFETY ISSUES OF WORKING IN PROXIMITY TO COMPROMISED STRUCTURES.
- SPOT ELEVATIONS AND BREAKLINE INFORMATION RESIDE ON LAYERS "TOPO–ELEV" AND "TOPO–BREAKLINES" OF ASSOCIATED PROJECT CAD FILE.
- MEASUREMENTS AND ELEVATIONS ARE IN METERS AND DECIMALS THEREOF.
- ELEVATIONS ARE BASED ON COS BENCHMARK D1–008 (ORTHOMETRIC ELEV. 499.033).
- HORIZONTAL COORDINATES ARE DERIVED FROM PRECISE POINT POSITIONING.
- CONTOUR INTERVALS ARE 0.50 METERS.
- BACKGROUND PARCEL INFORMATION IS DERIVED FROM THE GeoSask BASE.
- DATA PICKUP BETWEEN HOUSES IS SPARCE AND CONTOURS ARE INTERPOLATED BASED ON DATA ACQUIRED.

TOPOGRAPHIC SURVEY

SHOWING Surface Features of the
200 & 300 Blocks of Saskatchewan Crescent & 11th Street
in
S.W. Sec. 28 Twp. 36 - Rge. 5 - W3rd Mer.
Saskatoon, Saskatchewan

Drawn By: kgb	Date: July 31, 2013	Drawing Name: S13152Topo–UTMall.dwg	Scale: 1:500	Prepared by: Meridian Surveys Ltd.
Checked By: gar	Date: July 31, 2013	File No.: S13152	Rev. 1	

REVISIONS

NO.	DATE	REVISION	REV. BY	CHD. BY	DES. ENG.
1	Sept. 4, 2013	Added Piezometers and slope indicators.	kgb	mp	

APPENDIX E

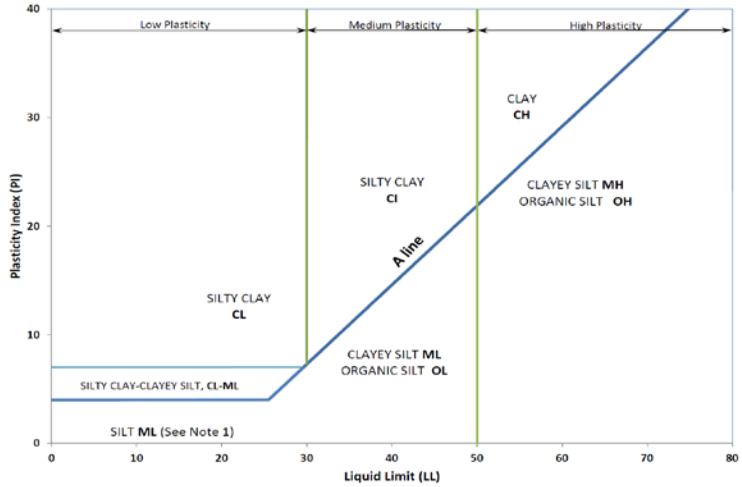
Records of Boreholes

METHOD OF SOIL CLASSIFICATION

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10}xD_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators					Organic Content	USCS Group Symbol	Primary Name
				Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)			
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)	Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
				Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
				Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
				None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)	Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% **(see Note 2)**	CL	SILTY CLAY
			Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
			Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures							30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat							75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.

Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.

For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.

For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.

A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to ~~or~~ indicate~~s~~ a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL, SAND and CLAY)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.).

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size
TP	Thin-walled, piston – note size
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 - 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects.
2. Definition of compactness descriptions based on SPT 'N' ranges from Terzaghi and Peck (1967) and correspond to typical average N_{60} values.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\,\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma$ - u)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil $(\gamma' = \gamma - \gamma_w)$
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength (ϕ = 0 analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes:
1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90^{o} angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN	Joint	PL	Planar
FLT	Fault	CU	Curved
SH	Shear	UN	Undulating
VN	Vein	IR	Irregular
FR	Fracture	K	Slickensided
SY	Stylolite	PO	Polished
BD	Bedding	SM	Smooth
FO	Foliation	SR	Slightly Rough
CO	Contact	RO	Rough
AXJ	Axial Joint	VR	Very Rough
KV	Karstic Void		
MB	Mechanical Break		

HISTORICAL BOREHOLE LOGS
TH 101, TH 101A, TH 102, TH103, TH 104, TH 105 (GE76)

Ground Engineering Ltd. Apr. 9, 1976. Geotechnical Investigation 216, 218 and 220 Saskatchewan Crescent

1/2 BH 101

GROUND ENGINEERING LTD.

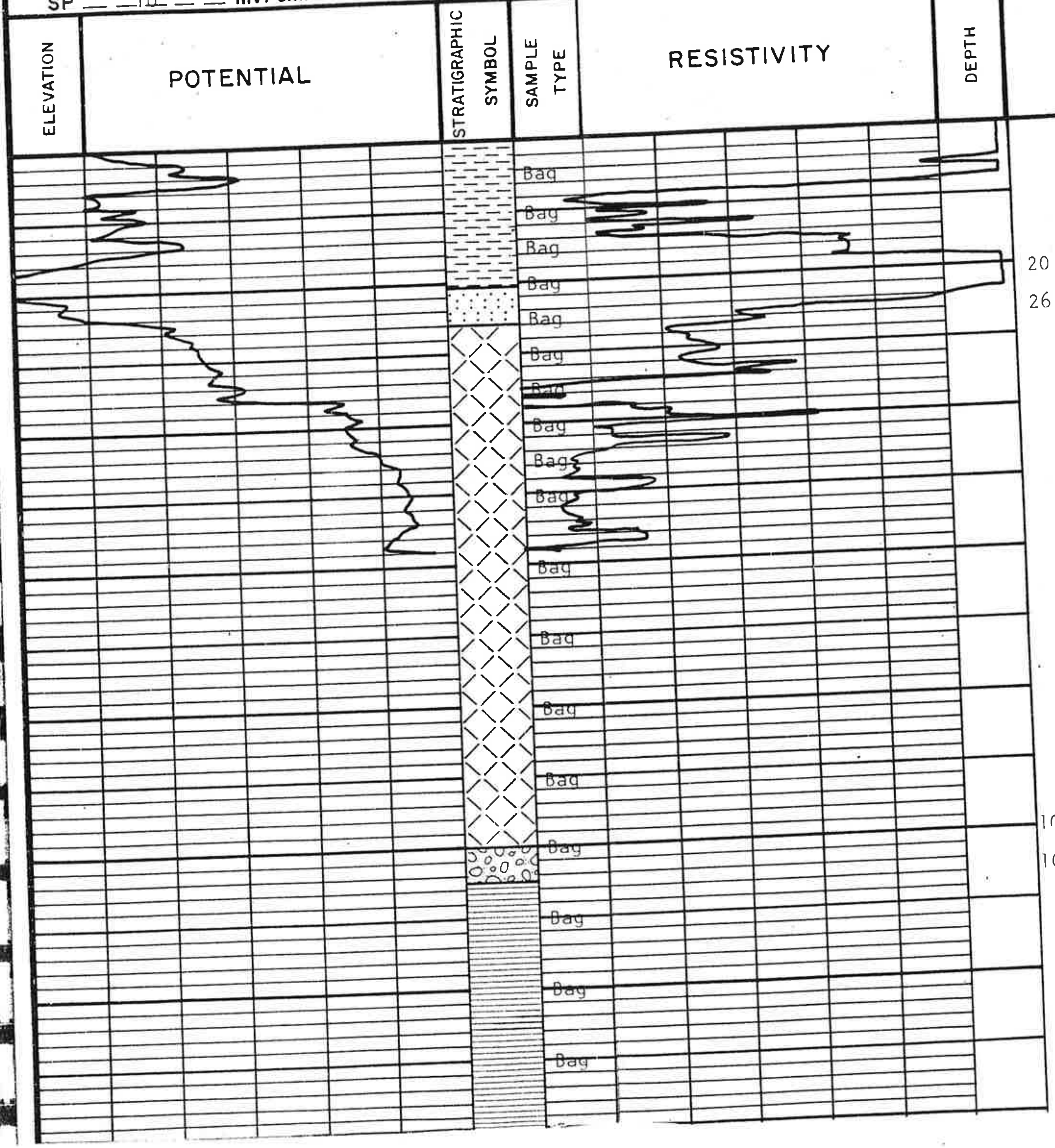
CIVIL AND GEOTECHNICAL ENGINEERS
REGINA SASKATOON

BOREHOLE TEST REPORT

SHEET ___ OF ___

JOB NO. ~~GS-033~~
LOCATION 216 - 220 Saskatchewan Crescent
SASKATOON, Saskatchewan
TEST HOLE REFERENCE ____
E LOGGED BY: ____ DATE ____
SP. COND. WATER ____ mmhoes/cm. at ____ °C
SP. COND. MUD ____ mmhoes/cm. at ____ °C
SP 10 mv/cm. R 12 ohms/cm.

BOREHOLE NO. 101 DATE February 10, 1976
SURFACE ELEVATION 1554.3 City Datum
VERTICAL SCALE 1" = 20'
DRILLED BY Hayter Drilling Co.
DRILLER ____
INTERPRETATION & SAMPLE DESCRIPTION BY:
GROUND ENGINEERING LTD



DESCRIPTION

CLAY - silty, sandy
- highly organic becoming sandy @ 15'
- pale olive, oxidized
- massive, Fe stains
- boulders @ 20'

20'6"

SAND - coarse grained
- well graded

26'0"

TILL - clayey with fine sand lenses @ 58'
- grey
- unoxidized
- pebbles
- boulders @ 27', 38'6" 40'6", 60'6", 66'6" and 72'0"
- hard
- massive

100'0"

GRAVEL - poorly graded
- 1" diameter maximum size

105'0"

CLAY SHALE - grey, unoxidized
- hard becoming softer with depth
- massive
- non calcareous

P.I. & UNIFIED

SHEAR STRENGTH K.S.F.
☐ POCKET PEN ■ UNCONFINED ☒ LAB VANE
1.0 2.0 3.0 4.0
▲ FIELD UNIT WEIGHT P.C.F
80 85 90 95 100 105 110 115 120
MOISTURE CONTENT %
Nw ○ Pw ⊢ Lw ⟶
10 20 30 40 50 60 70 80 90

2/2
BH 701

Bag

Bag

160'0" END OF HOLE

NOTES:
4-3/4" diameter rotary drill used.
Sloughing between 100 & 105'.
Bag samples taken from S700 to S720 inclusive.

TEST HOLE LOG

DATE February 10, 1976

HOLE NO. 101A

SAMPLE DATA

WEIGHT HAMMER

HEIGHT DROP

ELEV. COLLAR

ELEV. GROUND 1554.3 (City Datum)

CO-ORD. LOCATION

SYMBOL

DESCRIPTION OF MATERIAL

DEPTH ELEV.	NO TYPE	UNIF PI
10' 44.3		
20' 34.3		
30' 24.3	S721 Sy	CL 15.2
	S722 Sy	
40' 14.3	S723 Sy	CL 19.5
	S724 Sy	
50' 04.3		
	S725 Sy	
60' 494.3	S726 Sy	CL 22.0

CLAY - silty, sandy
- highly organic becoming sandy @ 15'
- pale olive
- oxidized
- massive
- Fe stains
- boulder @ 20

20'6"

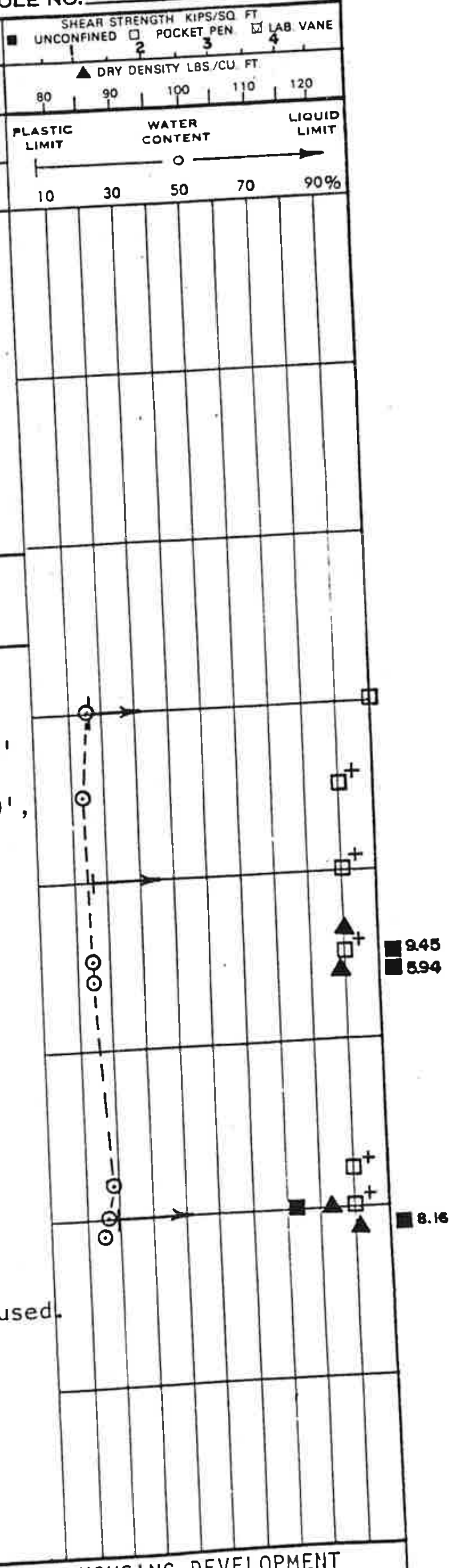
SAND - coarse grained
- well graded

26'0"

TILL - clayey
- unoxidized
- hard & moist becoming extremely hard & dry @ 60'
- pebbles
- boulders encountered @ 30', 35' and 58'
- massive

62'0" END OF HOLE

NOTES: 4-3/4" diameter rotary drill used.



GROUND ENGINEERING LTD.

GEOTECHNICAL ENGINEERS/Soil Mechanics & Foundations

PROJECT PROPOSED HOUSING DEVELOPMENT
216 - 220 SASKATCHEWAN CRESCENT

LOCATION SASKATOON, Saskatchewan

PLATE NO. GS-033-7

BH102

GROUND ENGINEERING LTD.
CIVIL AND GEOTECHNICAL ENGINEERS
REGINA SASKATOON

BOREHOLE TEST REPORT

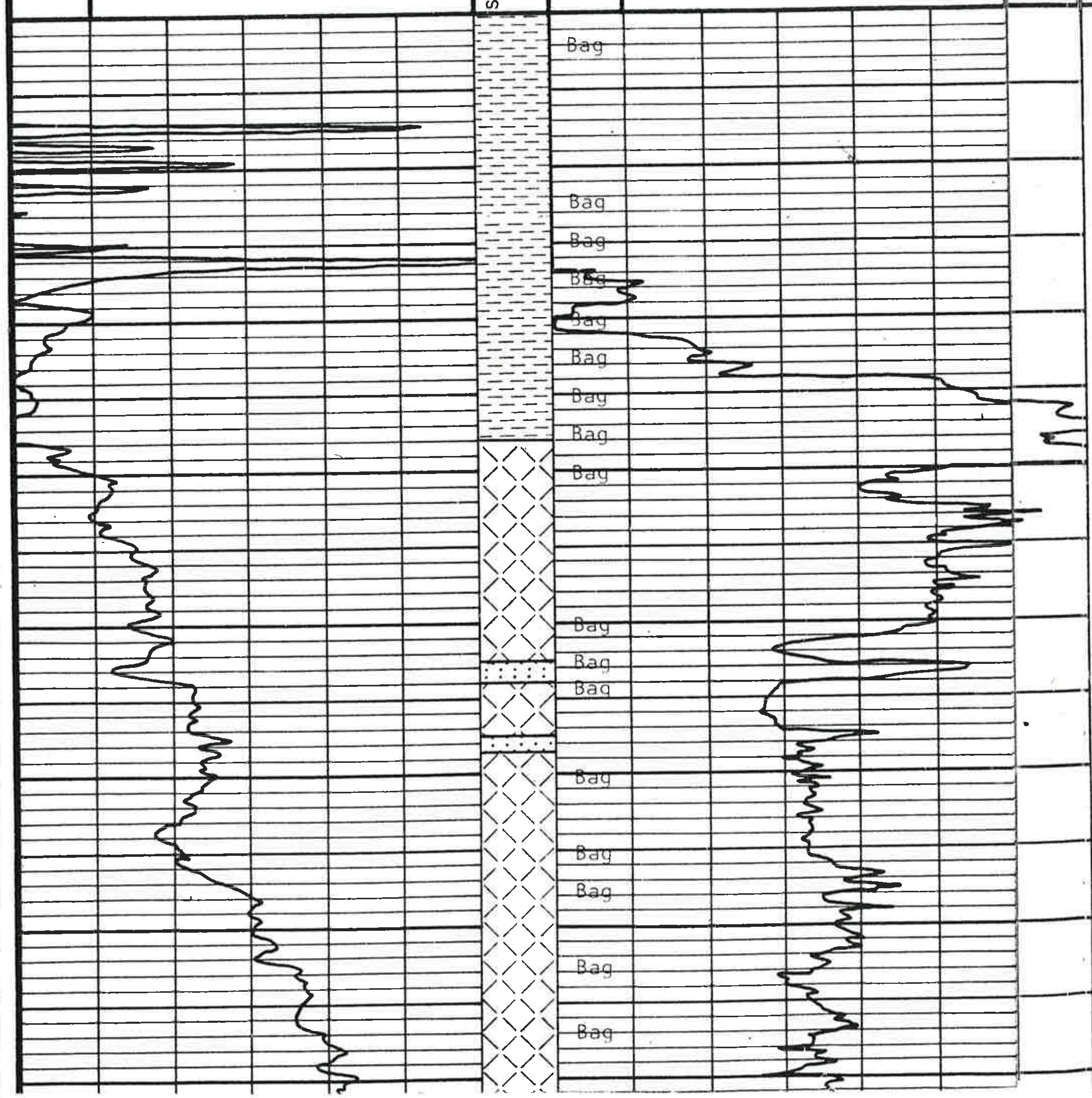
JOB NO. GS-033
LOCATION 216 - 220 Saskatchewan Crescent
SASKATOON, Saskatchewan
TEST HOLE REFERENCE
E LOGGED BY: DATE
SP. COND. WATER mmhoes/cm. at °C
SP. COND. MUD mmhoes/cm. at °C
SP 10 mv/cm. R 10 ohms/cm.

BOREHOLE NO. 102 DATE February 9, 1976
SURFACE ELEVATION 1615.3 City Datum
VERTICAL SCALE 1" = 20'
DRILLED BY Hayter Drilling Co.
DRILLER
INTERPRETATION & SAMPLE DESCRIPTION BY:
GROUND ENGINEERING LTD.

SHEET OF

SHEAR STRENGTH K.S.F.
☐ POCKET PEN ■ UNCONFINED ☑ LAB VANE
1.0 2.0 3.0 4.0
▲ FIELD UNIT WEIGHT P.C.F
80 85 90 95 100 105 110 115 120
Nw ○ Pw ⊢ MOISTURE CONTENT % Lw →
10 20 30 40 50 60 70 80 90

ELEVATION	POTENTIAL	STRATIGRAPHIC SYMBOL	SAMPLE TYPE	RESISTIVITY	DEPTH	DESCRIPTION	P.I. & UNIFIED



CLAY - pale olive & oxidized with Fe stains becoming unoxidized @ 30'
- massive
- hard

56'0"

TILL - silty clay, grey
- unoxidized, massive
- stiff & dry
- pebbles

85'0"
88'0"

SAND - coarse grained to fine grained, well graded to poorly graded
- clean

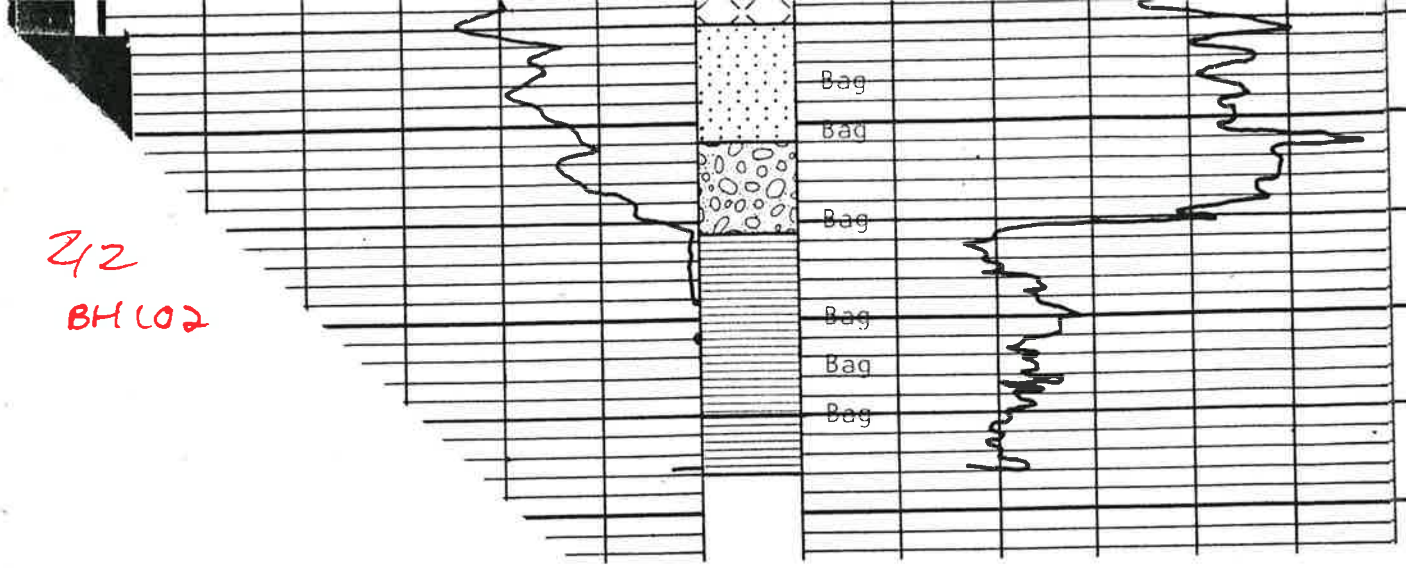
95'0"
97'0"

TILL - as above

SAND - as above

TILL - clayey, grey,
- unoxidized
- massive, hard
- numerous pebbles & boulders

2/2
BH L02



150'0"

SAND - medium to coarse grained
- poorly graded to medium graded,
- grey, unoxidized

162'0"

171'0" GRAVEL

CLAY SHALE - grey, unoxidized
- massive, hard
- non calcareous

196'0" END OF HOLE

TEST HOLE LOG

DATE February 9, 1976

HOLE NO. 103

ELEV. COLLAR

ELEV. GROUND 1554.7 (City Datum)

CO-ORD. LOCATION

SAMPLE DATA

WEIGHT HAMMER

HEIGHT DROP

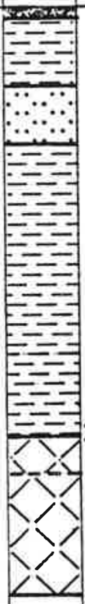
SHEAR STRENGTH KIPS/SQ. FT
■ UNCONFINED ☐ POCKET PEN ☒ LAB VANE

▲ DRY DENSITY LBS/CU. FT
80 90 100 110 120

PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT
10 30 50 70 90%

DEPTH ELEV.	NO. TYPE	UNIF PI	RE-COVERY
10' 44.7	S750 Bag	CL-ML 6.9	
	S751 Bag		0.10
20' 34.7	S752 Bag	CL 10.8	0.04
	S753 Bag	CL 25.1	
30' 24.7	S754 Bag	CL 17.3	0.04

SYMBOL



DESCRIPTION OF MATERIAL

0'6" TOPSOIL

CLAY - silty with some organic material

4'0"

SAND - silty
- medium brown
- oxidized
- non-plastic
- moist

7'0"

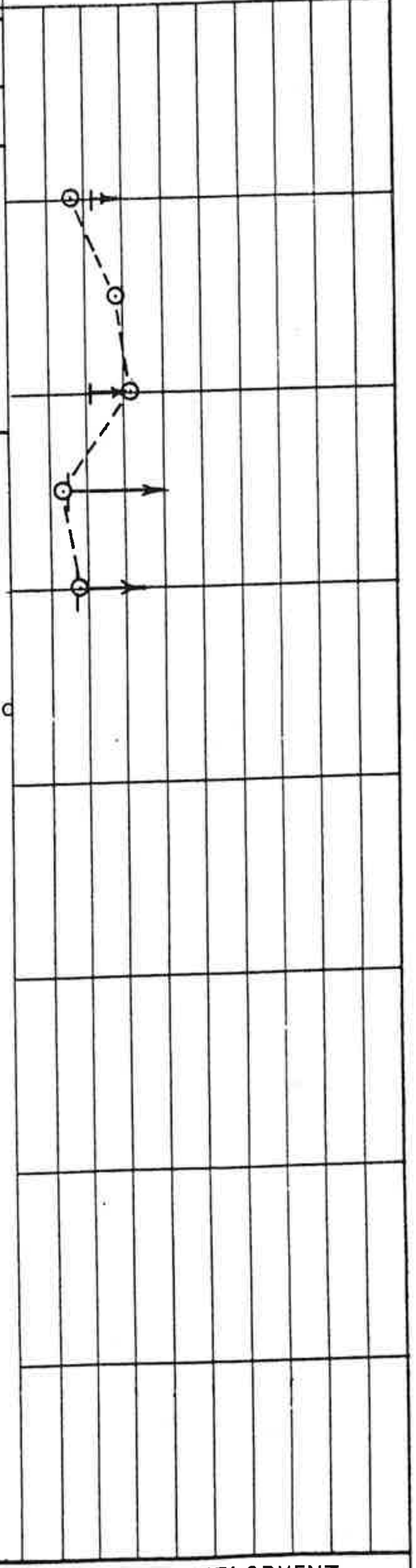
CLAY - silty and sandy
- olive brown becoming olive grey @ 20'
- oxidized
- low plastic
- soft & moist becoming very soft and saturated @ 20'
- massive becoming laminated @ 20'
- Fe stains

22'0"

TILL - silty clay
- grey
- oxidized becoming unoxidized @ 24'
- very soft becoming stiff & moist @ 25' & very stiff @ 30'
- pebbles

30'0"

NOTES: Hole terminated @ 30'0"
6" diameter continuous flight auger used. Water seepage.



GROUND ENGINEERING LTD.

GEOTECHNICAL ENGINEERS/Soil Mechanics & Foundations

PROJECT PROPOSED HOUSING DEVELOPMENT
216 - 220 SASKATCHEWAN CRESCENT

LOCATION SASKATOON, Saskatchewan

TEST HOLE LOG

DATE February 9, 1976

HOLE NO. 104

SAMPLE DATA

WEIGHT HAMMER

HEIGHT DROP

ELEV. COLLAR

ELEV. GROUND 1553.2 (City Datum)

CO-ORD. LOCATION 6'W & 6'S of NE lot corner

DEPTH ELEV.	NO. TYPE	UNIF PI	RE-COVERY
	S755 Bag		
10' 43.2	S756 Bag		
	S757 Bag		
20' 33.2	S758 Bag		
	S759 Bag		
	S760 Bag	CL 17.0	
30' 23.2	S761 Bag	CL 18.4	

SYMBOL

DESCRIPTION OF MATERIAL

1'0" TOPSOIL

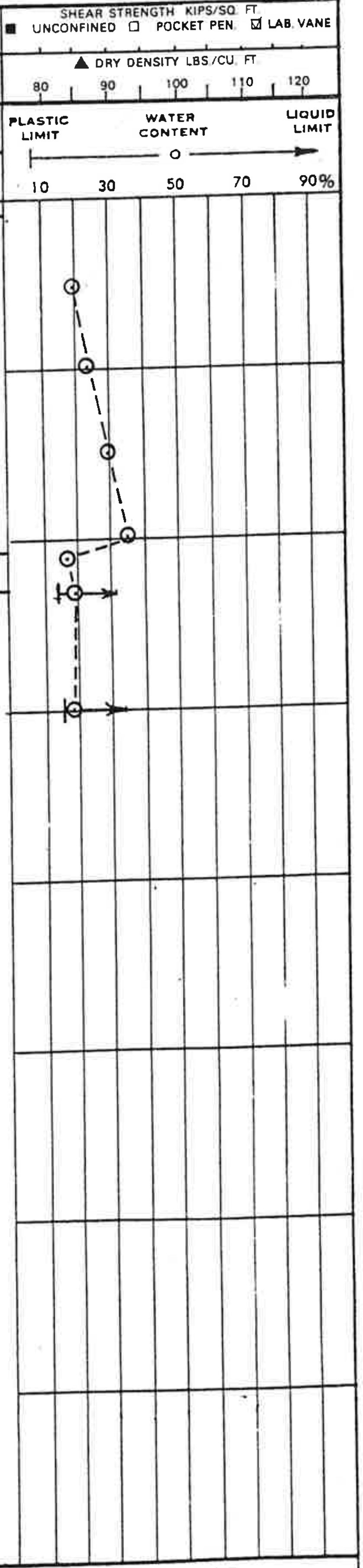
CLAY - silty and sandy with sand seams
- olive brown
- oxidized
- dry becoming moist then soft & saturated @ 15'
- massive
- Fe stains

21'0" SAND - medium to coarse grained
- poorly to medium graded
- pale olive
- wet

23'0" TILL - clayey
- grey
- unoxidized
- soft & wet becoming firm & moist @ 30'
- pebbles

30'0"

NOTES: Hole terminated @ 30'0"
6" diameter continuous flight auger used.
Water seepage @ 14'
Water level @ 17'



GROUND ENGINEERING LTD.

GEOTECHNICAL ENGINEERS/Soil Mechanics & Foundations

PROJECT PROPOSED HOUSING PROJECT
216 - 220 SASKATCHEWAN CRESCENT

LOCATION
SASKATOON, SASKATCHEWAN

TEST HOLE LOG

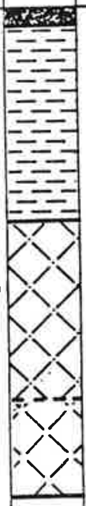
DATE February 9, 1976

HOLE NO. 105

SAMPLE DATA	ELEV. COLLAR
WEIGHT HAMMER	ELEV. GROUND 1556.3 (City Datum)
HEIGHT DROP	CO-ORD. LOCATION

DEPTH ELEV.	NO TYPE	UNIF PI	
	S762 Bag	CL-ML 4.8	
10' 46.3	S763 Bag		0.10
	S764 Bag	CL 25.4	0.09
	S765 Sy		
20' 36.3	S766 Bag	CL 20.0	
	S767 Sy		
	S768 Sy	CL 20.4	

SYMBOL



DESCRIPTION OF MATERIAL

1'0" TOPSOIL

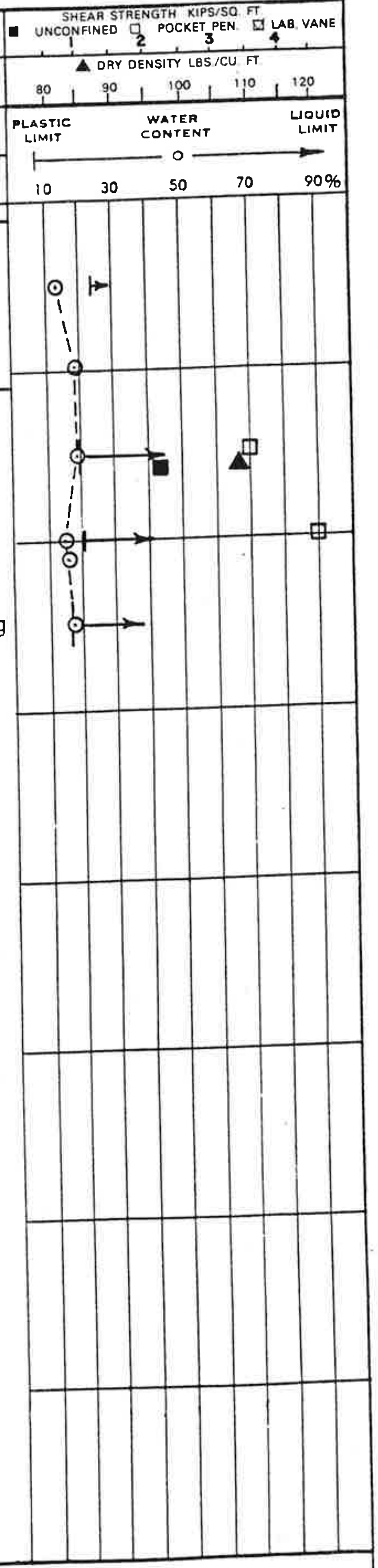
CLAY - silty with some organic material
- pale olive becoming olive @ 10'
- oxidized
- dry
- massive
- frost to 3'

11'0"

TILL - silty clay
- grey-brown becoming grey and unoxidized @ 20'
- low plastic
- very stiff & moist becoming hard & dry @ 20' (Floral)
- massive
- few pebbles
- Fe stains
- boulders @ 25'

25'0"

NOTES: Hole terminated @ 25'0"
6" diameter continuous flight auger used.
Water level @ 19'



GROUND ENGINEERING LTD.

GEOTECHNICAL ENGINEERS/Soil Mechanics & Foundations

PROJECT PROPOSED HOUSING PROJECT
216 - 220 SASKATCHEWAN CRESCENT

LOCATION SASKATOON, Saskatchewan

HISTORICAL BOREHOLE LOGS
TH 201, TH 202, TH203, TH 204 (GE77)

Ground Engineering Ltd. July 4, 1977. Geotechnical Site Investigation Proposed Housing Complex, Saskatchewan Crescent

TEST HOLE LOG

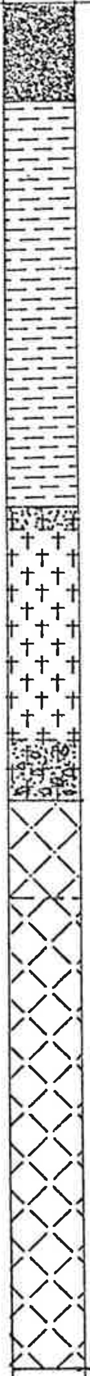
DATE 77/06/07

HOLE NO. 201

SAMPLE DATA	
WEIGHT HAMMER	
HEIGHT DROP	
ELEV. COLLAR	
ELEV. GROUND	1553.4 City Datum
CO-ORD. LOCATION	

DEPTH ELEV.	NO TYPE	UNIF PI	% SO_4
	S42 Bag		
5 48	S43 Bag		
	S44 Bag		
10 43	S45 Bag		
	S46		
	S47	Bags	
15 38	S48 Bag		
	S49 Bag		
20 33	S50 Bag		
	S51 Bag		
25 28	S52 Bag		
	S53 Bag		
30 23	S54 Bag		
	S55 Bag		
35 18	S56 Bag		

SYMBOL



DESCRIPTION OF MATERIAL

TOPSOIL - clay, silty, organic

2'6"

CLAY - low plasticity
- very silty, organic to 10'
- stratified, laminated
- moist, firm, becoming stiff
- light olive brown to olive grey, oxidized

13'0"

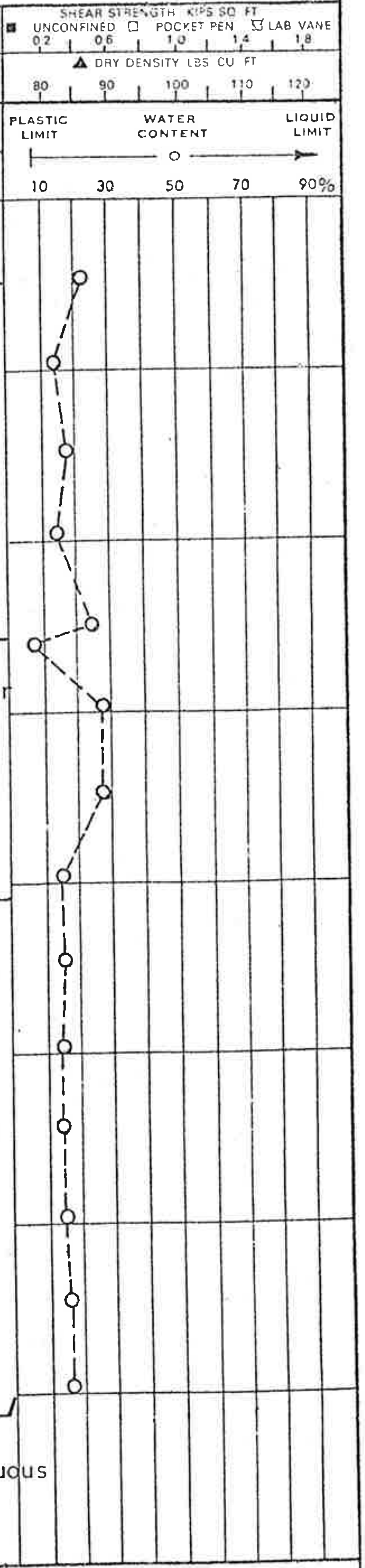
SILT - trace of sand
- well graded fine sand layer 13'-13½'
- poorly graded fine, silty gravel layer 19-20½'
- olive grey, oxidized
- wet, soft, stratified
- sloughing

20'6"

TILL - clay, silty, fine gravel
- dark olive grey, oxidized becoming very dark grey, unoxidized at 23'
- wet, firm, becoming moist, hard
- massive
- shale fragments, Fe stains

END OF HOLE

NOTES: - Mobile Model B52 continuous flight auger used, 6" diameter
- sloughing at 16'



GROUND ENGINEERING LTD.

GEOTECHNICAL ENGINEERS/Soil Mechanics & Foundations

PROJECT PROPOSED HOUSING PROJECT
222 - 224 SASKATCHEWAN CRESCENT

LOCATION SASKATOON, SASKATCHEWAN

TEST HOLE LOG

DATE 77/06/07

HOLE NO. 202

SAMPLE DATA	ELEV. COLLAR
WEIGHT HAMMER	ELEV. GROUND 1554.8 City Datum
HEIGHT DROP	CO-ORD. LOCATION

DEPTH ELEV.	NO TYPE		% SO₄
	S57 Bag		
5 50	S58 Bag		
	S59 Bag	6	
10 45			
15 40	S60 Sy		
	S61 Bag		
20 35	S62 S63	Bag Sy	
25 30	S64 Bag		
	S65 Bag		
30 25			

SYMBOL

DESCRIPTION OF MATERIAL

TOPSOIL - clay, silty, organic

2'6"

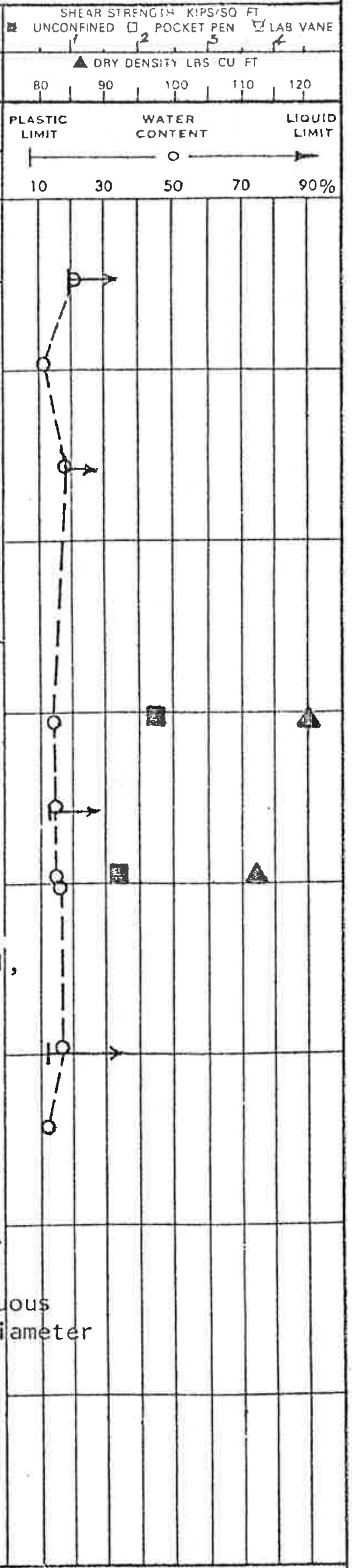
CLAY - very silty, low plasticity
- light olive brown to olive, oxidized
- stratified, laminated, soft, moist
- organic to 10'

13'0"

TILL - clay, silty, frequent fine gravel, low plasticity
- olive brown to dark olive grey, oxidized, becoming very dark grey, unoxidized at 23'
- massive, moist, stiff becoming very stiff
- Fe stains, shale fragments below 23'
- layer of fine, brown gravel, sandy 21'-23', saturated, sloughing

30'0" END OF HOLE

NOTES:
- Mobile Model B52 Continuous Flight Auger used, 6" diameter
- sloughing 21-23', water level at 18' 2 hours after completion



GROUND ENGINEERING LTD.
GEOTECHNICAL ENGINEERS/Soil Mechanics & Foundations

PROJECT PROPOSED HOUSING PROJECT
222 - 224 SASKATCHEWAN CRESCENT

LOCATION SASKATOON, SASKATCHEWAN

TEST HOLE LOG

DATE 77/06/07

HOLE NO. 203

SAMPLE DATA

WEIGHT HAMMER

HEIGHT DROP

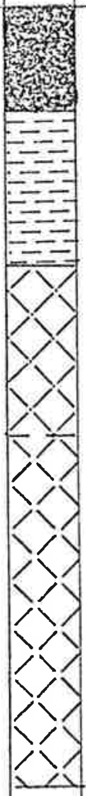
ELEV. COLLAR

ELEV. GROUND 1557.4 City Datum

CO-ORD. LOCATION

DEPTH ELEV.	NO TYPE	UNIF PI	% SO.
	S64		
5 52	S65		
	S66		
10 47	S67		
	S68		
15 42	S69		
	S70		
20 37	S71		

SYMBOL



DESCRIPTION OF MATERIAL

TOPSOIL - clay, silty, organic

2'0"

CLAY - very silty, low plasticity, organic
- stratified, dry, stiff
- dark greyish brown, oxidized

6'6"

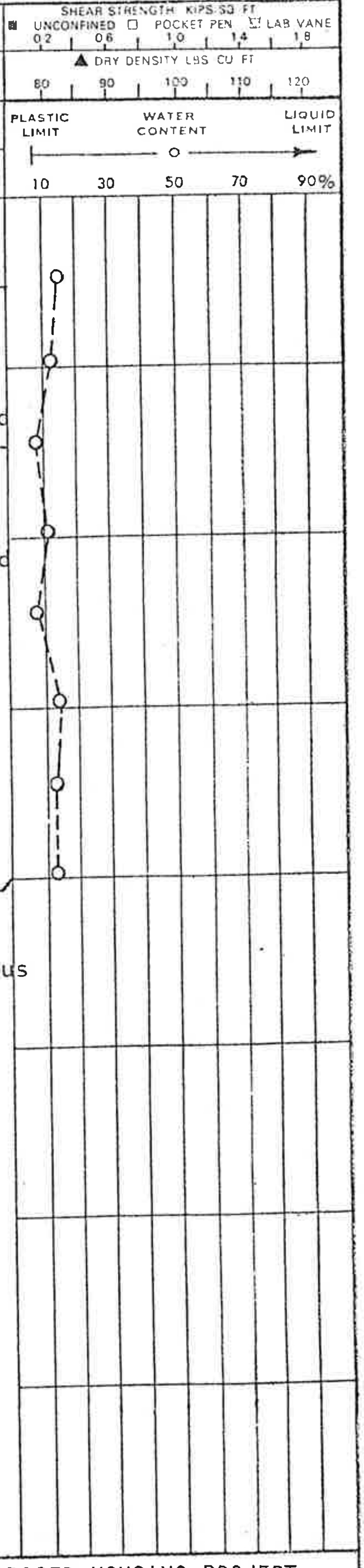
TILL - clay, silty, low plasticity frequent fine gravel
- massive, nuggetty to 9'
- dark greyish brown, oxidized becoming very dark grey, unoxidized at 11'
- dry, stiff
- shale stones from 11', Fe stains, gypsum

11'0"

20'0"

END OF HOLE

NOTES:
- Mobile Model B52 continuous flight auger used, 6" diameter
- hole dry



GROUND ENGINEERING LTD.

GEOTECHNICAL ENGINEERS/Soil Mechanics & Foundations

PROJECT PROPOSED HOUSING PROJECT
222 - 224 SASKATCHEWAN CRESCENT

LOCATION SASKATOON, SASKATCHEWAN

PLATE No. GS-033-20

TEST HOLE LOG

DATE 77/06/07

HOLE NO. 204

SAMPLE DATA

WEIGHT HAMMER

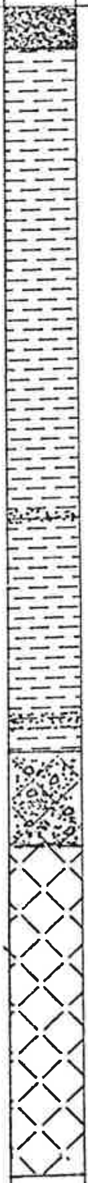
HEIGHT DROP

ELEV. COLLAR

ELEV. GROUND 1553.5 City Datum

CO-ORD. LOCATION

DEPTH ELEV.	NO TYPE	UNIF PI	% SO₄
	S76		
5 49	S77		
	S78		
10 44	S79		
	S80		
15 39	S81		
	S82		
20 34	S83		
25 29	S84		
	S85		
30 24	S86		



DESCRIPTION OF MATERIAL

1'0" TOPSOIL - clay, organic

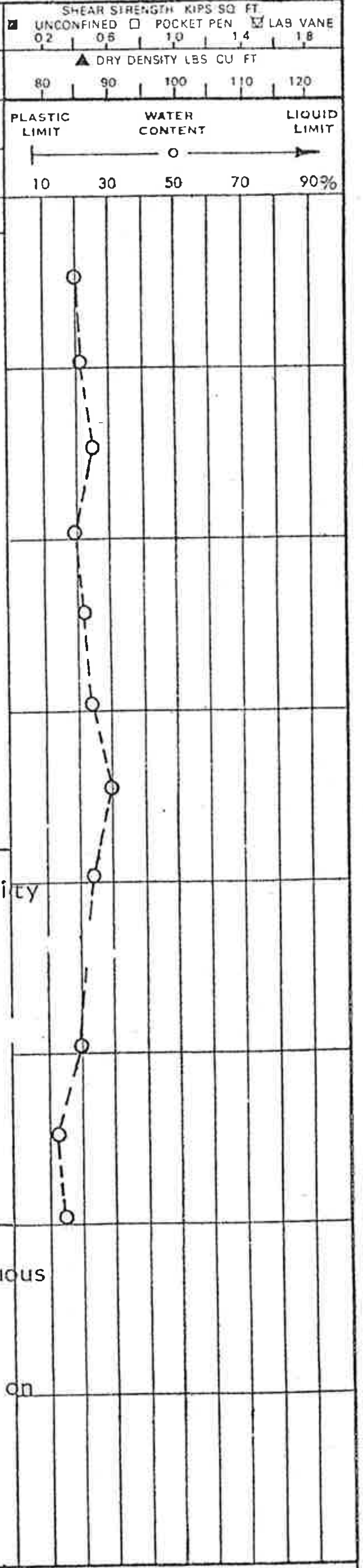
CLAY - very silty, moist
- sand layer at 13'; silty
- water bearing sand layer @ 18', sloughing
- olive grey, oxidized

19'0"

TILL - clayey, silty, low plasticity frequent gravel.
- 19 - 21½' gravel, fine, silty, water bearing
- very dark grey, unoxidized
- moist, stiff, massive

30'0" END OF HOLE

NOTES:
- Mobile Model B52 Continuous flight auger used, 6" diameter
- sloughing to 17', water level at 16' on completion



GROUND ENGINEERING LTD.
GEOTECHNICAL ENGINEERS/Soil Mechanics & Foundations

PROJECT PROPOSED HOUSING PROJECT
222-224 SASKATCHEWAN CRESCENT

LOCATION SASKATOON, Saskatchewan

GS-033-21

HISTORICAL BOREHOLE LOGS
TH 301 (PMEL81)

P. Machibroda Engineering Ltd. June 17, 1981. Geotechnical Investigation Proposed Apartment Building Saskatchewan Crescent, Saskatoon, Saskatchewan

TEST HOLE 301

ELEV. 476.9 m (CITY DATUM)

SO4	U	γD	Pw	Lw	w
					28.2
		1674	28.4	14.9	11.9
			25.6	14.4	10.1
	205	1813			9.6
					8.3
	404	1889			9.5
			49.5	21.1	17.0
	448	1779			14.1
			38.1	17.2	14.2
	603	1818			10.6
					13.8

ASPHALT

GRAVEL BASE

FILL, CLAYEY, SILTY, GRAVEL, BROWN, MOIST, ORGANICS THROUGHOUT

TOPSOIL, REWORKED, ORGANICS, CLAYEY, SANDY, MOIST, BLACK, WOOD FRAGMENTS

CLAY, MOIST, STIFF, LOW PLASTIC, LIGHT BROWN, TRACES OF SILT

GLACIAL TILL, CLAYEY, SILTY, SANDY, GRAVEL SIZES, MOIST, VERY STIFF, LOW PLASTIC, MOTTED BROWN, OXIDE STAINS
- HARD AND FRACTURED BELOW 3.0 m
- COBBLES @ 3.4 m
- SAND LENSE @ 3.9 m
- GREY BELOW 5.2 m
- SAND LENSE @ 6.1 m
- GYPSUM CRYSTALS BELOW 7.3 m
- COBBLES @ 9.2 m

LEGEND:

TOPSOIL | GRAVEL | SAND | SILT | CLAY | GLACIAL TILL

COMBINATION OF ABOVE SHOWN WITH PREDOMINANT SOIL TYPE IN HEAVY LINE AND MODIFYING SOIL TYPE IN LIGHT LINE.

γD ..... DRY DENSITY (kg/m³)
w ..... WATER CONTENT (PERCENT OF DRY SOIL WT)
Lw ..... LIQUID LIMIT
Pw ..... PLASTIC LIMIT
U ..... UNCONFINED COMPRESSIVE STRENGTH (k Pa)
SO4 ..... SULPHATE CONTENT (PERCENT OF DRY SOIL)
TR ..... TRACE
* ..... SULPHATE CONTENT WATER SAMPLE (PPM)
▼ ..... RECORDED WATER LEVEL
N ..... NUMBER OF BLOWS TO ADVANCE A 51 mm O.D. SPLIT SAMPLER 30 cm INTO THE SOIL USING A 63.5 kg HAMMER DROPPING FREELY A DISTANCE OF 76 cm (475 J PER BLOW).

LIMITATIONS:

THE FIELD DRILL LOG IS A SUMMARY OF FIELD CONDITIONS ENCOUNTERED AT A SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDTIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THE SPECIFIC LOCATION OF ANY TEST HOLE.

P. MACHIBRODA ENGINEERING LTD.

CONSULTING ENGINEERS

2331 MILLAR AVENUE
SASKATOON, SASK.

FIELD DRILL LOGS AND SOIL TEST RESULTS

PROJECT:
PROPOSED APARTMENT BUILDING
SASKATOON, SASKATCHEWAN

LOCATION:
200 BLOCK SASKATCHEWAN CRES.
SASKATOON, SASKATCHEWAN

SCALE: 1:50

DATE: JUNE 17, 1981

DRAWING NUMBER: S81-335-2

HISTORICAL BOREHOLE LOGS
TH 101, TH102, TH 103, TH 104, TH 105, TH 106, TH 107, P201, P202
(CLIF83)

Clifton Associates Ltd. Aug. 17, 1983. Geotechnical Studies Proposed Park Terrace Condominiums 222 Saskatchewan Crescent East Saskatoon, SK.

TEST HOLE LOG

DATE 83/07/28
DRILL Brat 22
LOGGED BY Dave Williamson

GROUND ELEV. 486.36 m (Geodetic)
LOCATION

TEST HOLE NO. **101**

DEPTH m | **SYMBOL** | **DESCRIPTION OF MATERIALS** | **SAMPLE** | **USC**

CLAY - silty
- some sand
- olive (5y5/3), oxidized
- very moist, soft
- disturbed (Fill)
- organic

1.5 m

CLAY - medium to highly plastic, silty
- olive (5y4/3), oxidized
- very moist, firm
- salt stains

2.2 m

TILL - medium plastic silty clay matrix
- olive (5y5/3), oxidized, very grey (5y3/1), unoxidized below 3.5 m
- very moist, firm to stiff
- Fe stains
- highly plastic disturbed clay lamination from 2.25 to 2.3 m
- saturated coarse gravel layer at 5.7 m

5.7 m

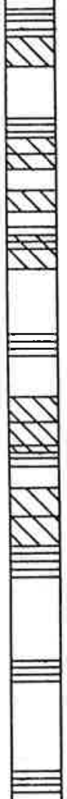
6.0 m E.O.H.

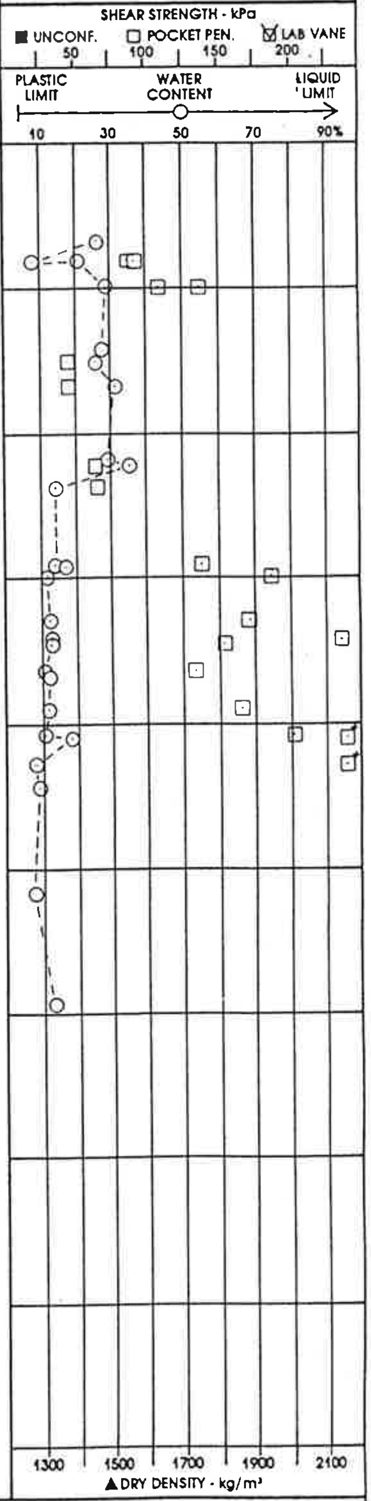
1
2
3
4
5
6

NOTES:

1). Drilled using 125 mm diameter solid stem augers.

2). Piezometer installed.





Clifton Associates Ltd.
CONSULTING GEOTECHNICAL ENGINEERS
REGINA SASKATOON

PROJECT PARK TERRACE CONDOMINIUMS
LOCATION Saskatoon, Saskatchewan
PROJECT NO. S145 **PAGE NO.**

TEST HOLE LOG

DATE 83/07/28

DRILL Brat 22

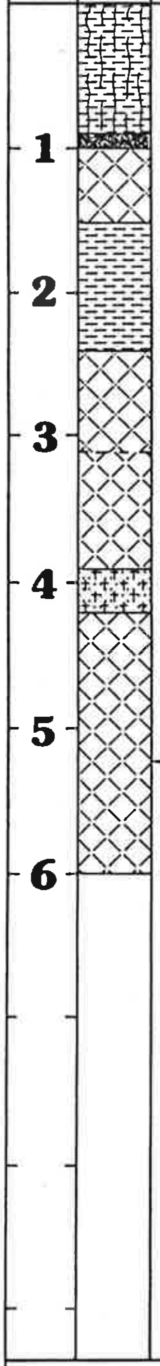
LOGGED BY Dave Williamson

GROUND ELEV. 485.57 m (Geodetic)

LOCATION

TEST HOLE NO. **102**

DEPTH m	SYMBOL	DESCRIPTION OF MATERIALS		SAMPLE	USC



CLAY - silty
- black (10YR2/1)
- very moist, very soft
- organics
- disturbed (Fill)

0.9 m TOPSOIL

1.0 m TILL - silty, sandy clay matrix
- olive grey (5y4/2), oxidized
- very moist, Fe stains

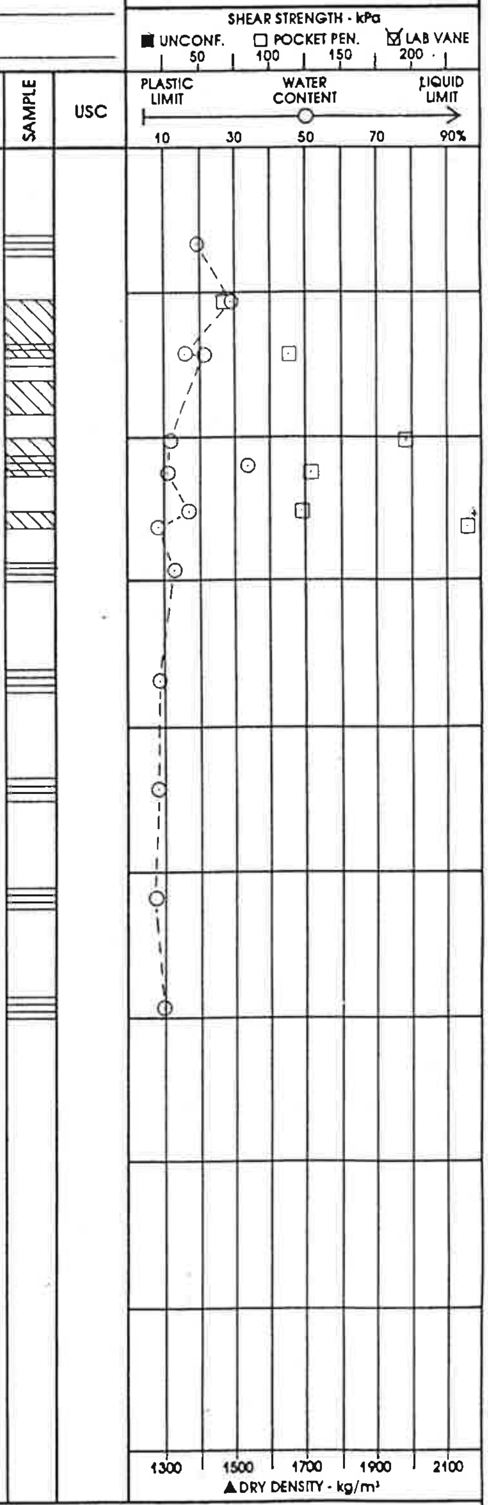
1.5 m CLAY - highly plastic
- olive (5y5/3), oxidized
- very moist, firm
- laminated, slickensided
- trace organics

2.4 m TILL - medium plastic, silty clay matrix
- dark greyish brown (2.5y4/2), oxidized becoming dark grey (5y4/1), unoxidized below 3.1 m
- stiff becoming very stiff and brittle below 3.1 m
- saturated sandy silt layer from 3.9 to 4.2 m

6.0 m E.O.H.

NOTES:

1). Drilled using 125 mm diameter solid stem continuous flight augers.
2). Bore hole sloughed to 5.1 m and water level measured 3.6 m, 3.5 hours after completion.
3). Piezometer installed.



Clifton Associates Ltd.

CONSULTING GEOTECHNICAL ENGINEERS

REGINA SASKATOON

PROJECT PARK TERRACE CONDOMINIUMS

LOCATION Saskatoon, Saskatchewan

PROJECT NO. S145 PAGE NO.

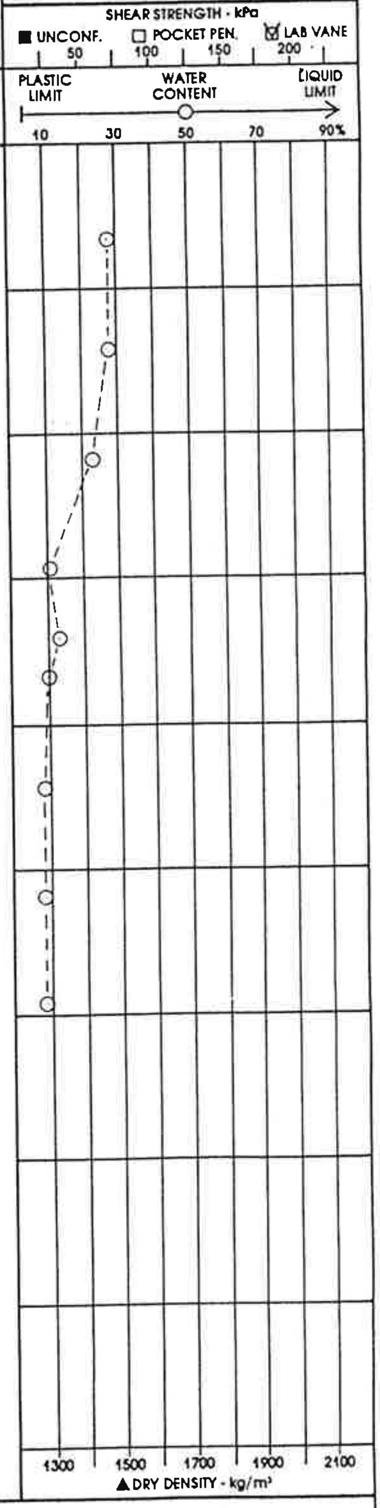
TEST HOLE LOG

DATE 83/07/28
DRILL Brat 22
LOGGED BY Dave Williamson

GROUND ELEV. 484.84 m (Geodetic)
LOCATION

TEST HOLE NO. 103

DEPTH m	DESCRIPTION OF MATERIALS
	CLAY - silty - olive gray (5y5/2), oxidized - very moist, soft - organics - disturbed (Fill)
1.5 m	CLAY - medium plastic - silty - olive (5y5/3), oxidized - moist, firm - laminated, Fe stains
2.3 m	TILL - low plastic, sandy silty clay matrix - light olive brown (2.5y5/4), oxidized - damp, stiff - heavy Fe stains
3.1 m	SAND - fine grained, silty, occasional pebbles - yellowish brown (10YR5/6), oxidized - Fe stains
3.6 m	TILL - medium plastic, sandy clay matrix - olive grey (5y4/2), oxidized becoming very dark grey (5y3/1), unoxidized below 4.0 m - heavy Fe stains - saturated sand seams below 5.25 m
6.0 m	E.O.H.



NOTES:

1). Drilled using 125 mm diameter solid stem continuous flight augers.

Clifton Associates Ltd.
CONSULTING GEOTECHNICAL ENGINEERS
REGINA SASKATOON

PROJECT PARK TERRACE CONDOMINIUMS
LOCATION Saskatoon, Saskatchewan
PROJECT NO. S145 **PAGE NO.**

TEST HOLE LOG

DATE 83/07/28

DRILL Brat 22

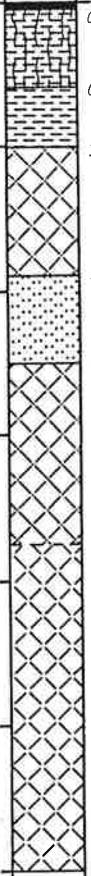
LOGGED BY Dave Williamson

GROUND ELEV. 483.62 (Geodetic)

LOCATION

TEST HOLE NO. 104

DEPTH m	SYMBOL	DESCRIPTION OF MATERIALS	SAMPLE	USC



0.05 m ASPHALT, TOPSOIL, AND GRAVEL

FILL

0.6 m

CLAY - medium plastic, silty, laminated
- olive (5y5/3), oxidized
- very moist, soft to firm, Fe and salt stains

1.0 m

TILL - medium plastic, silty clay matrix
- olive (5y5/3), oxidized
- moist, firm
- heavy Fe stains
- salts

1.9 m

SAND - fine grained, silty
- olive yellow (2.5y6/6), oxidized
- moist
- Fe stains

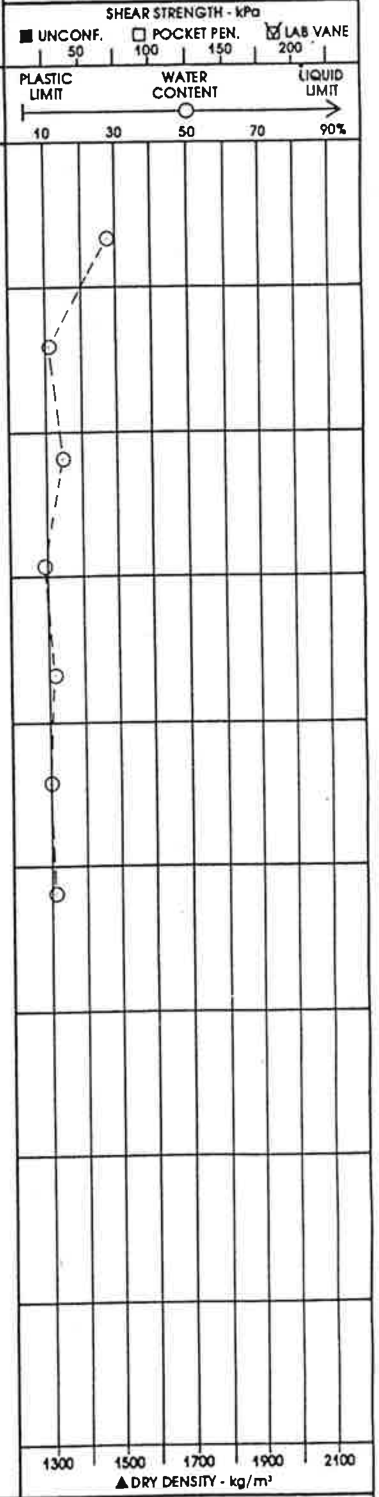
2.5 m

TILL - medium plastic, silty clay matrix
- olive brown (2.5y4/4), oxidized, becoming dark grey (5y4/1), unoxidized below 3.75 m
- moist, stiff
- becomes stiffer with depth

6.0 m E.O.H.

NOTES:

1). Drilled using 125 mm diameter continuous flight augers.



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CONSULTING GEOTECHNICAL ENGINEERS

REGINA SASKATOON

PROJECT PARK TERRACE CONDOMINIUMS

LOCATION Saskatoon, Saskatchewan

PROJECT NO. S145 PAGE NO.

TEST HOLE LOG

DATE 83/07/28

DRILL Brat 22

LOGGED BY Dave Williamson

GROUND ELEV. 480.82 m (Geodetic)

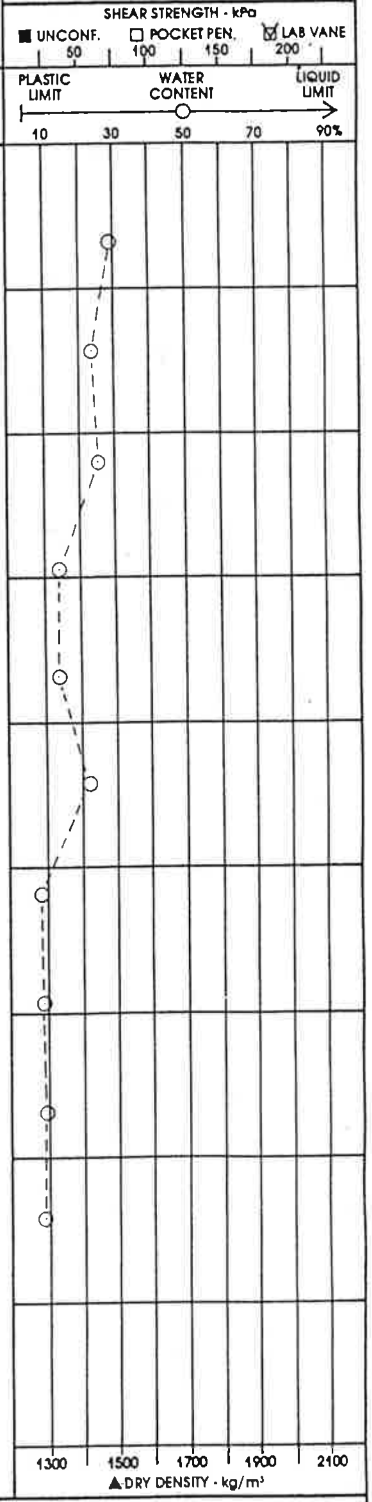
LOCATION

TEST HOLE NO. 105

DEPTH m	DESCRIPTION OF MATERIALS
	SILT - with organics - black (10YR2/1), oxidized - moist, firm - wood chips - disturbed (Fill)
1.6 m	CLAY - medium plastic, silty - dark greyish brown (2.5y4/2), oxidized - very moist, firm - laminated - Fe stains - trace organics - with silt and sand below 3.2 m
3.5 m	TILL - medium plastic silty clay matrix - light olive brown (2.5y5/4), oxidized - moist, firm becoming stiffer with depth - Fe stains
4.5 m	SAND - medium grained, silty - dark yellowish brown (10YR4/4), oxidized - moist - heavy Fe stains - occasional till lumps
5.4 m	TILL - medium plastic silty clay matrix - olive brown (2.5y4/4), oxidized, becoming dark olive grey (5y3/2), unoxidized below 6.3 m - damp, very stiff - brittle - heavy Fe stains
7.5 m	E.O.H.

NOTES:

1). Drilled using 125 mm diameter solid stem continuous flight augers.



Clifton Associates Ltd.

CONSULTING GEOTECHNICAL ENGINEERS

REGINA SASKATOON

PROJECT PARK TERRACE CONDOMINIUMS

LOCATION Saskatoon, Saskatchewan

PROJECT NO. S145 **PAGE NO.**

TEST HOLE LOG

DATE 83/07/28

DRILL Brat 22

LOGGED BY Dave Williamson

GROUND ELEV. 481.95 m (Geodetic)

LOCATION

TEST HOLE NO. 106

DEPTH m | **SYMBOL** | **DESCRIPTION OF MATERIALS** | **SAMPLE** | **USC**

CLAY - silty, with organics
- black (10YR2/1), oxidized
- moist
- disturbed (Fill)

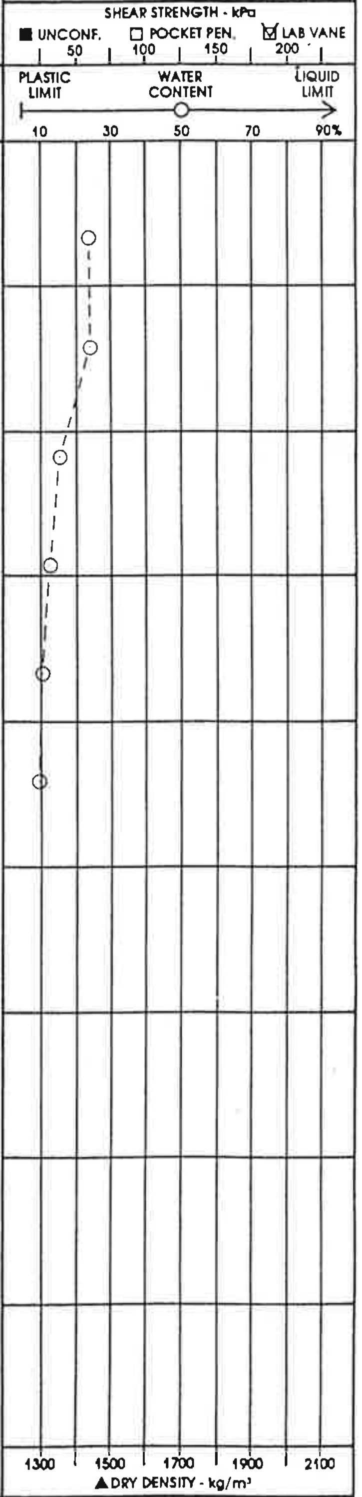
1.4 m

TILL - medium plastic silty sandy clay matrix
- light olive brown (2.5y5/4), oxidized
- becoming olive brown (2.5y4/4), with depth
- moist
- stiff to very stiff
- brittle
- heavy Fe stains

4.5 m E.O.H.

NOTES:

1). Drilled using 125 mm diameter continuous flight, solid stem augers.



Clifton Associates Ltd.

CONSULTING GEOTECHNICAL ENGINEERS

REGINA SASKATOON

PROJECT PARK TERRACE CONDOMINIUMS

LOCATION Saskatoon, Saskatchewan

PROJECT NO. S145 **PAGE NO.**

TEST HOLE LOG

DATE 83/07/28

DRILL Brat 22

LOGGED BY Dave Williamson

GROUND ELEV. 497.254 m (Geodetic)

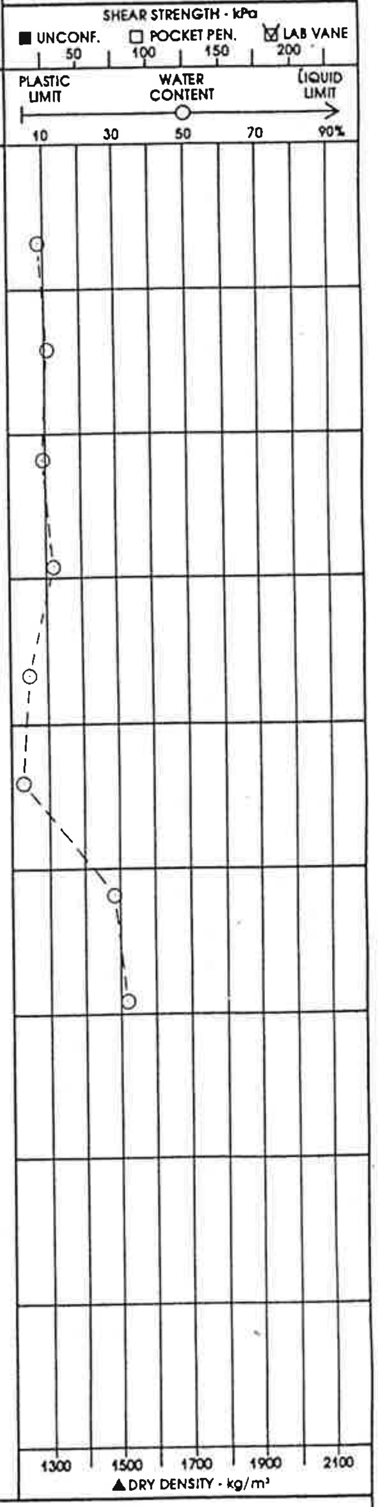
LOCATION

TEST HOLE NO. 107

DEPTH m	SYMBOL	DESCRIPTION OF MATERIALS		SAMPLE	USC
		0.1 m TOPSOIL			
1 2 3		SILT - with silty clay lumps and fine sand - dark brown (10YR3/3), oxidized, becoming light grey (2.5y7/2) below 0.8 m - heavy organics to 0.8 m - damp			
4		3.9 m SAND - fine grained, silty - light yellowish brown (2.5y6/4), oxidized - damp			
5		4.8 m CLAY - highly plastic - olive (5y4/3), oxidized - moist, stiff - laminated - organic odour - Fe stains			
6		6.0 m E.O.H.			

NOTES:

1). Drilled using 125 mm diameter, continuous flight, solid stem augers.



Clifton Associates Ltd.

CONSULTING GEOTECHNICAL ENGINEERS

REGINA SASKATOON

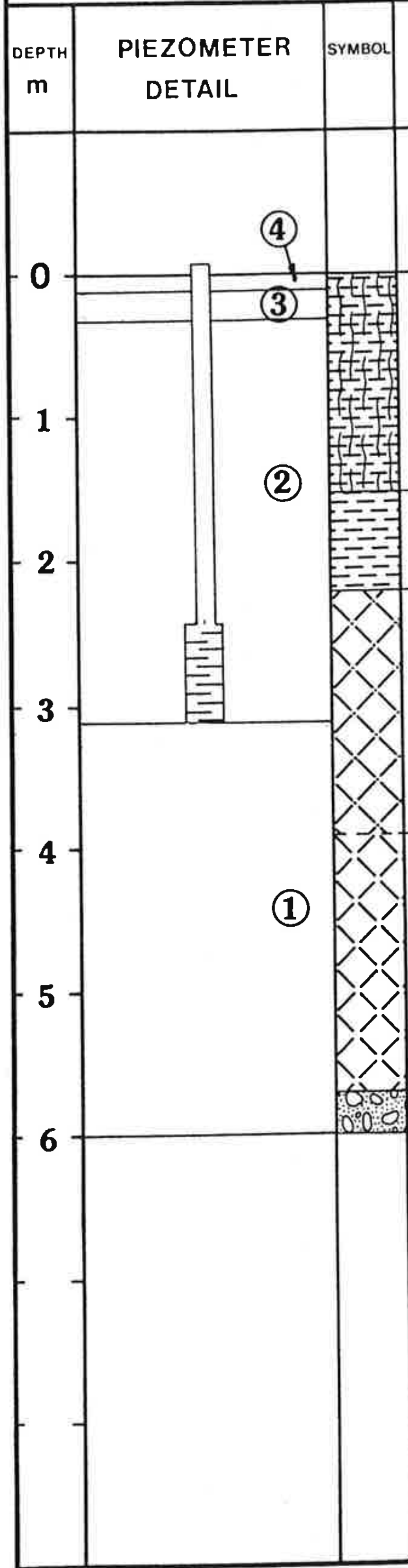
PROJECT PARK TERRACE CONDOMINIUMS

LOCATION Saskatoon, Saskatchewan

PROJECT NO. S145 PAGE NO.

PIEZOMETER CONSTRUCTION DETAILS

PIEZOMETER NO. P101
TEST HOLE NO. 101



SOIL DESCRIPTION	ELEV. m
	486.44
CLAY - fill - silty	486.36
CLAY - medium to highly plastic	
TILL - oxidized	483.90
	483.26
- unoxidized	
GRAVEL	480.36

LOCATION

TOP PIPE ELEV. 486.44
GROUND ELEV. 486.36
BASE SCREEN ELEV. 483.05
PIPE TYPE 38 mm PVC Schedule 80
SCREEN 51 mm PVC Johnson 10 slot
TEST HOLE DIA. 125 mm
INST. DATE July 28, 1983
TECHNICIAN D.W. Williamson
CONTRACTOR Anderson Drilling
DRILL Brat 22 Continuous Flight

DATE	WATER TIME	LEVELS DEPTH-m	ELEV.-m
UPON COMPLETION			
83/07/28	1545	----	----
ADDITIONAL READINGS			
83/08/02	0915	2.04	484.40
83/08/09	1355	2.13	484.31

REMARKS Construction Materials
1. Auger Cuttings
2. 12-20 Silica Sand
3. Bentonite Pellets
4. Auger Cuttings

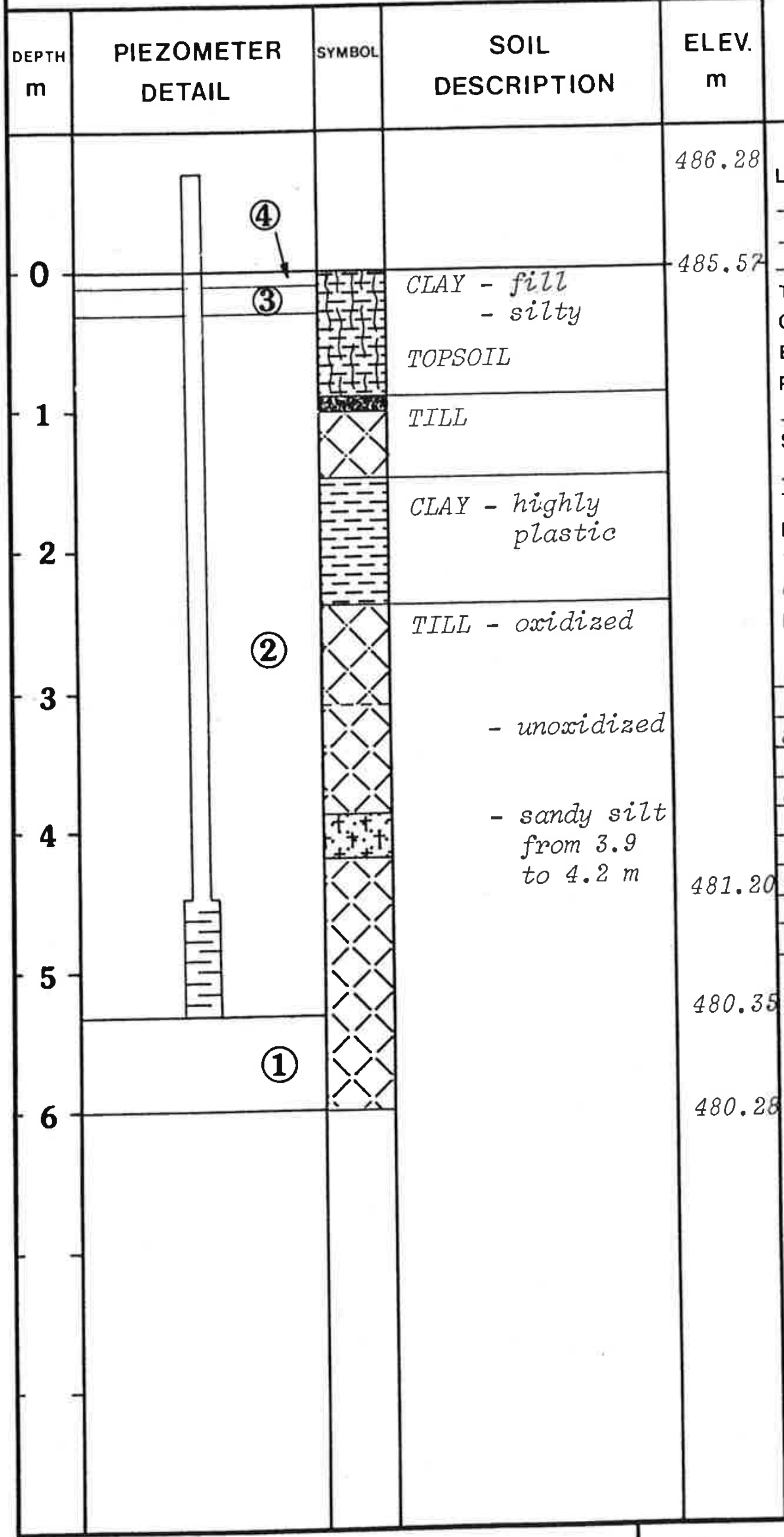
All elevations referenced to Geodetic Datum.

DRAWN BY GJB
APPROVED BY

Clifton Associates Ltd.
CONSULTING GEOTECHNICAL ENGINEERS
REGINA SASKATOON

CLIENT Starport Investments Ltd.
PROJECT Park Terrace Condominiums
LOCATION Saskatoon, Saskatchewan
DATE 83/08/09 PROJECT NO. S145

PIEZOMETER CONSTRUCTION DETAILS



PIEZOMETER NO. P102
TEST HOLE NO. 102

LOCATION

TOP PIPE ELEV. 486.28 m
GROUND ELEV. 485.57 m
BASE SCREEN ELEV. 480.35 m
PIPE TYPE 38 mm PVC Schedule 80
SCREEN 51 mm PVC Johnson 10 slot
TEST HOLE DIA. 125 mm
INST. DATE July 28, 1983
TECHNICIAN D. W. Williamson
CONTRACTOR Anderson Drilling
DRILL Brat 22 Continuous Flight

WATER LEVELS

DATE	TIME	DEPTH-m	ELEV.-m
UPON COMPLETION			
83/07/28	1800	3.37	482.91
ADDITIONAL READINGS			
83/08/02	0920	3.60	482.68
83/08/09	1350	3.63	482.65

REMARKS Construction Materials
1. Auger Cuttings
2. 12-20 Silica Sand
3. Bentonite Pellets
4. Auger Cuttings

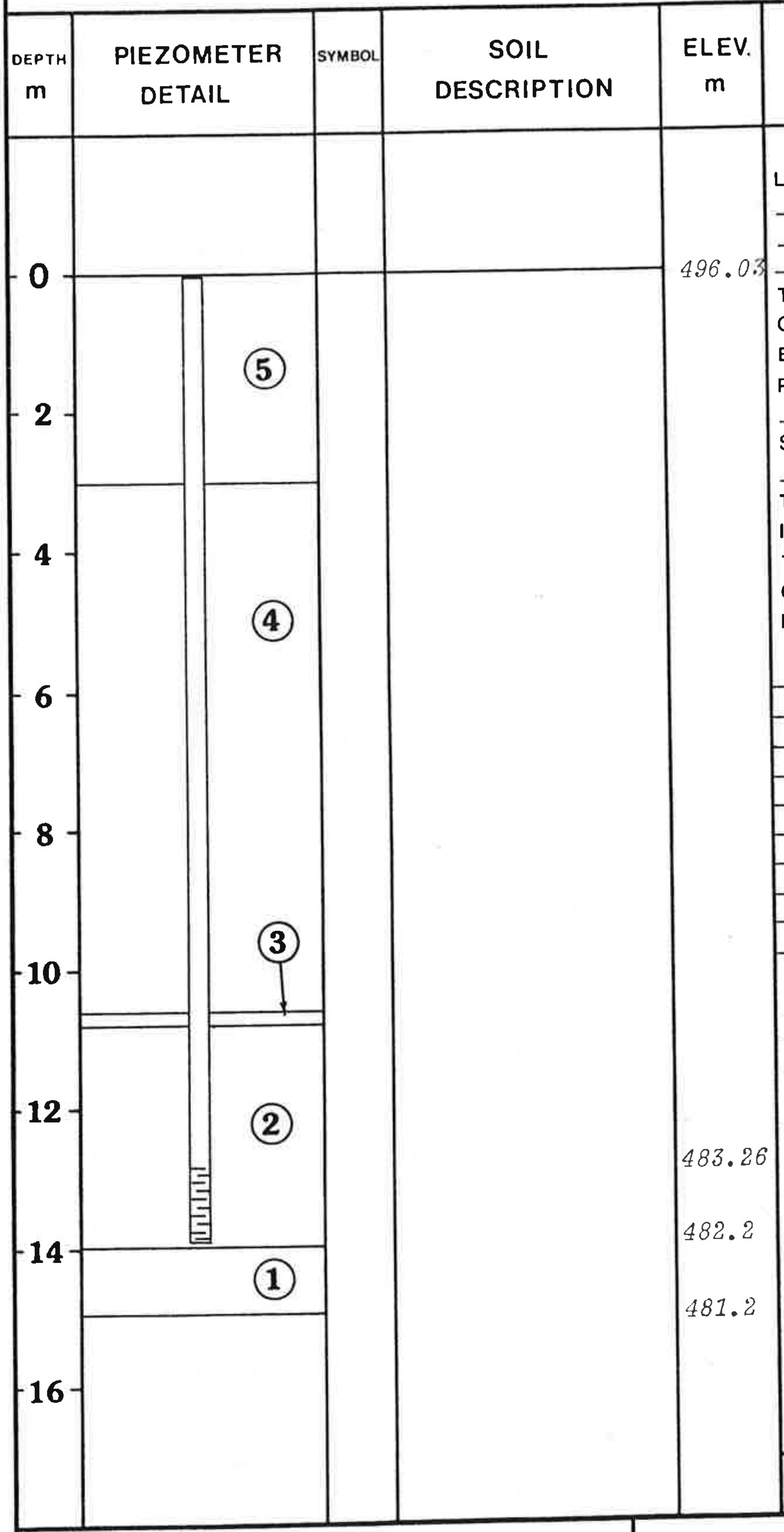
All elevations referenced to Geodetic Datum

DRAWN BY GJB
APPROVED BY

Clifton Associates Ltd.
CONSULTING GEOTECHNICAL ENGINEERS
REGINA SASKATOON

CLIENT Starport Investments Ltd.
PROJECT Park Terrace Condominiums
LOCATION Saskatoon, Saskatchewan
DATE 83/08/09 PROJECT NO. S145

PIEZOMETER CONSTRUCTION DETAILS



PIEZOMETER NO. P202

TEST HOLE NO.

LOCATION

TOP PIPE ELEV. 496.03 m

GROUND ELEV. 496.10 m

BASE SCREEN ELEV. 482.20 m

PIPE TYPE 51 mm PVC Schedule 80

SCREEN 51 mm PVC slotted with circular saw

TEST HOLE DIA. 410 mm

INST. DATE July 22, 1983

TECHNICIAN Gerry J. Berube

CONTRACTOR

DRILL

WATER LEVELS

DATE	TIME	DEPTH-m	ELEV.-m
UPON COMPLETION			
ADDITIONAL READINGS			
83/07/25	1025	11.61	484.42
83/08/09	1605	11.83	484.20

REMARKS

Construction Materials
1. Natural slough
2. Concrete sand
3. Bentonite pellets
4. Sand bentonite (10% Bentonite) mixture
5. Cuttings

Water depths referenced to top of pipe.

Screen wrapped with filter cloth.

DRAWN BY GJB

APPROVED BY

Clifton Associates Ltd.
CONSULTING GEOTECHNICAL ENGINEERS
REGINA SASKATOON

CLIENT Starport Investments Ltd.

PROJECT PARK TERRACE CONDOMINIUMS

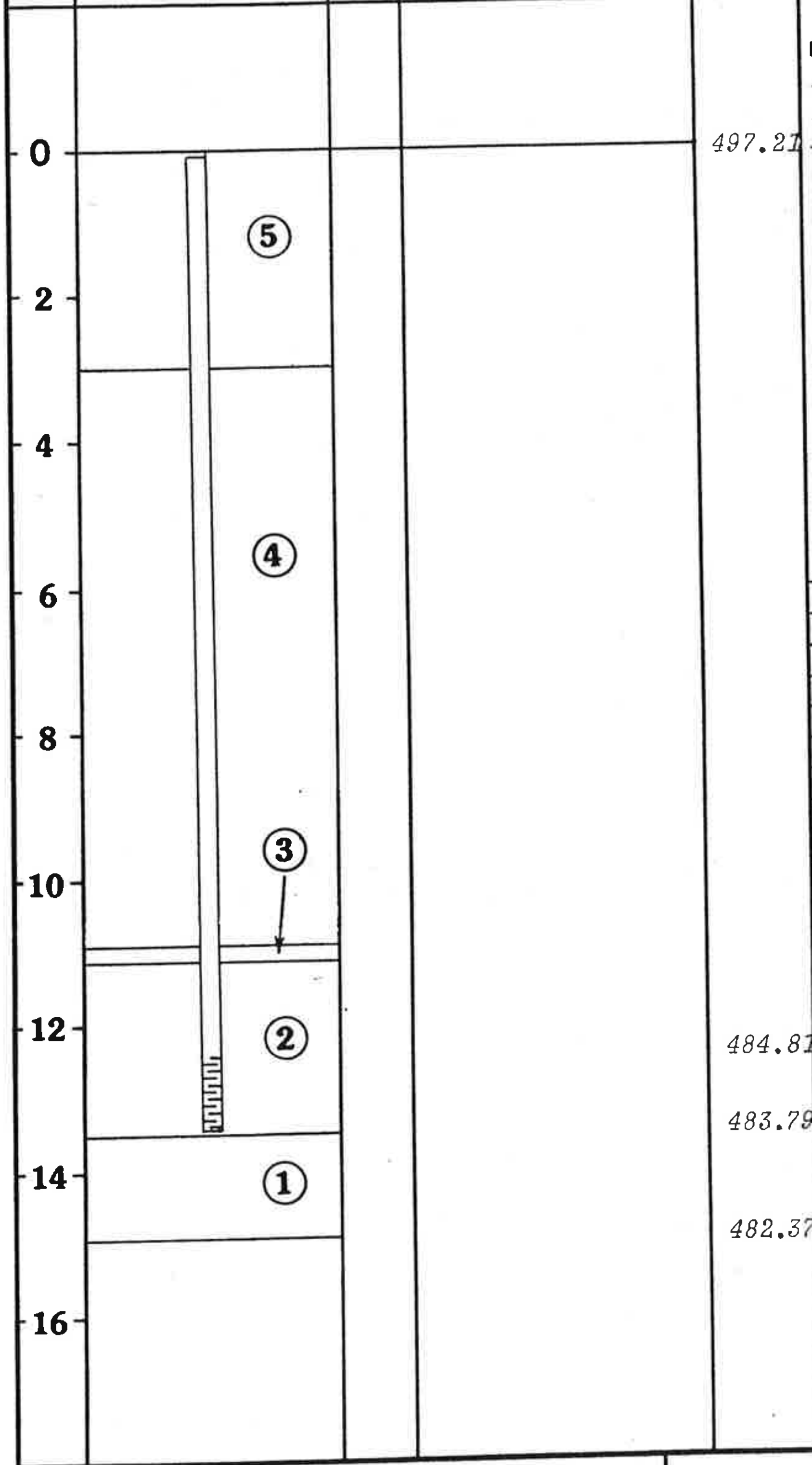
LOCATION Saskatoon, Saskatchewan

DATE 83/07/25

PROJECT NO. S145

PIEZOMETER CONSTRUCTION DETAILS

DEPTH m	PIEZOMETER DETAIL	SYMBOL	SOIL DESCRIPTION	ELEV. m



PIEZOMETER NO. **P201**
TEST HOLE NO.

LOCATION 237 - 11th Street East

TOP PIPE ELEV. 497.21 m
GROUND ELEV. 497.27 m
BASE SCREEN ELEV. 483.79 m
PIPE TYPE 51 mm PVC Schedule 80

SCREEN 51 mm PVC slotted with circular saw
TEST HOLE DIA. 410 mm
INST. DATE July 22, 1983
TECHNICIAN Gerry Berube
CONTRACTOR
DRILL

	WATER LEVELS		
DATE	TIME	DEPTH-m	ELEV.-m
UPON COMPLETION			
ADDITIONAL READINGS			
83/07/25	1020	11.63	485.58
83/08/09	1610	11.65	485.56

REMARKS
Construction Materials
1. Natural slough
2. Concrete Sand
3. Bentonite Pellets
4. Sand Bentonite (10% Bentonite) mixture
5. Cuttings

Water depths referenced to top of pipe.

Screen wrapped with filter cloth.

DRAWN BY GJB
APPROVED BY

Clifton Associates Ltd.
CONSULTING GEOTECHNICAL ENGINEERS
REGINA SASKATOON

CLIENT Starport Investments Ltd.
PROJECT PARK TERRACE CONDOMINIUMS
LOCATION Saskatoon, Saskatchewan
DATE 83/07/25 PROJECT NO. S145

HISTORICAL BOREHOLE LOGS
SI1, SI2, SI3, P801G, P802G, P803G (GAL85)

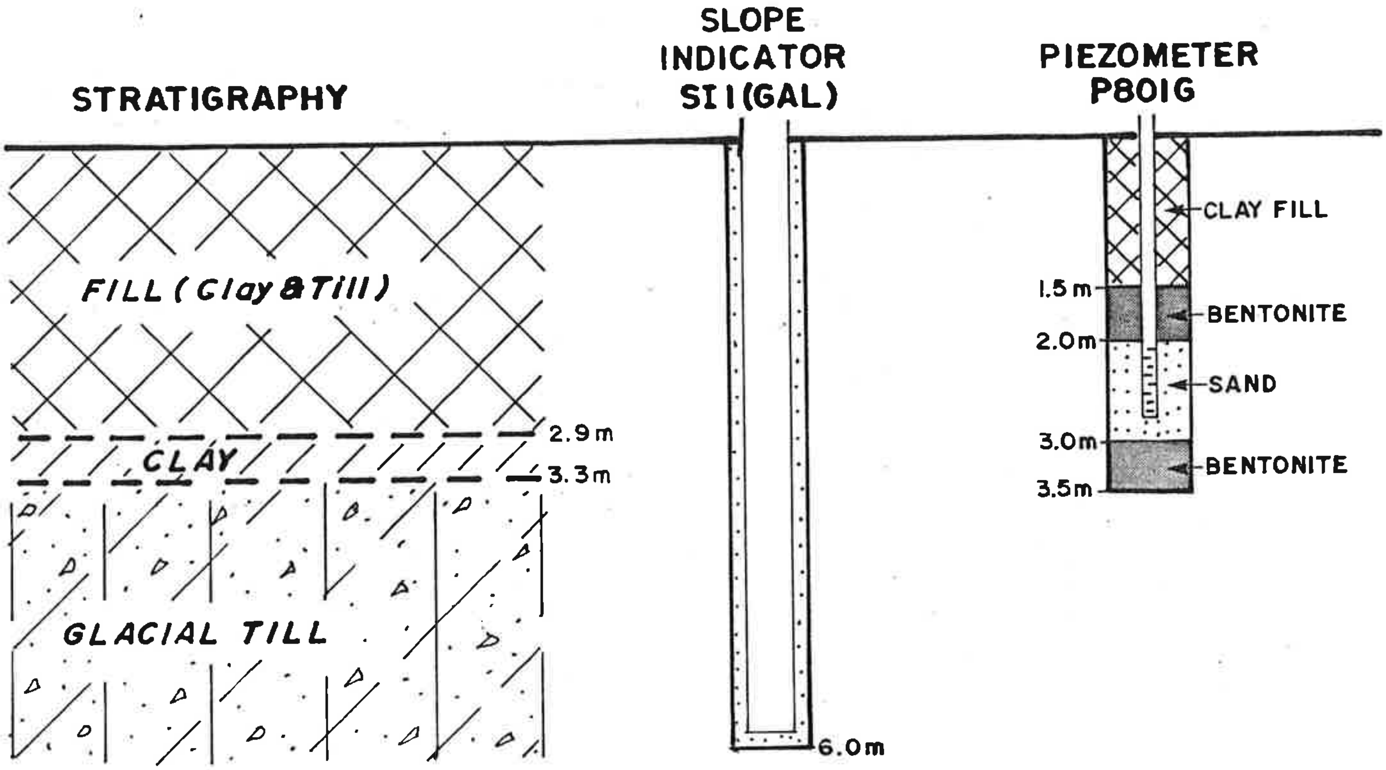
Golder Associates Ltd. May 1985. Progress Report No. 1 Slope Monitoring Program, Park Terrace Condominiums, 222 Saskatchewan Crescent East, Saskatoon, Saskatchewan

INSTRUMENTATION NEST NO. 1
SLOPE MONITORING PROGRAM

PARK TERRACE CONDOMINIUMS SASKATOON, SASK.

FIGURE **SM 1**

LOCATION – IN CHERRY LANE NEAR EAST PROPERTY LINE. (SEE LOCATION PLAN.)



SCALE – 1 : 75

DATE OF INSTALLATION

SLOPE INDICATOR SI 1 – APRIL 2, 1985.
PIEZOMETER P801G – MAY 7, 1985.

Date MAY 16 /85.
Project 852-6010

Golder Associates

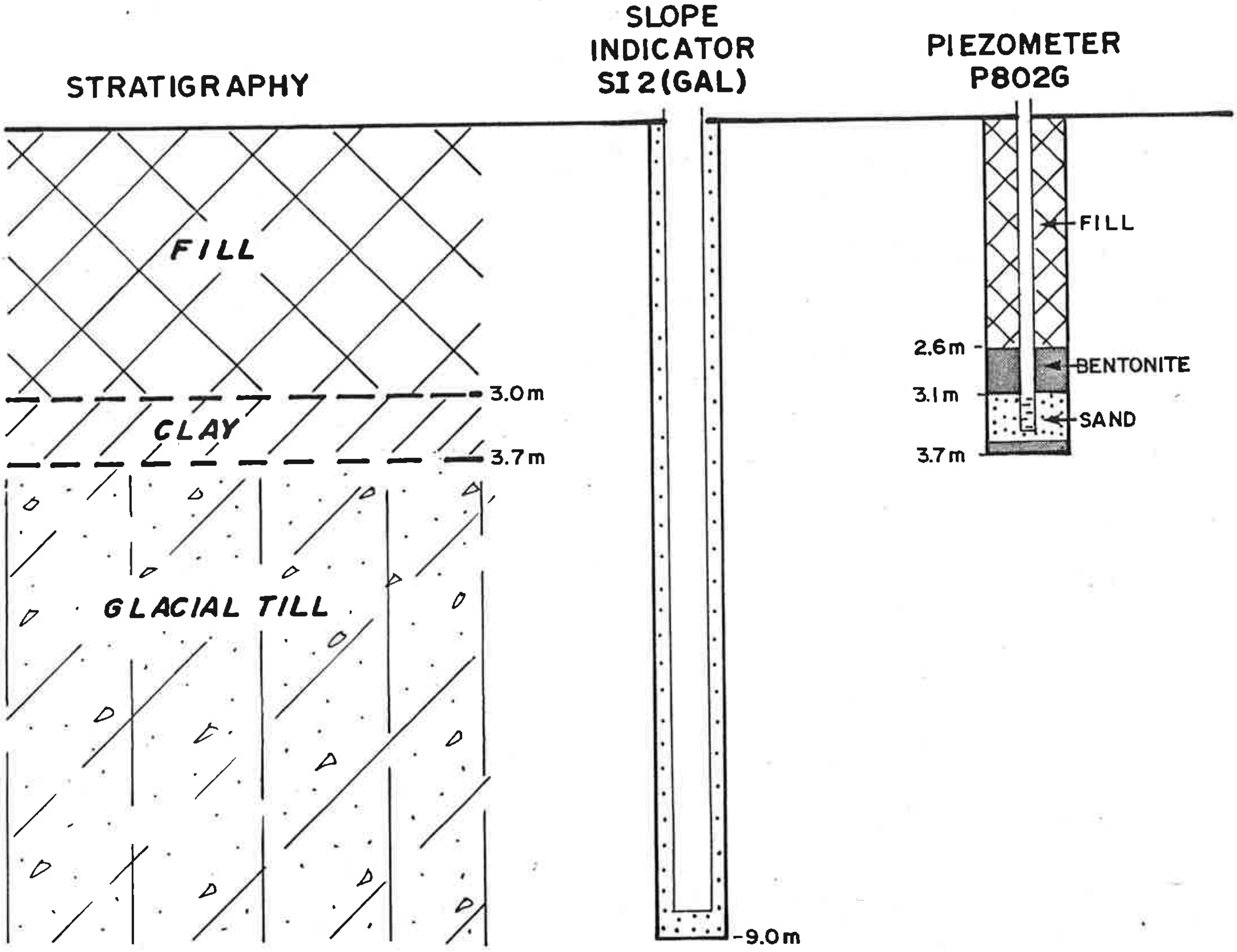
Drawn N.E.
Chkd

INSTRUMENTATION NEST NO. 2
SLOPE MONITORING PROGRAM

PARK TERRACE CONDOMINIUMS
SASKATOON, SASK.

FIGURE **SM 2**

LOCATION – CHERRY LANE NEAR WEST PROPERTY LINE (SEE LOCATION PLAN.)



SCALE – 1 : 75

DATE OF INSTALLATION

SLOPE INDICATOR SI 2 – APRIL 2, 1985.
PIEZOMETER P802G – MAY 7, 1985.

Date MAY 21/85.
Project 852-6010

Golder Associates

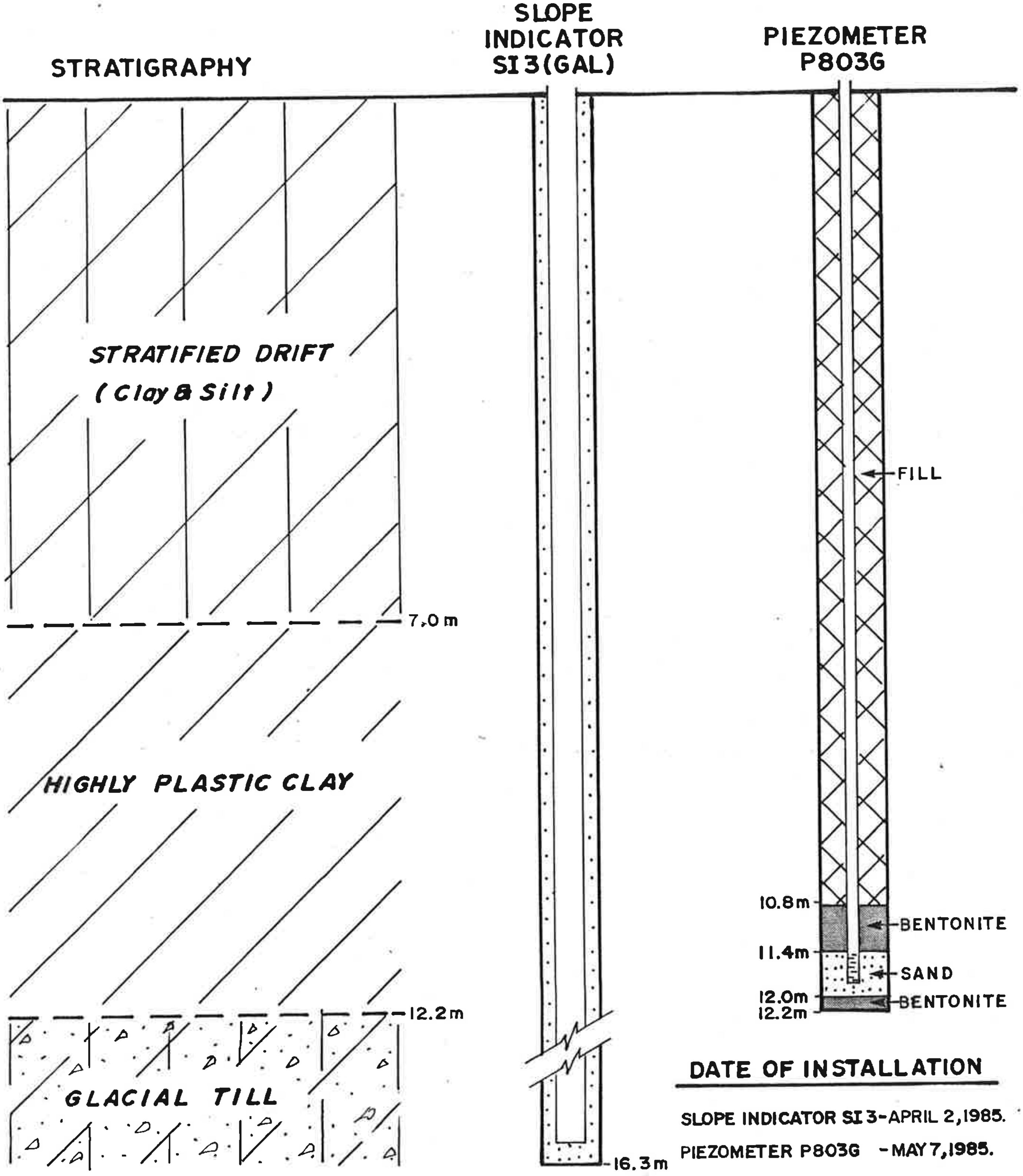
Drawn N.E.
Chkd

INSTRUMENTATION NEST NO. 3
SLOPE MONITORING PROGRAM

PARK TERRACE CONDOMINIUMS SASKATOON, SASK.

FIGURE **SM 3**

LOCATION – TOP OF SLOPE NEAR ELEVENTH STREET.



DATE OF INSTALLATION

SLOPE INDICATOR SI 3 - APRIL 2, 1985.

PIEZOMETER P803G - MAY 7, 1985.

SCALE – 1 : 75

Date MAY. 21/85

Project 852-6010

Golder Associates

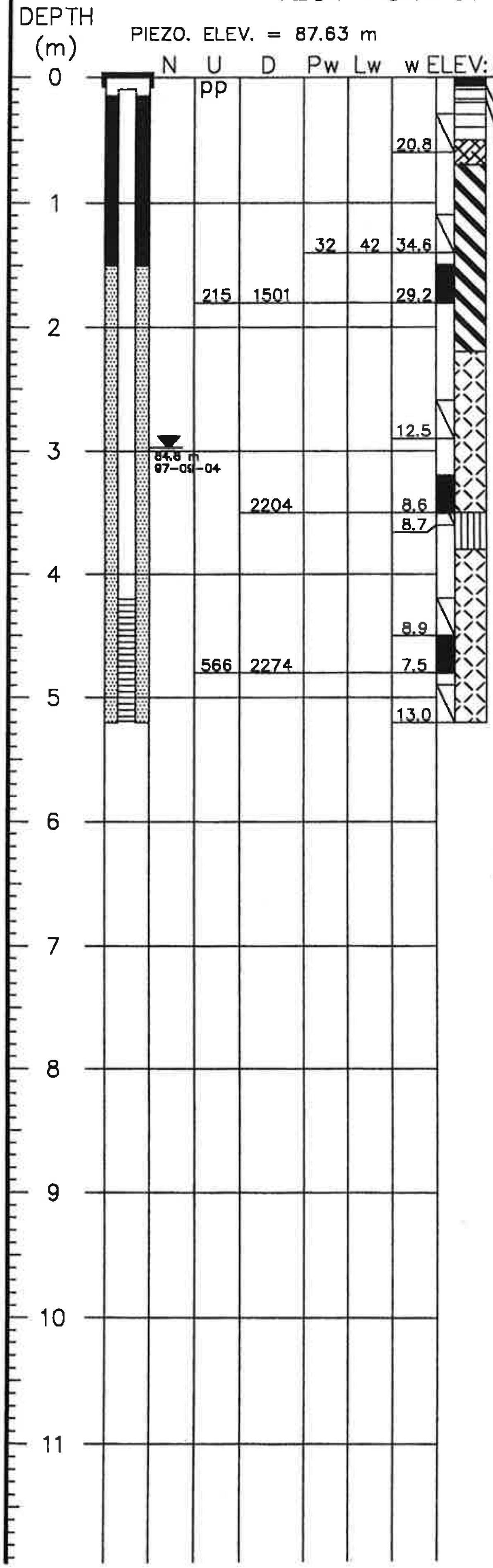
Drawn N.E.

Chkd

HISTORICAL BOREHOLE LOGS
TH 97-01, TH 97-02, TH 97-03, TH 97-04 (PMEL97)

P. Machibroda Engineering Ltd. Sept. 15, 1997. Geotechnical Investigation and Slope Stability Study Proposed Residential Development, 237-11th Street East, Saskatoon, Saskatchewan

TEST HOLE 97-1



ASPHALT CONCRETE

BASE COURSE

FILL, Clay, silty, some sand, firm, medium plastic, dark brown.

TOPSOIL- silty, moist, black, rootlets, organics.

CLAY, silty, firm, medium to highly plastic, moist, olive brown, oxidized, iron stained.

GLACIAL TILL- Clay, silty, some sand, trace gravel, firm to stiff, medium plastic, olive brown, oxidized, iron stained, gypsum crystals,

—wet, sand lenses at 3.0 m.

SILT, some sand, non to low plastic, moist, grey.

GLACIAL TILL- Clay, silty, some sand, trace gravel, stiff, low plastic, moist, grey.

—boulder at 5.2 m.

NOTE:

1)Auger refusal at 5.2 m.

LEGEND:

TOPSOIL ▨ GRAVEL ▨ SAND ▨ SILT ▨ CLAY ▨ GLACIAL TILL ▨ FILL ▨

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

D......DRY DENSITY (kg/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO....SULPHATE CONTENT (PERCENT OF DRY SOIL)

TR....TRACE

*......SULPHATE CONTENT WATER SAMPL (ppm)

▼....RECORDED WATER LEVEL

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE FIELD CONDITION ENCOUNTERED AT A SPECIFIC TEST HOL LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MA VARY AT OTHER LOCATIONS OF THIS SIT AND IN TIME, MAY CHANGE AT TH SPECIFIC TEST HOLE LOCATION

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
SLOPE STABILITY STUDY
237-11TH STREET EAST

LOCATION:
SASKATOON, SK

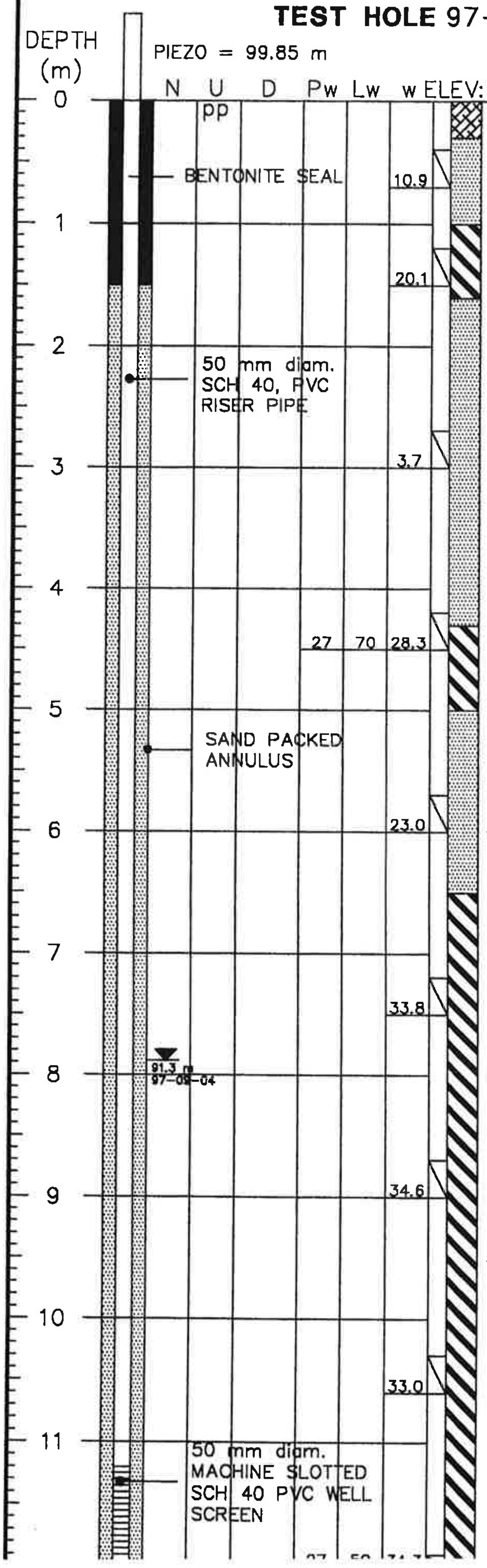
DATE DRILLED: AUG 5, 1997

DRAWING NUMBER: S97-2778-2

TEST HOLE 97-2

PIEZO = 99.85 m

ELEV: 99.14 m



TOPSOIL- Silty, dark, brown, organics, rootlets.

SAND, silty, fine grained, poorly graded, medium dense, brown, oxidized, sloughing.

CLAY, silty, firm, highly plastic, moist, olive brown, oxidized.

SAND, some silt, medium dense, poorly graded, fine grained, damp light olive brown, sloughing.

CLAY, silty, stiff, highly plastic, moist, dark olive brown, oxidized, jointed, iron stained, gypsum crystals.

SAND, silty, medium dense, poorly graded, fine grained, moist olive brown, oxidized, sloughing.

–wet, seepage, sloughing at 6.0 m

CLAY, very silty, soft to firm, low to medium plastic, wet, olive brown, oxidized.

–firm to stiff, highly plastic, moist below 7.8 m.

–firm, grey below 9.5 m.

LEGEND:

▨	TOPSOIL
▨	GRAVEL
▨	SAND
▥	SILT
▧	CLAY
☒	GLACIAL TILL
▤	FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

D......DRY DENSITY (kg/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO....SULPHATE CONTENT (PERCENT OF DRY SOIL)

TR....TRACE

*......SULPHATE CONTENT WATER SAMPLE (ppm)

▼....RECORDED WATER LEVEL

■	SHELBY TUBE
☒	SPLIT SPOON
⧅	CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE FIELD CONDITIONS ENCOUNTERED AT A SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND IN TIME, MAY CHANGE AT THE SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
SLOPE STABILITY STUDY
237-11TH STREET EAST

LOCATION:
SASKATOON, SK

DATE DRILLED: AUG 5, 1997

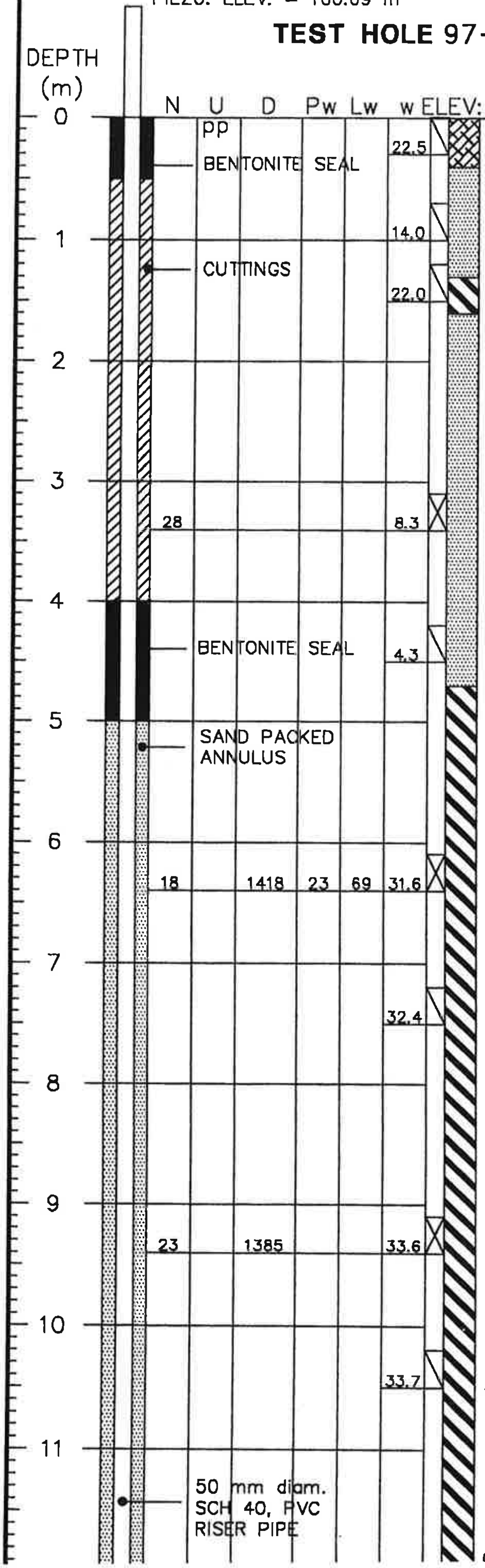
DRAWING NUMBER: S97-2778-3

PIEZO. ELEV. = 100.09 m

PAGE 1 OF 2

TEST HOLE 97-3

ELEV: 99.33 m



TOPSOIL- Organics, silty, some clay, soft, black to brown, rootlets.

SAND, silty, some clay, dense, poorly graded, fine grained, moist brown.

CLAY silty, trace sand, firm, medium plastic, moist, brown.

SAND, silty, trace clay, loose to medium dense, poorly graded, fine grained, damp, brown, sloughing.

CLAY, some silt, firm, medium to highly plastic, moist, olive to brown, oxides.

–highly plastic, olive below 7.0 m

–grey below 10.5 m.

CONTINUE ON NEXT PAGE

LEGEND:

▩	▦	▒	▥	▧	⊠	▤
TOPSOIL	GRAVEL	SAND	SILT	CLAY	GLACIAL TILL	FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

D......DRY DENSITY (kg/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO....SULPHATE CONTENT (PERCENT OF DRY SOIL)

TR....TRACE

*......SULPHATE CONTENT WATER SAMPLE (ppm)

▼....RECORDED WATER LEVEL

■	☒	⧅
SHELBY TUBE	SPLIT SPOON	CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE FIELD CONDITIONS ENCOUNTERED AT A SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND IN TIME, MAY CHANGE AT THE SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
SLOPE STABILITY STUDY
237-11TH STREET EAST

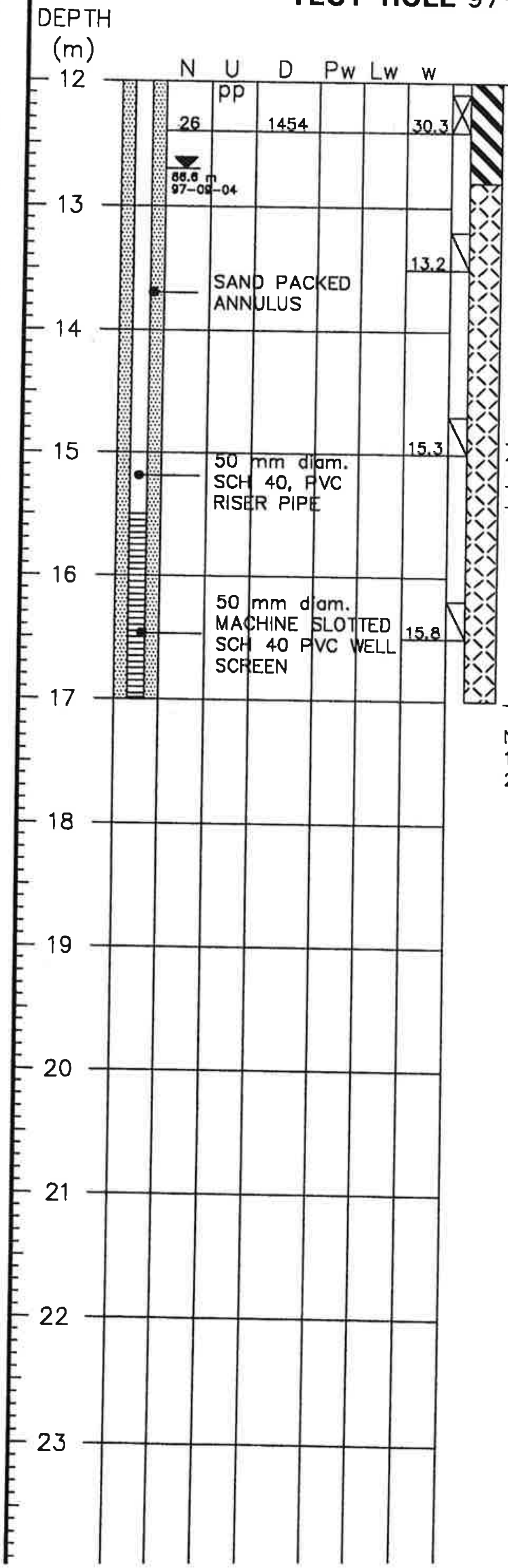
LOCATION:
SASKATOON, SK

DATE DRILLED: AUG 5, 1997

DRAWING NUMBER: S97-2778-4

PAGE 2 OF 2

TEST HOLE 97-3



CLAY, some silt, firm, highly plastic, moist, grey, oxides.

GLACIAL TILL- Clay, silty, some sand, trace gravel, firm, medium plastic, moist, grey, unoxidized.

-sand silty, some clay below 14.9 m.
-seepage at 15.0 m.
-cobbles below 15.0 m.
-sloughedto 15.7 m immediately after drilling.

-cobbles/boulders at 17.0 m.

NOTE:
1. Auger refusal at 17.0 m.
2. Test Hole sloughed to 15.7 m immediately after drilling.

LEGEND:

TOPSOIL
GRAVEL
SAND
SILT
CLAY
GLACIAL TILL
FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

D......DRY DENSITY (kg/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO....SULPHATE CONTENT (PERCENT OF DRY SOIL)

TR....TRACE

*......SULPHATE CONTENT WATER SAMPLE (ppm)

▼....RECORDED WATER LEVEL

■ SHELBY TUBE
☒ SPLIT SPOON
◪ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE FIELD CONDITIONS ENCOUNTERED AT A SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND IN TIME, MAY CHANGE AT THE SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG
AND
SOIL TEST RESULTS

PROJECT:
SLOPE STABILITY STUDY
237-11TH STREET EAST

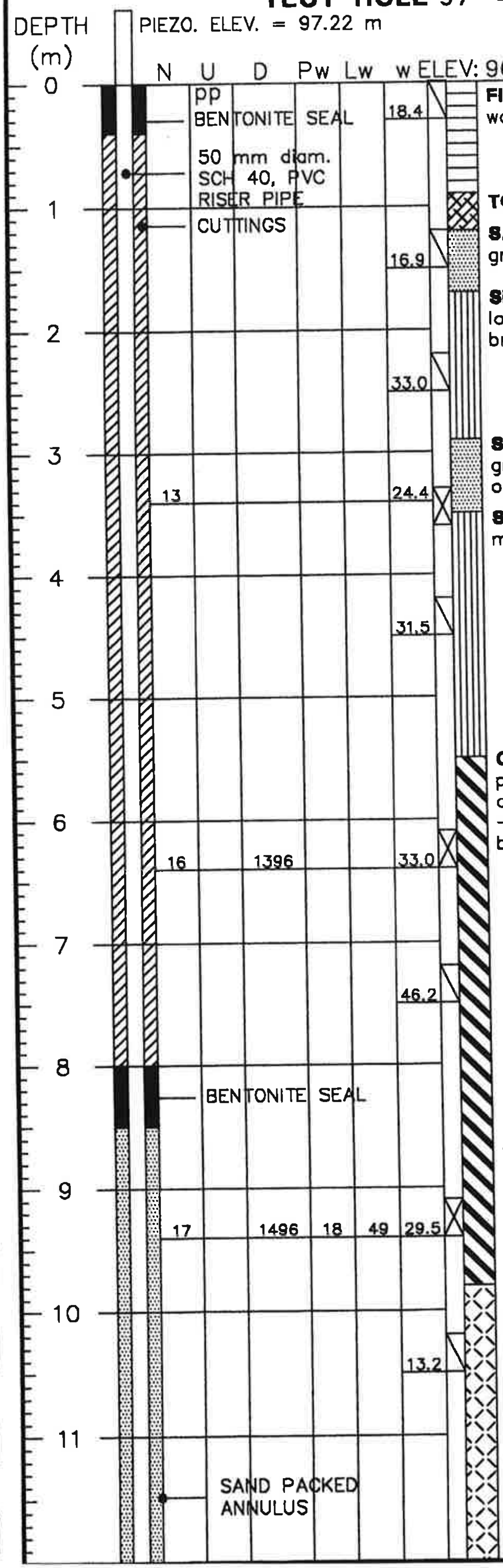
LOCATION:
SASKATOON, SK

DATE DRILLED:
AUG 5, 1997

DRAWING NUMBER:
S97-2778-4A

PAGE 1 OF 3

TEST HOLE 97-4



FILL- Clay, silty, some sand, brick, wood chips, wires, branches.

TOPSOIL- Organics, black, rootlets.

SAND, silty, medium dense, poorly graded, fine grained, damp, brown.

SILT, clayey, trace sand, soft, low to medium plastic, moist, brown, oxide stained.

SAND, silty, medium dense, poorly graded, fine grained, wet, brown, oxide stained, seepage, sloughing.

SILT, some clay, soft, low plastic, moist, brown, oxide stained.

CLAY, silty, firm to soft, medium plastic, moist, brown to olive, oxide stained,
—medium to highly plastic, olive below 6.0 m.

—trace sand, medium plastic, grey below 8.7 m.

GLACIAL TILL- Clay, silty, some sand, trace gravel, firm, medium plastic, moist, grey, unoxidized.

CONTINUED ON NEXT PAGE

LEGEND:

TOPSOIL ▩ GRAVEL ● SAND ░ SILT ▥ CLAY ▧ GLACIAL TILL ☒ FILL ▤

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

D......DRY DENSITY (kg/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO....SULPHATE CONTENT (PERCENT OF DRY SOIL)

TR....TRACE

*......SULPHATE CONTENT WATER SAMPLE (ppm)

▼....RECORDED WATER LEVEL

■ SHELBY TUBE ☒ SPLIT SPOON ◸ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE FIELD CONDITIONS ENCOUNTERED AT A SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND IN TIME, MAY CHANGE AT THE SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

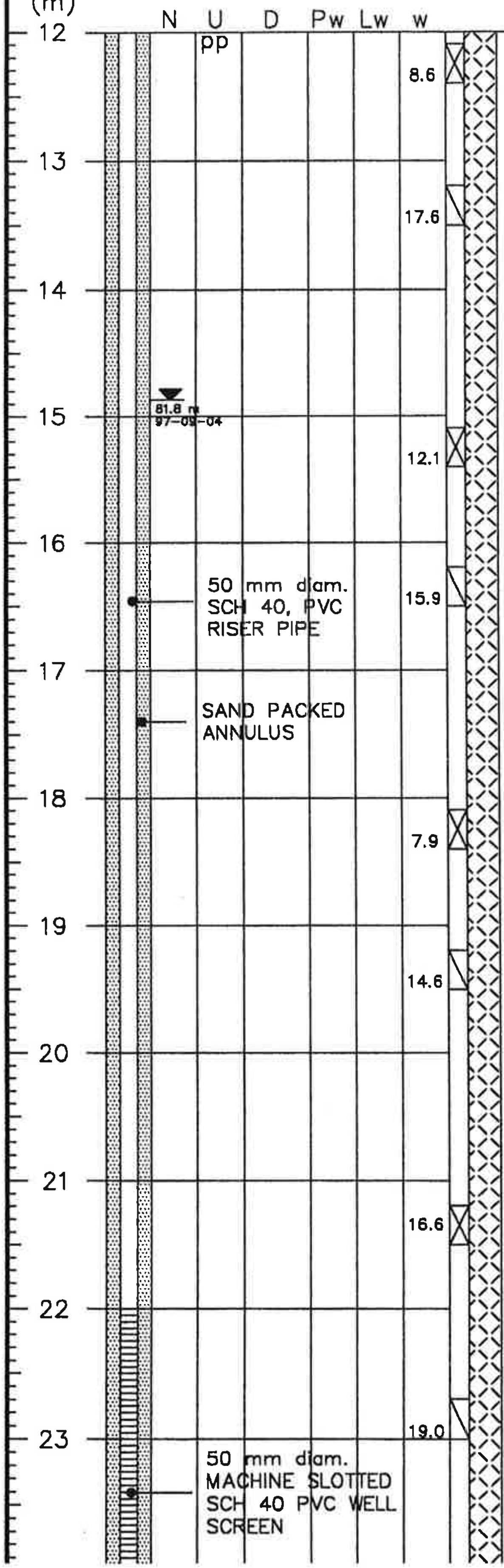
PROJECT:
SLOPE STABILITY STUDY
237-11TH STREET EAST

LOCATION:
SASKATOON, SK

DATE DRILLED:
AUG 5, 1997

DRAWING NUMBER:
S97-2778-5

TEST HOLE 97-4



GLACIAL TILL- Clay, silty, some sand, trace gravel, stiff, low to medium plastic, moist, grey.
-seepage at 12.0 m.
-cobbles below 12.5 m.
-soft below 12.8 m.

-hard medium plastic below 13.5 m.

CONTINUED ON NEXT PAGE

LEGEND:

TOPSOIL, GRAVEL, SAND, SILT, CLAY, GLACIAL TILL, FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

D......DRY DENSITY (kg/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO....SULPHATE CONTENT (PERCENT OF DRY SOIL)

TR....TRACE

*......SULPHATE CONTENT WATER SAMPL (ppm)

▼....RECORDED WATER LEVEL

■ SHELBY TUBE ☒ SPLIT SPOON ◸ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE FIELD CONDITIONS ENCOUNTERED AT A SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITI AND IN TIME, MAY CHANGE AT THE SPECIFIC TEST HOLE LOCATION

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG
AND
SOIL TEST RESULTS

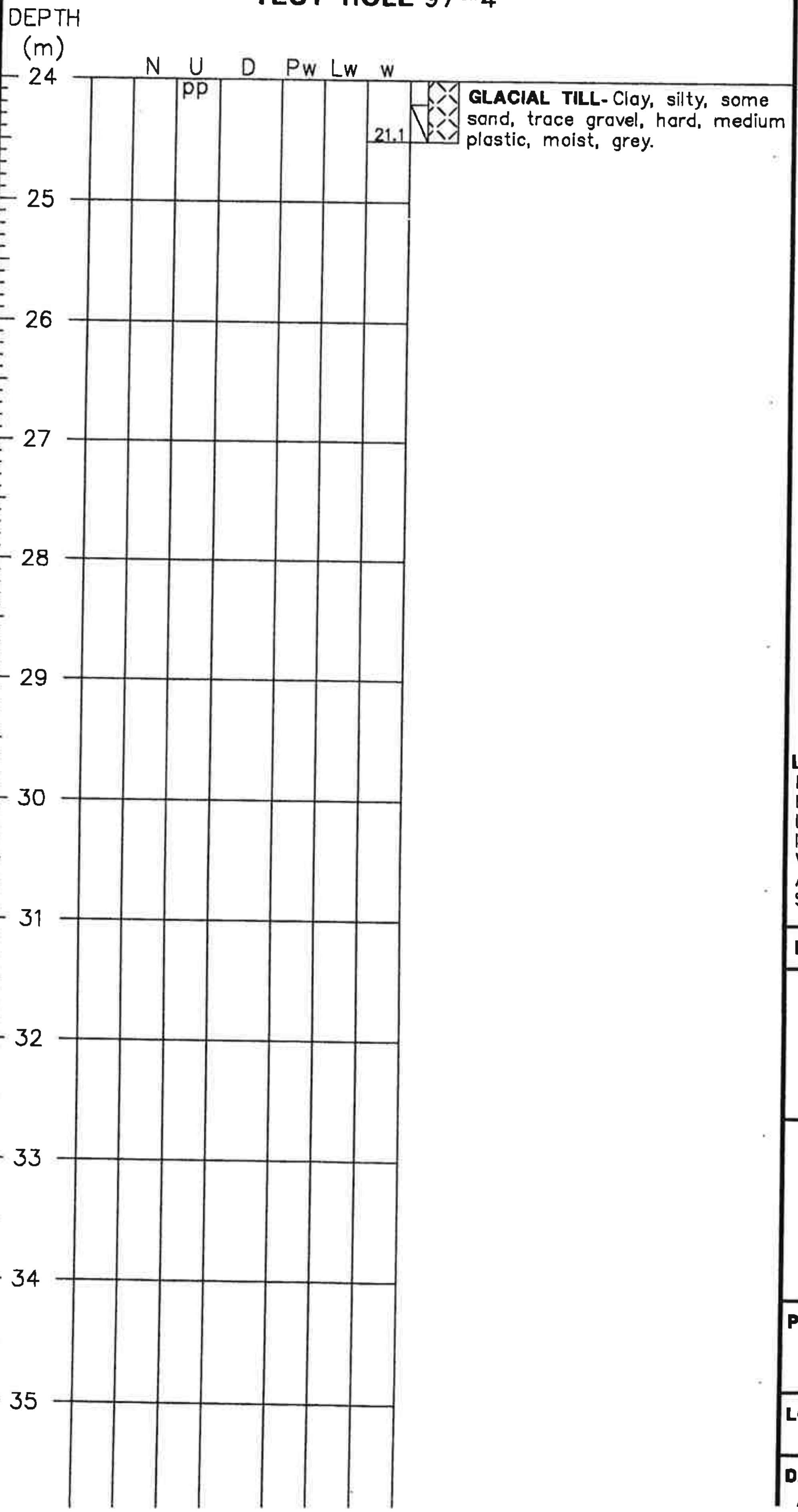
PROJECT:
SLOPE STABILITY STUDY
237-11TH STREET EAST

LOCATION:
SASKATOON, SK

DATE DRILLED:	**DRAWING NUMBER:**
AUG 5, 1997	S97-2778-5A

PAGE 3 OF 3

TEST HOLE 97-4



GLACIAL TILL- Clay, silty, some sand, trace gravel, hard, medium plastic, moist, grey.

LEGEND:

TOPSOIL ▩ GRAVEL ▩ SAND ▨ SILT ▥ CLAY ▧ GLACIAL TILL ▨ FILL ▤

pp....POCKET PENETROMETER (kg/cm^2)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

D......DRY DENSITY (kg/m^3)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO....SULPHATE CONTENT (PERCENT OF DRY SOIL)

TR....TRACE

*......SULPHATE CONTENT WATER SAMPLE (ppm)

▼....RECORDED WATER LEVEL

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE FIELD CONDITIONS ENCOUNTERED AT A SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND IN TIME, MAY CHANGE AT THE SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG
AND
SOIL TEST RESULTS

PROJECT:
SLOPE STABILITY STUDY
237-11TH STREET EAST

LOCATION:
SASKATOON, SK

DATE DRILLED: AUG 5, 1997

DRAWING NUMBER: S97-2778-5D

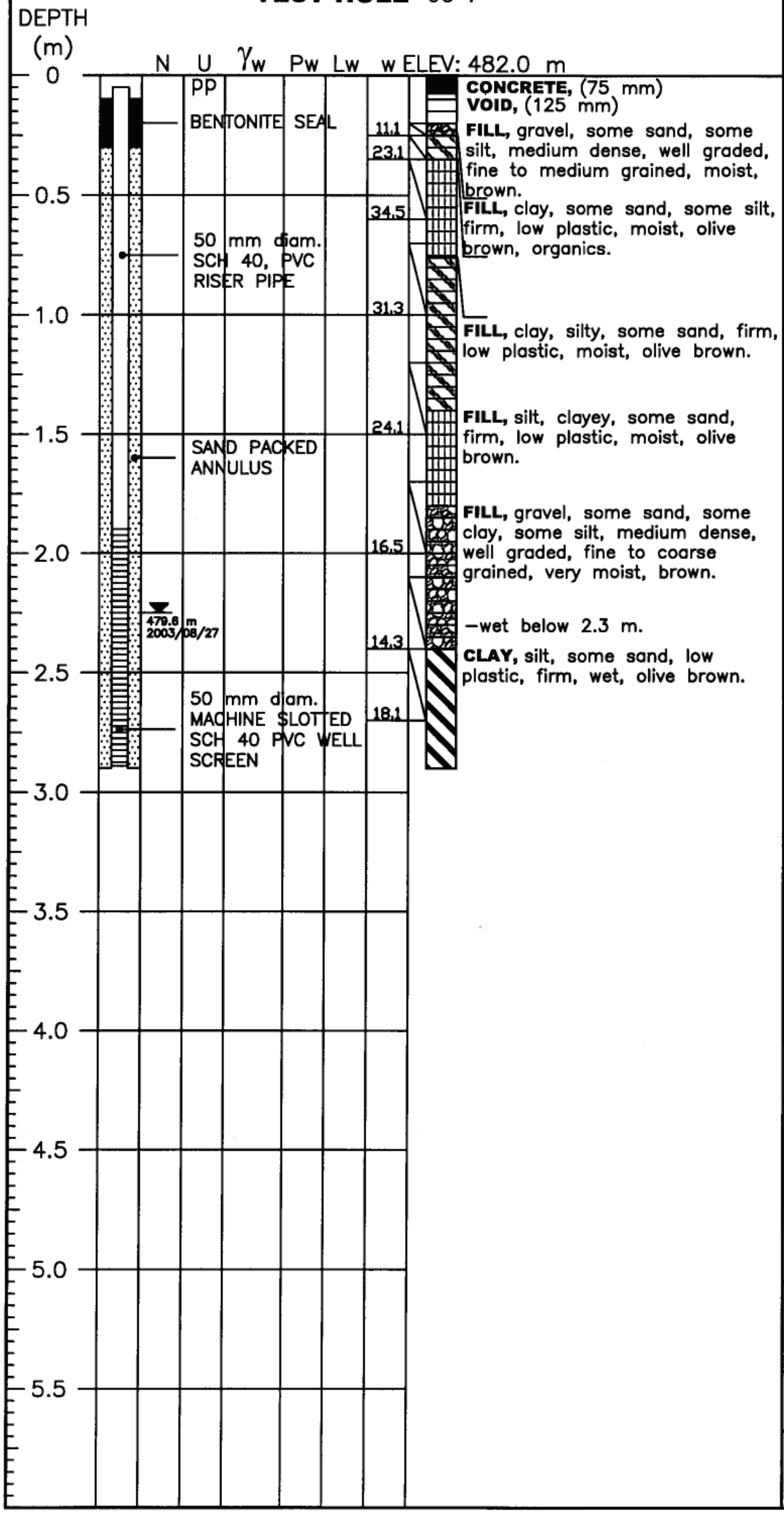
HISTORICAL BOREHOLE LOGS

TH03-1, TH 03-2, TH 03-3, TH 03-101, TH 03-101A, TH 03-102, TH 03-103 (PMEL03A)

P. Machibroda Engineering Ltd. September 11, 2003. Geotechnical Investigation and Slope Stability Study Proposed Garage, 306 Saskatchewan Crescent East, Saskatoon, Saskatchewan, PMEL File No. S03-4869

PIEZO. ELEV.= 481.9 m

TEST HOLE 03-1



CONCRETE, (75 mm)
VOID, (125 mm)

FILL, gravel, some sand, some silt, medium dense, well graded, fine to medium grained, moist, brown.

FILL, clay, some sand, some silt, firm, low plastic, moist, olive brown, organics.

FILL, clay, silty, some sand, firm, low plastic, moist, olive brown.

FILL, silt, clayey, some sand, firm, low plastic, moist, olive brown.

FILL, gravel, some sand, some clay, some silt, medium dense, well graded, fine to coarse grained, very moist, brown.

—wet below 2.3 m.

CLAY, silt, some sand, low plastic, firm, wet, olive brown.

LEGEND:

TOPSOIL
GRAVEL
SAND
SILT
CLAY
GLACIAL TILL
FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γ_w....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4 ...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE
☒ SPLIT SPOON
◪ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

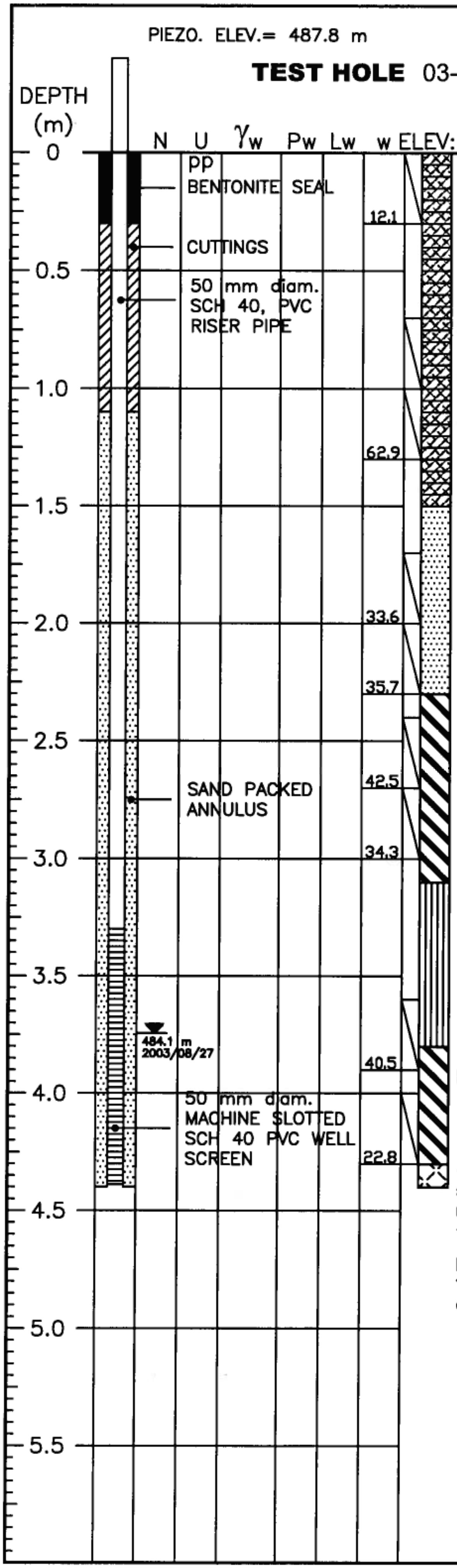
FIELD DRILL LOG
AND
SOIL TEST RESULTS

PROJECT:
306 SASK CRESCENT EAST

LOCATION:
SASKATOON, SK

DATE DRILLED:	**DRAWING NUMBER:**
JULY 3/03	SO3-4869-2

TEST HOLE 03-2



FILL, topsoil, organic.

—some clay, moist at 1.0 m.

FILL, organics, wood pieces.

SAND, silty, some clay, poorly graded, fine grained, moist, brown, trace organics.

CLAY, some silt, firm, medium plastic, moist, olive brown, oxide stained.

SILT, clayey, firm to stiff, low plastic, moist, olive brown.

CLAY, some silt, stiff, highly plastic, moist, olive brown.

GLACIAL TILL - Silt and sand, some clay, trace gravel, stiff, moist, dark grey.
—auger refusal at 4.4 m.

NOTE:
1. Test Hole open to 4.4 m and dry I.A.D.

LEGEND:

▩	▩	░	▥	▨	☒	☰
TOPSOIL	GRAVEL	SAND	SILT	CLAY	GLACIAL TILL	FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γ_w....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4 ...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■	☒	⧄
SHELBY TUBE	SPLIT SPOON	CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
306 SASK CRESCENT EAST

LOCATION:
SASKATOON, SK

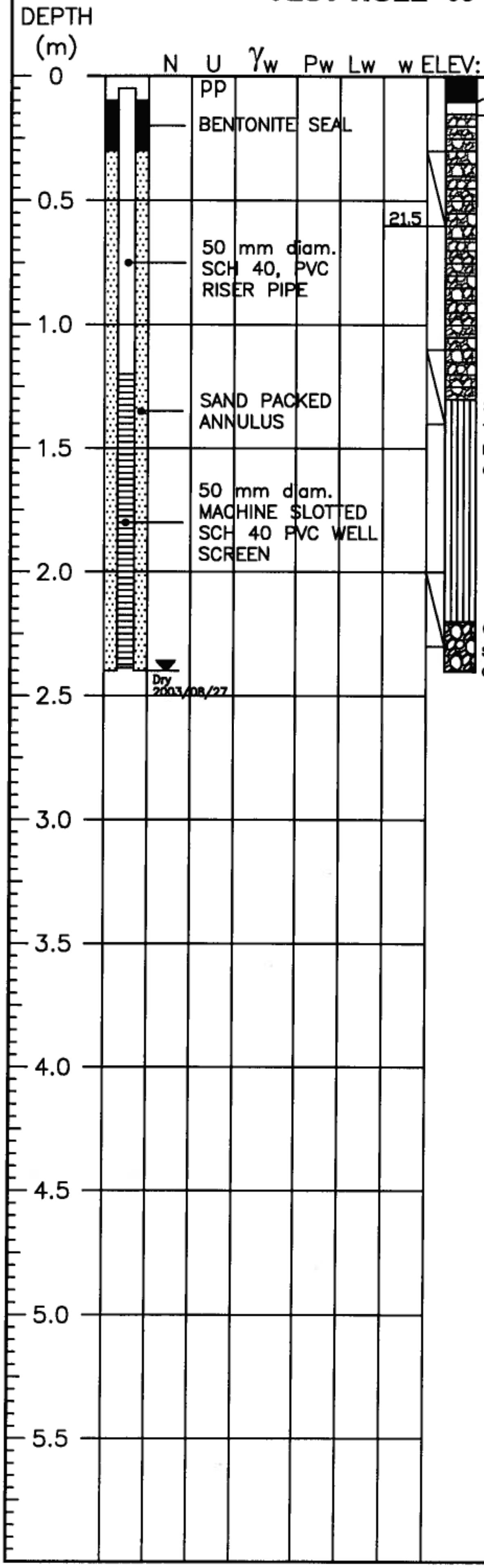
DATE DRILLED: JULY 3/03

DRAWING NUMBER: S03-4869-3

PIEZO. ELEV.= 481.9 m

TEST HOLE 03-3

ELEV: 482.0 m



CONCRETE, (100 mm)

VOID, (50 mm)

FILL, gravel, some sand, some silt, medium dense, well graded, fine to coarse grained, moist, brown.

SILT, some sand, some clay, trace gravel, firm, low plastic, moist, olive brown, oxide stained, organics.

–sandy, some gravel, very moist below 2 m.

GRAVEL, some sand, some silt, some clay, well graded, fine to coarse grained, wet, brown.

LEGEND:

TOPSOIL ▨ GRAVEL ▨ SAND ▨ SILT ▨ CLAY ▨ GLACIAL TILL ▨ FILL ▨

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γw....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4 ...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:

306 SASK CRESCENT EAST

LOCATION:

SASKATOON, SK

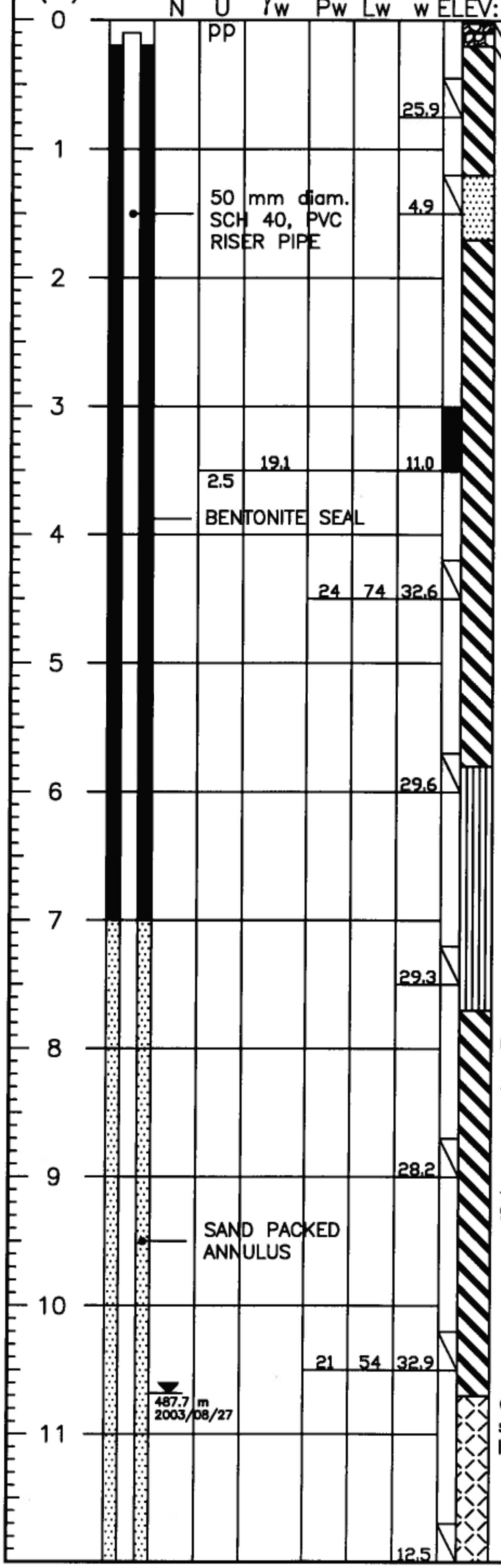
DATE DRILLED:	**DRAWING NUMBER:**
JULY 3/03	S03-4869-4

PIEZO. ELEV.= 498.2 m

PAGE 1 OF 2

TEST HOLE 03-101

ELEV: 498.4 m



ASPHALT CONCRETE (25 mm)

BASE, gravel

CLAY, some silt, firm, highly plastic, moist, brown.

SAND, some silt, medium dense, poorly graded, fine grained, damp, brown.

CLAY, some silt, stiff, highly plastic, moist, brown.

–silt lense at 3.2 m.

–silty, trace seepage at 4.7 m.

SILT, sandy, soft, low plastic, moist to wet, brown, sloughing.

CLAY, silty, firm, highly plastic, moist, brown.

–stiff 8.3 to 8.5 m.

–some silt, stiff, grey below 9.1 m.

GLACIAL TILL, silt and sand, some clay, trace gravel, stiff, low plastic, moist, grey.

CONTINUED ON NEXT PAGE

LEGEND:

▩ TOPSOIL ▩ GRAVEL ▨ SAND ▥ SILT ▧ CLAY ▨ GLACIAL TILL ▤ FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γ_w....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED GARAGE
306 SASKATCHEWAN CRESCENT

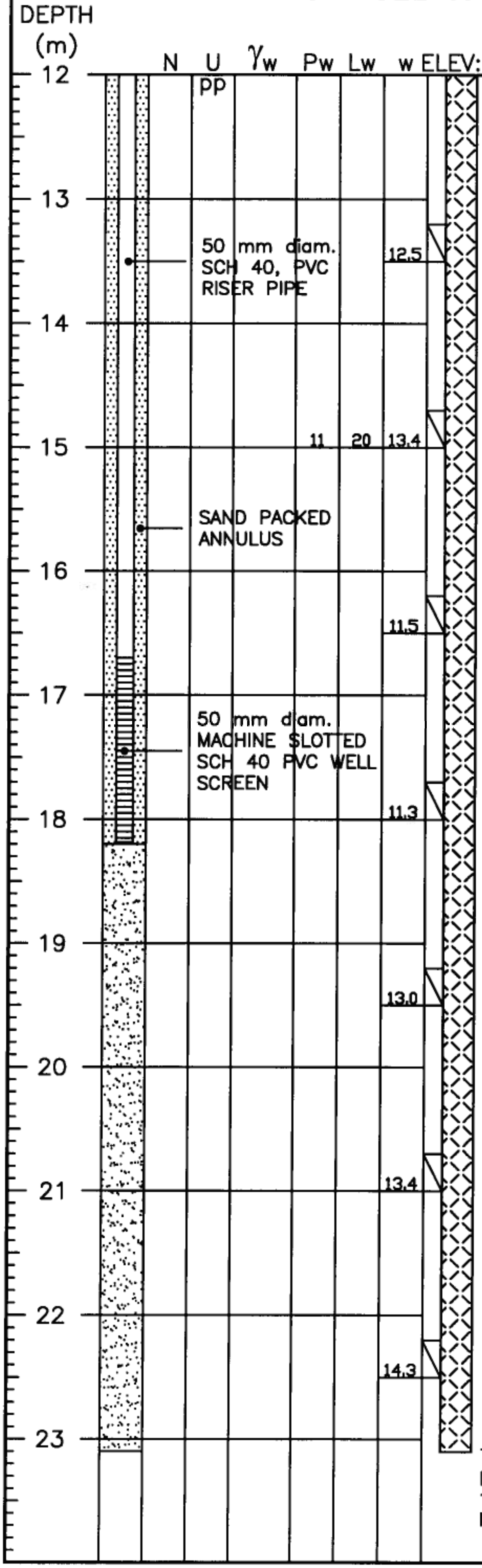
LOCATION:
SASKATOON, SK

DATE DRILLED: AUG 14/03

DRAWING NUMBER: S03-4869-5

PAGE 2 OF 2

TEST HOLE 03-101



GLACIAL TILL, silt and sand, some clay, trace gravel, stiff, low plastic, moist, grey.

—very stiff below 12.8 m.

—hard below 13.8 m.

—broke auger at 23.1 m.

NOTE:
1. Test Hole sloughed to 5.2 m I.A.D.

LEGEND:

TOPSOIL	GRAVEL	SAND	SILT	CLAY	GLACIAL TILL	FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γw....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4 ...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ◪ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED GARAGE
306 SASKATCHEWAN CRESCENT

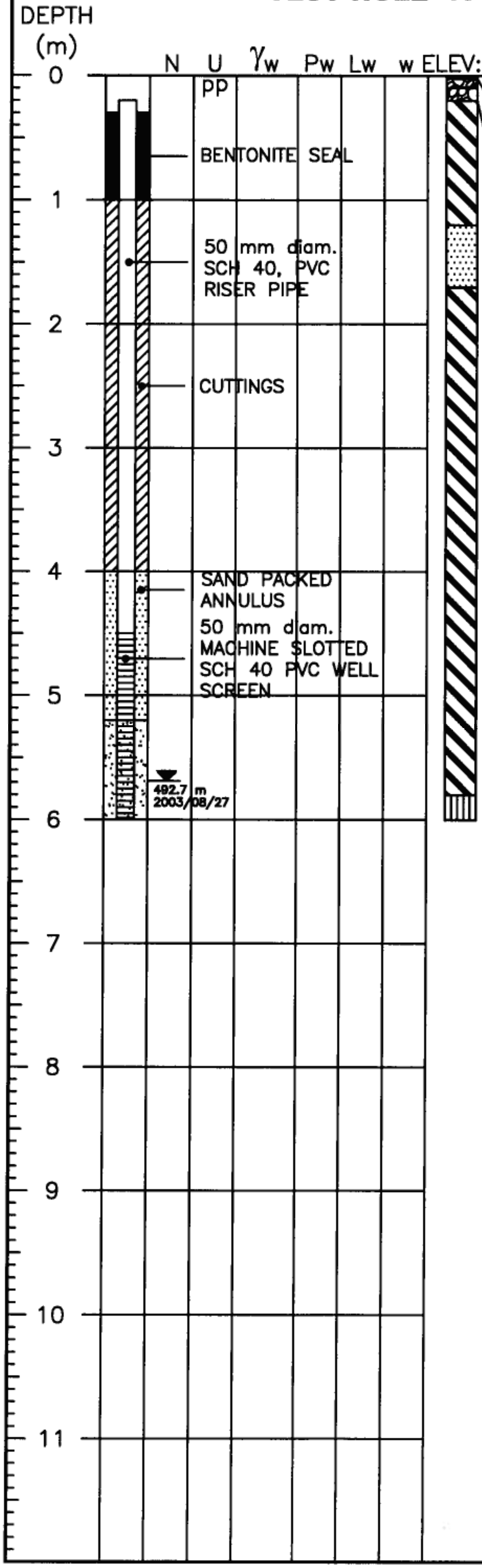
LOCATION:
SASKATOON, SK

DATE DRILLED: AUG 14/03

DRAWING NUMBER: S03-4869-5A

PIEZO. ELEV.= 498.2 m

TEST HOLE 03-101A



ASPHALT CONCRETE (25 mm)

FILL, gravel and sand, some silt, moist, brown.

CLAY, some silt, firm, highly plastic, moist, brown.

SAND, some silt, medium dense, poorly graded, fine grained, moist, brown.

CLAY, some silt, stiff, highly plastic, moist, brown.

–silt lense 3.2 m.

–silty, trace seepage, sloughing below 4.7 m.

SILT, sandy, soft, low plastic, wet, brown, seepage, sloughing.

NOTE:
1. Test Hole sloughed to 5.2 m I.A.D.

LEGEND:

▩	▩	░	▥	▧	▨	▤
TOPSOIL	GRAVEL	SAND	SILT	CLAY	GLACIAL TILL	FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γw....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■	☒	⧅
SHELBY TUBE	SPLIT SPOON	CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

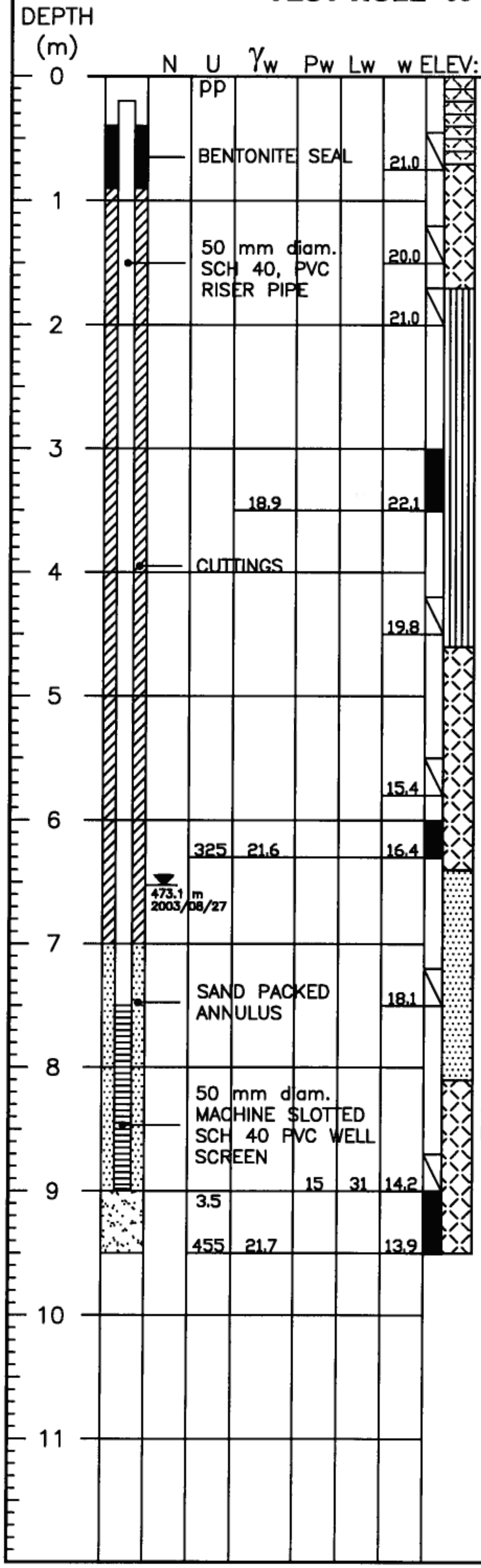
PROJECT:
PROPOSED GARAGE
306 SASKATCHEWAN CRESCENT

LOCATION:
SASKATOON, SK

DATE DRILLED:	DRAWING NUMBER:
AUG 14/03	S03-4869-6

PIEZO. ELEV.= 479.4 m

TEST HOLE 03-102



FILL, till, clay, silt, sand, gravel.

GLACIAL TILL, clay, some silt, some sand, trace gravel, stiff, medium plastic, moist, dark brown, trace topsoil.

SILT, sandy, firm, low plastic, moist, olive brown.

—some sand, medium plastic, below 2.6 m.

GLACIAL TILL, silt and sand, some clay, trace gravel, stiff, low plastic, moist, brown.

—grey below 5.8 m.

SAND, silty, dense, poorly graded, fine grained, moist, grey, seepage, sloughing.

GLACIAL TILL, silt, sandy, some clay, trace gravel, stiff, medium plastic, moist, grey.

LEGEND:

▩	▩	░	▥	▧	☒	▤
TOPSOIL	GRAVEL	SAND	SILT	CLAY	GLACIAL TILL	FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γ_w....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4 ...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■	☒	⧅
SHELBY TUBE	SPLIT SPOON	CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED GARAGE
306 SASKATCHEWAN CRESCENT

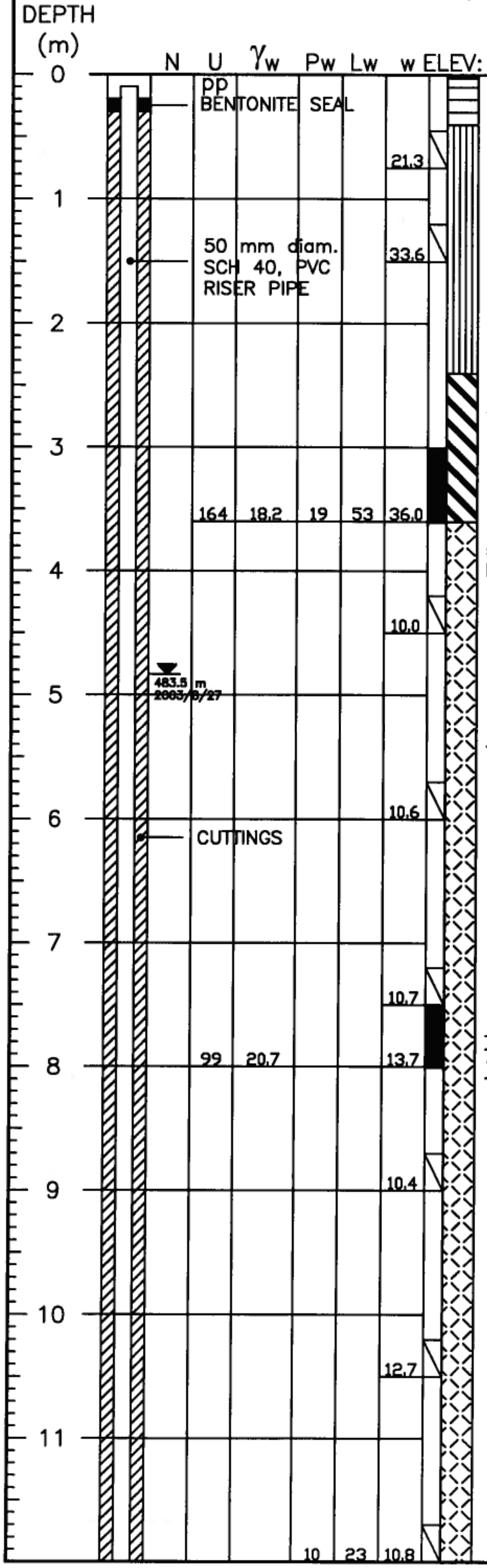
LOCATION:
SASKATOON, SK

DATE DRILLED: AUG 15/03

DRAWING NUMBER: S03-4869-7

PIEZO. ELEV.= 488.1 m

TEST HOLE 03-103



ASPHALT CONCRETE (25 mm)
FILL- Clay, some silt, moist, brown.

SILT, sandy, soft to firm, low plastic, moist, olive brown.

—clay seam 1.4 to 1.5 m.

CLAY, some sand, stiff. highly plastic, moist, brown.

GLACIAL TILL, silt and sand, some clay, trace gravel, stiff, low plastic, moist, grey.

—very stiff below 5.4 m.

—cobbles/boulders, seepage at 7.8 m.
—hard below 8.0 m.

LEGEND:

▩ TOPSOIL
▩ GRAVEL
▒ SAND
▥ SILT
▨ CLAY
☒ GLACIAL TILL
▤ FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γw....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4 ...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ◸ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG
AND
SOIL TEST RESULTS

PROJECT:
PROPOSED GARAGE
306 SASKATCHEWAN CRESCENT

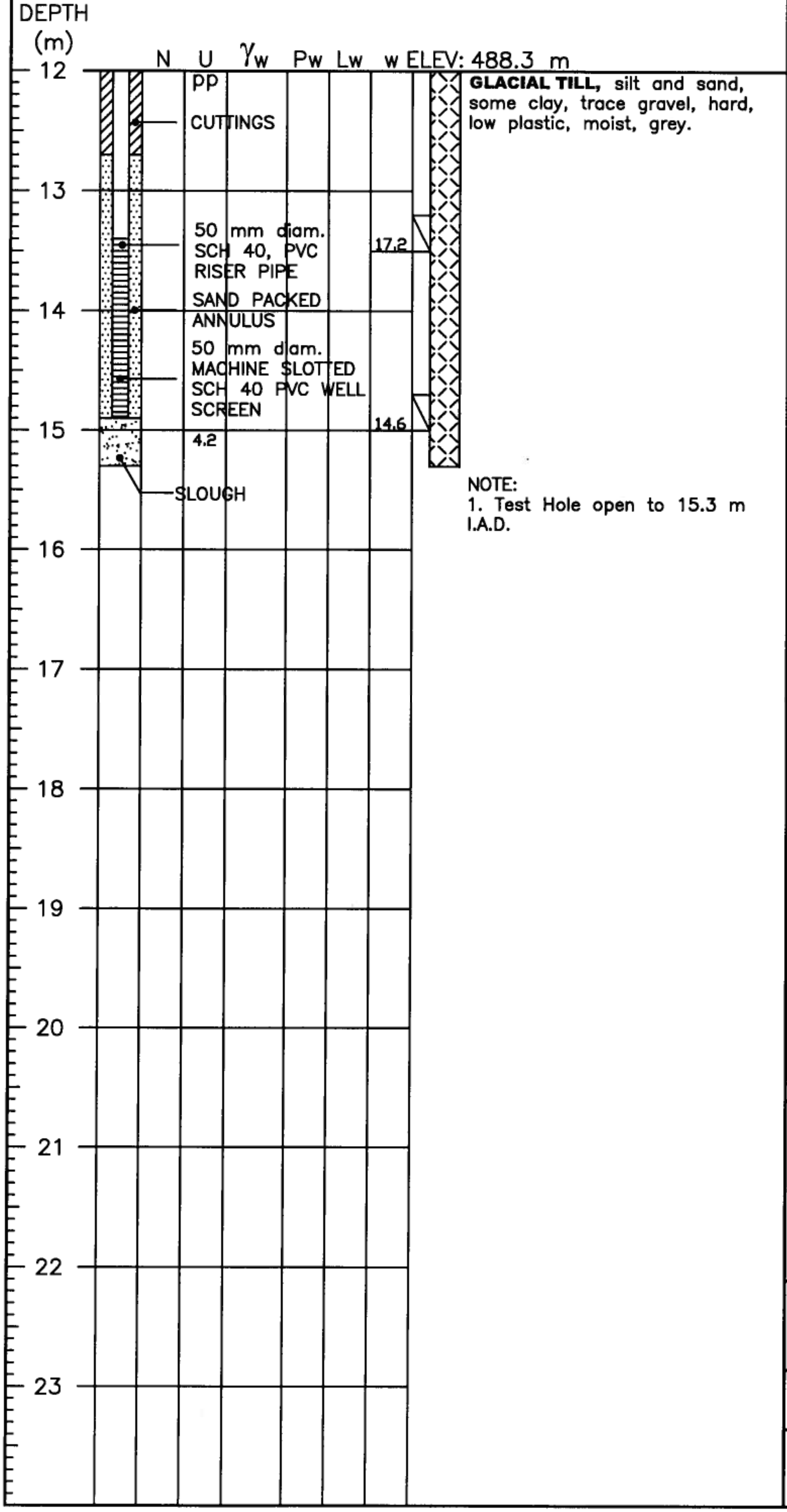
LOCATION:
SASKATOON, SK

DATE DRILLED: AUG 15/03

DRAWING NUMBER: S03-4869-8

PIEZO. ELEV.= 488.1 m

TEST HOLE 03-103



GLACIAL TILL, silt and sand, some clay, trace gravel, hard, low plastic, moist, grey.

NOTE:
1. Test Hole open to 15.3 m I.A.D.

LEGEND:

TOPSOIL, GRAVEL, SAND, SILT, CLAY, GLACIAL TILL, FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γ_w....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4 ...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED GARAGE
306 SASKATCHEWAN CRESCENT

LOCATION:
SASKATOON, SK

DATE DRILLED: AUG 15/03

DRAWING NUMBER: S03-4869-8A

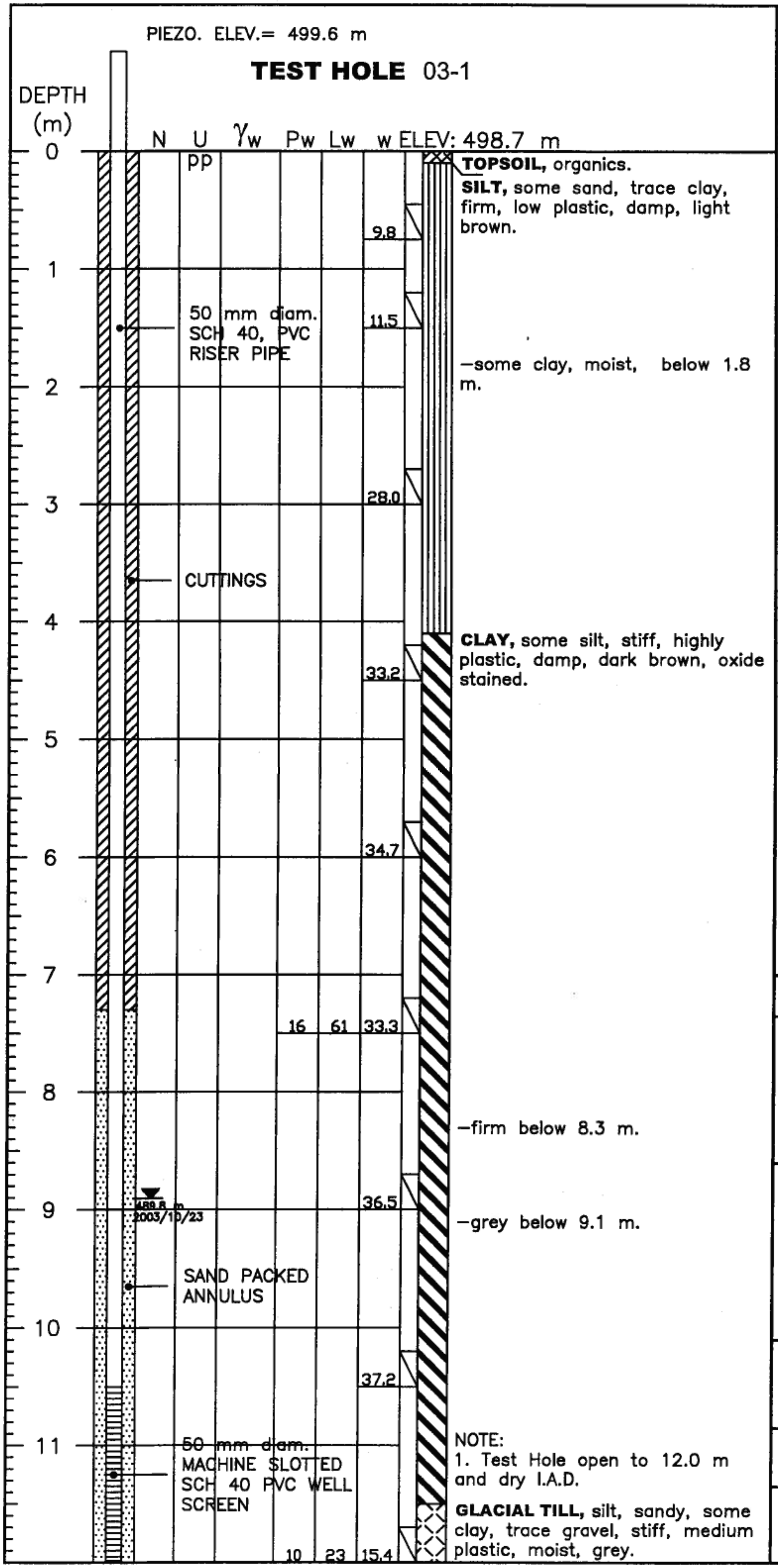
HISTORICAL BOREHOLE LOGS
TH03-1, TH 03-2, TH 03-3, TH 03-4, TH 03-5 (PMEL03B)

P. Machibroda Engineering Ltd. October 31, 2003. Geotechnical Investigation and Slope Stability Study Proposed Residence, 313-11th Street East, Saskatoon, Saskatchewan, PMEL File No. S03-4925

PIEZO. ELEV.= 499.6 m

TEST HOLE 03-1

ELEV: 498.7 m



TOPSOIL, organics.

SILT, some sand, trace clay, firm, low plastic, damp, light brown.

–some clay, moist, below 1.8 m.

CLAY, some silt, stiff, highly plastic, damp, dark brown, oxide stained.

–firm below 8.3 m.

–grey below 9.1 m.

NOTE:
1. Test Hole open to 12.0 m and dry I.A.D.

GLACIAL TILL, silt, sandy, some clay, trace gravel, stiff, medium plastic, moist, grey.

LEGEND:

▨ TOPSOIL
▨ GRAVEL
▨ SAND
▨ SILT
▨ CLAY
▨ GLACIAL TILL
▨ FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γ_w....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
SLOPE STABILITY STUDY

LOCATION:
313 - 11TH STREET, SASKATOON, SK

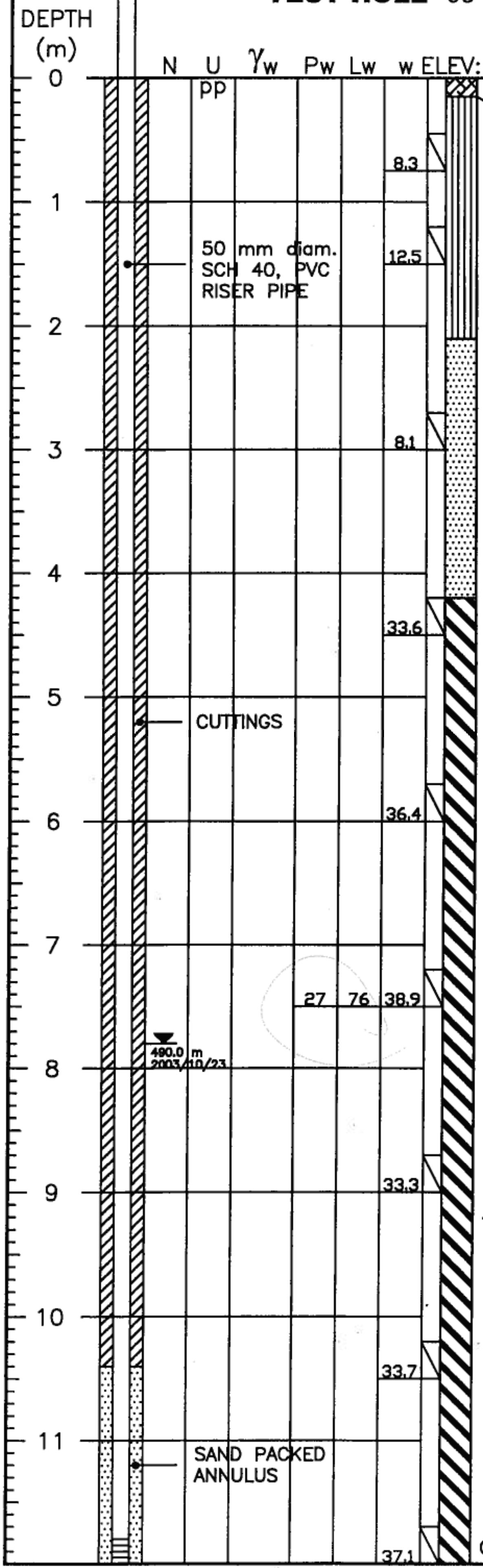
DATE DRILLED:
OCTOBER 7/03

DRAWING NUMBER:
S03-4925-2

PIEZO. ELEV.= 498.8 m

PAGE 1 OF 2

TEST HOLE 03-2



TOPSOIL, organics.

SILT, some sand, firm, low plastic, damp, light brown.

SAND, silty, medium dense, poorly graded, fine grained, moist, light brown.

CLAY, some silt, stiff, highly plastic, moist, brown, oxide stained.

–grey below 9.2 m.

CONTINUED ON NEXT PAGE

LEGEND:

▨ TOPSOIL ▨ GRAVEL ▨ SAND ▥ SILT ▨ CLAY ▨ GLACIAL TILL ▤ FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γ_w....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:

SLOPE STABILITY STUDY

LOCATION:

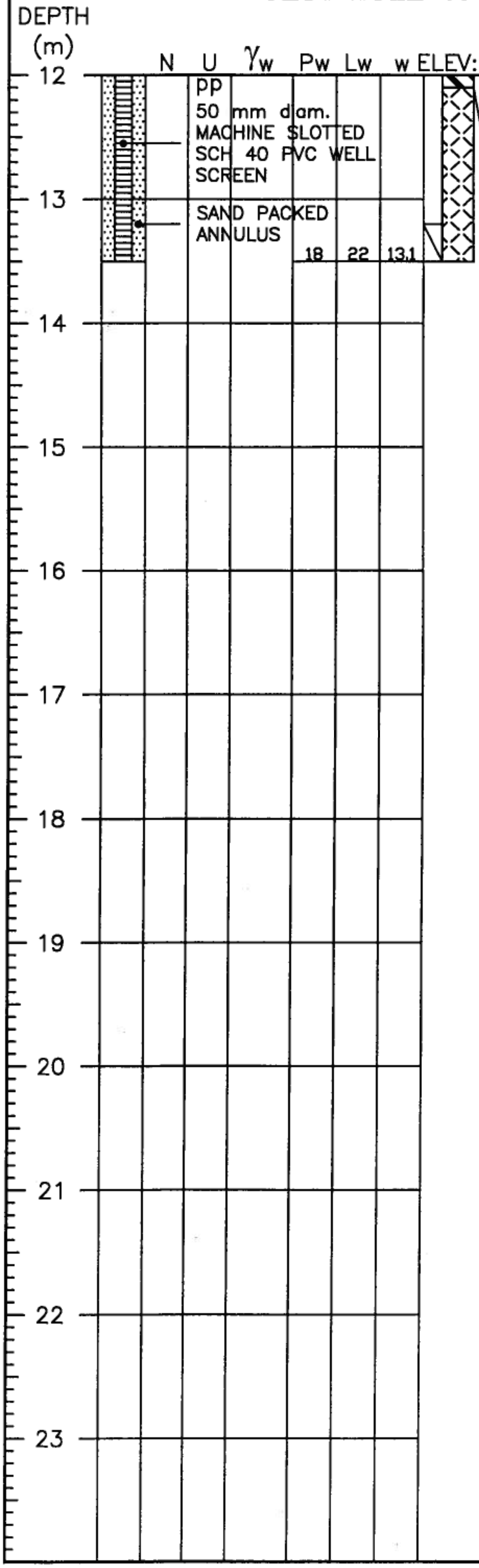
313 - 11TH STREET, SASKATOON, SK

DATE DRILLED: OCTOBER 7/03

DRAWING NUMBER: S03-4925-3

TEST HOLE 03-2

ELEV: 497.8 m



CLAY, some silt, stiff, highly plastic, moist, grey, gypsum crystals, oxide stained.

GLACIAL TILL, silt, sandy, some clay, trace gravel, stiff, low plastic, moist, grey.

NOTE:
1. Test Hole open to 13.5 m and dry I.A.D.

LEGEND:

- ▨ TOPSOIL
- ▨ GRAVEL
- ▨ SAND
- ▥ SILT
- ▧ CLAY
- ▨ GLACIAL TILL
- ▤ FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γw....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG
AND
SOIL TEST RESULTS

PROJECT:
SLOPE STABILITY STUDY

LOCATION:
313 - 11TH STREET, SASKATOON, SK

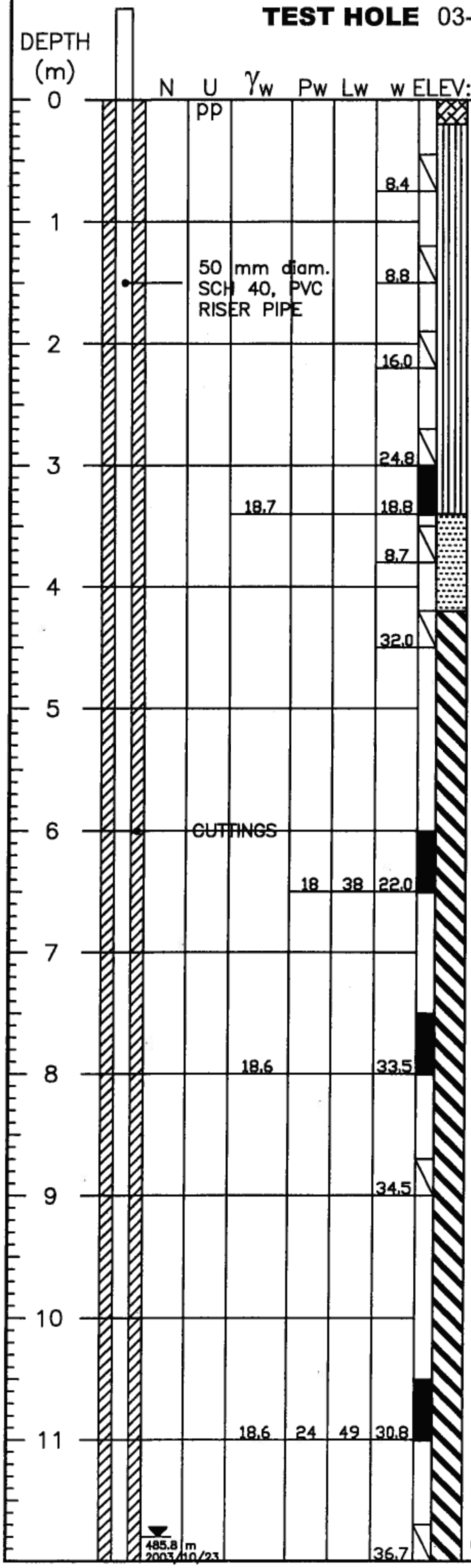
DATE DRILLED:	**DRAWING NUMBER:**
OCTOBER 7/03	S03-4925-3A

PAGE 1 OF 2

PIEZO. ELEV.= 498.4 m

TEST HOLE 03-3

ELEV: 497.6 m



TOPSOIL, organics.

SILT, sandy, stiff, low plastic, damp, light brown.

—sand lense at 1.5 m.

—clay, some silt, medium to highly plastic, moist, brown below 2.0 m.

SAND, some silt, medium dense, poorly graded, fine grained, moist, brown.

CLAY, some silt, stiff, highly plastic, moist, olive brown.

—grey below 9.3 m.

CONTINUED ON NEXT PAGE

LEGEND:

TOPSOIL GRAVEL SAND SILT CLAY GLACIAL TILL FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γ_w....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG
AND
SOIL TEST RESULTS

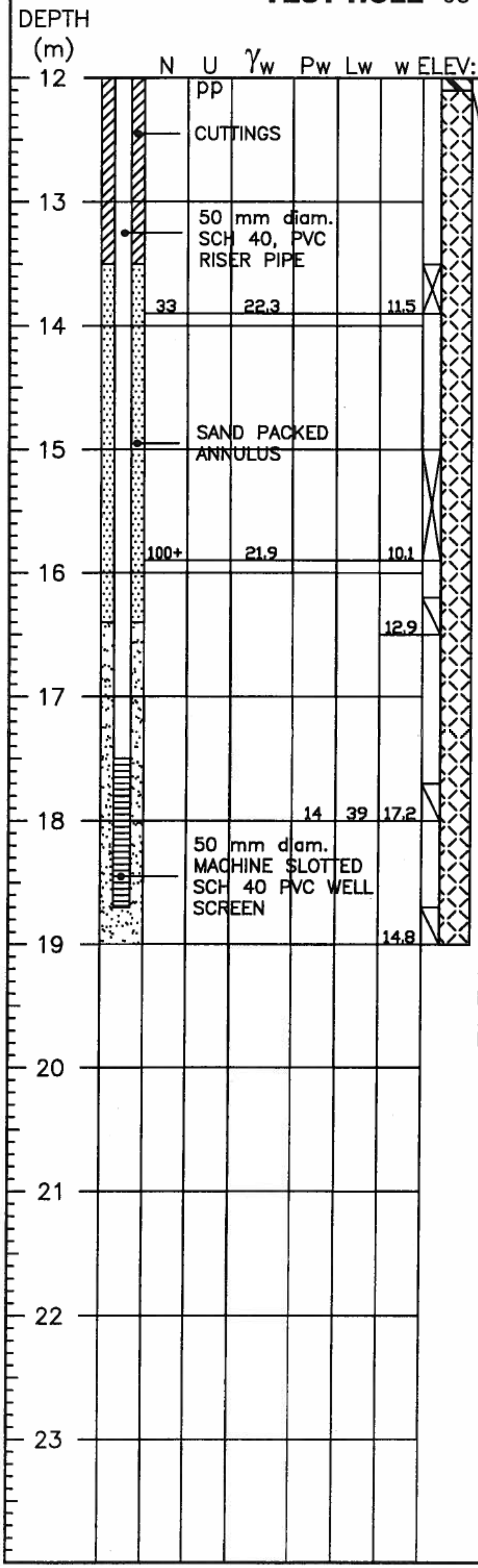
PROJECT:
SLOPE STABILITY STUDY

LOCATION:
313 - 11TH STREET, SASKATOON, SK

DATE DRILLED:	**DRAWING NUMBER:**
OCTOBER 7/03	S03-4925-4

TEST HOLE 03-3

ELEV: 497.6 m



CLAY, some silt, stiff, highly plastic, moist, olive brown.

GLACIAL TILL, silt, sandy, some clay, trace gravel, stiff, medium plastic, moist, grey.

–very stiff to hard below 14.3 m.

–trace seepage at 15.5 m.

–hard below 16.0 m.

NOTE:
1. Auger refusal at 19.0 m on boulder.
2. Test Hole sloughed to 16.4 m I.A.D.

LEGEND:

TOPSOIL GRAVEL SAND SILT CLAY GLACIAL TILL FILL

pp....POCKET PENETROMETER (kg/cm^2)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γ_w....WET UNIT WEIGHT (kN/m^3)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
SLOPE STABILITY STUDY

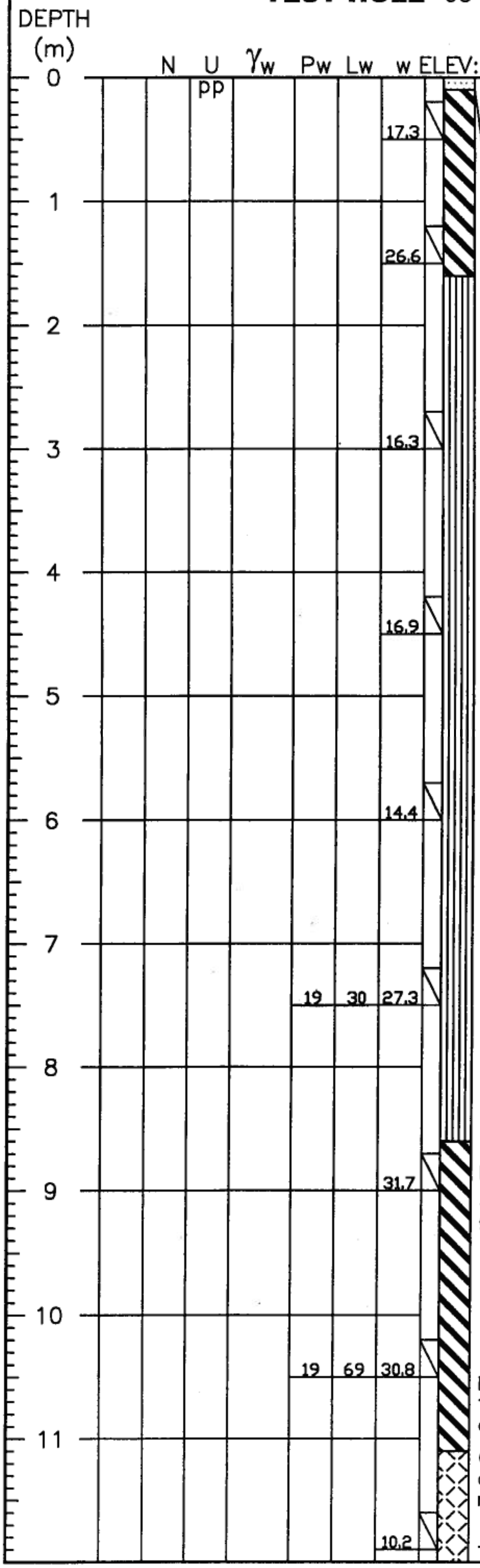
LOCATION:
313 - 11TH STREET, SASKATOON, SK

DATE DRILLED: OCTOBER 7/03

DRAWING NUMBER: S03-4925-4A

TEST HOLE 03-4

ELEV: 493.4 m



FILL, sand, gravelly, some silt, trace clay, dense, well graded, fine to coarse grained, damp, brown.

CLAY, silty, stiff, low to medium plastic, moist, brown.
–highly plastic below 650 mm.

–silt lense at 1.3 m.

SILT, some clay, trace sand, stiff, low plastic, moist, light olive brown.

–soft, wet, seepage, sloughing below 7.3 m.

CLAY, silty, firm, low to medium plastic, moist, olive brown.

–highly plastic, stiff, grey below 9.1 m.

NOTE:
1. Test Hole sloughed to 11.8 m and dry I.A.D.

GLACIAL TILL, silt, sandy, some clay, trace gravel, very stiff, medium plastic, moist, grey.

–cobbles/boulders at 12.0 m.

LEGEND:

▩ TOPSOIL ▩ GRAVEL ▒ SAND ▥ SILT ▧ CLAY ☒ GLACIAL TILL ▤ FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γw....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO$_4$...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG
AND
SOIL TEST RESULTS

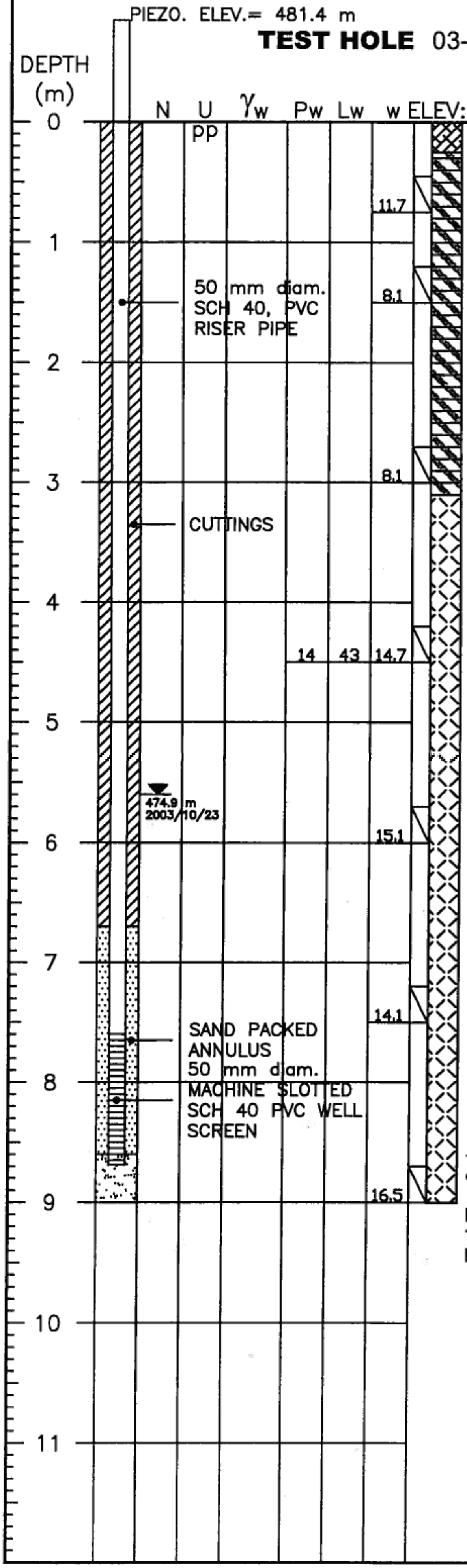
PROJECT:
SLOPE STABILITY STUDY

LOCATION:
313 - 11TH STREET, SASKATOON, SK

DATE DRILLED: OCTOBER 7/03

DRAWING NUMBER: S03-4925-5

TEST HOLE 03-5



TOPSOIL, organic, black, rootlets.

FILL, clay, silty, trace organics, firm, medium plastic, damp, brown.
—low plastic below 800 mm.

—trace glass at 1.3 m.

—wire at 2.1 m.
—some sand, trace gravel, medium plastic, damp to moist below 2.1 m.

GLACIAL TILL, silt, sandy, some clay, trace gravel, very stiff to hard, medium plastic, moist, olive brown, oxide stained.

—cobbles/boulders 5.4 to 6.9 m.

—sand seam, seepage, sloughing at 8.6 m.

NOTE:
1. Test Hole sloughed to 8.6 m I.A.D.

LEGEND:

▨	●	░	▥	▧	☒	▤
TOPSOIL	GRAVEL	SAND	SILT	CLAY	GLACIAL TILL	FILL

pp....POCKET PENETROMETER (kg/cm²)

w......WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw....LIQUID LIMIT

Pw....PLASTIC LIMIT

γw....WET UNIT WEIGHT (kN/m³)

U......UNCONFINED COMPRESSIVE STRENGTH (kPa)

N......STANDARD PENETRATION TEST

SO_4...SULPHATE CONTENT (PERCENT OF DRY SOIL)

I.A.D....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼.....RECORDED WATER LEVEL (PIEZO)

■	☒	⧄
SHELBY TUBE	SPLIT SPOON	CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
SLOPE STABILITY STUDY

LOCATION:
313 - 11TH STREET, SASKATOON, SK

DATE DRILLED:
OCTOBER 7/03

DRAWING NUMBER:
S03-4925-6

HISTORICAL BOREHOLE LOGS
TH 1, TH 2, TH 3, TH 4, TH 5, TH 6 (AMEC05)

AMEC Earth & Environmental. July 27, 2005. Revised Slope Stability Assessment Proposed Condominium Development, 316 Saskatchewan Crescent, Saskatoon, Saskatchewan

HBT AGRA Limited
Engineering & Environmental Services

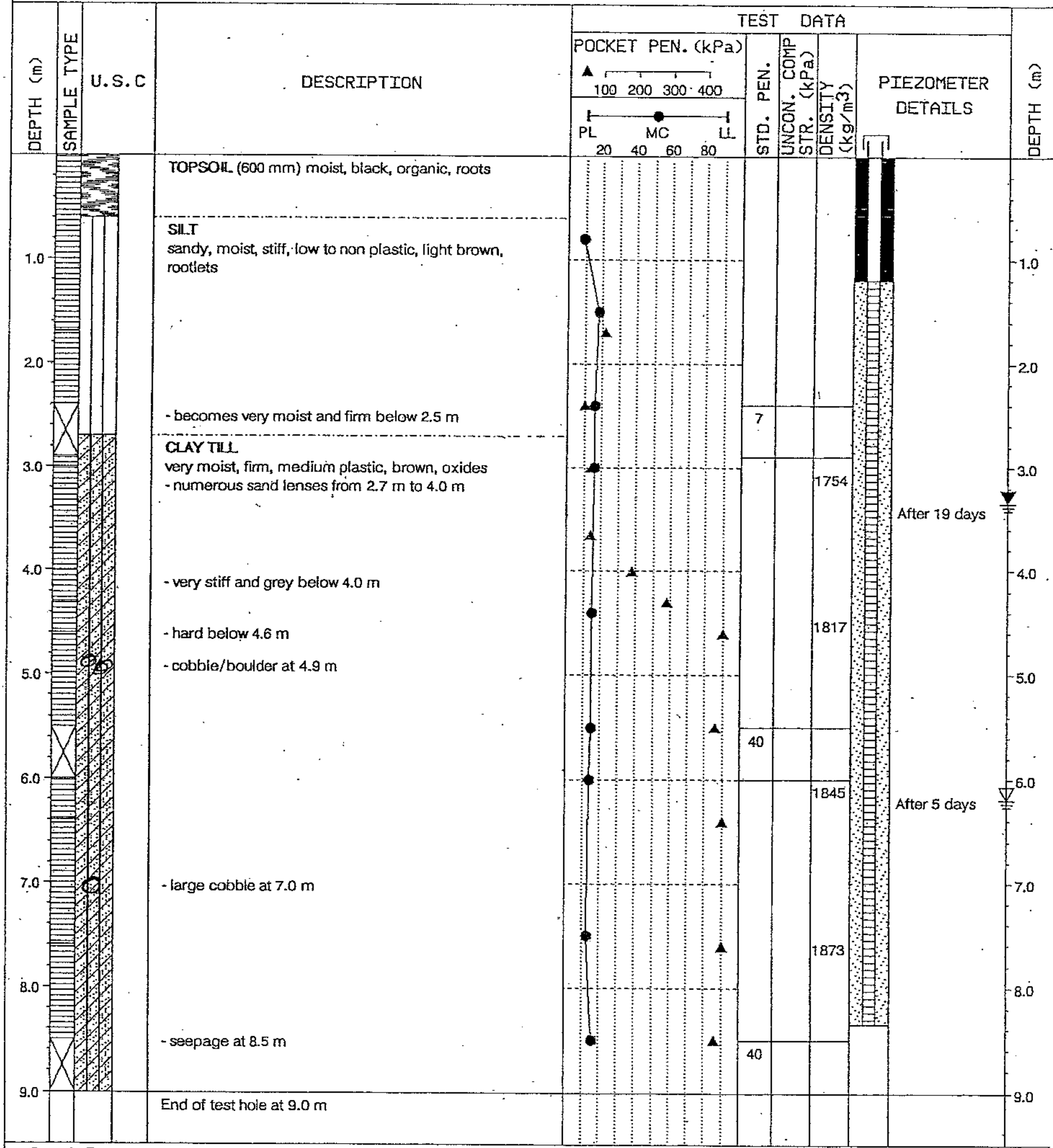
TEST HOLE LOG

TEST HOLE NO.

Project No. **SG-01965**

Project: PROPOSED CONDOMINIUM DEVELOPMENT
306 SASKATCHEWAN CRESCENT
SASKATOON, SASKATCHEWAN

Elevation(m): 479.50
Date Drilled: 12/10/93
Drill Method: CME 75 cont. hollow stem auger



TOPSOIL (600 mm) moist, black, organic, roots

SILT
sandy, moist, stiff, low to non plastic, light brown, rootlets

- becomes very moist and firm below 2.5 m

CLAY TILL
very moist, firm, medium plastic, brown, oxides
- numerous sand lenses from 2.7 m to 4.0 m
- very stiff and grey below 4.0 m
- hard below 4.6 m
- cobble/boulder at 4.9 m
- large cobble at 7.0 m
- seepage at 8.5 m

End of test hole at 9.0 m

Sample Type:

◿ DISTURBED	☒ SPT SAMPLE	◧ CORE
■ SHELBY	☰ CONT.SAMPLER	▥ NO RECOVERY

FIGURE A4

Sheet 1 of 1

HBT AGRA Limited
Engineering & Environmental Services

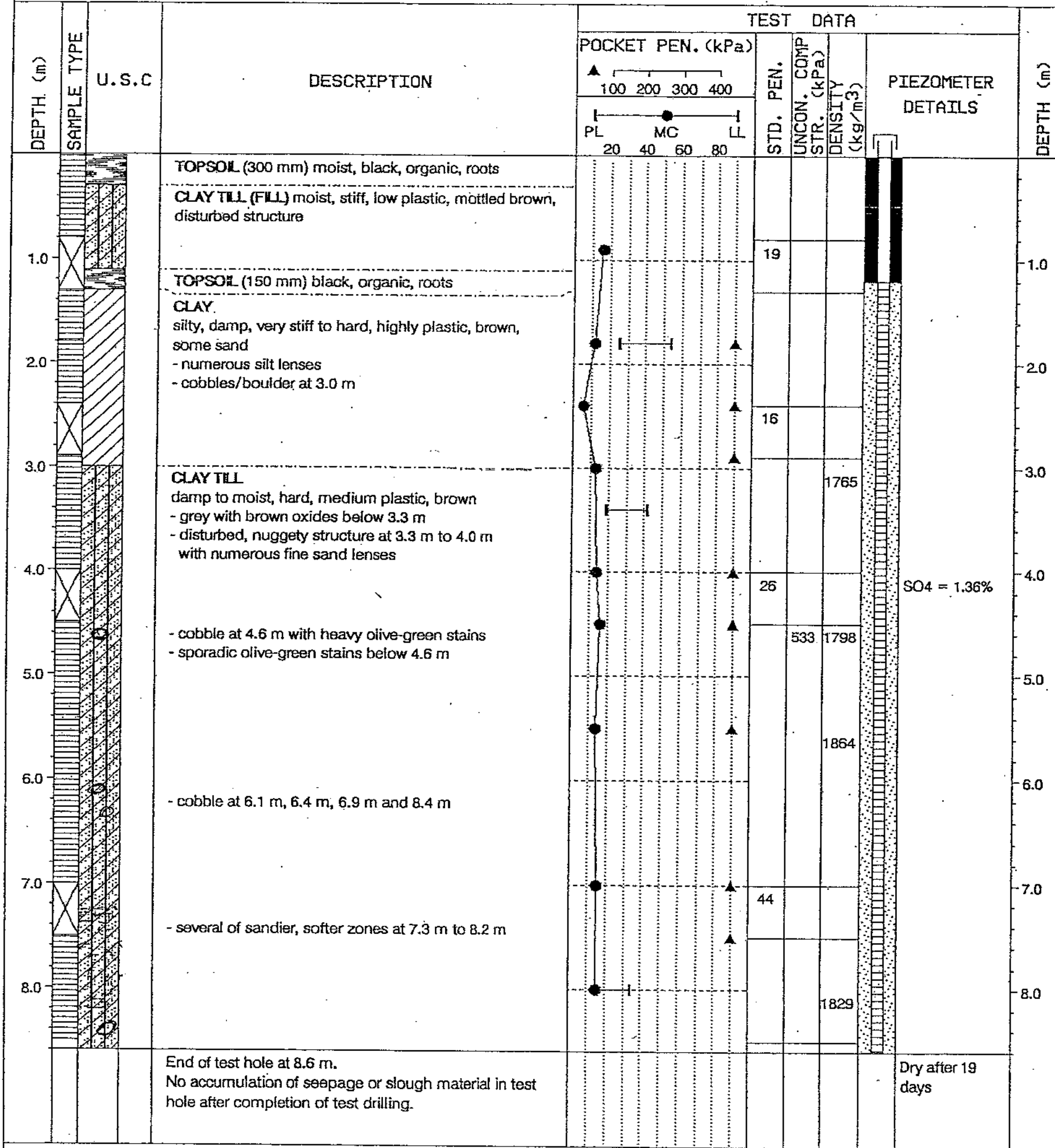
TEST HOLE LOG

TEST HOLE NO. 2

Project No. SG-01965

Project: PROPOSED CONDOMINIUM DEVELOPMENT
306 SASKATCHEWAN CRESCENT
SASKATOON, SASKATCHEWAN

Elevation(m): 480.53
Date Drilled: 12/10/93
Drill Method: CME 75 cont. hollow stem auger



TOPSOIL (300 mm) moist, black, organic, roots

CLAY TILL (FILL) moist, stiff, low plastic, mottled brown, disturbed structure

TOPSOIL (150 mm) black, organic, roots

CLAY
silty, damp, very stiff to hard, highly plastic, brown, some sand
- numerous silt lenses
- cobbles/boulder at 3.0 m

CLAY TILL
damp to moist, hard, medium plastic, brown
- grey with brown oxides below 3.3 m
- disturbed, nuggety structure at 3.3 m to 4.0 m with numerous fine sand lenses
- cobble at 4.6 m with heavy olive-green stains
- sporadic olive-green stains below 4.6 m
- cobble at 6.1 m, 6.4 m, 6.9 m and 8.4 m
- several of sandier, softer zones at 7.3 m to 8.2 m

End of test hole at 8.6 m.
No accumulation of seepage or slough material in test hole after completion of test drilling.

Sample Type:

▨ DISTURBED	☒ SPT SAMPLE	▮ CORE
■ SHELBY	☰ CONT.SAMPLER	▯ NO RECOVERY

FIGURE A5

Sheet 1 of 1

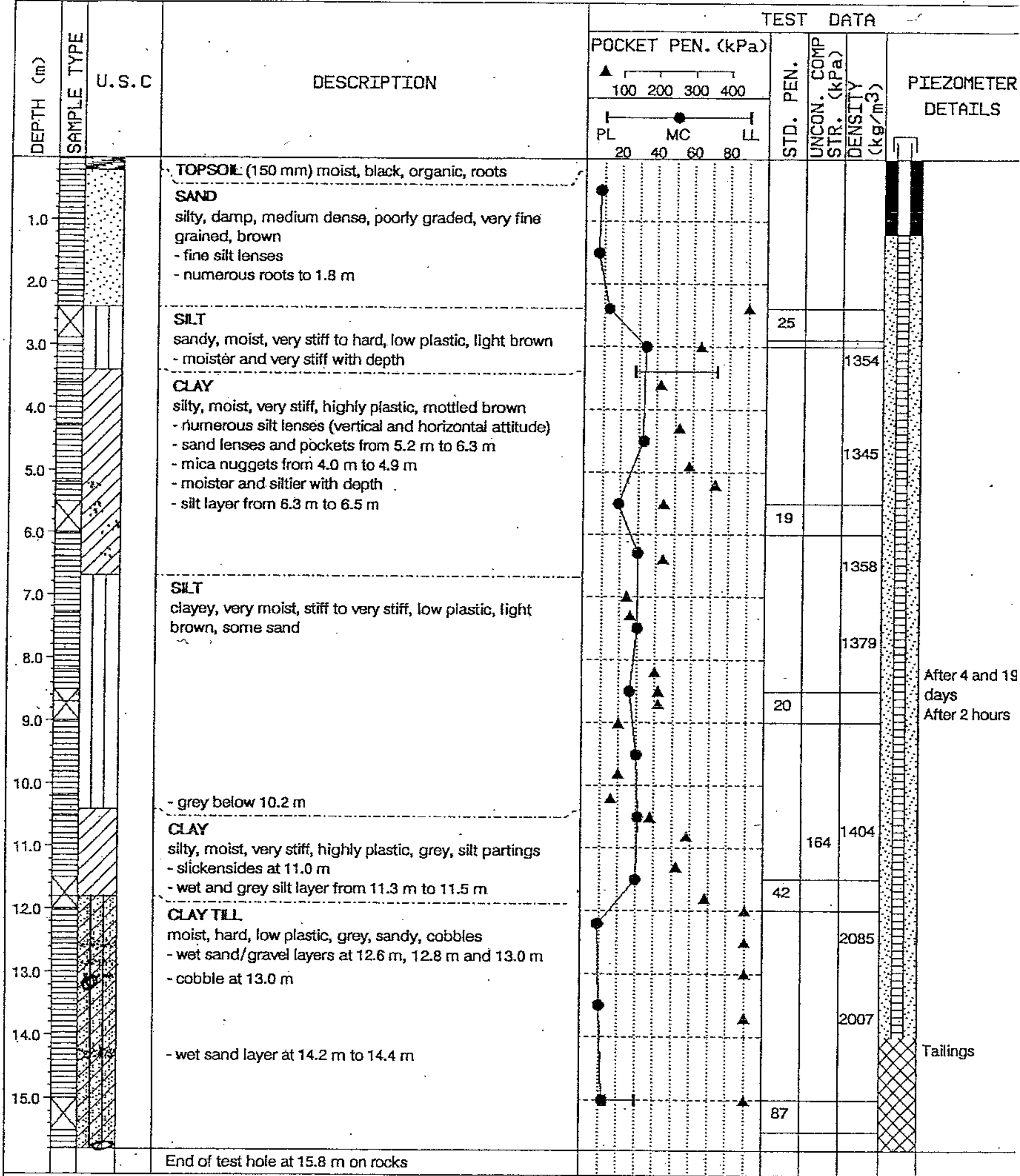
HBT AGRA Limited
Engineering & Environmental Services

TEST HOLE LOG

TEST HOLE NO. 6
Project No. **SG-01965**

Project: PROPOSED CONDOMINIUM DEVELOPMENT
306 SASKATCHEWAN CRESCENT
SASKATOON, SASKATCHEWAN

Elevation(m): 494.36
Date Drilled: 12/10/93
Drill Method: CME 75 cont. hollow stem auger



TOPSOIL (150 mm) moist, black, organic, roots

SAND
silty, damp, medium dense, poorly graded, very fine grained, brown
- fine silt lenses
- numerous roots to 1.8 m

SILT
sandy, moist, very stiff to hard, low plastic, light brown
- moister and very stiff with depth

CLAY
silty, moist, very stiff, highly plastic, mottled brown
- numerous silt lenses (vertical and horizontal attitude)
- sand lenses and pockets from 5.2 m to 6.3 m
- mica nuggets from 4.0 m to 4.9 m
- moister and siltier with depth
- silt layer from 6.3 m to 6.5 m

SILT
clayey, very moist, stiff to very stiff, low plastic, light brown, some sand
- grey below 10.2 m

CLAY
silty, moist, very stiff, highly plastic, grey, silt partings
- slickensides at 11.0 m
- wet and grey silt layer from 11.3 m to 11.5 m

CLAY TILL
moist, hard, low plastic, grey, sandy, cobbles
- wet sand/gravel layers at 12.6 m, 12.8 m and 13.0 m
- cobble at 13.0 m
- wet sand layer at 14.2 m to 14.4 m

End of test hole at 15.8 m on rocks

STD. PEN.	UNCON. COMP STR. (kPa)	DENSITY (kg/m3)
25		
		1354
		1345
19		
		1358
		1379
20		
	164	1404
42		
		2085
		2007
87		

Sample Type:

▨ DISTURBED	☒ SPT SAMPLE	◨ CORE
■ SHELBY	☰ CONT.SAMPLER	▥ NO RECOVERY

FIGURE A6

Sheet 1 of 1

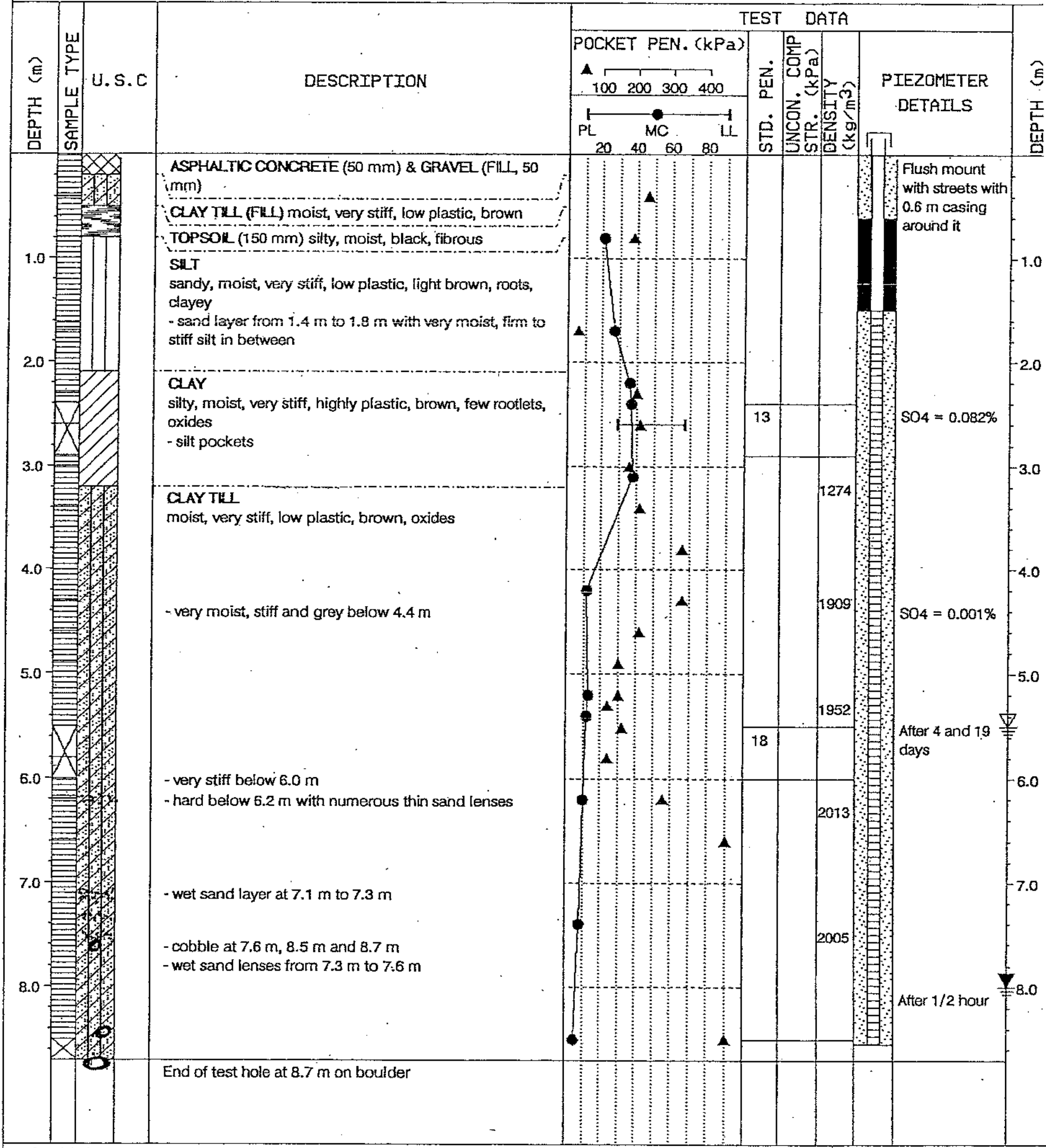
HBT AGRA Limited
Engineering & Environmental Services

TEST HOLE LOG

Project No. **SG-01965**

Project: PROPOSED CONDOMINIUM DEVELOPMENT
306 SASKATCHEWAN CRESCENT
SASKATOON, SASKATCHEWAN

Elevation(m): 488.67
Date Drilled: 13/10/93
Drill Method: CME 75 cont. hollow stem auger



ASPHALTIC CONCRETE (50 mm) & **GRAVEL** (FILL, 50 mm)

CLAY TILL (FILL) moist, very stiff, low plastic, brown

TOPSOIL (150 mm) silty, moist, black, fibrous

SILT
sandy, moist, very stiff, low plastic, light brown, roots, clayey
- sand layer from 1.4 m to 1.8 m with very moist, firm to stiff silt in between

CLAY
silty, moist, very stiff, highly plastic, brown, few rootlets, oxides
- silt pockets

CLAY TILL
moist, very stiff, low plastic, brown, oxides

- very moist, stiff and grey below 4.4 m

- very stiff below 6.0 m
- hard below 6.2 m with numerous thin sand lenses

- wet sand layer at 7.1 m to 7.3 m

- cobble at 7.6 m, 8.5 m and 8.7 m
- wet sand lenses from 7.3 m to 7.6 m

End of test hole at 8.7 m on boulder

Sample Type:

▨ DISTURBED	☒ SPT SAMPLE	◧ CORE
■ SHELBY	▤ CONT.SAMPLER	▥ NO RECOVERY

FIGURE A7

Sheet 1 of 1

HBT AGRA Limited
Engineering & Environmental Services

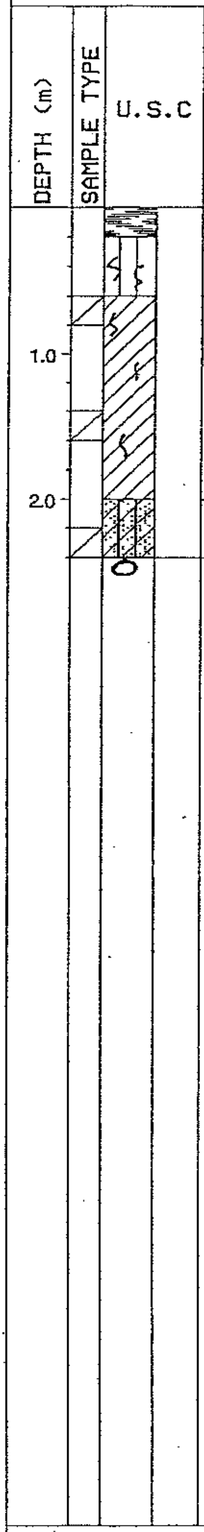
TEST HOLE LOG

TEST HOLE NO.

Project No. **SG-01965**

Project: PROPOSED CONDOMINIUM DEVELOPMENT
306 SASKATCHEWAN CRESCENT
SASKATOON, SASKATCHEWAN

Elevation(m): 485.18
Date Drilled: 14/10/93
Drill Method: Hand auger



DESCRIPTION

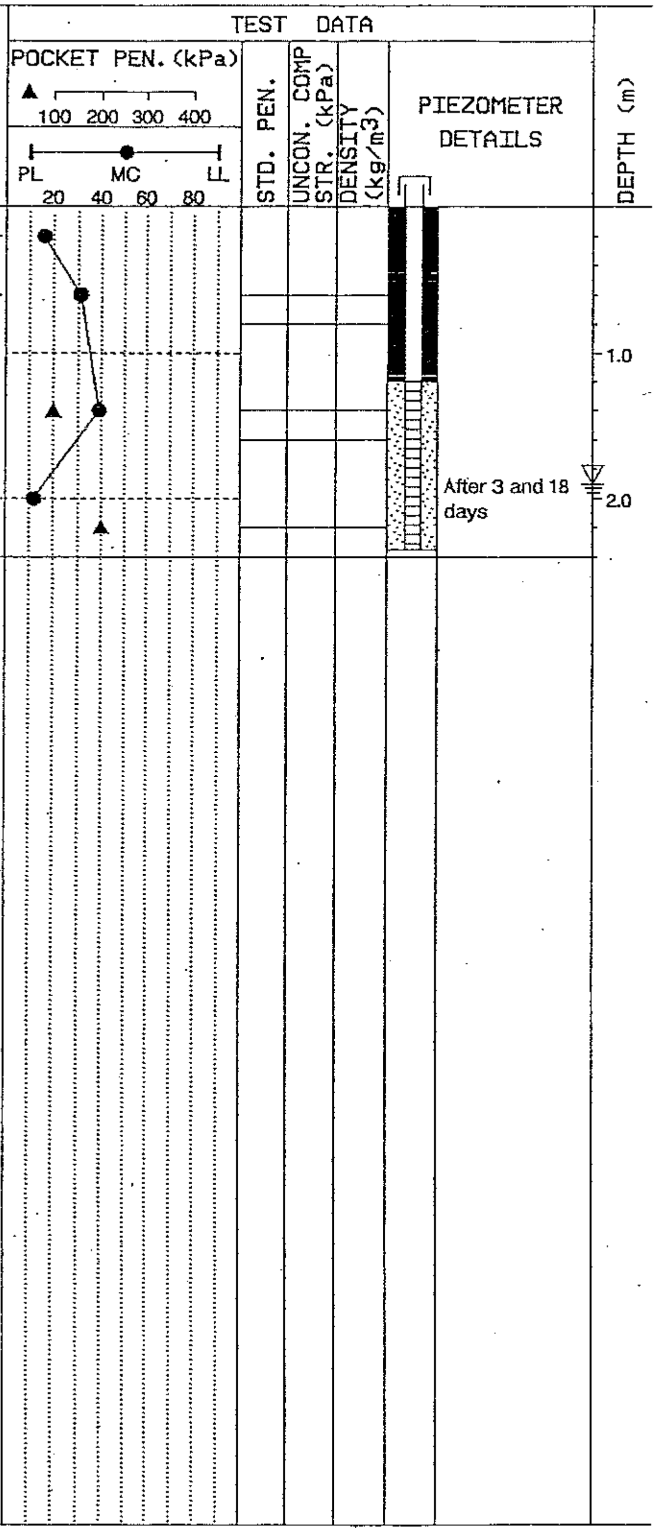
TOPSOIL (50 mm) silty, moist, black, fibrous

SILT
sandy, damp, low plastic, brown, clayey, organics

CLAY
silty, moist, stiff, medium to highly plastic, brown
- rootlets, sand lenses, salts
- very moist below 1.0 m

CLAY TILL moist, stiff to very stiff, medium plastic, dark brown, rootlets, oxides

End of test hole at 2.4 m on cobble or boulder



Sample Type:

- ▨ DISTURBED
- ■ SHELBY
- ☒ SPT SAMPLE
- ☰ CONT.SAMPLER
- ◧ CORE
- ▥ NO RECOVERY

FIGURE A8

Sheet 1 of 1

HBT AGRA Limited
Engineering & Environmental Services

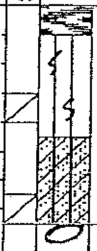
TEST HOLE LOG

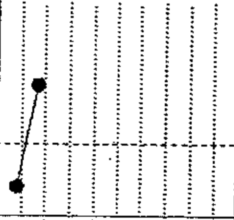
TEST HOLE NO. [illegible]
Project No. SG-01965

Project: PROPOSED CONDOMINIUM DEVELOPMENT
306 SASKATCHEWAN CRESCENT
SASKATOON, SASKATCHEWAN

Elevation(m): 486.23
Date Drilled: 14/10/93
Drill Method: Hand auger

DEPTH (m)	SAMPLE TYPE	U.S.C	DESCRIPTION	TEST DATA: POCKET PEN. (kPa) ▲ 100 200 300 400 / PL MC LL 20 40 60 80	STD. PEN.	UNCON. COMP STR. (kPa)	DENSITY (kg/m3)	OTHER TESTS	DEPTH (m)
			TOPSOIL (190 mm) silty, moist, black, fibrous						
			SILT sandy, damp, low plastic, light brown, clayey, organics						
1.0			**CLAY TILL** damp, low plastic, brown, oxides, few rootlets						1.0
			End of test hole at 1.5 m on cobble or boulder						





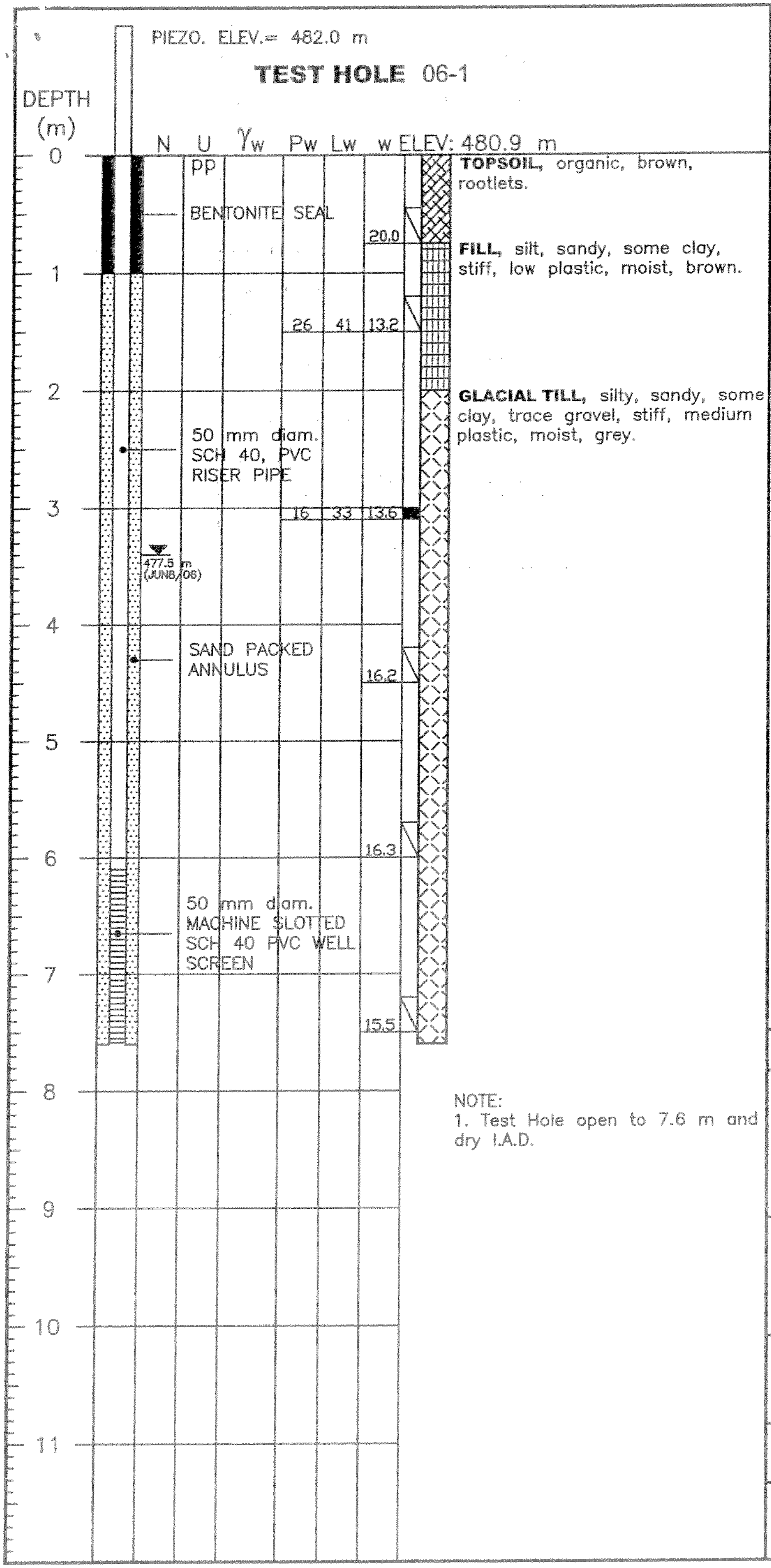
Sample Type:
- ▨ DISTURBED
- ■ SHELBY
- ☒ SPT SAMPLE
- ☰ CONT.SAMPLER
- ◧ CORE
- ▥ NO RECOVERY

FIGURE A9

Sheet 1 of 1

HISTORICAL BOREHOLE LOGS
TH 06-1, TH 06-2 (PMEL06)

P. Machibroda Engineering Ltd. July 14, 2006. Geotechnical Investigation and Slope Stability Study Proposed Condominium 316 - Saskatchewan Crescent East, Saskatoon, SK



TOPSOIL, organic, brown, rootlets.

FILL, silt, sandy, some clay, stiff, low plastic, moist, brown.

GLACIAL TILL, silty, sandy, some clay, trace gravel, stiff, medium plastic, moist, grey.

NOTE:
1. Test Hole open to 7.6 m and dry I.A.D.

LEGEND:

TOPSOIL, GRAVEL, SAND, SILT, CLAY, GLACIAL TILL, FILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γw...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (ROPE–CATHEAD & DONUT HAMMER) (50/125mm = BLOWS/SAMPLER PENETRATION)

SO_4 .....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT: PROPOSED CONDOMINIUM DEVELOPMENT

LOCATION: SASKATOON, SK

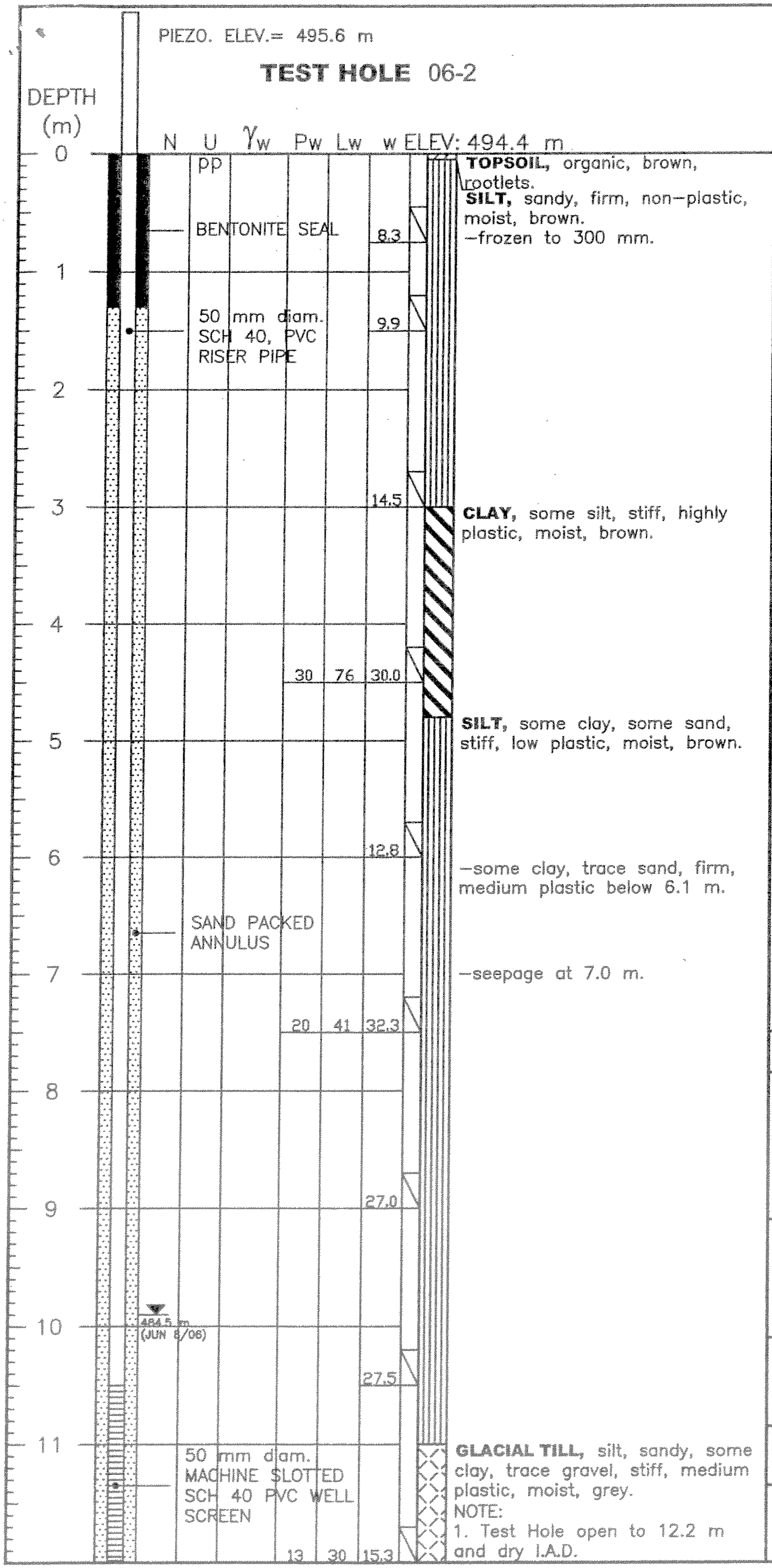
DATE DRILLED: MAR 17/06

DRAWING NUMBER: S06-5722-3

PIEZO. ELEV.= 495.6 m

TEST HOLE 06-2

ELEV: 494.4 m



TOPSOIL, organic, brown, rootlets.

SILT, sandy, firm, non-plastic, moist, brown.
-frozen to 300 mm.

CLAY, some silt, stiff, highly plastic, moist, brown.

SILT, some clay, some sand, stiff, low plastic, moist, brown.

-some clay, trace sand, firm, medium plastic below 6.1 m.

-seepage at 7.0 m.

GLACIAL TILL, silt, sandy, some clay, trace gravel, stiff, medium plastic, moist, grey.

NOTE:
1. Test Hole open to 12.2 m and dry I.A.D.

LEGEND:

TOPSOIL ▨ GRAVEL ▨ SAND ▨ SILT ▨ CLAY ▨ GLACIAL TILL ▨ FILL ▨

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γw...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (ROPE-CATHEAD & DONUT HAMMER) (50/125mm = BLOWS/SAMPLER PENETRATION)

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL TEST HOLE (I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧅ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED CONDOMINIUM DEVELOPMENT

LOCATION:
SASKATOON, SK

DATE DRILLED:	DRAWING NUMBER:
MAR 17/06	S06-5722-4

HISTORICAL BOREHOLE LOGS
TH07-01, TH 07-02, TH 07-03, TH 07-04, TH 07-5 (PMEL07)

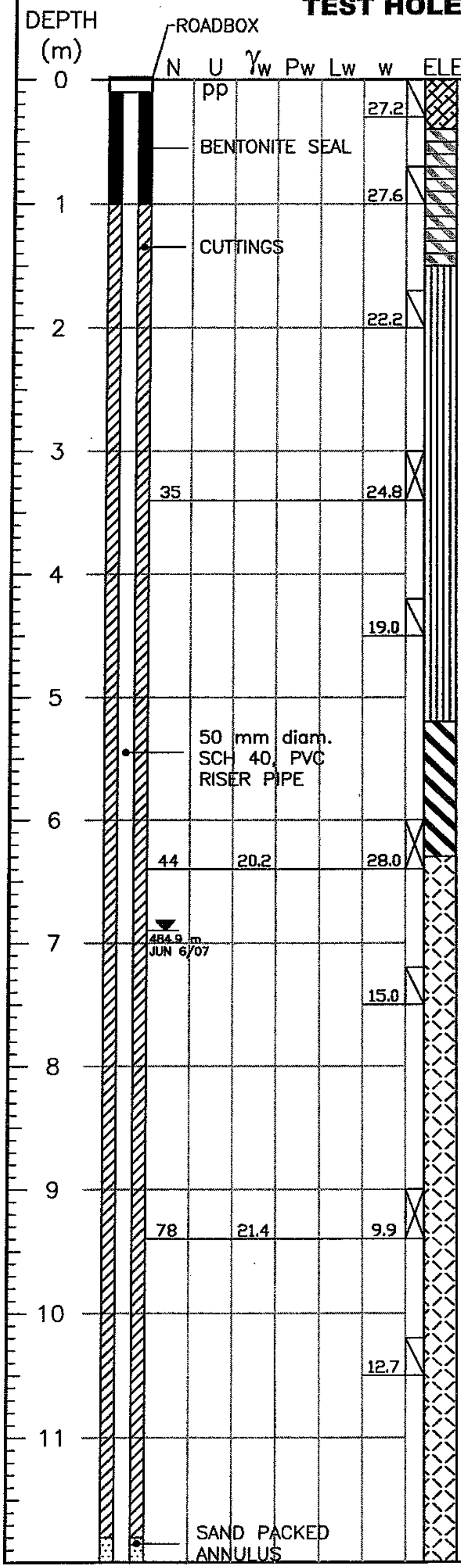
P. Machibroda Engineering Ltd. June 12, 2007. Geotechnical Investigation and Slope Stability Study Proposed Residences, 221 & 225 - 11th Street East, Saskatoon, SK

PIEZO. ELEV.= 491.7 m

PAGE 1 OF 2

TEST HOLE 07-1

ELEV: 491.8 m



TOPSOIL, organic, brown, rootlets.

FILL, clay, some silt, some sand, trace gravel, stiff, medium plastic, moist, olive, oxide stained.

SILT, some clay, trace sand, stiff, medium plastic, moist, brown, trace gypsum crystals.

CLAY, some silt, stiff, highly plastic, moist, grey, trace seepage.

GLACIAL TILL, clay, some silt, some sand, trace gravel, very stiff, medium plastic, moist, grey.

—hard below 9.0 m.

—sand lense, wet, seepage, sloughing at 10.0 m.

11th STREET

CONTINUED ON NEXT PAGE

LEGEND:

TOPSOIL ▩ FILL ▤ GRAVEL SAND SILT ▥ CLAY ▧ GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γw...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (ROPE–CATHEAD & DONUT HAMMER) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧅ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:

PROPOSED RESIDENCE

LOCATION:

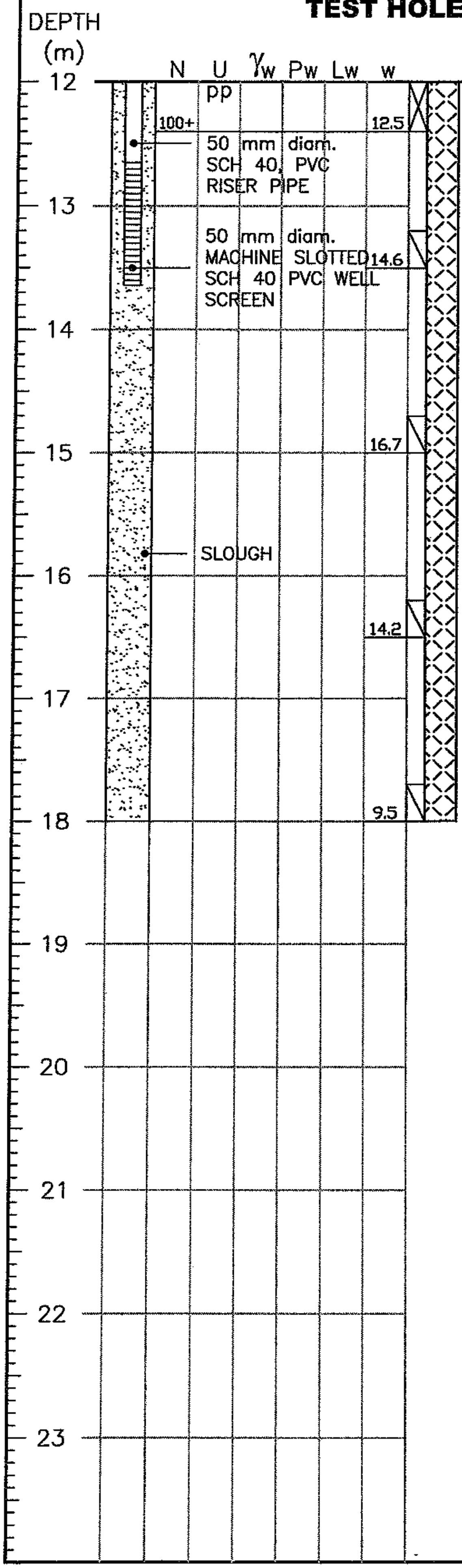
221 & 225 - 11th STREET EAST
SASKATOON, SK

NORTHING:

EASTING:

DATE DRILLED:	**DRAWING NUMBER:**
MAY 1/07	S07-6078-2

TEST HOLE 07-1



GLACIAL TILL, clay, some silt, some sand, trace gravel, hard, medium plastic, moist, grey, cobbles/boulders

—sand seam, wet, seepage, sloughing 17.2 to 17.7 m.

NOTE:
1. Test Hole sloughed to 11.8 m I.A.D.

11th STREET

LEGEND:

▨ TOPSOIL ▤ FILL ▨ GRAVEL ▨ SAND ▥ SILT ▨ CLAY ☒ GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (ROPE–CATHEAD & DONUT HAMMER) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4 .....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧅ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED RESIDENCE

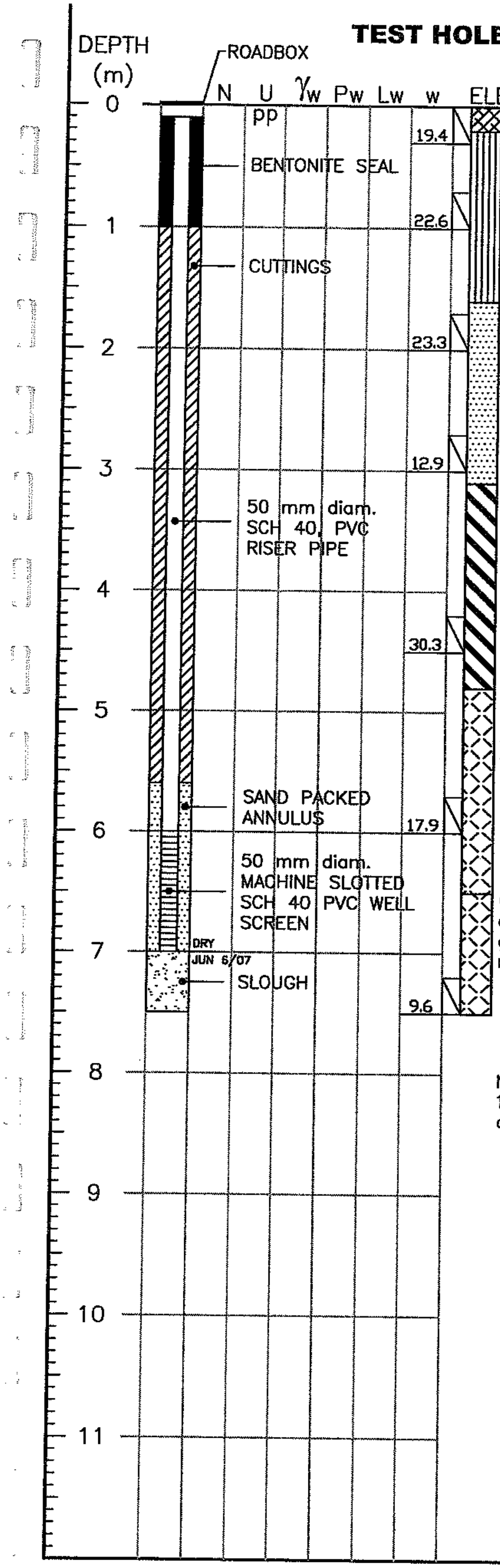
LOCATION:
221 & 225 - 11th STREET EAST
SASKATOON, SK

NORTHING: **EASTING:**

DATE DRILLED: MAY 1/07

DRAWING NUMBER: S07-6078-2A

TEST HOLE 07-2



TOPSOIL, organic, brown, rootlets.

SILT, some clay, firm, low to medium plastic, moist, brown.

SAND, silty, compact, poorly graded, fine grained, moist, brown.

–trace seepage, sloughing below 2.6 m.

CLAY, some silt, stiff, medium plastic, moist, brown, oxide stained.

GLACIAL TILL, clay, silty, some sand, trace gravel, stiff, medium plastic, moist, brown, oxide stained, gypsum crystals.

GLACIAL TILL, sand, silty, some clay, trace gravel, dense, poorly graded, fine to medium grained, moist, brown, oxide stained.

NOTE:
1. Test Hole sloughed to 7.1 m and dry I.A.D.

11th STREET

▩	☰	▩	▒	▥	▨	☒
TOPSOIL	FILL	GRAVEL	SAND	SILT	CLAY	GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γw...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (ROPE–CATHEAD & DONUT HAMMER) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■	☒	◸
SHELBY TUBE	SPLIT SPOON	CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED RESIDENCE

LOCATION:
221 & 225 - 11th STREET EAST
SASKATOON, SK

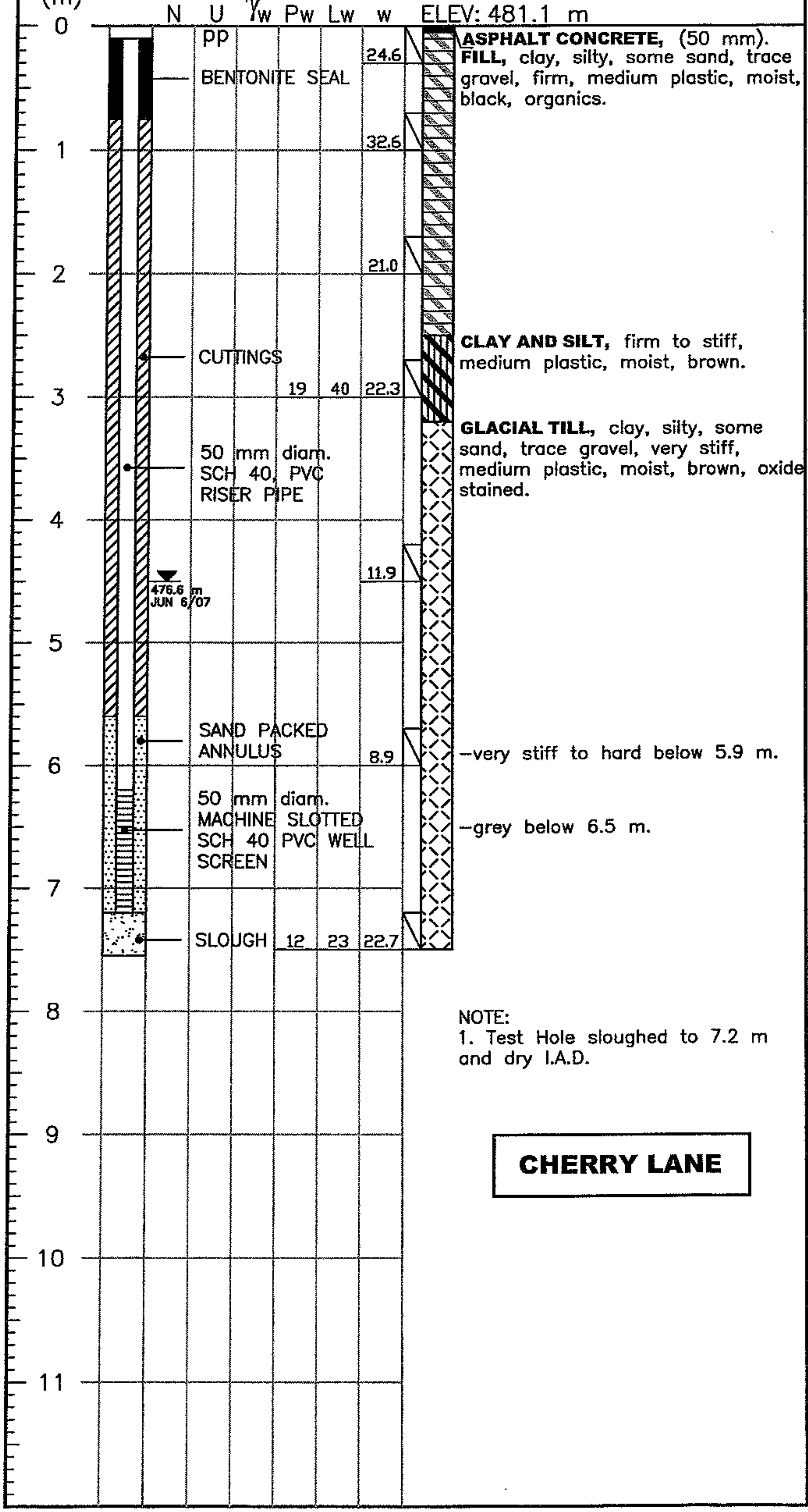
NORTHING:
EASTING:

DATE DRILLED: MAY 3/07

DRAWING NUMBER: S07-6078-3

PIEZO. ELEV.= 481.0 m

TEST HOLE 07-3



ASPHALT CONCRETE, (50 mm).
FILL, clay, silty, some sand, trace gravel, firm, medium plastic, moist, black, organics.

CLAY AND SILT, firm to stiff, medium plastic, moist, brown.

GLACIAL TILL, clay, silty, some sand, trace gravel, very stiff, medium plastic, moist, brown, oxide stained.

–very stiff to hard below 5.9 m.

–grey below 6.5 m.

NOTE:
1. Test Hole sloughed to 7.2 m and dry I.A.D.

CHERRY LANE

LEGEND:

TOPSOIL, FILL, GRAVEL, SAND, SILT, CLAY, GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m^3)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm^2)

N.....STANDARD PENETRATION TEST (ROPE–CATHEAD & DONUT HAMMER) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧅ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED RESIDENCE

LOCATION:
221 & 225 - 11th STREET EAST
SASKATOON, SK

NORTHING: **EASTING:**

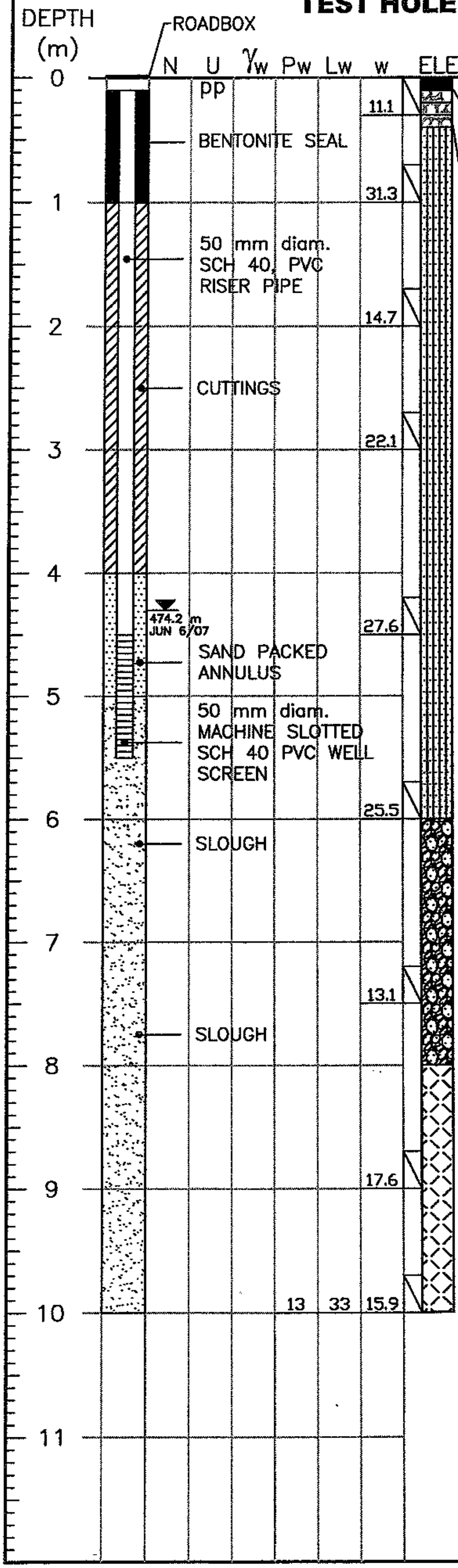
DATE DRILLED: MAY 10/07

DRAWING NUMBER: S07-6078-4

PIEZO. ELEV.= 478.4 m

TEST HOLE 07-4

ELEV: 478.5 m



ASPHALT CONCRETE, (100 mm).

FILL, gravel, sandy, some silt, dense, well graded, fine to coarse grained, moist, brown.

SAND AND SILT, compact to dense, poorly graded, fine grained, moist, brown.

–some silt below 2.7 m.

–wet, seepage, sloughing below 3.0 m.

SAND AND GRAVEL, some silt, dense, well graded, fine to coarse grained, wet, brown, seepage, sloughing.

GLACIAL TILL, clay, some silt, some sand, trace gravel, hard, medium plastic, moist, grey.

NOTE:
1. Test Hole sloughed to 5.0 m I.A.D.

SASKATCHEWAN CRESCENT

LEGEND:

▨ TOPSOIL
☰ FILL
● GRAVEL
░ SAND
‖ SILT
▧ CLAY
☒ GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m^3)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm^2)

N.....STANDARD PENETRATION TEST (ROPE–CATHEAD & DONUT HAMMER) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE
☒ SPLIT SPOON
◺ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED RESIDENCE

LOCATION:
221 & 225 - 11th STREET EAST
SASKATOON, SK

NORTHING:
EASTING:

DATE DRILLED: MAY 3/07

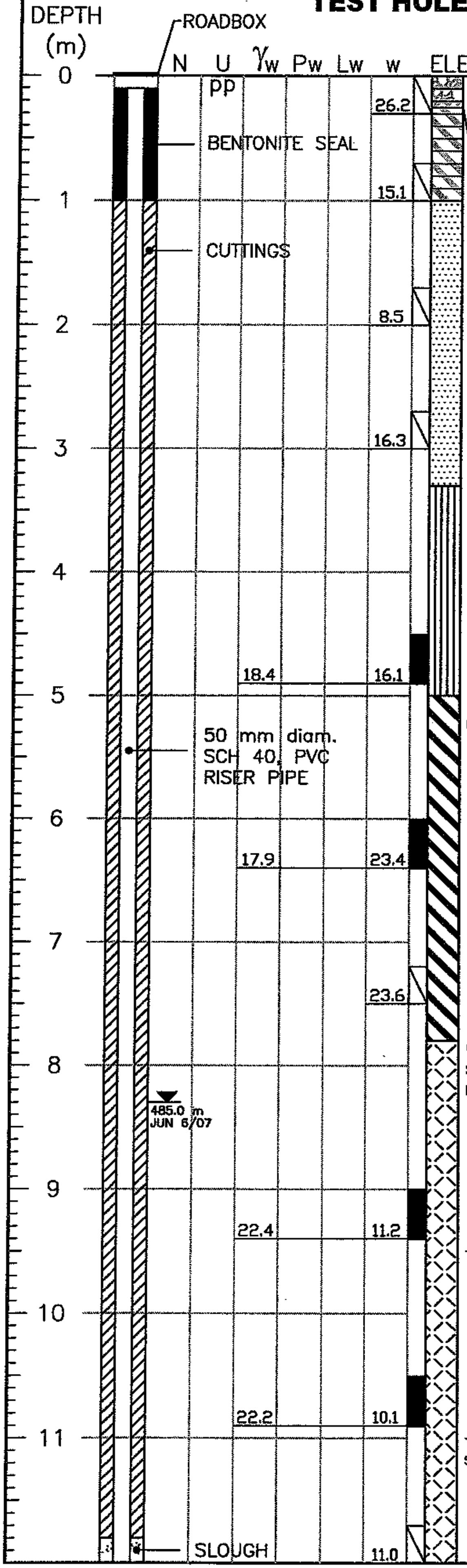
DRAWING NUMBER: S07-6078-5

PIEZO. ELEV.= 493.2 m

PAGE 1 OF 2

TEST HOLE 07-5

ELEV: 493.3 m



FILL, gravel, sandy, dense, well graded, fine to coarse grained, moist, brown.

FILL, clay, some silt, some sand, some gravel, stiff, medium plastic, moist, brown, oxide stained.

SAND, some silt, compact, poorly graded, fine grained, moist, brown.

–silty below 2.5 m.

SILT, clayey, some sand, firm, medium plastic, moist, brown.

CLAY, silty, stiff, medium plastic, moist, brown.

GLACIAL TILL, clay, some silt, some sand, trace gravel, very stiff, medium plastic, moist, grey.

–hard below 9.5 m.

11th STREET

–sand layer, wet, , seepage, sloughing 11.0 to 11.8 m.

CONTINUED ON NEXT PAGE

LEGEND:

▩	☰	⁂	░	▥	▧	⊠
TOPSOIL	FILL	GRAVEL	SAND	SILT	CLAY	GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γw...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (ROPE–CATHEAD & DONUT HAMMER) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■	☒	⧄
SHELBY TUBE	SPLIT SPOON	CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED RESIDENCE

LOCATION:
221 & 225 - 11th STREET EAST
SASKATOON, SK

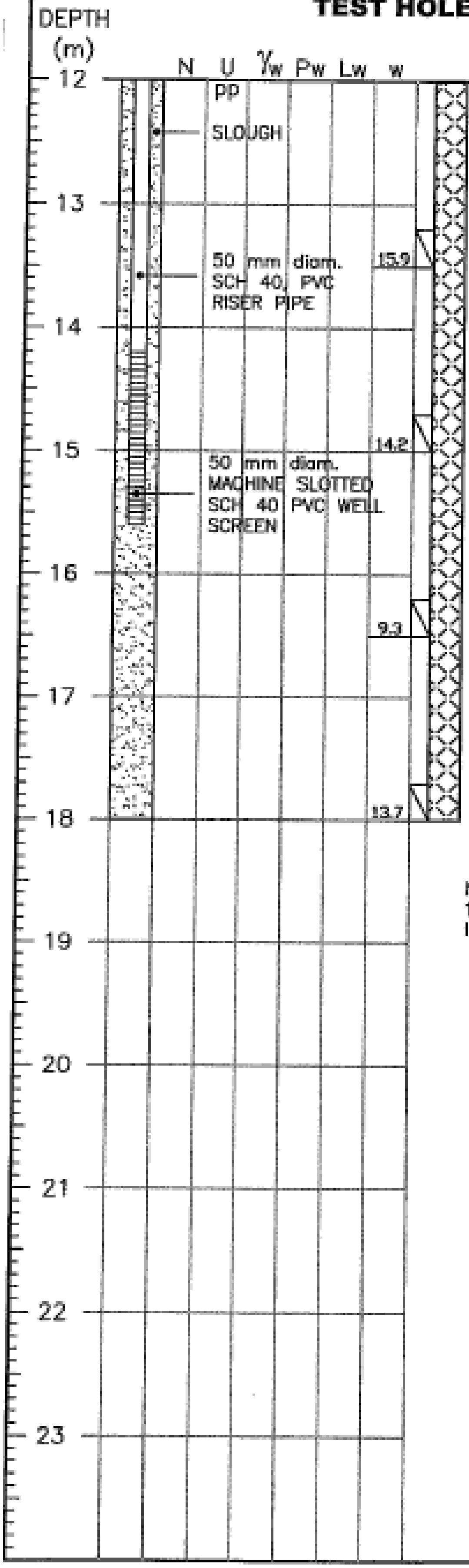
NORTHING:
EASTING:

DATE DRILLED: MAY 2/07

DRAWING NUMBER: S07-6078-6

PAGE 2 OF 2

TEST HOLE 07-5



GLACIAL TILL, clay, some silt, some sand, trace gravel, hard, medium plastic, moist, grey.

NOTE:
1. Test Hole sloughed to 11.8 m I.A.D.

11th STREET

LEGEND:

TOPSOIL, FILL, GRAVEL, SAND, SILT, CLAY, GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γw...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (ROPE–CATHEAD & DONUT HAMMER) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧅ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED RESIDENCE

LOCATION:
221 & 225 - 11th STREET EAST
SASKATOON, SK

NORTHING: **EASTING:**

DATE DRILLED: MAY 2/07

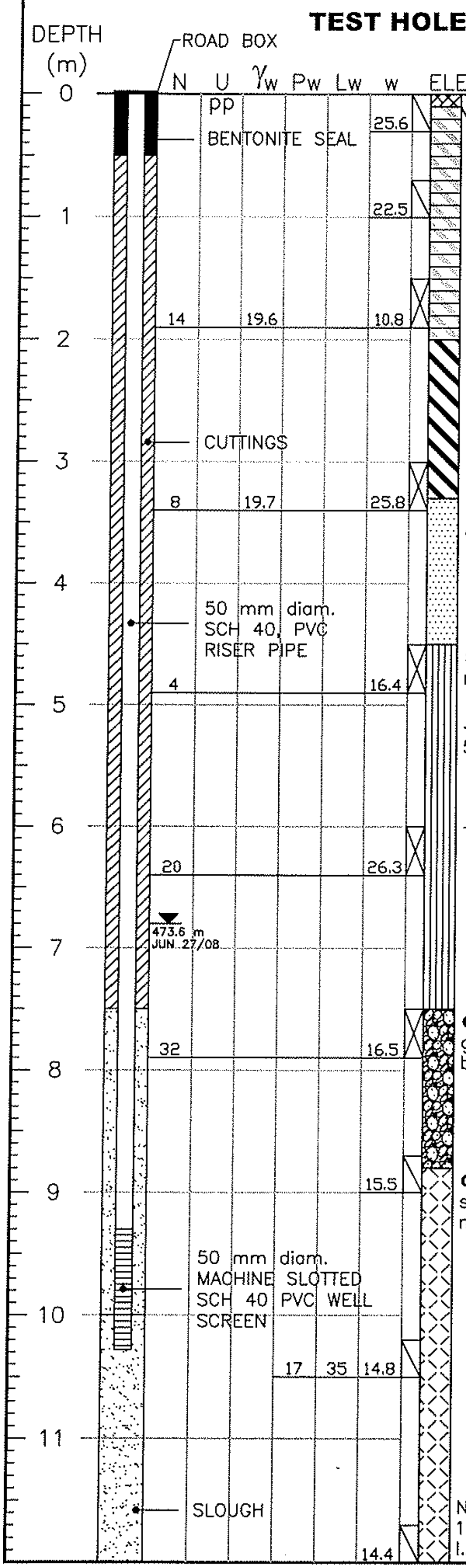
DRAWING NUMBER: S07-6078-6A

HISTORICAL BOREHOLE LOGS
TH08-01, TH 08-02, TH 08-03, TH 08-04 (PMEL08)

P. Machibroda Engineering Ltd. July 8, 2008. Proposed Commercial/Residential Development 328 Saskatchewan Crescent East, Saskatoon, SK

PIEZO. ELEV.= 480.4 m

TEST HOLE 08-1



TOPSOIL, organic, rootlets.

FILL, clay, silty, some sand, trace gravel, stiff, medium plastic, moist, brown.

–sand and gravel 1.5 to 1.7 m.

–black, organics 1.9 to 2.0 m.

CLAY, silty, firm, medium plastic, moist, brown, oxide stained.

SAND, silty, compact, poorly graded, fine grained, moist, brown.

SILT, sandy, soft, low plastic, moist, brown.

–wet, seepage, sloughing below 5.2 m.

–stiff below 6.0 m.

GRAVEL AND SAND, dense, poorly graded, medium grained, wet, brown, seepage, sloughing.

GLACIAL TILL, clay, some silt, some sand, trace gravel, stiff, medium plastic, moist, grey.

NOTE:
1. Test Hole sloughed to 7.5 m I.A.D.

LEGEND:

TOPSOIL, FILL, GRAVEL, SAND, SILT, CLAY, GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ◸ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED COMMERCIAL / RESIDENTIAL DEVELOPMENT

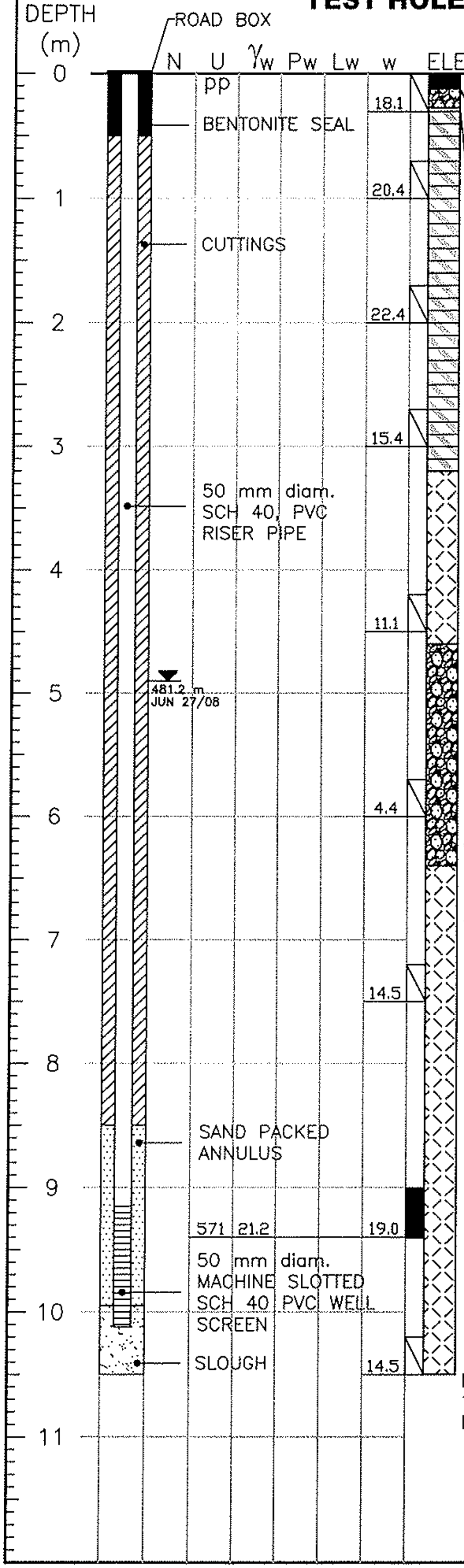
LOCATION:
328 SASKATCHEWAN CRESCENT
SASKATOON, SK

NORTHING:
EASTING:

DATE DRILLED: MAY 26/08
DRAWING NUMBER: S08-6500-2

PIEZO. ELEV.= 485.9 m

TEST HOLE 08-2



ASPHALT CONCRETE (120 mm)

FILL, sand and gravel, dense, well graded, coarse to fine grained, moist, brown.

FILL, clay, silty, some sand, trace gravel, stiff, medium plastic, moist, brown, oxide stained.

FILL, clay, silty, firm, medium plastic, moist, brown, oxide stained.

–concrete at 3.2 m.

GLACIAL TILL, clay, some silt, some sand, trace gravel, stiff, medium plastic, moist, brown, oxide stained.

SAND AND GRAVEL, dense, well graded, coarse to fine grained, moist, brown, oxide stained.

–wet, seepage, sloughing 6.1 to 6.4 m.

GLACIAL TILL, clay, some silt, some sand, trace gravel, very stiff, medium plastic, moist, grey.

NOTE:
1. Test Hole sloughed to 10.0 m I.A.D.

LEGEND:

TOPSOIL, FILL, GRAVEL, SAND, SILT, CLAY, GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m^3)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm^2)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO$_4$.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED COMMERCIAL / RESIDENTIAL DEVELOPMENT

LOCATION:
328 SASKATCHEWAN CRESCENT
SASKATOON, SK

NORTHING: **EASTING:**

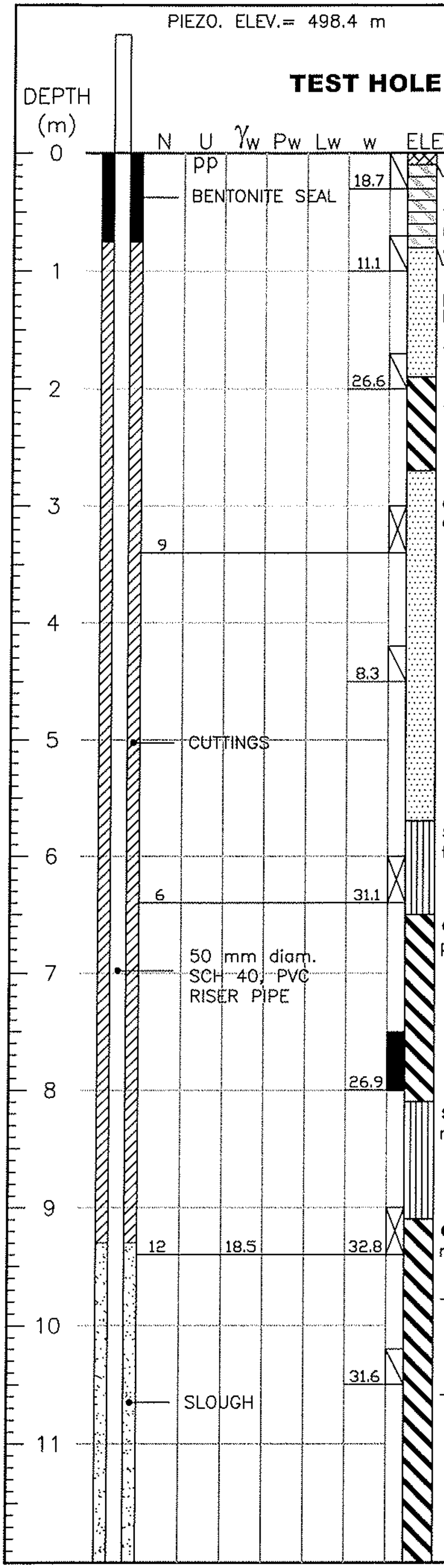
DATE DRILLED: MAY 23/08

DRAWING NUMBER: S08-6500-3

PIEZO. ELEV.= 498.4 m

PAGE 1 OF 2

TEST HOLE 08-3



TOPSOIL, black, organic, rootlets.

FILL, clay, sandy, some silt, trace gravel, firm, low to medium plastic, moist, mottled brown/black, organics, rootlets, brick pieces.

SAND, silty, loose to compact, poorly graded, fine grained, moist, brown.

-silt seam 1.6 to 1.8 m.

CLAY, some silt, very stiff, medium to highly plastic, moist, brown.

SAND, silty, trace clay, loose to compact, poorly graded, fine grained, moist, brown.

SILT, some clay, soft to firm, low to medium plastic, moist, brown.

CLAY, some silt, stiff, medium plastic, moist, brown.

SILT, some clay, firm, low plastic, moist, brown.

CLAY, silty, stiff, medium plastic, moist, brown, oxide stained.

-silt layer 9.8 to 10.1 m.

-grey below 10.6 m.

CONTINUED ON NEXT PAGE

LEGEND:

TOPSOIL FILL GRAVEL SAND SILT CLAY GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γw...WET UNIT WEIGHT (kN/m^3)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm^2)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

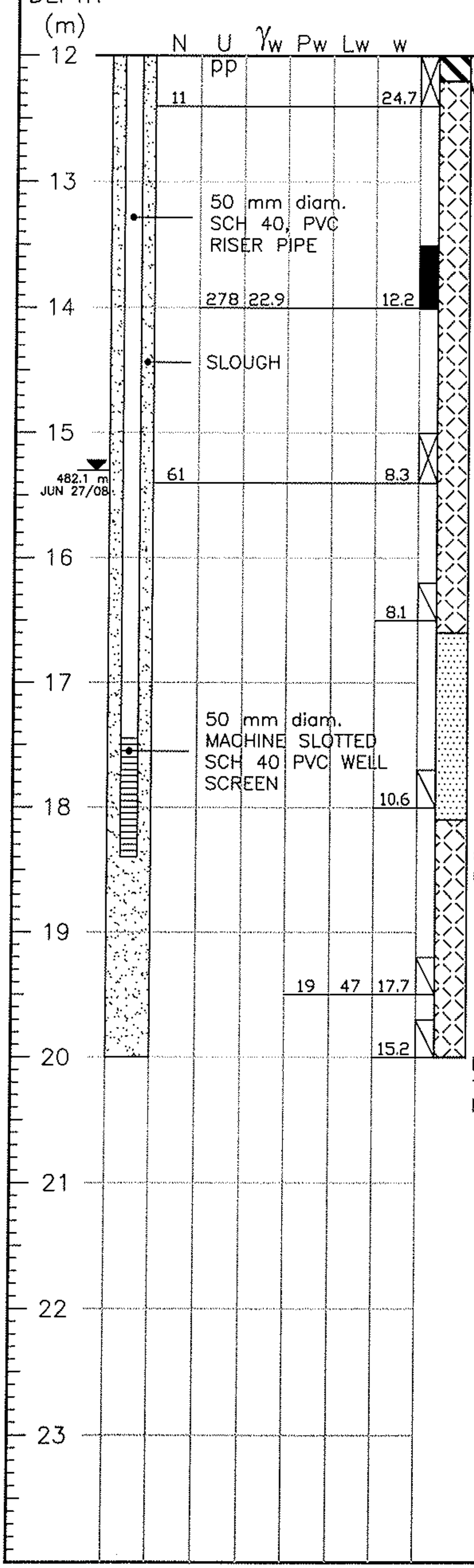
PROJECT:
PROPOSED COMMERCIAL / RESIDENTIAL DEVELOPMENT

LOCATION:
325 SASKATCHEWAN CRESCENT
SASKATOON, SK

NORTHING: **EASTING:**

DATE DRILLED:	**DRAWING NUMBER:**
MAY 22/08	S08-6500-4

TEST HOLE 08-3



CLAY, silty, stiff, medium plastic, moist, grey.

GLACIAL TILL, clay, silty, some sand, trace gravel, stiff, medium plastic, moist, grey.

–hard below 14.4 m.

–sand lense, wet, seepage, sloughing at 15.3 m.

SAND, gravelly, some silt, very dense, well graded, coarse to fine grained, wet, grey, seepage, sloughing.

GLACIAL TILL, clay, some silt, some sand, trace gravel, hard, medium plastic, moist, grey.

NOTE:
1. Test Hole sloughed to 9.3 m I.A.D.

LEGEND:

TOPSOIL, FILL, GRAVEL, SAND, SILT, CLAY, GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m^3)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm^2)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED COMMERCIAL / RESIDENTIAL DEVELOPMENT

LOCATION:
328 SASKATCHEWAN CRESCENT
SASKATOON, SK

NORTHING: **EASTING:**

DATE DRILLED: MAY 22/08

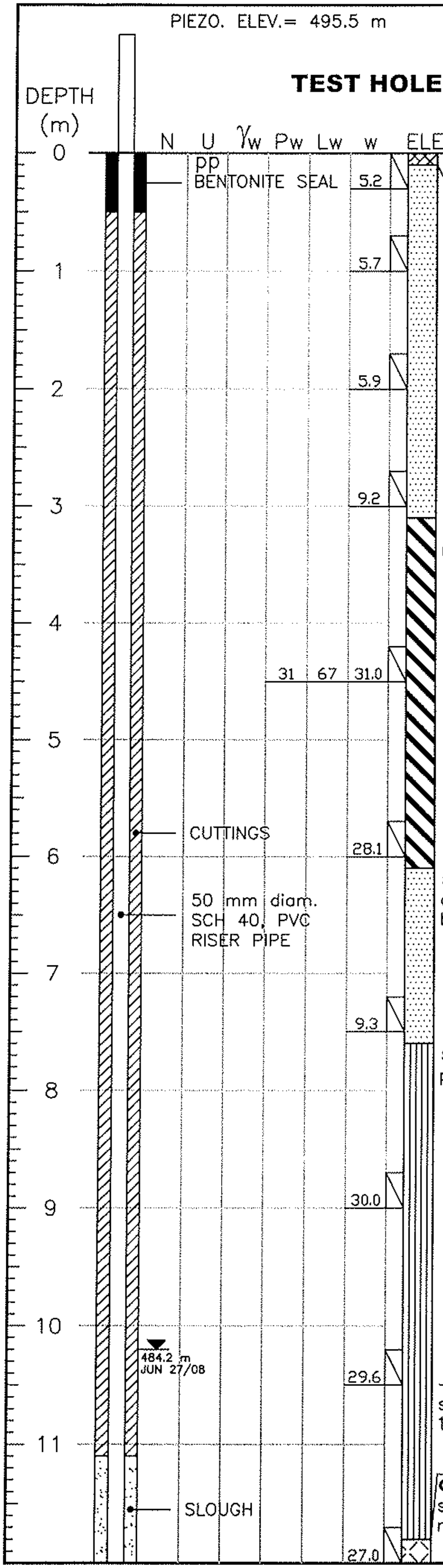
DRAWING NUMBER: S08-6500-4A

PIEZO. ELEV.= 495.5 m

PAGE 1 OF 2

TEST HOLE 08-4

ELEV: 494.4 m



TOPSOIL, organic, rootlets.

SAND, some silt, compact, poorly graded, fine grained, damp, brown.

CLAY, silty, stiff, highly plastic, moist, brown, oxide stained.

SAND, silty, compact, poorly graded, fine grained, moist, brown, oxide stained.

SILT, some clay, firm, medium plastic, wet, brown.

–sand and gravel seam, wet, seepage, sloughing 11.0 to 11.2 m.

GLACIAL TILL, clay, some silt, some sand, trace gravel, stiff, medium plastic, moist, grey.

CONTINUED ON NEXT PAGE

LEGEND:

▩	☰	▦	░	▥	▧	☒
TOPSOIL	FILL	GRAVEL	SAND	SILT	CLAY	GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γw...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4 .....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■	☒	◺
SHELBY TUBE	SPLIT SPOON	CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED COMMERCIAL / RESIDENTIAL DEVELOPMENT

LOCATION:
328 SASKATCHEWAN CRESCENT
SASKATOON, SK

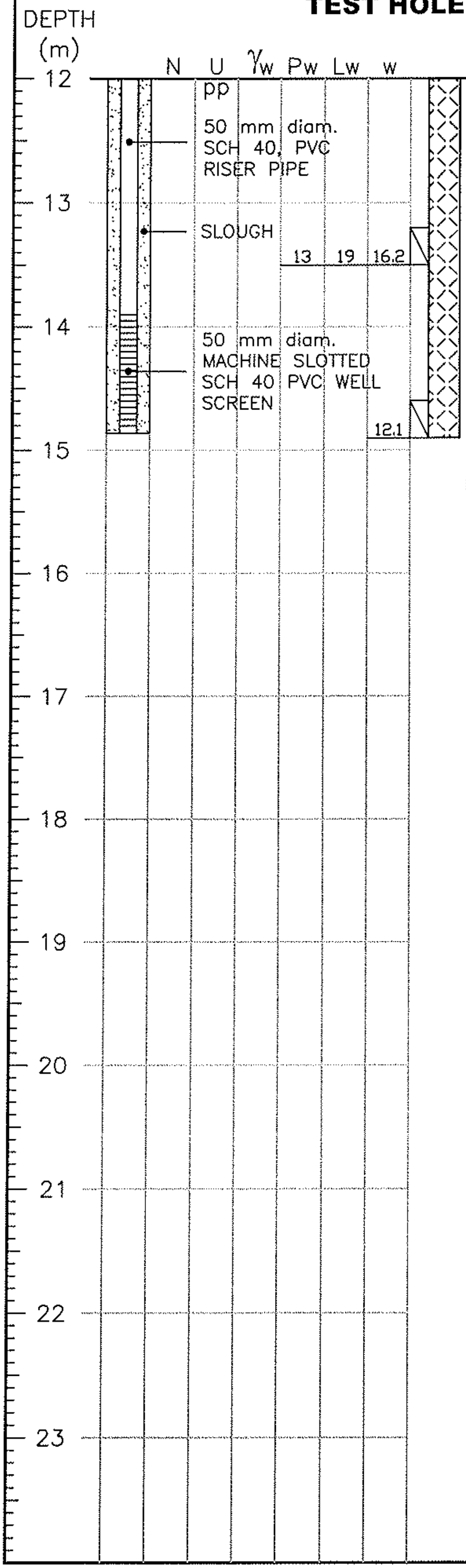
NORTHING:

EASTING:

DATE DRILLED: MAY 26/08

DRAWING NUMBER: S08-6500-5

TEST HOLE 08-4



GLACIAL TILL, clay, some silt, some sand, trace gravel, stiff, low to medium plastic, moist, grey.

NOTE:
1. Test Hole sloughed to 11.1 m I.A.D.

LEGEND:

TOPSOIL
FILL
GRAVEL
SAND
SILT
CLAY
GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γw...WET UNIT WEIGHT (kN/m^3)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm^2)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO$_4$ .....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE
☒ SPLIT SPOON
◺ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
PROPOSED COMMERCIAL / RESIDENTIAL DEVELOPMENT

LOCATION:
328 SASKATCHEWAN CRESCENT
SASKATOON, SK

NORTHING:
EASTING:

DATE DRILLED: MAY 26/08

DRAWING NUMBER: S08-6500-5A

HISTORICAL BOREHOLE LOGS
11-0057-BH1, 11-0057-BH2, 11-0057-BH3 (GAL12)

Golder Associates Ltd. May 2013. Assessment of Slope Instability at 200 Block, 11th Street East.

PROJECT: 11-1362-0057.5000

RECORD OF BOREHOLE: 11-0057-BH1

SHEET 1 OF 1

LOCATION: Cherry Lane N 5775616.80 E 386010.50

BORING DATE: 23/6/12
DRILL RIG: Acker MP-5
DRILLING CONTRACTOR: Paddock Drilling Ltd.

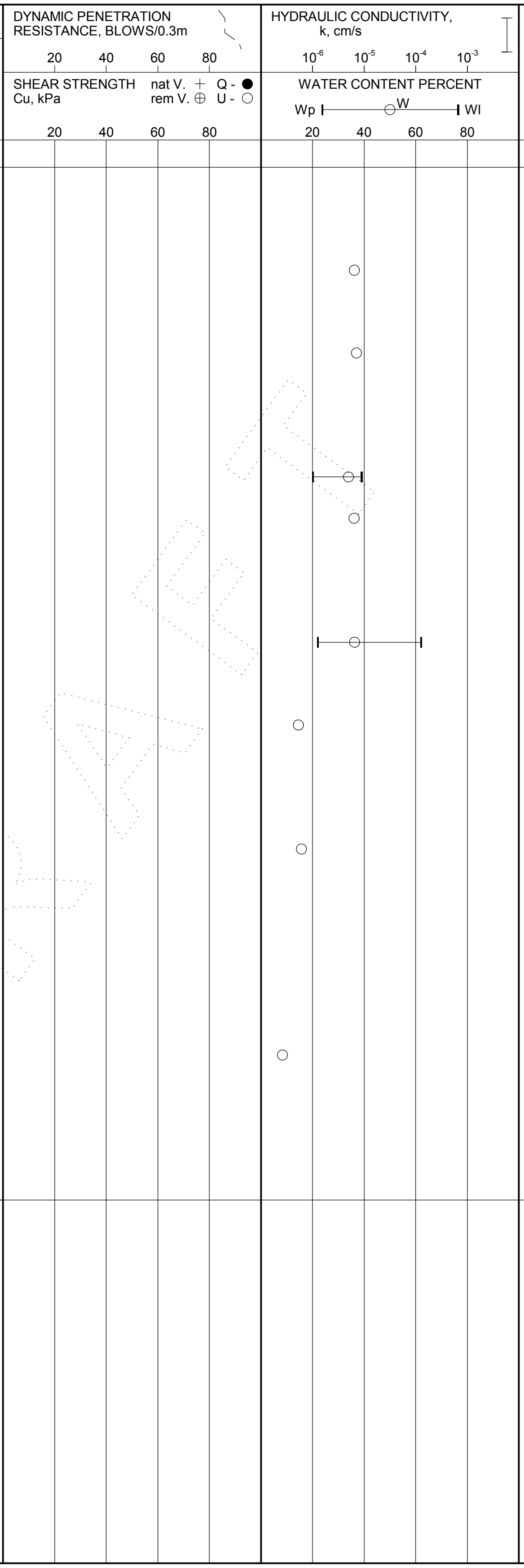
DATUM: City Datum

BORING METHOD: Acker MP-5 Power Auger Boring, Solid Stem Augers

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	488.30
ASPHALT PAVEMENT	488.10 0.20
SAND and GRAVEL, well graded, angular, some silt, medium brown, dry (GRANULAR BASE)	487.84 0.46
(ML) CLAYEY SILT, trace fine sand, medium brown, (FILL), w>PL, soft	487.08 1.22
(CI) SILTY CLAY, medium brown, w>PL, soft to firm	485.86 2.44
(CH) CLAY, medium brown, w>PL, firm	484.64 3.66
(CI) SILTY CLAY, some sand and gravel, medium brown, (TILL), w~PL, stiff - medium grey	481.90 6.40
(ML) sandy SILT, some fine gravel, medium grey, (TILL), w<PL, very stiff	481.29 7.01
(SM) SILTY SAND, fine grained, medium brown, wet	480.68 7.62
END OF BOREHOLE = 7.62m	

SAMPLES NUMBER	TYPE	ADDITIONAL LAB. TESTING
1-1	AS	PP= 0.25
1-2	AS	PP= 0.5
1-3	AS	PP= 1.0
1-4	AS	
1-5	AS	PP= 0.75 MH
1-6	AS	PP= 1.25
1-7	AS	PP= 1.25
1-8	AS	PP= 3.0

PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS:
Flushmount
Slope Indicator in Grout
Slough



DEPTH SCALE
1 : 50

LOGGED: CSF
CHECKED: HV

PROJECT: 11-1362-0057.5000

RECORD OF BOREHOLE: 11-0057-BH1P

SHEET 1 OF 1

LOCATION: Cherry Lane N 5775616.80 E 386010.50

BORING DATE: 23/6/12

DRILL RIG: Acker MP-5

DRILLING CONTRACTOR: Paddock Drilling Ltd.

DATUM: City Datum

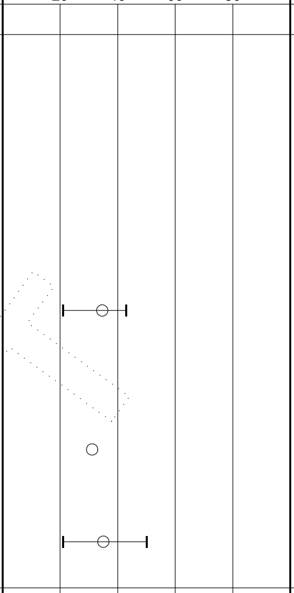
DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS
		GROUND SURFACE		488.30					
0	Acker MP-5 Power Auger Boring Solid Stem Augers	ASPHALT PAVEMENT		488.10 0.20					
		SAND and GRAVEL, well graded, angular, some silt, medium brown, dry (GRANULAR BASE)		487.84 0.46					
1		(ML) CLAYEY SILT, trace fine sand, medium brown, (FILL), w>PL, soft		487.08 1.22					
2		(CI) SILTY CLAY, medium brown, w>PL, soft to firm		485.86 2.44	1P-1	TO		PP= 0.5 MH	Grout
3		(CH) CLAY, medium brown, w>PL, firm		484.64 3.66	1P-2 1P-3	TO TO		PP= 1.25 PP= 1.5 MH	VW11192
4		END OF BOREHOLE = 3.66m NOTE: Borehole was drilled 0.3m west of borehole 11-0057-BH1. Soil description derived from the adjacent borehole.							
5									
6									
7									
8									
9									
10									

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80

SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80



DEPTH SCALE

1 : 50

LOGGED: CSF

CHECKED: HV

PROJECT: 11-1362-0057.5000

RECORD OF BOREHOLE: 11-0057-BH2

SHEET 1 OF 1

LOCATION: Cherry Lane N 5775620.20 E 385980.90

BORING DATE: 23/6/12

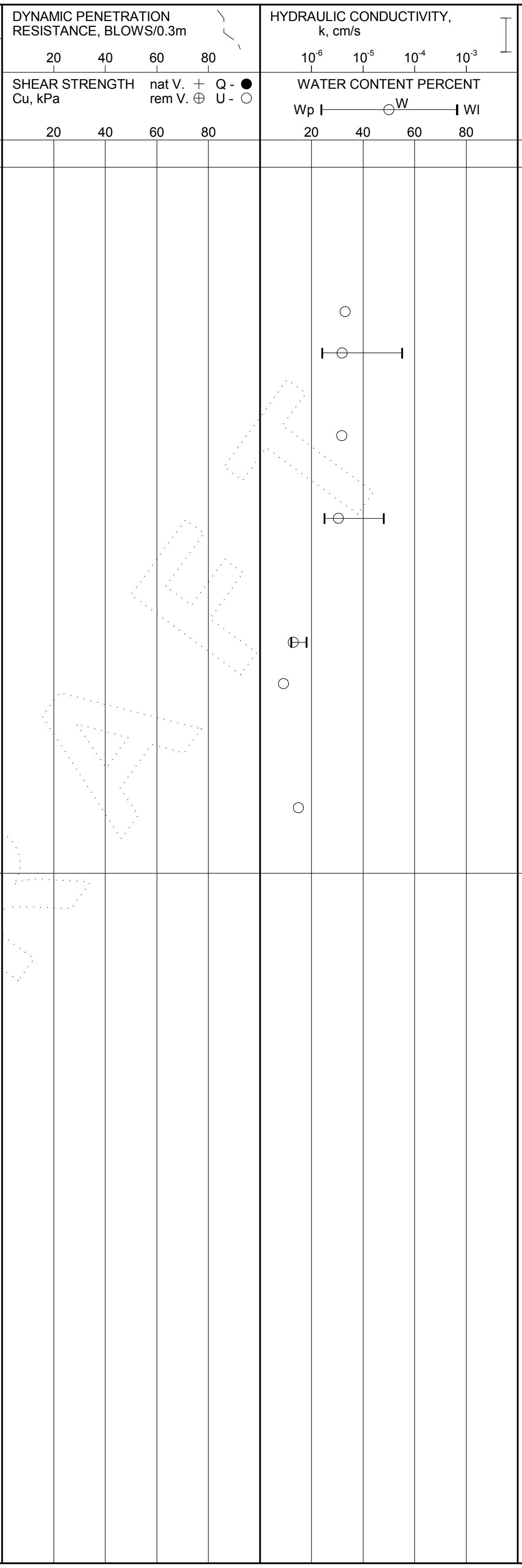
DRILL RIG: Acker MP-5

DRILLING CONTRACTOR: Paddock Drilling Ltd.

DATUM: City Datum

BORING METHOD: Acker MP-5 Power Auger Boring
Solid Stem Augers

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS
GROUND SURFACE	485.90					
ASPHALT PAVEMENT	0.00					Flushmount
ORGANIC SILT, black, wet, soft	485.67 0.23					
(CI) SILTY CLAY, trace fine sand, medium brown, w>PL, firm	485.14 0.76	2-1	AS		PP= 0.5	
		2-2	AS		PP= 0.75	
- stiff		2-3	AS		PP= 1.5	
(CH) CLAY, medium brown, w>PL, firm	483.46 2.44	2-4	AS		PP= 0.5	Slope Indicator in Grout
(CI) SILTY CLAY, some sand and gravel, medium brown, (TILL), w~PL, very stiff	483.00 2.90	2-5	AS		PP= 3.0	
(ML) sandy SILT, some fine gravel, medium brown, (TILL), w<PL, very stiff	482.24 3.66	2-6	AS		PP= 3.0	
- grey		2-7	AS			
END OF BOREHOLE = 5.21m	480.69 5.21					



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: CSF
CHECKED: HV

PROJECT: 11-1362-0057.5000

RECORD OF BOREHOLE: 11-0057-BH2P

SHEET 1 OF 1

LOCATION: Cherry Lane N 5775620.20 E 385980.90

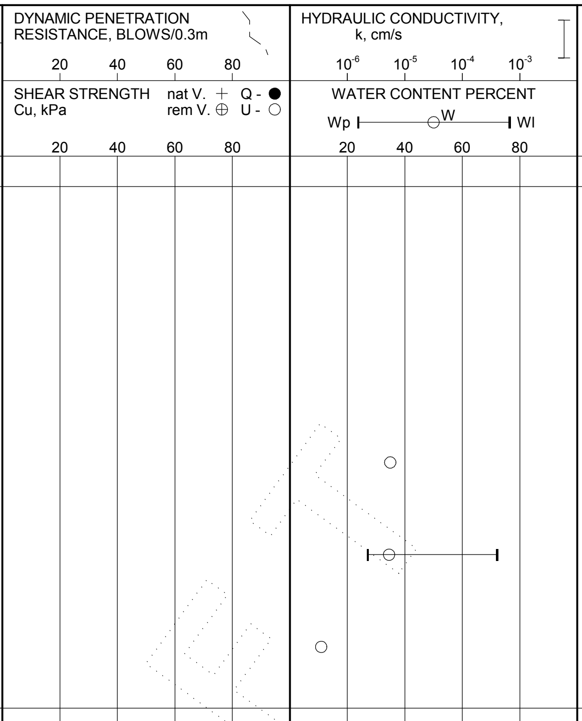
BORING DATE: 23/6/12

DRILL RIG: Acker MP-5

DRILLING CONTRACTOR: Paddock Drilling Ltd.

DATUM: City Datum

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS
0	Acker MP-5 Power Auger Boring Solid Stem Augers	GROUND SURFACE	485.90					
		ASPHALT PAVEMENT	0.00					
		ORGANIC SILT, black, wet, soft	485.67 0.23					
1		(CI) SILTY CLAY, trace fine sand, medium brown, w>PL, firm	485.14 0.76					Grout
2		- stiff		2P-1	TO		PP= 1.0	
		(CH) CLAY, medium brown, w>PL, firm	483.46 2.44	2P-2	TO		PP= 3.0 MH	VW11200
3		(CI) SILTY CLAY, some sand and gravel, medium brown, (TILL), w~PL, very stiff	483.00 2.90	2P-3	TO		PP> 4.0	
		END OF BOREHOLE = 3.45m	482.45 3.45					
4		NOTE: Borehole was drilled 0.3m west of borehole 11-0057-BH2. Soil description derived from the adjacent borehole.						
5								
6								
7								
8								
9								
10								



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: CSF

CHECKED: HV

PROJECT: 11-1362-0057.5000

RECORD OF BOREHOLE: 11-0057-BH3

SHEET 1 OF 1

LOCATION: Cherry Lane N 5775622.30 E 385959.40

BORING DATE: 23/6/12

DRILL RIG: Acker MP-5

DRILLING CONTRACTOR: Paddock Drilling Ltd.

DATUM: City Datum

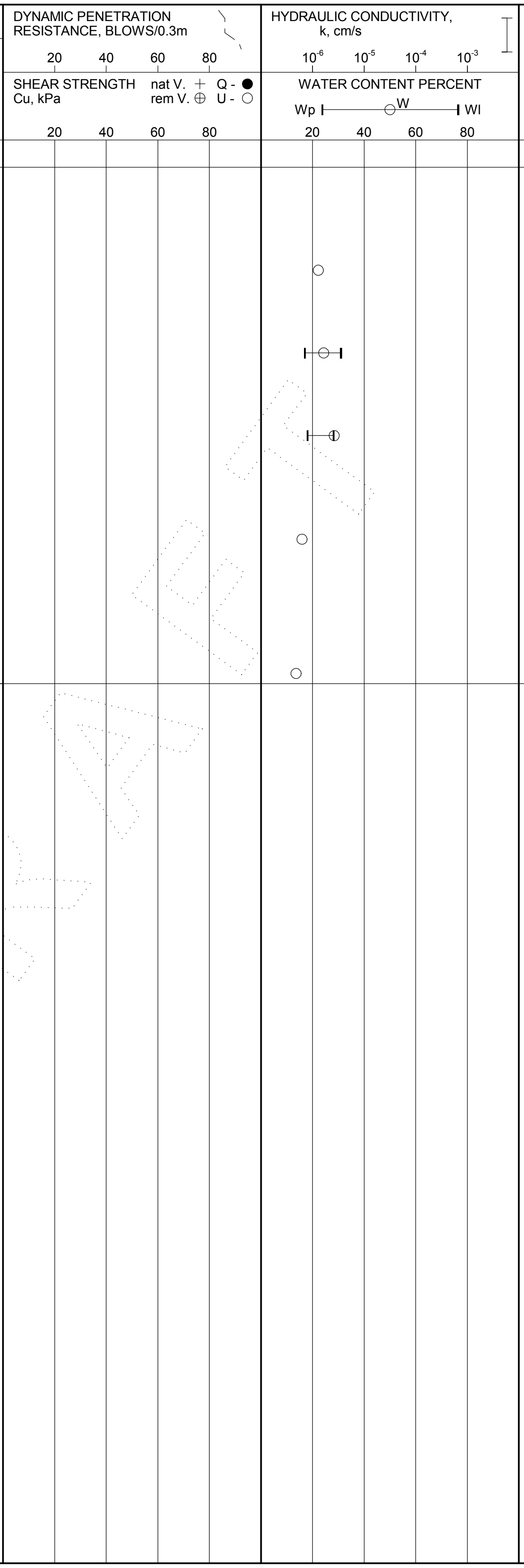
BORING METHOD: Acker MP-5 Power Auger Boring
Solid Stem Augers

SOIL PROFILE

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	484.10
ASPHALT PAVEMENT	0.08
SAND and GRAVEL, well graded, angular, some silt, medium brown, moist (GRANULAR BASE)	0.13
(CL) sandy SILTY CLAY, some gravel, medium brown, (Possibly FILL), w>PL	482.58 1.52
(SC) CLAYEY SAND, fine grained, some silt, medium brown, moist	481.66 2.44
(SM) SILTY SAND, fine grained, some to trace gravel, light brown, very moist	480.29 3.81
END OF BOREHOLE = 3.81m	

SAMPLES

NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
3-1	AS		
3-2	AS		
3-3	AS		MH
3-4	AS		
3-5	AS		



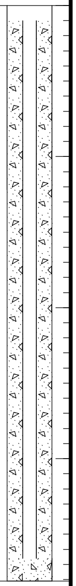
PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS

Flushmount

Grout

VW11984

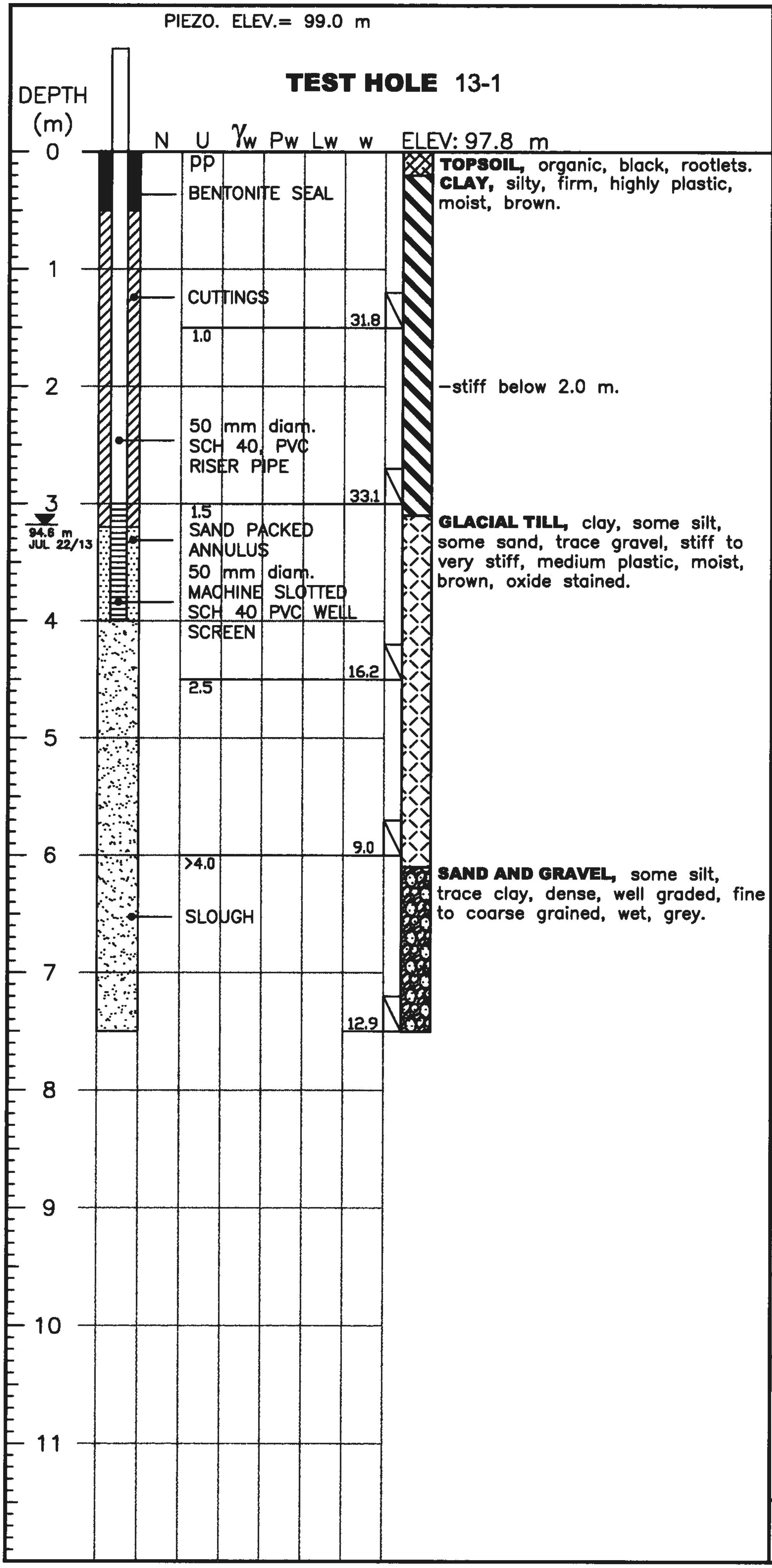
Slope Indicator in Grout



HISTORICAL BOREHOLE LOGS
TH 13-1, 13-2, 13-3, 13-4, 13-5, 13-6 AND CPT 13-1 (PMEL13)

P. Machibroda Engineering Ltd. July 18, 2013. Slope Instability 230/306 Saskatchewan Crescent Saskatoon, SK. Drawing No S13-8517-1 to 7,

TEST HOLE 13-1



TOPSOIL, organic, black, rootlets.

CLAY, silty, firm, highly plastic, moist, brown.

–stiff below 2.0 m.

GLACIAL TILL, clay, some silt, some sand, trace gravel, stiff to very stiff, medium plastic, moist, brown, oxide stained.

SAND AND GRAVEL, some silt, trace clay, dense, well graded, fine to coarse grained, wet, grey.

LEGEND:

TOPSOIL ▩ FILL ▤ GRAVEL ▨ SAND ░ SILT ▥ CLAY ▧ GLACIAL TILL ☒

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γw...WET UNIT WEIGHT (kN/m^3)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm^2)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ◪ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:

SLOPE INSTABILITY

LOCATION:

230/306 SASKATCHEWAN CRESCENT
SASKATOON, SK

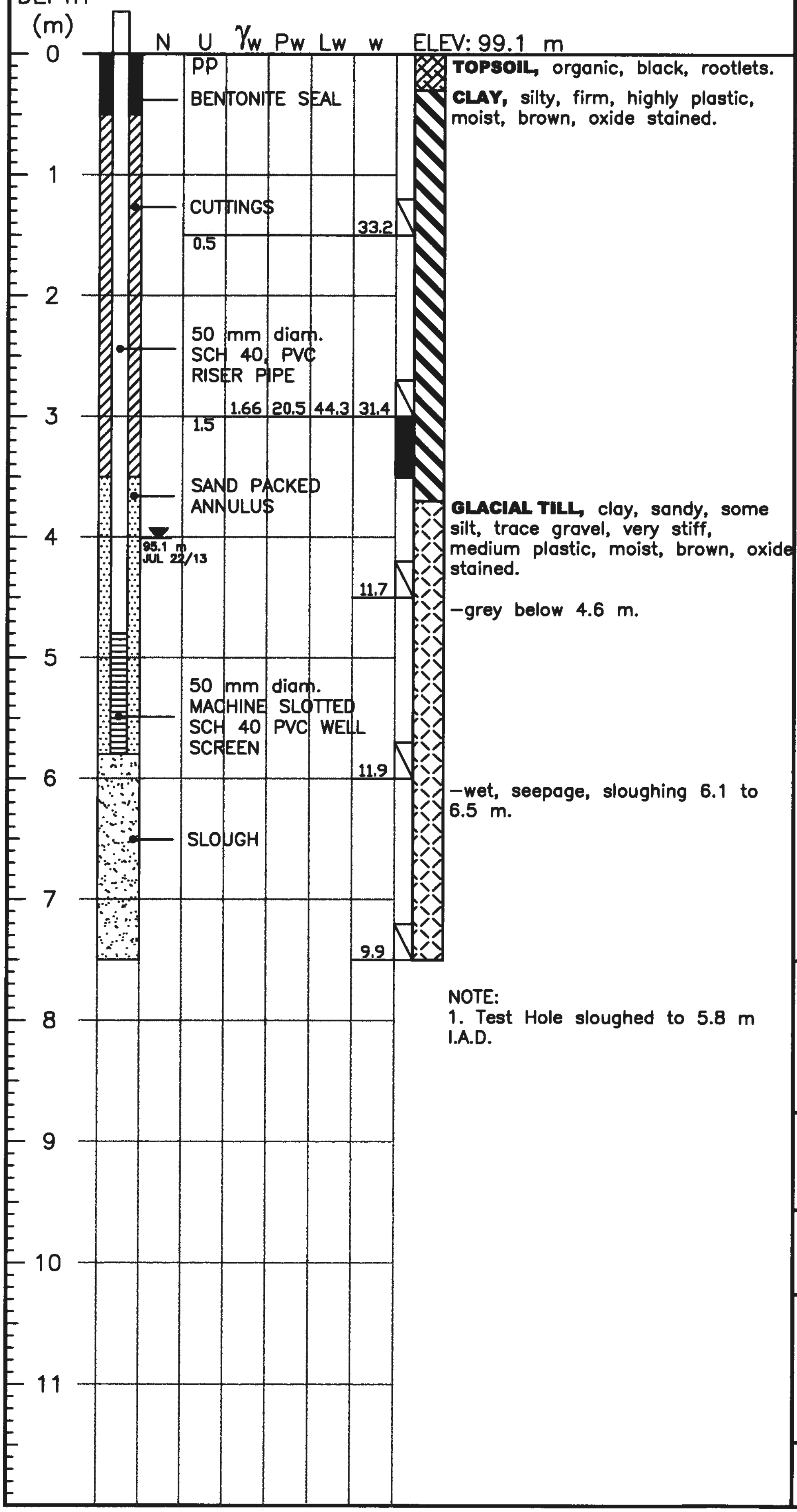
NORTHING: **EASTING:**

DATE DRILLED: JUL 17/13

DRAWING NUMBER: S13-8517-2

PIEZO. ELEV.= 99.5 m

TEST HOLE 13-2



TOPSOIL, organic, black, rootlets.

CLAY, silty, firm, highly plastic, moist, brown, oxide stained.

GLACIAL TILL, clay, sandy, some silt, trace gravel, very stiff, medium plastic, moist, brown, oxide stained.

–grey below 4.6 m.

–wet, seepage, sloughing 6.1 to 6.5 m.

NOTE:
1. Test Hole sloughed to 5.8 m I.A.D.

LEGEND:

TOPSOIL	FILL	GRAVEL	SAND	SILT	CLAY	GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γw...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4 .....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■	☒	⧅
SHELBY TUBE	SPLIT SPOON	CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
SLOPE INSTABILITY

LOCATION:
230/306 SASKATCHEWAN CRESCENT
SASKATOON, SK

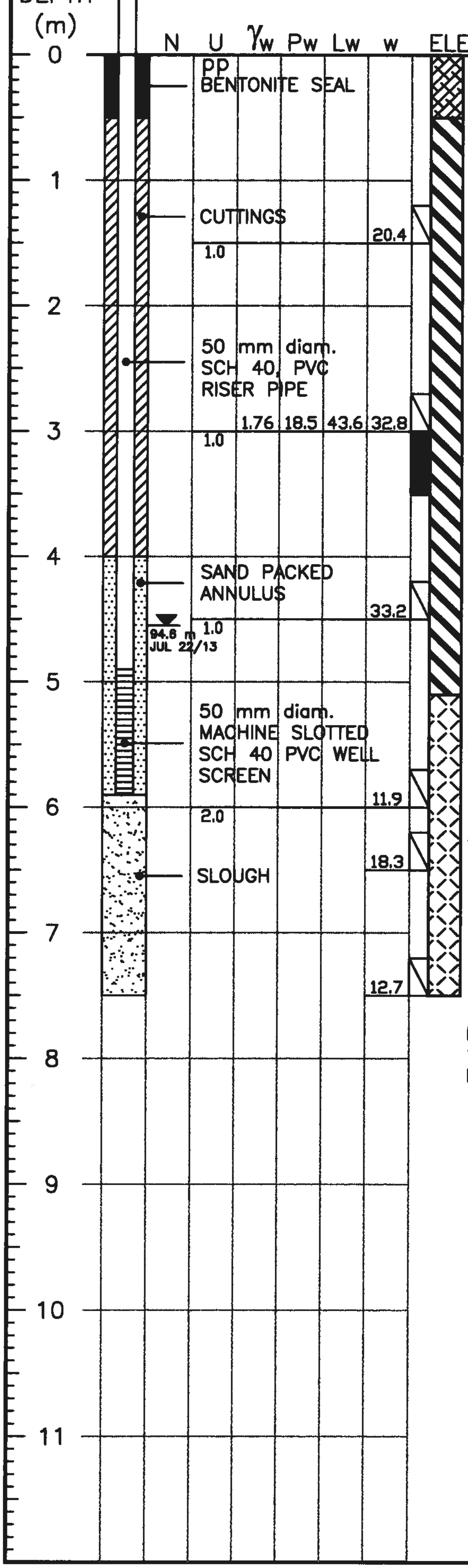
NORTHING:
EASTING:

DATE DRILLED: JUL 17/13

DRAWING NUMBER: S13-8517-3

PIEZO. ELEV.= 99.9 m

TEST HOLE 13-3



TOPSOIL, organic, black, rootlets.

CLAY, silty, some sand, firm to stiff, highly plastic, moist, brown, oxide stained.

GLACIAL TILL, clay, sandy, some silt, trace gravel, stiff to very stiff, medium plastic, moist, brown.
—grey below 5.5 m.

—wet, seepage, sloughing 6.1 to 6.5 m.

NOTE:
1. Test Hole sloughed to 5.9 m I.A.D.

LEGEND:

TOPSOIL	FILL	GRAVEL	SAND	SILT	CLAY	GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γw...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■	☒	◺
SHELBY TUBE	SPLIT SPOON	CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
SLOPE INSTABILITY

LOCATION:
230/306 SASKATCHEWAN CRESCENT
SASKATOON, SK

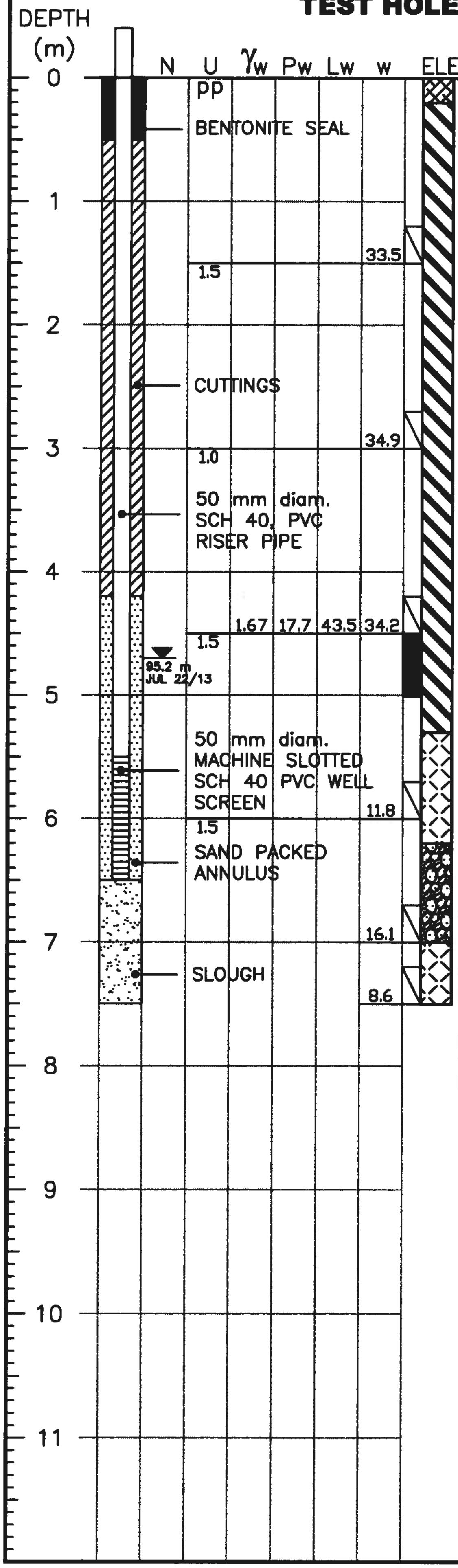
NORTHING: **EASTING:**

DATE DRILLED: JUL 17/13

DRAWING NUMBER: S13-8517-4

PIEZO. ELEV.= 100.3 m

TEST HOLE 13-4



TOPSOIL, organic, black, rootlets.

CLAY, silty, firm to stiff, highly plastic, moist, brown, oxide stained.

GLACIAL TILL, clay, silty, some sand, trace gravel, stiff, medium plastic, moist, grey.

SAND AND GRAVEL, some silt, some clay, dense, poorly graded, fine to medium grained, wet, grey, seepage, sloughing.

GLACIAL TILL, clay, sandy, some silt, trace gravel, hard, medium plastic, moist, grey.

NOTE:
1. Test Hole sloughed to 6.5 m I.A.D.

LEGEND:

TOPSOIL ▨ FILL ▤ GRAVEL SAND SILT ▥ CLAY ▧ GLACIAL TILL ☒

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γw...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4 .....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ◺ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:

SLOPE INSTABILITY

LOCATION:

230/306 SASKATCHEWAN CRESCENT
SASKATOON, SK

NORTHING: **EASTING:**

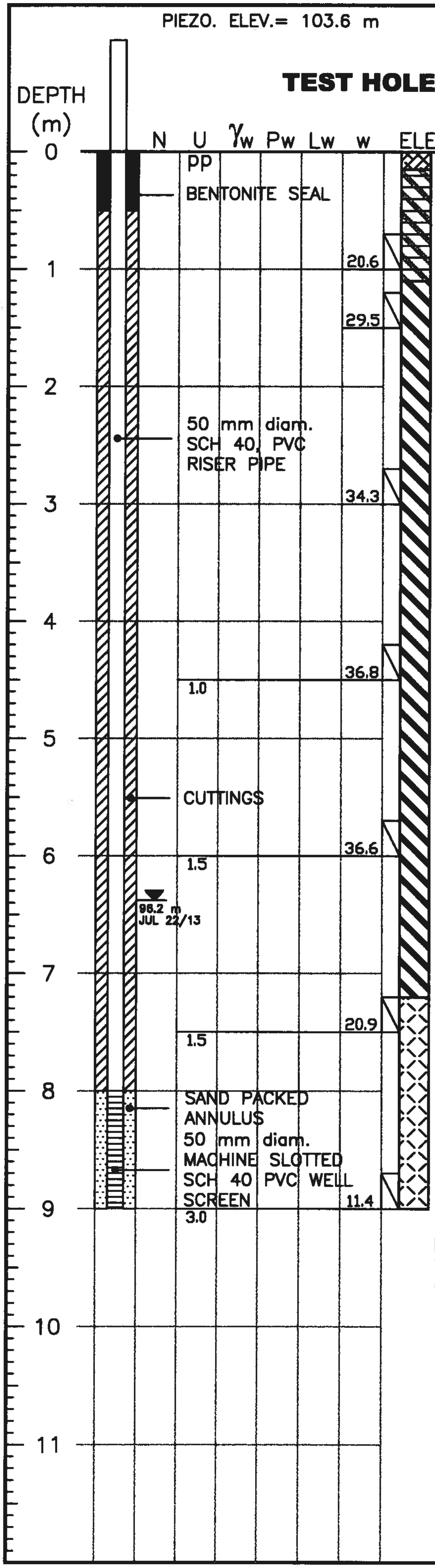
DATE DRILLED: JUL 17/13

DRAWING NUMBER: S13-8517-5

PIEZO. ELEV.= 103.6 m

TEST HOLE 13-5

ELEV: 102.6 m



TOPSOIL, organic, black, rootlets.

FILL, clay, sandy, some silt, trace gravel, firm, medium plastic, moist, brown.

CLAY, silty, trace sand, firm, highly plastic, moist, brown, oxide stained.

–grey below 5.1 m.

GLACIAL TILL, clay, some silt, some sand, trace gravel, stiff, medium plastic, moist, grey.

NOTE:
1. Test Hole open to 9.0 m and dry I.A.D.

LEGEND:

TOPSOIL ▩ FILL ☰ GRAVEL ▦ SAND ▤ SILT ▥ CLAY ▧ GLACIAL TILL ☒

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γw...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4 .....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ◪ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:

SLOPE INSTABILITY

LOCATION:

230/306 SASKATCHEWAN CRESCENT
SASKATOON, SK

NORTHING: **EASTING:**

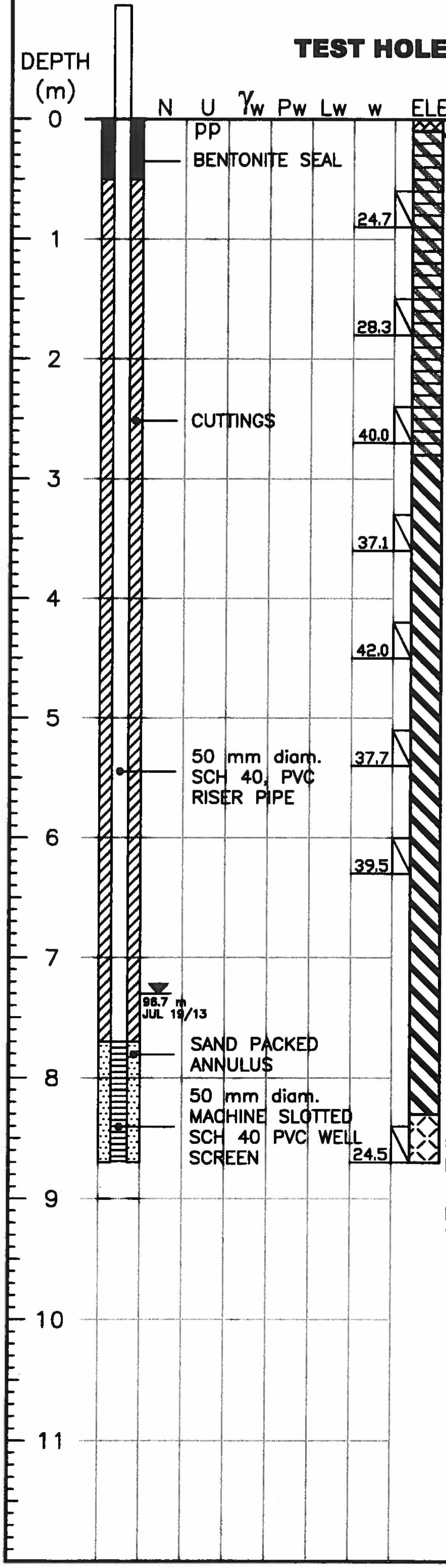
DATE DRILLED: JUL 18/13

DRAWING NUMBER: S13-8517-6

PIEZO. ELEV.= 104.9 m

TEST HOLE 13-6

ELEV: 104.0 m



TOPSOIL, organic, black, rootlets.

FILL, clay, silty, trace sand, firm, medium plastic, moist, brown.

–sandy, some silt, trace gravel, oxide stained below 1.5 m.

CLAY, silty, trace sand, firm, highly plastic, moist, brown.

–wet, seepage, sloughing below 3.8 m.

GLACIAL TILL, clay, sandy, some silt, trace gravel, stiff, medium plastic, moist, grey.

NOTE:
1. Test Hole open to 8.7 m I.A.D.

LEGEND:

- ▩ TOPSOIL
- ☰ FILL
- ● GRAVEL
- ⠿ SAND
- ▥ SILT
- ▧ CLAY
- ☒ GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4 .....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

■ SHELBY TUBE ☒ SPLIT SPOON ⧄ CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
SLOPE INSTABILITY

LOCATION:
230/306 SASKATCHEWAN CRESCENT
SASKATOON, SK

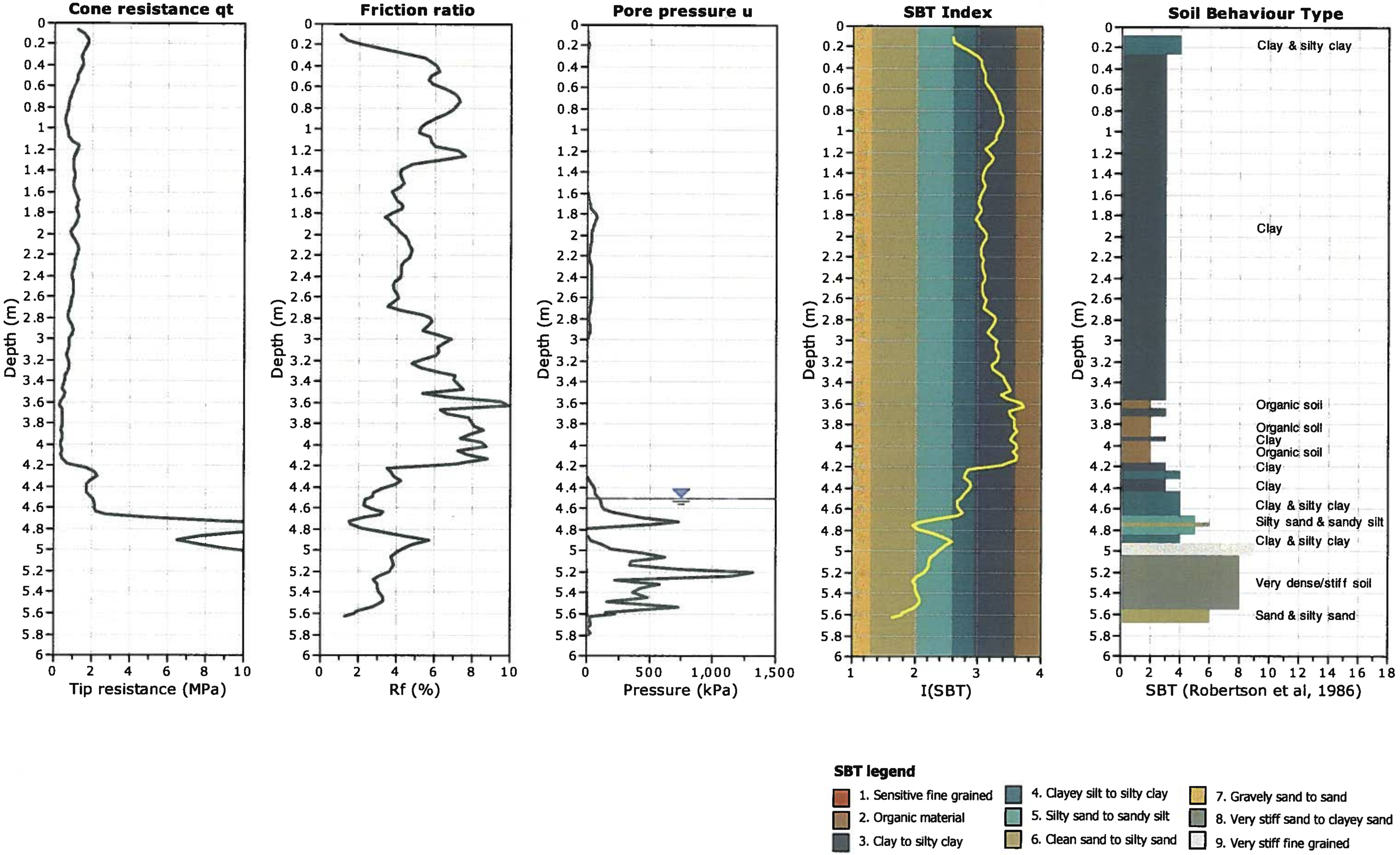
NORTHING:
EASTING:

DATE DRILLED:	**DRAWING NUMBER:**
JUL 18/13	S13-8517-7

P. Machibroda Engineering Ltd.
806-48th Street East
Saskatoon, Saskatchewan S7K 4A2
www.machibroda.com

Project: **Slope Stability Assessment**
Location: **230/306 Saskatchewan Crescent East, Saskatoon, Saskatchewan**

CPT: 13-1
Total depth: 5.81 m, Date: 18/07/2013
Surface Elevation: 0.00 m
Coords: X:0.00, Y:0.00
Cone Type: 15 cm^2
Cone Operator: PMEL



CPeT-IT v.1.7.5.17 - CPTU data presentation & interpretation software - Report created on: 19/07/2013, 8:39:55 AM
Project file: Y:\S13\8517\CPT.cpt

2013 BOREHOLE LOGS

COS-13-001, COS-13-001B, COS-13-002, COS-13-003, COS-13-004, COS 13-005, COS-13-006, COS-13-007 (GAL13)

PROJECT: Cherry Lane Slope Remediation

RECORD OF BOREHOLE: COS-13-001

SHEET 1 OF 1

LOCATION: N 5775616.7 E 386038.9

BORING DATE: 07/26/13

DRILL RIG: CME

DRILLING CONTRACTOR: Boss Drilling

DATUM: NAD83

BORING METHOD: 150mm Dia. Solid Stem Auger Continuous Flight

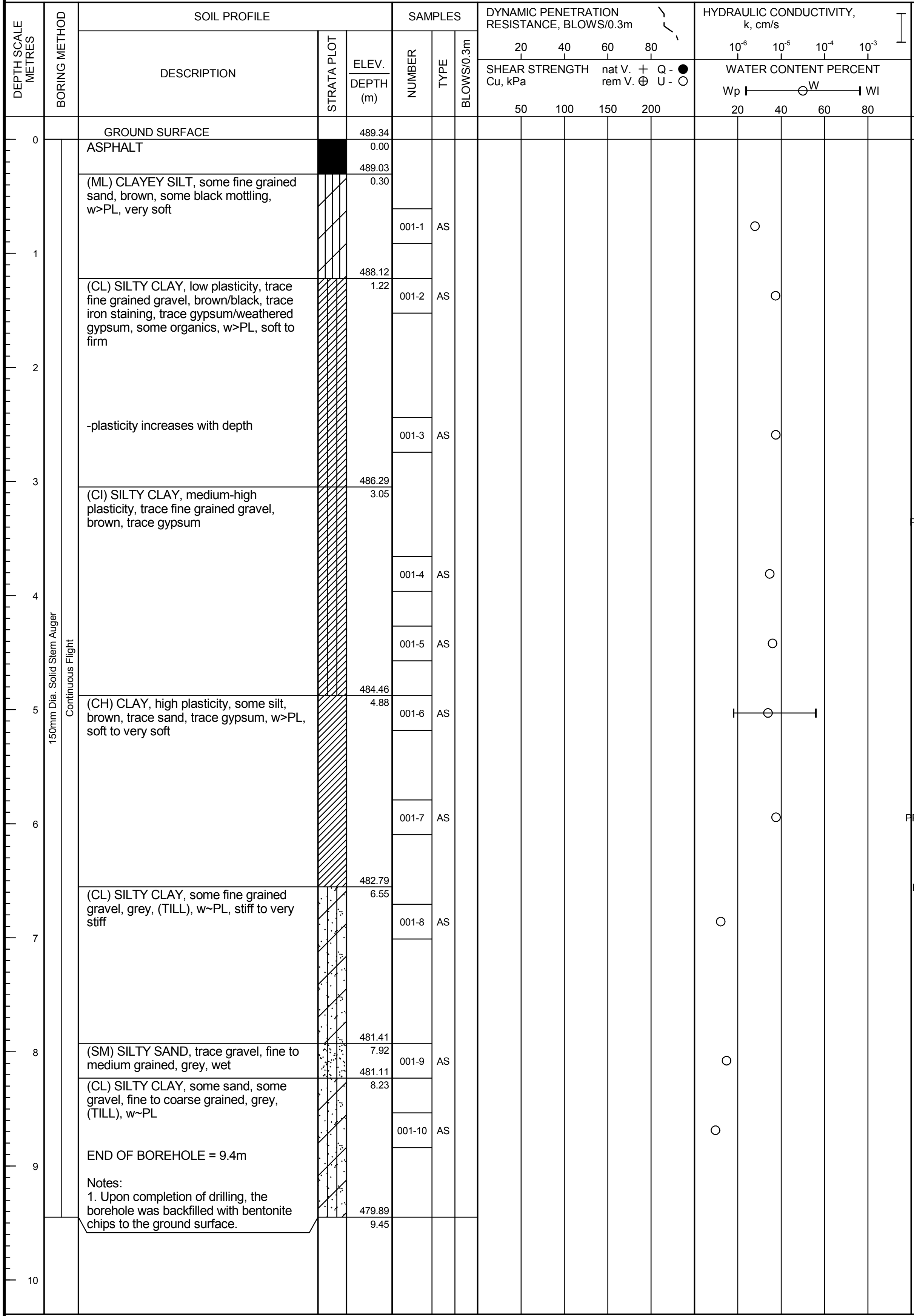
SOIL PROFILE

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	489.34
ASPHALT	0.00
(ML) CLAYEY SILT, some fine grained sand, brown, some black mottling, w>PL, very soft	489.03 0.30
(CL) SILTY CLAY, low plasticity, trace fine grained gravel, brown/black, trace iron staining, trace gypsum/weathered gypsum, some organics, w>PL, soft to firm -plasticity increases with depth	488.12 1.22
(CI) SILTY CLAY, medium-high plasticity, trace fine grained gravel, brown, trace gypsum	486.29 3.05
(CH) CLAY, high plasticity, some silt, brown, trace sand, trace gypsum, w>PL, soft to very soft	484.46 4.88
(CL) SILTY CLAY, some fine grained gravel, grey, (TILL), w~PL, stiff to very stiff	482.79 6.55
(SM) SILTY SAND, trace gravel, fine to medium grained, grey, wet	481.41 7.92
(CL) SILTY CLAY, some sand, some gravel, fine to coarse grained, grey, (TILL), w~PL	481.11 8.23
END OF BOREHOLE = 9.4m	479.89 9.45

Notes:
1. Upon completion of drilling, the borehole was backfilled with bentonite chips to the ground surface.

SAMPLES

NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
001-1	AS		PP>0
001-2	AS		
001-3	AS		PP=1
			PP=0.75
001-4	AS		
001-5	AS		PP>0
001-6	AS		SG MH
001-7	AS		PP=0.75-1
			PP=1.5
001-8	AS		
001-9	AS		MH
001-10	AS		



PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS

07/26/13▽

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: LM

CHECKED: LDN

PROJECT: Cherry Lane Slope Remediation

RECORD OF BOREHOLE: COS-13-001B

SHEET 1 OF 1

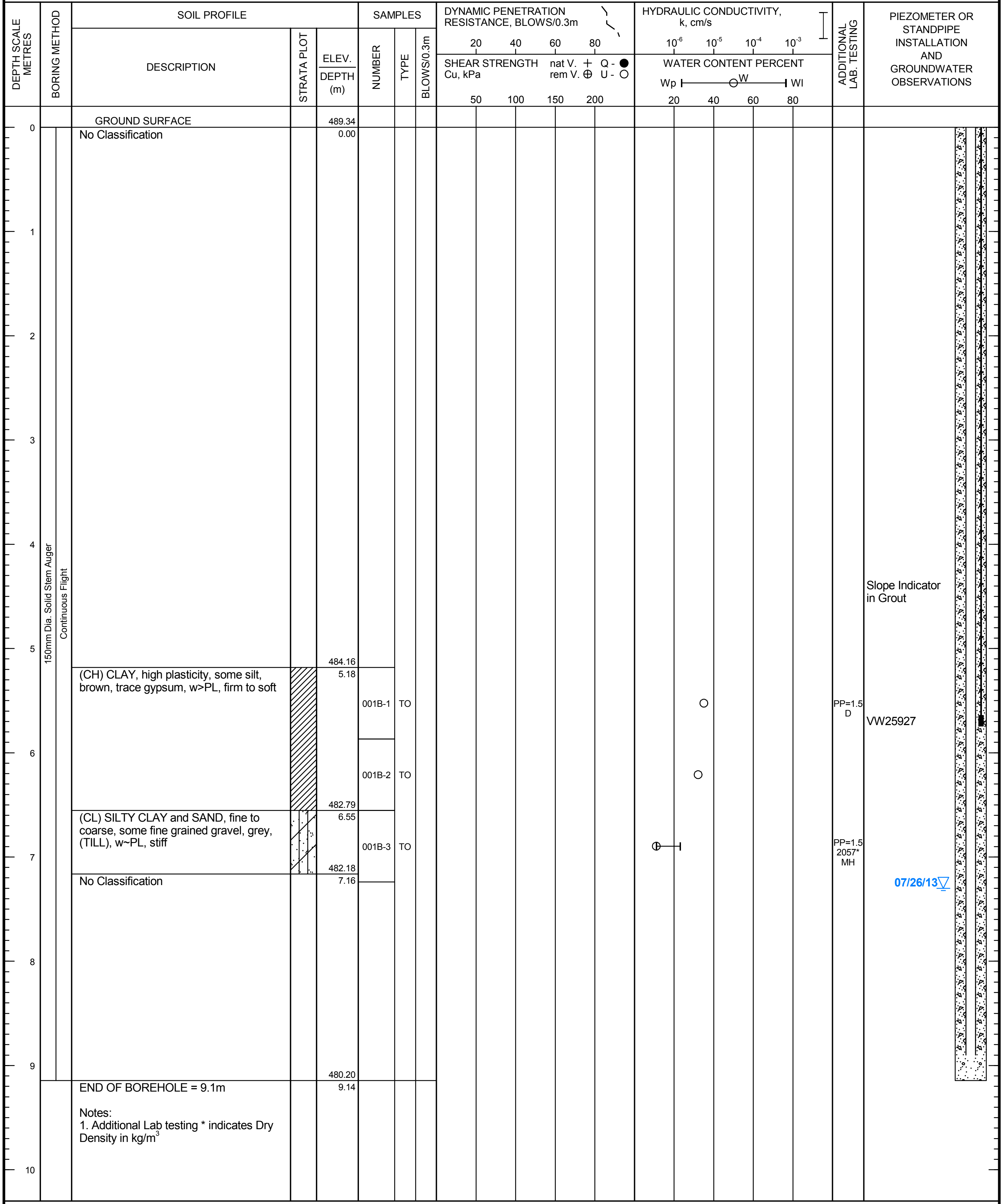
LOCATION: N 5775616.7 E 386038.9

BORING DATE: 07/26/13

DRILL RIG: CME

DRILLING CONTRACTOR: Boss Drilling

DATUM: NAD83



SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS
GROUND SURFACE	489.34					
No Classification	0.00					Slope Indicator in Grout
(CH) CLAY, high plasticity, some silt, brown, trace gypsum, w>PL, firm to soft	484.16 5.18	001B-1	TO		PP=1.5 D	VW25927
		001B-2	TO			
(CL) SILTY CLAY and SAND, fine to coarse, some fine grained gravel, grey, (TILL), w~PL, stiff	482.79 6.55	001B-3	TO		PP=1.5 2057* MH	
No Classification	482.18 7.16					07/26/13▽
END OF BOREHOLE = 9.1m	480.20 9.14					

Notes:
1. Additional Lab testing * indicates Dry Density in kg/m^3

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: LM
CHECKED: LDN

PROJECT: Cherry Lane Slope Remediation

RECORD OF BOREHOLE: COS-13-002

SHEET 1 OF 2

LOCATION: N 5775616.7 E 386038.9

BORING DATE: 07/25/13

DRILL RIG: CME

DRILLING CONTRACTOR: Boss Drilling

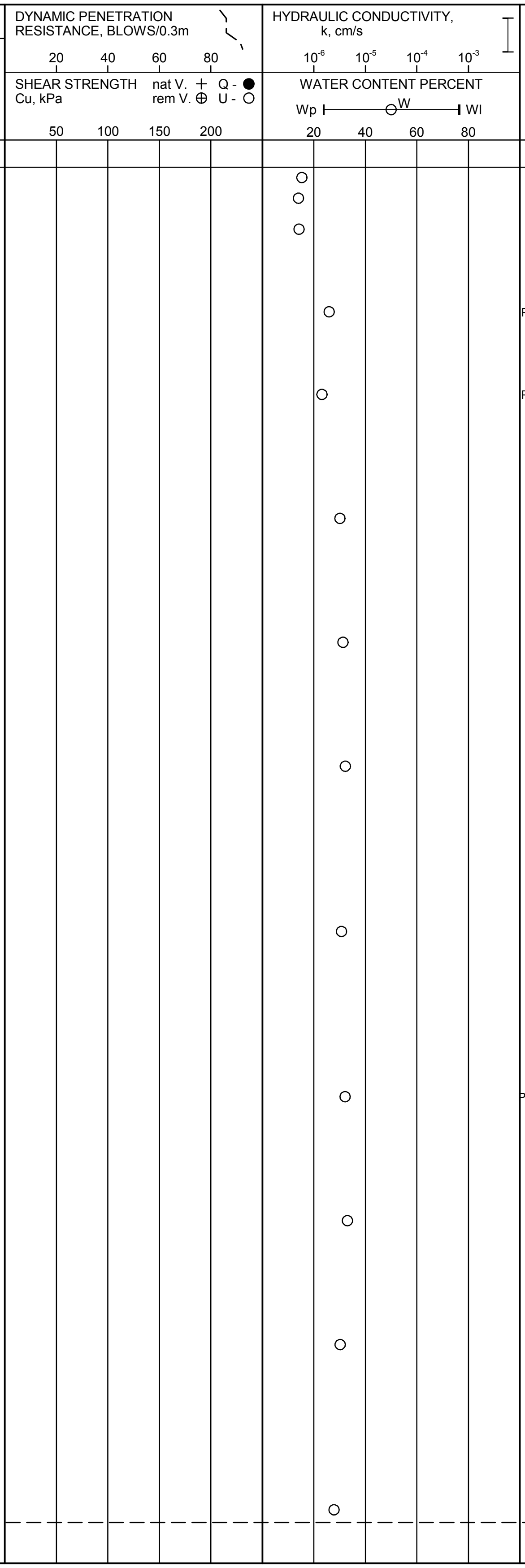
DATUM: NAD83

BORING METHOD: 150mm Dia. Solid Stem Auger
Continuous Flight

DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	498.48
TOPSOIL	498.33
FILL, (SC) CLAYEY SILT, fine, dark brown, some organics, non-cohesive, dry	498.18 0.30
(SM) SILTY SAND, fine, some clay, low plasticity, brown, some organics, non-cohesive, dry	497.87 0.61
(CL) SILTY CLAY, low plastic, brown, some iron staining, some white staining, cohesive, w~PL, hard -some fine grained sand at approximately 2.4m -becomes stiff at approximately 2.4m	
(CI) SILTY CLAY, medium plastic, trace sand, fine, trace/some iron staining, trace/some white staining, cohesive, w>PL, stiff to very stiff	495.44 3.05
(CL) sandy, SILTY CLAY, fine grained, brown, wet, very soft	488.73 9.75

CONTINUED NEXT PAGE

SAMPLE NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
002-1	AS		
002-2	AS		
002-3	AS		
002-4	AS		PP=4.5
002-5	AS		PP=1.5
002-6	AS		
002-7	AS		PP=3
002-8	AS		
002-9	AS		
002-10	AS		PP=0.25
002-11	AS		
002-12	AS		
002-13	AS		PP=0



PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS: Slope Indicator in Grout

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: LM
CHECKED: LDN

PROJECT: Cherry Lane Slope Remediation

RECORD OF BOREHOLE: COS-13-002

SHEET 2 OF 2

LOCATION: N 5775616.7 E 386038.9

BORING DATE: 07/25/13

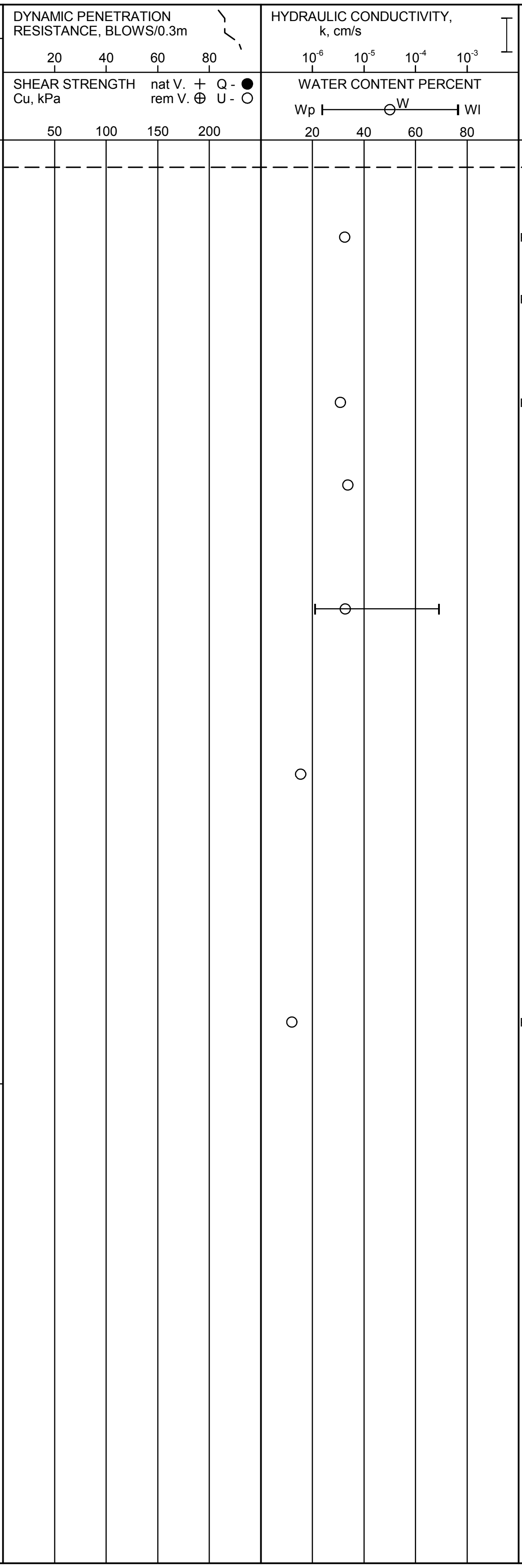
DRILL RIG: CME

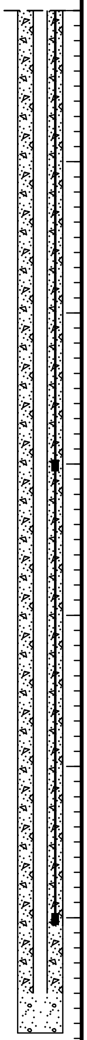
DRILLING CONTRACTOR: Boss Drilling

DATUM: NAD83

BORING METHOD: 150mm Dia. Solid Stem Auger Continuous Flight

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS
10	*CONTINUED FROM PREVIOUS PAGE* (CL) sandy, SILTY CLAY, fine grained, brown, wet, very soft *(continued)*	488.12				MH	
	(CL) SILTY CLAY, low plasticity, some sand, fine, brown, cohesive, w>PL, soft to very soft	10.36 487.21	002-14	AS		PP=0.5 PP=1.0	
11	(CI) SILTY CLAY, medium plastic, brown, cohesive, w>PL, firm to stiff -becomes grey at approximately 12m	11.28 485.38	002-15 002-16	AS AS		PP=1.5 PP=1	
13	(CH) CLAY, some silt, high plasticity, grey, cohesive, w>PL, stiff	13.11 484.46	002-17	AS		PP=2 SG	VW25400 Slope Indicator in Grout
14	(CL) SILTY CLAY, some gravel, fine-coarse, grey, (TILL), cohesive, w>PL, stiff	14.02 481.72	002-18 002-19	AS AS		PP=1 PP=2.5	VW25399
	END OF BOREHOLE = 16.8m	16.76					





DEPTH SCALE

1 : 50

LOGGED: LM

CHECKED: LDN

PROJECT: Cherry Lane Slope Remediation

RECORD OF BOREHOLE: COS-13-003

SHEET 1 OF 1

LOCATION: N 5775674.7 E 386061.6

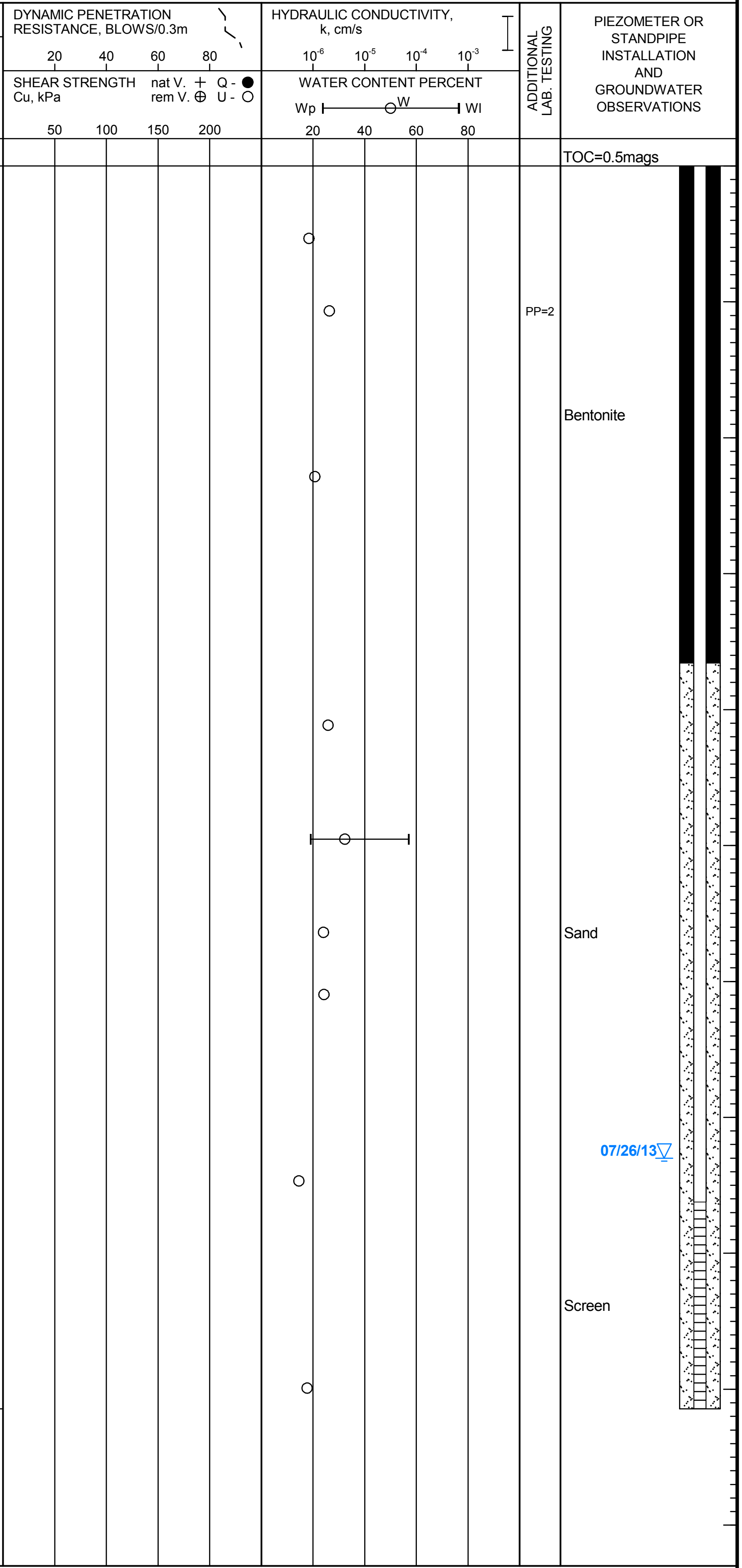
BORING DATE: 07/26/13
DRILL RIG: CME
DRILLING CONTRACTOR: Boss Drilling

DATUM: NAD83

BORING METHOD: 150mm Dia. Solid Stem Auger Continuous Flight

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	480.34
FILL, (CL) SILTY CLAY and SAND, well graded, some gravel, fine to coarse grained, black, w~PL, stiff to very stiff	0.00
(CL) SILTY CLAY, low plasticity, some gravel, fine to coarse grained, brown, trace iron staining, trace gypsum and weathered gypsum, trace petrified wood, trace coal, w~PL, stiff to very stiff	479.43 0.91
(GW) GRAVEL, dry	478.82
(CL) SILTY CLAY, low plasticity, some gravel, fine to coarse grained, brown, trace iron staining, trace gypsum and weathered gypsum, trace petrified wood, trace coal, w~PL, stiff to very stiff	478.67 1.68
(CH) CLAY, high plasticity, trace gravel, fine to coarse grained, brown, trace iron staining, some weathered gypsum, some coal, w~PL, stiff to very stiff	475.47 4.88
(SM) SILTY SAND, brown, trace iron staining, wet	474.86 5.49
(GW) GRAVEL, well graded, fine to coarse grained, brown, very wet	473.03 7.32
(CL) SILTY CLAY, some gravel, fine grained, (TILL), w>PL, firm to stiff	471.50 8.84
END OF BOREHOLE = 9.1m	471.20 9.14

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
003-1	AS		
003-2	AS		PP=2
003-3	AS		
003-4	AS		
003-5	AS		
003-6	AS		
003-7	TO		
003-8	AS		
003-9	AS		



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: LM
CHECKED: LDN

PROJECT: Cherry Lane Slope Remediation

RECORD OF BOREHOLE: COS-13-004

SHEET 1 OF 2

LOCATION: N 5775605.0 E 386050.6

BORING DATE: 08/19/13

DRILL RIG: M4CT

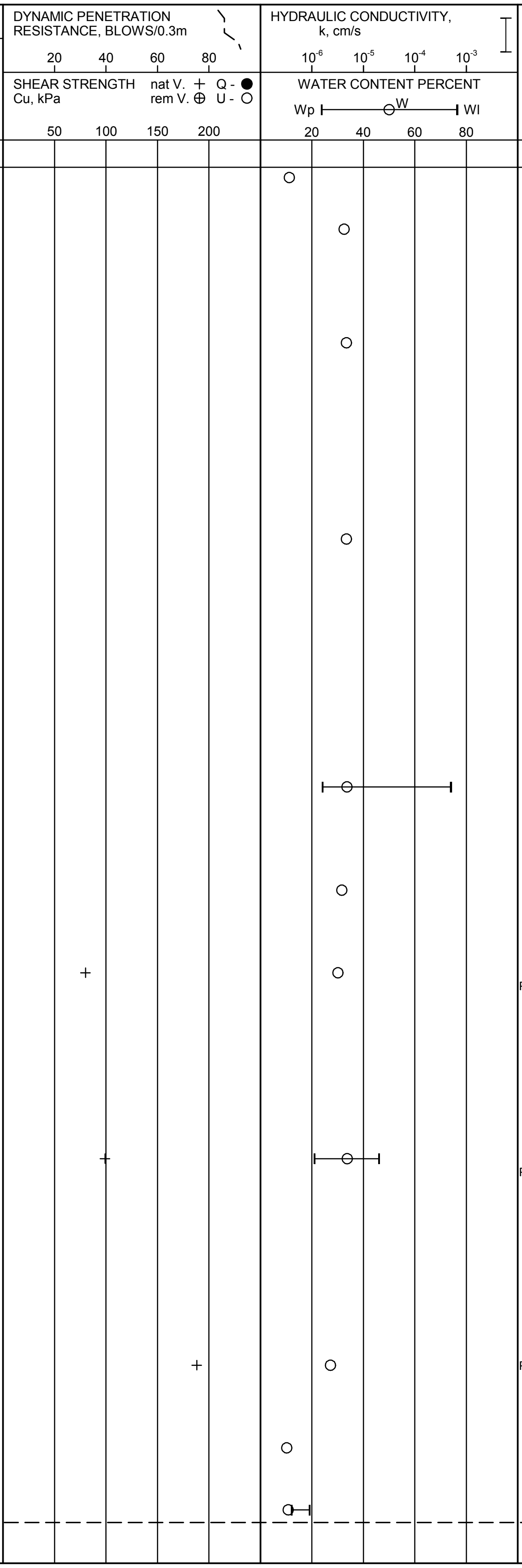
DRILLING CONTRACTOR: Mobile Augers and Research Ltd.

DATUM: NAD83

BORING METHOD: 150mm Dia. Solid Stem Auger
Continuous Flight

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	491.74
TOPSOIL, clayey, some fine-medium grained sand, some fine gravel, some organics, dark brown/black	0.00
(CL) SILTY CLAY, low plasticity, trace fine grained sand, light brown, some rust staining, some organics, trace weathered gypsum, cohesive, w>PL, very soft to soft	491.43 0.30
(CH) CLAY, high plasticity, some silt, brown/black mottling, some rust staining, cohesive, w>PL, stiff	487.32 4.42
(CI) SILTY CLAY, medium plastic, brown, cohesive, w>PL, stiff	486.56 5.18
(CL-ML) SILTY CLAY/CLAYEY SILT and fine to medium grained sand, some gravel, trace cobbles, grey, cohesive, (TILL), w~PL, very stiff	483.05 8.69

NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
004-1	AS		
004-2	AS		MH
		6	
004-3	DO		
		5	
004-4	DO		
		11	
004-5	DO		
		7	
004-6	AS		
		6	
004-7	TO		SG PP=1.5
004-8	TO		DS PP=2.5
004-9	TO		PP=3.5
		38	
004-10	AS		
		50	
004-11	AS		MH



PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS

Slope Indicator in Grout

VW26020

08/19/13▽

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

LOGGED: LM

CHECKED: LDN

PROJECT: Cherry Lane Slope Remediation

RECORD OF BOREHOLE: COS-13-004

SHEET 2 OF 2

LOCATION: N 5775605.0 E 386050.6

BORING DATE: 08/19/13

DRILL RIG: M4CT

DRILLING CONTRACTOR: Mobile Augers and Research Ltd.

DATUM: NAD83

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 50 100 150 200	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS
		CONTINUED FROM PREVIOUS PAGE									
10	Continuous Flight	(CL-ML) SILTY CLAY/CLAYEY SILT and fine to medium grained sand, some gravel, trace cobbles, grey, cohesive, (TILL), w~PL, very stiff *(continued)*	▨	480.71 11.02							VW25397 Slope Indicator in Grout
11		END OF BOREHOLE = 11.02m									
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: LM

CHECKED: LDN

SK_SOIL 11-1362-0057-5100 BOREHOLES.GPJ GAL-SASK.GDT 05/05/14

PROJECT: Cherry Lane Slope Remediation

RECORD OF BOREHOLE: COS-13-005

SHEET 1 OF 2

LOCATION: N 5775637.7 E 386047.6

BORING DATE: 08/20/13

DRILL RIG: M10

DRILLING CONTRACTOR: Mobile Augers and Research Ltd.

DATUM: NAD83

BORING METHOD: 150mm Dia. Solid Stem Auger, Continuous Flight

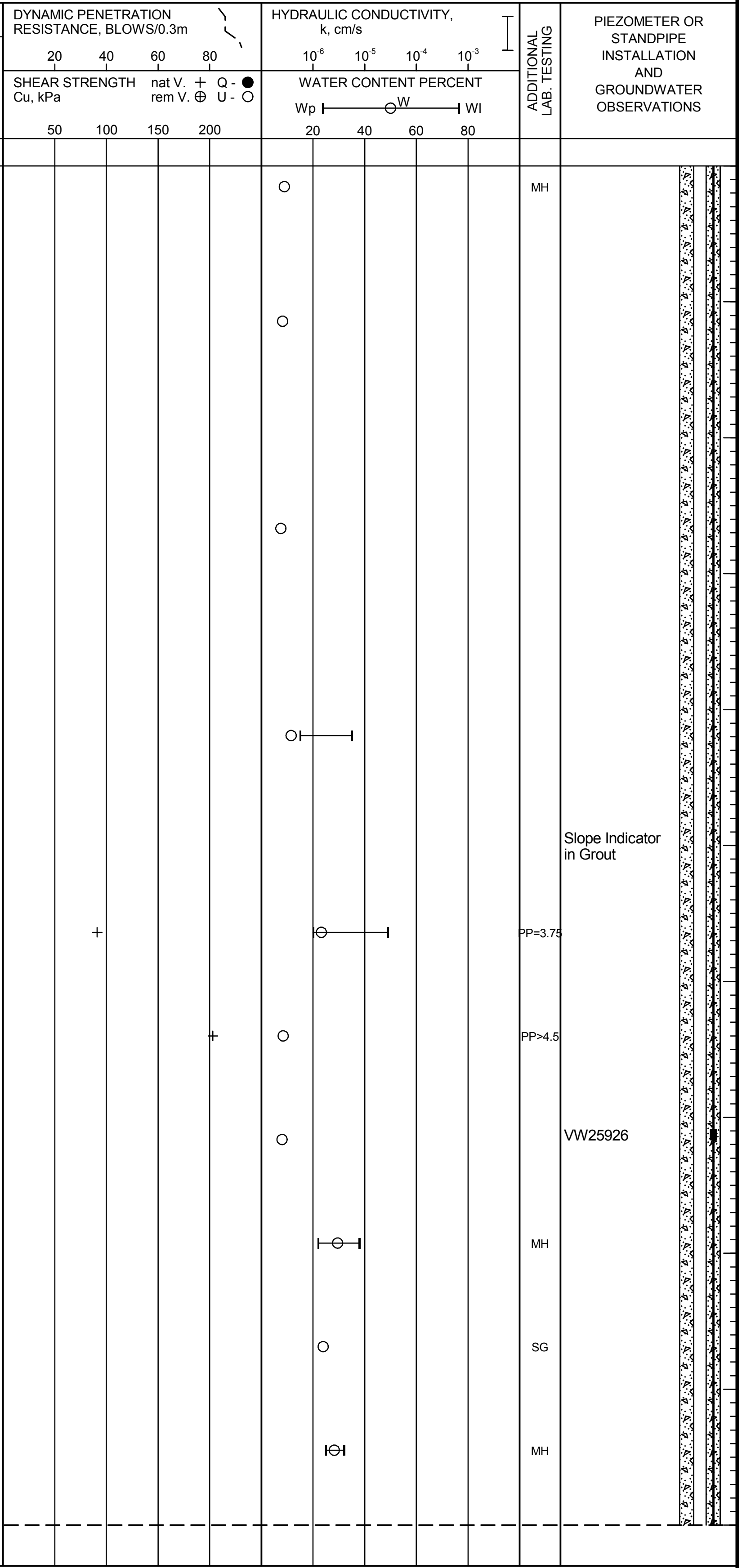
SOIL PROFILE

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	494.48
(SM) SILTY SAND, fine grained, light brown, trace organics, non-cohesive, moist, loose	0.00
(SC) CLAYEY SAND, fine grained, light brown with black and white seams, cohesive, dry, compact	490.82 3.66
(CI) SILTY CLAY, sand seams, brown, w~PL	488.99 5.49
(SM) SILTY SAND, some clay, light brown, cohesive, dry-moist, compact	487.77 6.71
(CI) SILTY CLAY, medium plastic, trace sand, brown, cohesive, w~PL	486.86 7.62
(ML) SANDY, CLAYEY SILT, fine grained, brown, moist, compact	485.34 9.14

CONTINUED NEXT PAGE

SAMPLES

NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
005-1	AS		MH
		12	
005-2	DO		
		19	
005-3	DO		
		15	
005-4	DO		
005-5	TO		PP=3.75
005-6	TO		PP>4.5
005-7	TO		
005-8	TO		MH
005-9	TO		SG
005-10	TO		MH
005-11	TO		



DEPTH SCALE 1 : 50

Golder Associates

LOGGED: LM

CHECKED: LDN

SK_SOIL 11-1362-0057-5100 BOREHOLES.GPJ GAL-SASK.GDT 05/05/14

PROJECT: Cherry Lane Slope Remediation

RECORD OF BOREHOLE: COS-13-005

SHEET 2 OF 2

LOCATION: N 5775637.7 E 386047.6

BORING DATE: 08/20/13

DATUM: NAD83

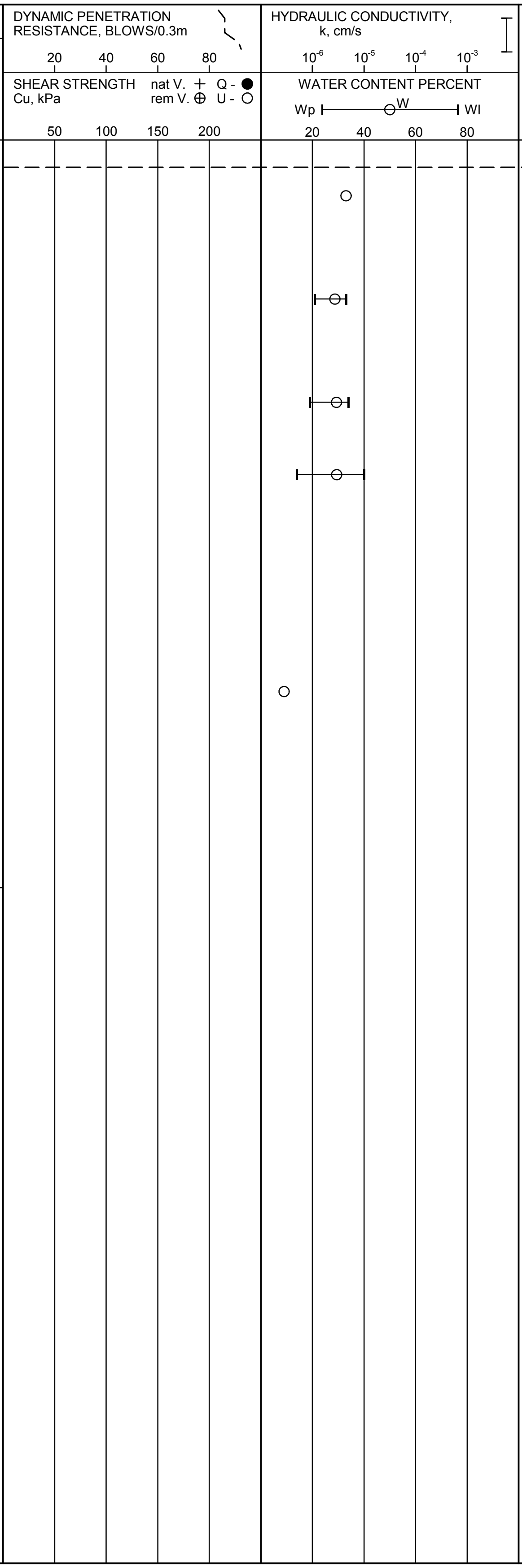
DRILL RIG: M10

DRILLING CONTRACTOR: Mobile Augers and Research Ltd.

BORING METHOD: 150mm Dia. Solid Stem Auger, Continuous Flight

CONTINUED FROM PREVIOUS PAGE

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS
10	(ML) SANDY, CLAYEY SILT, fine grained, brown, moist, compact *(continued)*	483.81 10.67	005-11	TO		MH	
11	(CI) SILTY CLAY, medium plastic, fine grained, grey and brown laminated, w~PL, very stiff		005-12	TO		MH	
			005-13	TO		DS	VW26019
12		482.14 12.34	005-14	TO			
	(CI) SILTY CLAY, medium plastic, some sand, grey, w>PL, (TILL)						Slope Indicator in Grout
13–14			005-15	DO	64		
15		479.16 15.32					VW25401
	END OF BOREHOLE = 15.32m						



DEPTH SCALE 1 : 50

LOGGED: LM

CHECKED: LDN

PROJECT: Cherry Lane Slope Remediation

RECORD OF BOREHOLE: COS-13-006

SHEET 1 OF 2

LOCATION: N 5775572.7 E 385959.2

BORING DATE: 08/21/13

DRILL RIG: M10

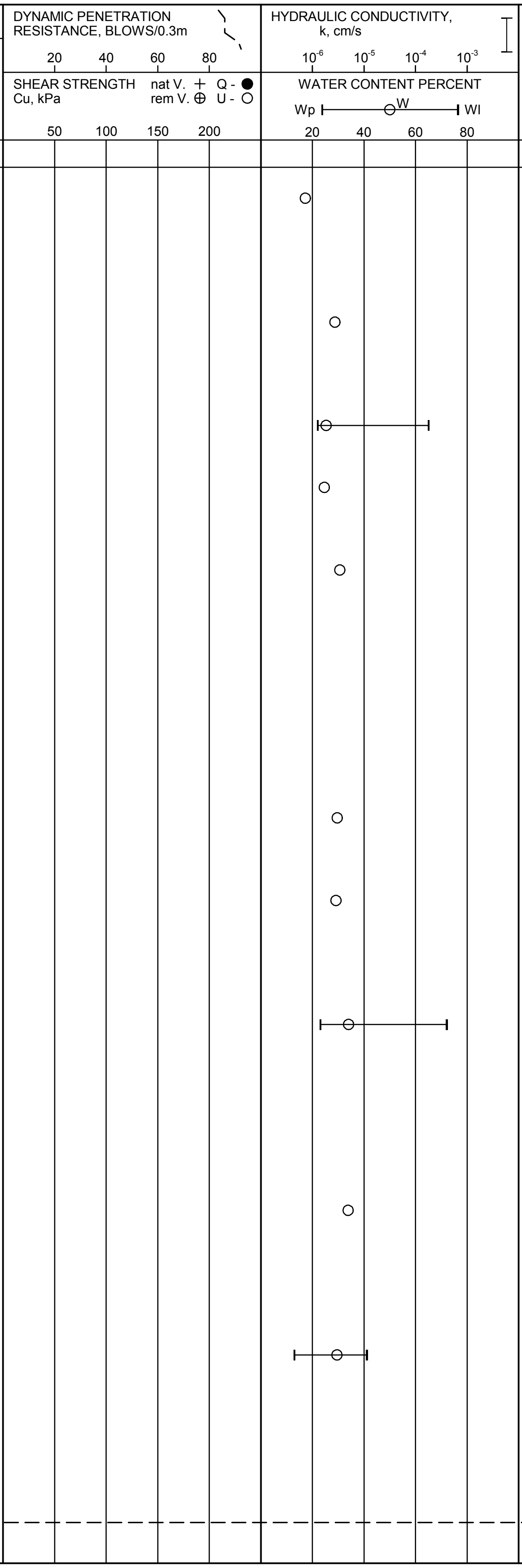
DRILLING CONTRACTOR: Mobile Augers and Research Ltd.

DATUM: NAD83

BORING METHOD: 150mm Dia. Solid Stem Auger Continuous Flight

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	494.77
FILL (CL) SILTY CLAY, low plasticity, sandy, some organics, black and brown, cohesive, w<PL	0.00
(CI-CL) SILTY CLAY, low to medium plastic, trace sand, brown, some white staining, some iron staining, cohesive, w~PL, very soft to stiff	494.46 0.30
(CH) CLAY, high plasticity, brown, some iron staining, cohesive, w~PL, very stiff -some white staining and gypsum crystals below 3.4m	492.94 1.83
(CI) SILTY CLAY, medium plasticity, trace sand, cohesive, w>PL, firm to stiff	486.23 8.53

SAMPLE NUMBER	TYPE	ADDITIONAL LAB. TESTING
006-1	AS	
006-2	AS	
006-3	AS	
006-4	AS	
006-5	AS	
006-6	AS	
006-7	AS	
006-8	AS	
006-9	AS	
006-10	AS	MH



PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS: Slope Indicator in Grout

CONTINUED NEXT PAGE

DEPTH SCALE 1 : 50

LOGGED: LM

CHECKED: LDN

Golder Associates

PROJECT: Cherry Lane Slope Remediation

RECORD OF BOREHOLE: COS-13-006

SHEET 2 OF 2

LOCATION: N 5775572.7 E 385959.2

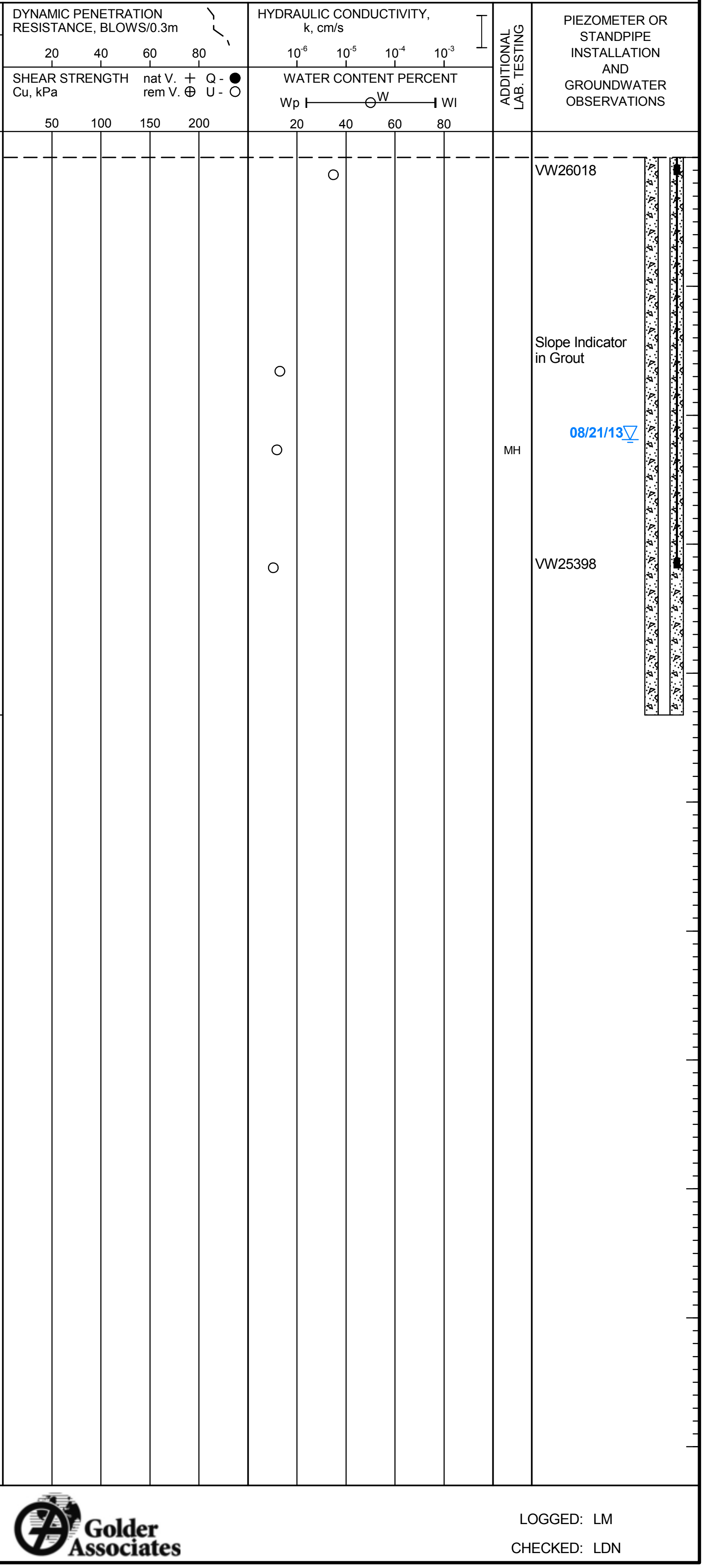
BORING DATE: 08/21/13

DRILL RIG: M10

DRILLING CONTRACTOR: Mobile Augers and Research Ltd.

DATUM: NAD83

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS
10	150mm Dia. Solid Stem Auger Continuous Flight	*CONTINUED FROM PREVIOUS PAGE*						
		(CI) SILTY CLAY, medium plasticity, trace sand, cohesive, w>PL, firm to stiff *(continued)*	484.25 10.52	006-11	AS			VW26018
11		(CL) SILTY CLAY, low plasticity, some fine gravel and sand, trace coarse gravel, grey, (TILL), cohesive, w~PL, stiff	482.57	006-12	AS			Slope Indicator in Grout
12		(SM) SILTY SAND, some fine grained gravel, grey, non-cohesive, wet	482.42 12.34	006-13	AS		MH	08/21/13▽
		(CL) SILTY CLAY, low plasticity, some fine gravel and sand, trace coarse gravel, grey, (TILL), cohesive, w~PL, stiff	481.66 13.11					
13		(SM) SILTY SAND, some fine grained gravel, grey, non-cohesive, wet	481.36 13.41	006-14	AS			VW25398
14		(CL) SILTY CLAY, low plasticity, some fine gravel and sand, trace coarse gravel, grey, (TILL), cohesive, w~PL, stiff	480.44 14.33					
		END OF BOREHOLE = 14.33m						
15								
16								
17								
18								
19								
20								



DEPTH SCALE

1 : 50

LOGGED: LM

CHECKED: LDN

PROJECT: Cherry Lane Slope Remediation

RECORD OF BOREHOLE: COS-13-007

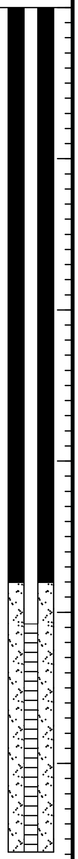
SHEET 1 OF 1

LOCATION: N 5775573.5 E 385959.1

BORING DATE: 08/21/13
DRILL RIG: M10
DRILLING CONTRACTOR: Mobile Augers and Research Ltd.

DATUM: NAD83

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 50 100 150 200	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION AND GROUNDWATER OBSERVATIONS
		GROUND SURFACE		494.80							
0	150mm Dia. Solid Stem Auger Continuous Flight	FILL (CL) SILTY CLAY, low plasticity, sandy, some organics, black and brown, w<PL		0.00							
		(CI-CL) SILTY CLAY, low to medium plasticity, trace sand, brown, some white staining, some iron staining, cohesive, w~PL, very soft to stiff		494.50 0.30							
2		(CH) CLAY, high plasticity, brown, some iron staining, cohesive, w~PL, very stiff with some soft spots		492.97 1.83							Bentonite
		-some white staining and gypsum crystals below 3.4m									
4											Sand
5											Screen
		END OF BOREHOLE = 5.59m		489.21 5.59							



SK_SOIL 11-1362-0057-5100 BOREHOLES.GPJ GAL-SASK.GDT 05/05/14

DEPTH SCALE
1 : 50

Golder Associates

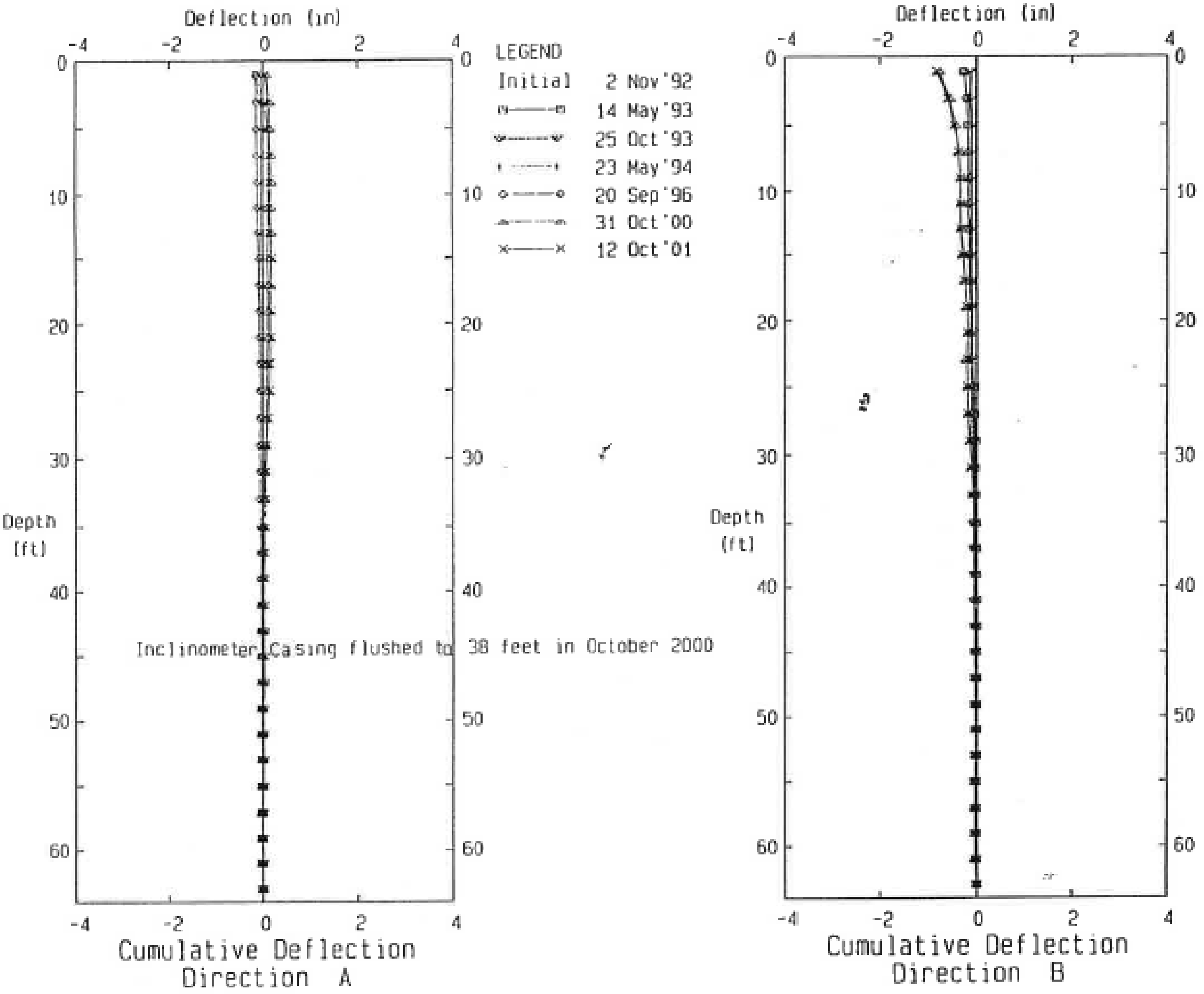
LOGGED: LM
CHECKED: LDN

APPENDIX F

Monitoring Data

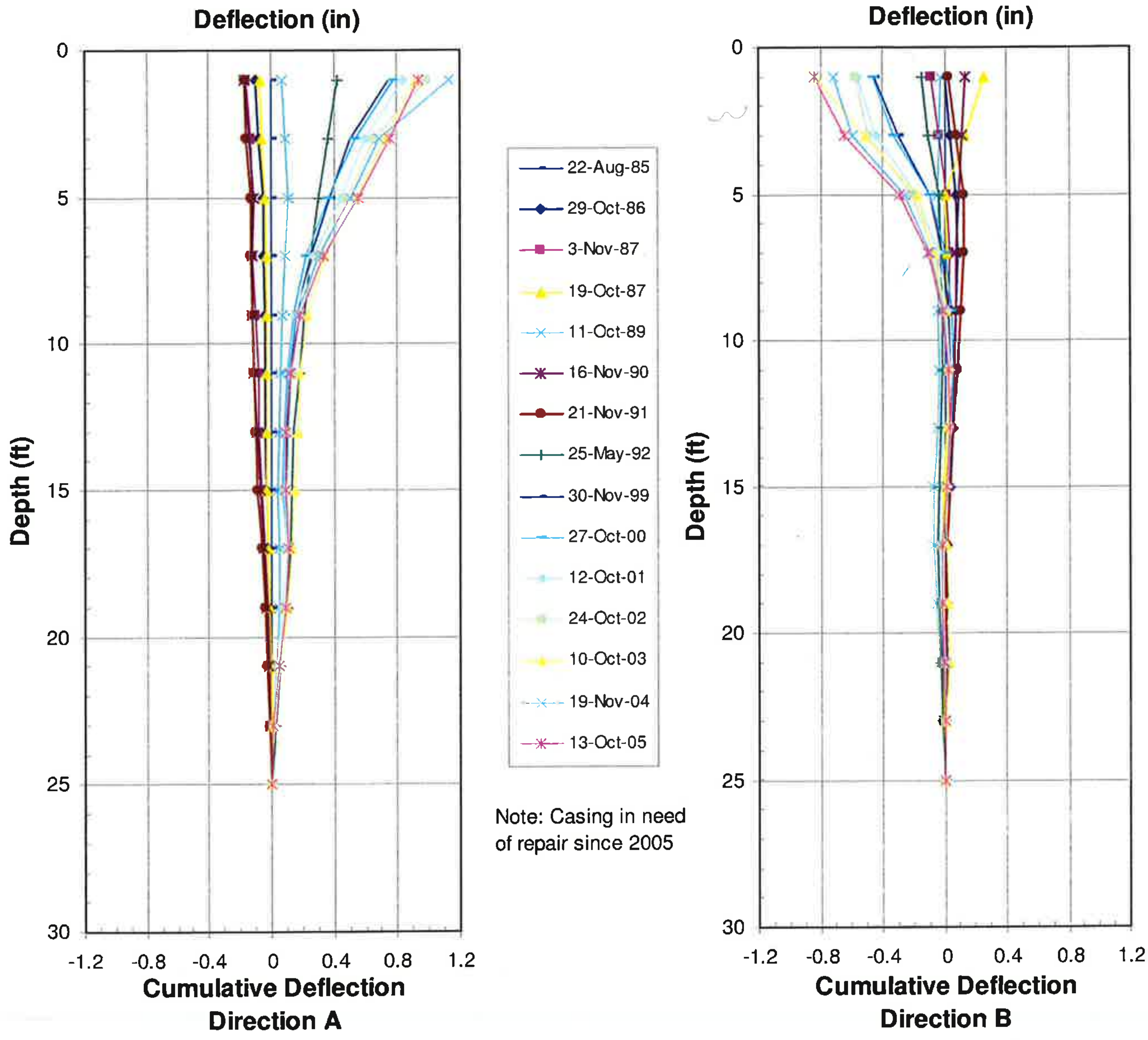
F.1. SLOPE INCLINOMETER PLOTS

AGRA Earth & Environmental Limited - Saskatoon, SK



COS#12 - EAST RIVER BANK, Inclinometer SI-84ICL
Cherry Lane (West Casing)

AMEC Earth & Environmental - Saskatoon, SK



Note: Casing in need of repair since 2005

COS #11 - EAST RIVER BANK, Inclinometer 85-511
Cherry Lane (East Casing)

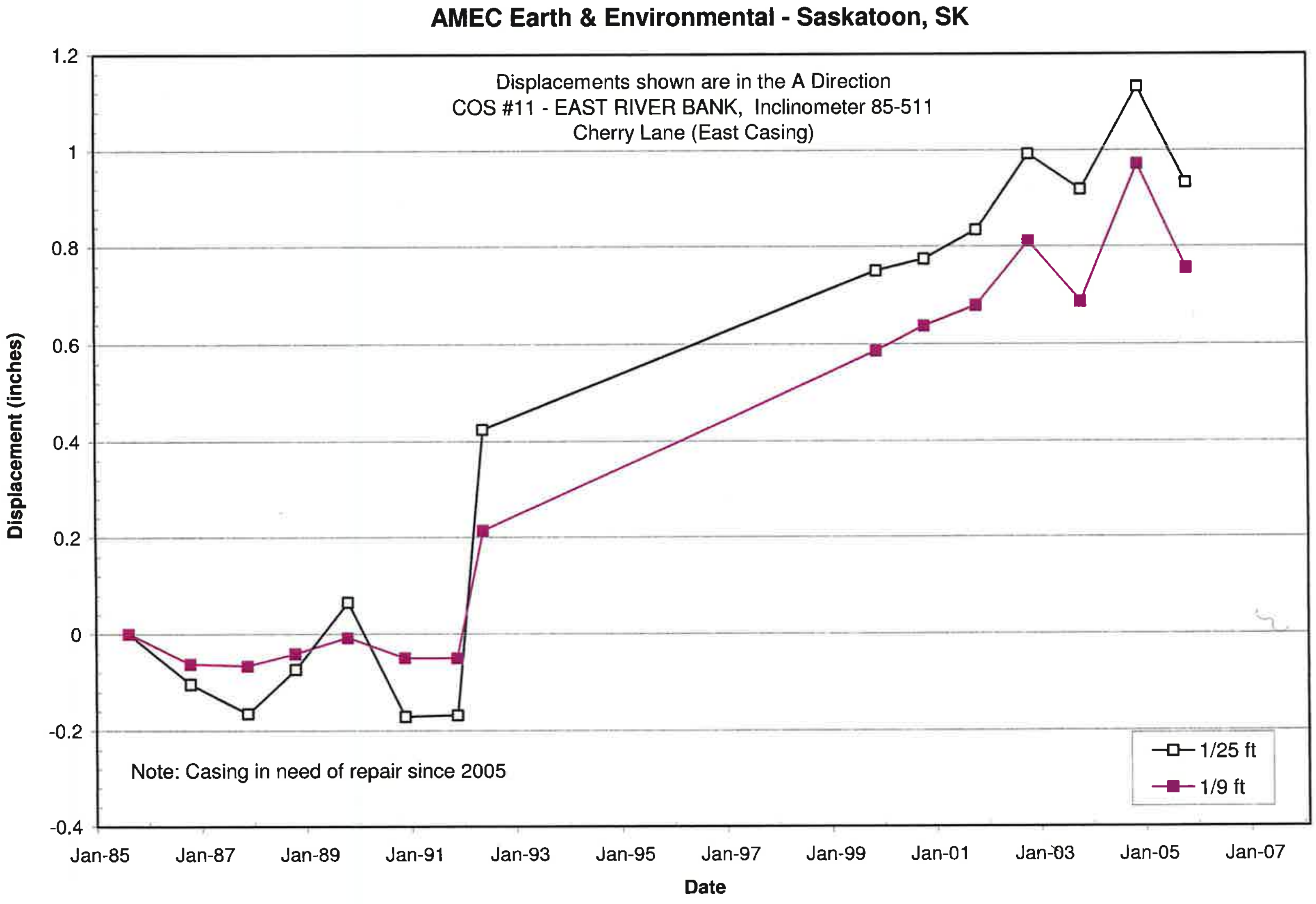
amec
Earth & Environmental
A Division of AMEC Americas Limited

CITY OF SASKATOON
2008 EAST RIVER BANK MONITORING PROGRAM

COS#11 – EAST RIVER BANK – 85-511
CUMULATIVE DEFLECTION

SOUTH SASKATCHEWAN RIVER
SASKATOON, SASKATCHEWAN

Drawn: EM	Scale: As Shown	Date: Nov/08	Proj. No: SX0258510	Figure: 33



Earth & Environmental
A Division of AMEC Americas Limited

CITY OF SASKATOON

2008 EAST RIVER BANK MONITORING PROGRAM

COS#11 – EAST RIVER BANK – 85-511
DISPLACEMENT TIME – A-DIRECTION

SOUTH SASKATCHEWAN RIVER
SASKATOON, SASKATCHEWAN

Drawn by: EM	Scale: As Shown	Date: Nov/08	Proj. No: SX0258510	Figure: 34

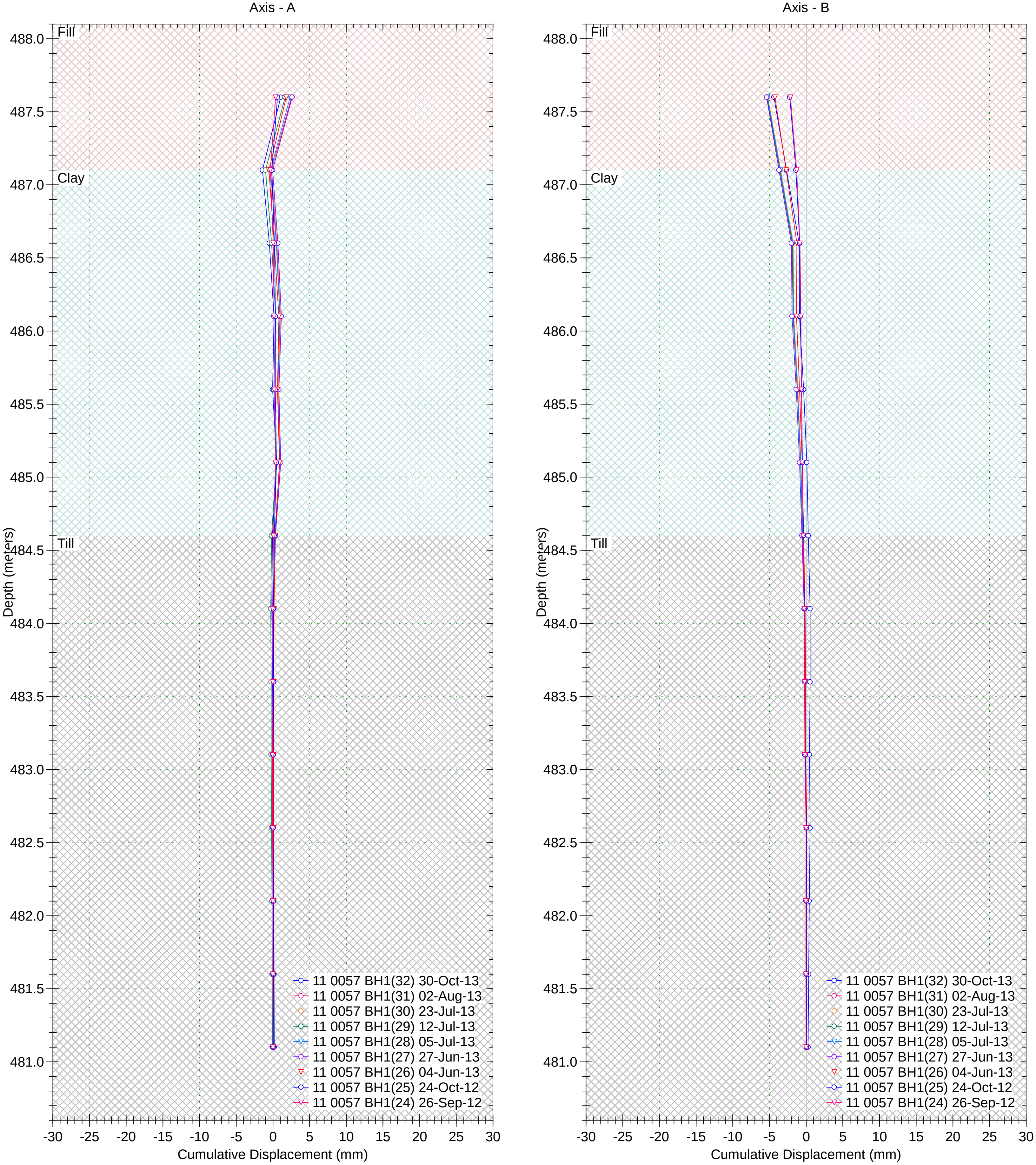
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.47.0

Borehole : BH1
Project : 11-1362-0057 Cherry Lane
Location : Lane - 241 11th St E
Northing : 5775616.8
Easting : 386010.5
Collar :

Spiral Correction : N/A
Collar Elevation : 488.1 meters
Borehole Total Depth : 7.0 meters
A+ Groove Azimuth :
Base Reading : 2012 Jun 25 08:55
Applied Azimuth : 0.0 degrees



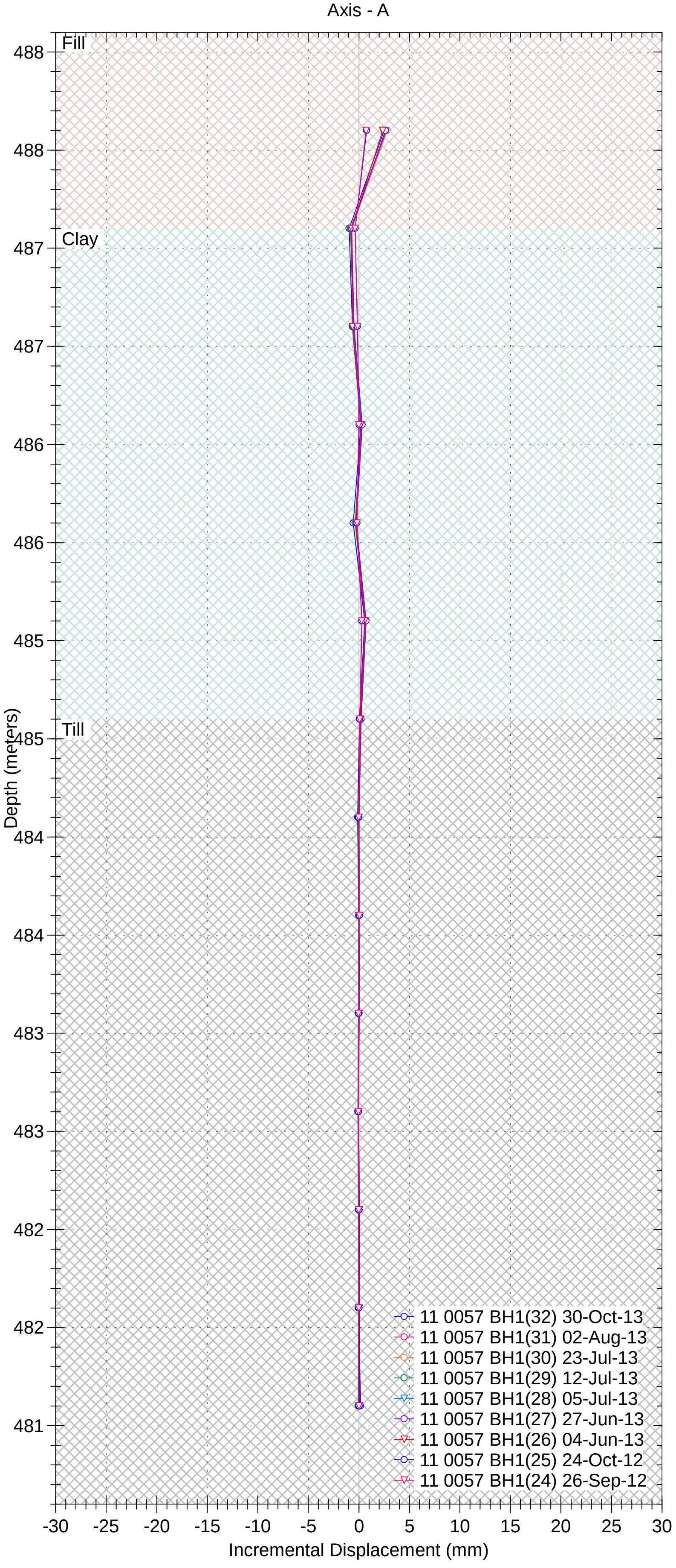
RST Instruments Ltd.

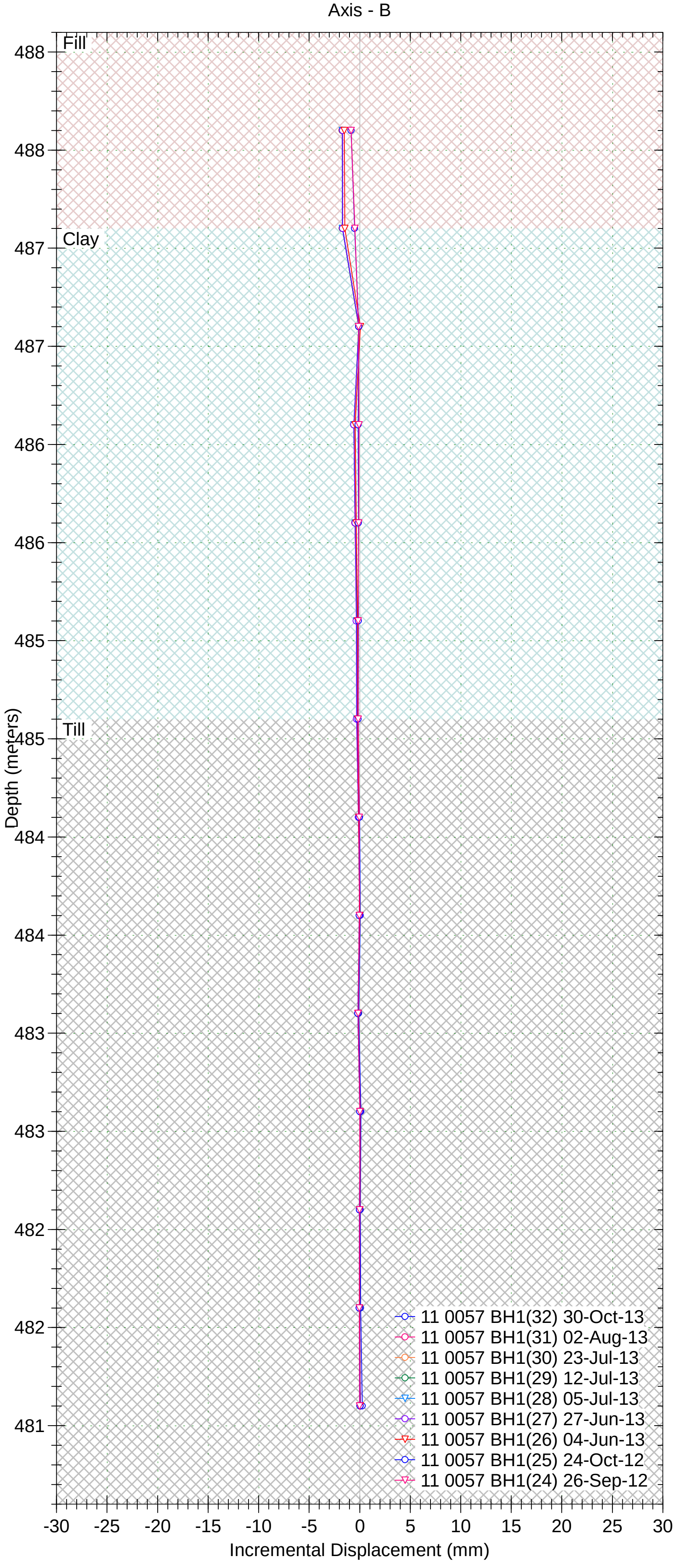
INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.47.0

Borehole : BH1
Project : 11-1362-0057 Cherry Lane
Location : Lane - 241 11th St E
Northing : 5775616.8
Easting : 386010.5
Collar :

Spiral Correction : N/A
Collar Elevation : 488.1 meters
Borehole Total Depth : 7.0 meters
A+ Groove Azimuth :
Base Reading : 2012 Jun 25 08:55
Applied Azimuth : 0.0 degrees





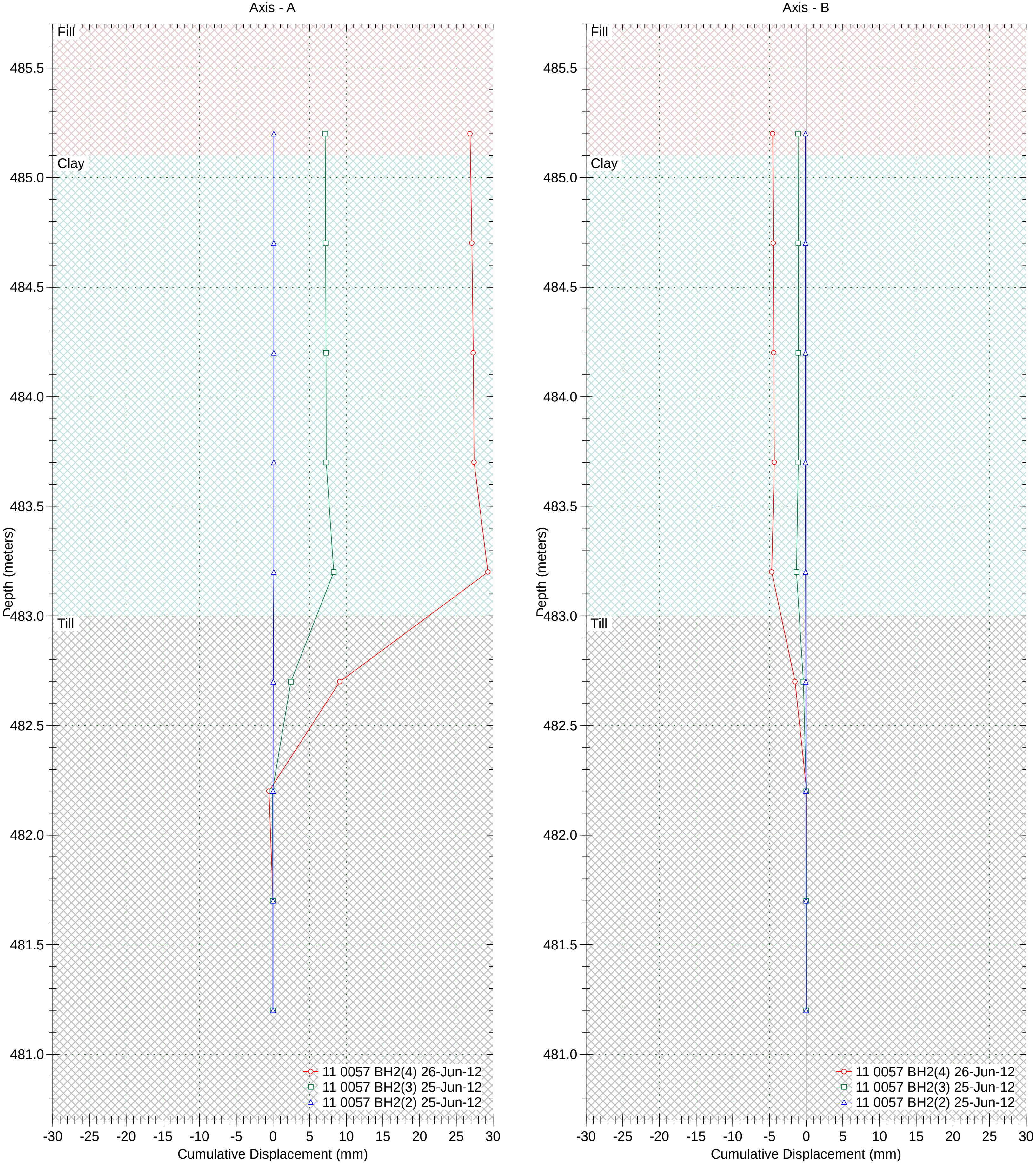
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.47.0

Borehole : BH 2
Project : 11-1362-0057 Cherry Lane
Location : Lane - 233 11th St E.
Northing : 5775623.7
Easting : 385980.0
Collar :

Spiral Correction : N/A
Collar Elevation : 485.7 meters
Borehole Total Depth : 4.5 meters
A+ Groove Azimuth :
Base Reading : 2012 Jun 25 09:39
Applied Azimuth : 0.0 degrees



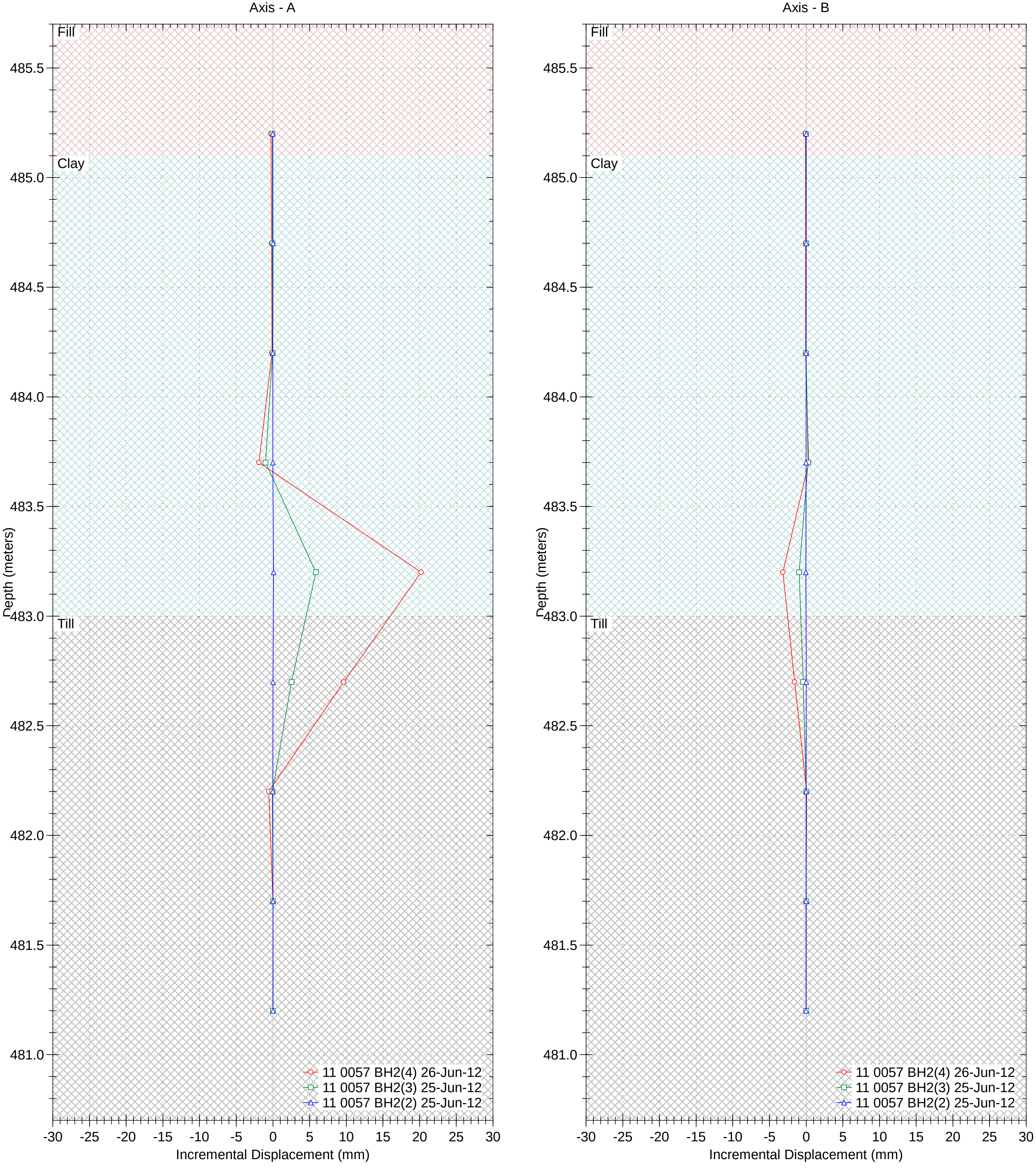
RST Instruments Ltd.

INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.47.0

Borehole : BH 2
Project : 11-1362-0057 Cherry Lane
Location : Lane - 233 11th St E.
Northing : 5775623.7
Easting : 385980.0
Collar :

Spiral Correction : N/A
Collar Elevation : 485.7 meters
Borehole Total Depth : 4.5 meters
A+ Groove Azimuth :
Base Reading : 2012 Jun 25 09:39
Applied Azimuth : 0.0 degrees



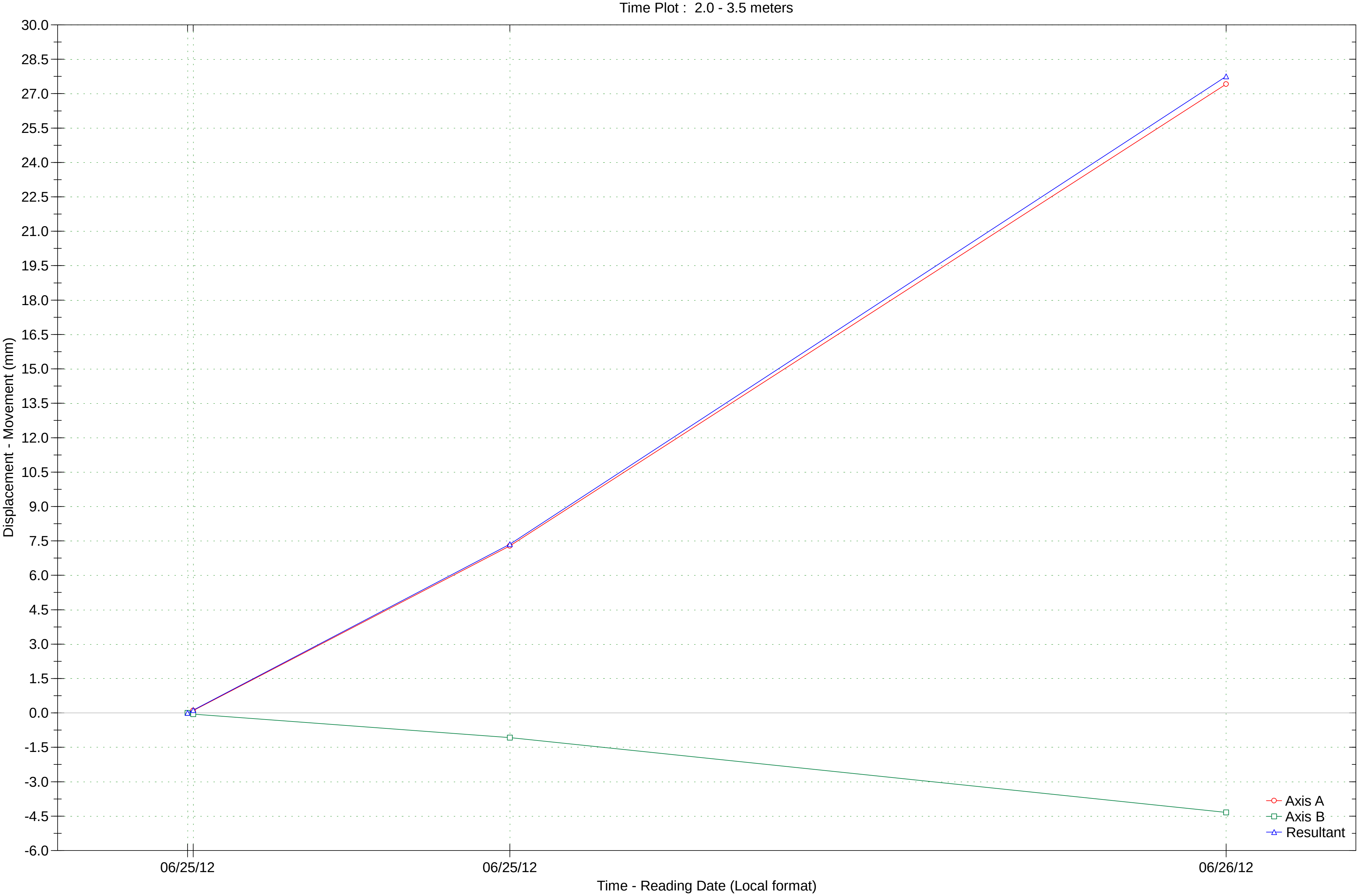
RST Instruments Ltd.

TIME PLOT
Displacement vs. Time

Inclinalysis v. 2.47.0

Borehole : BH 2
Project : 11-1362-0057 Cherry Lane
Location : Lane - 233 11th St E.
Northing : 5775623.7
Easting : 385980.0
Collar :
Collar Elev : 485.7 meters

Spiral Correction : N/A
Movement Depth : 2.0 - 3.5 meters
Borehole Total Depth : 4.5 meters
A+ Groove Azimuth :
Latest Reading : 2012 Jun 26 09:02
Initial Reading : 2012 Jun 25 09:39
Applied Azimuth : 0.0 degrees



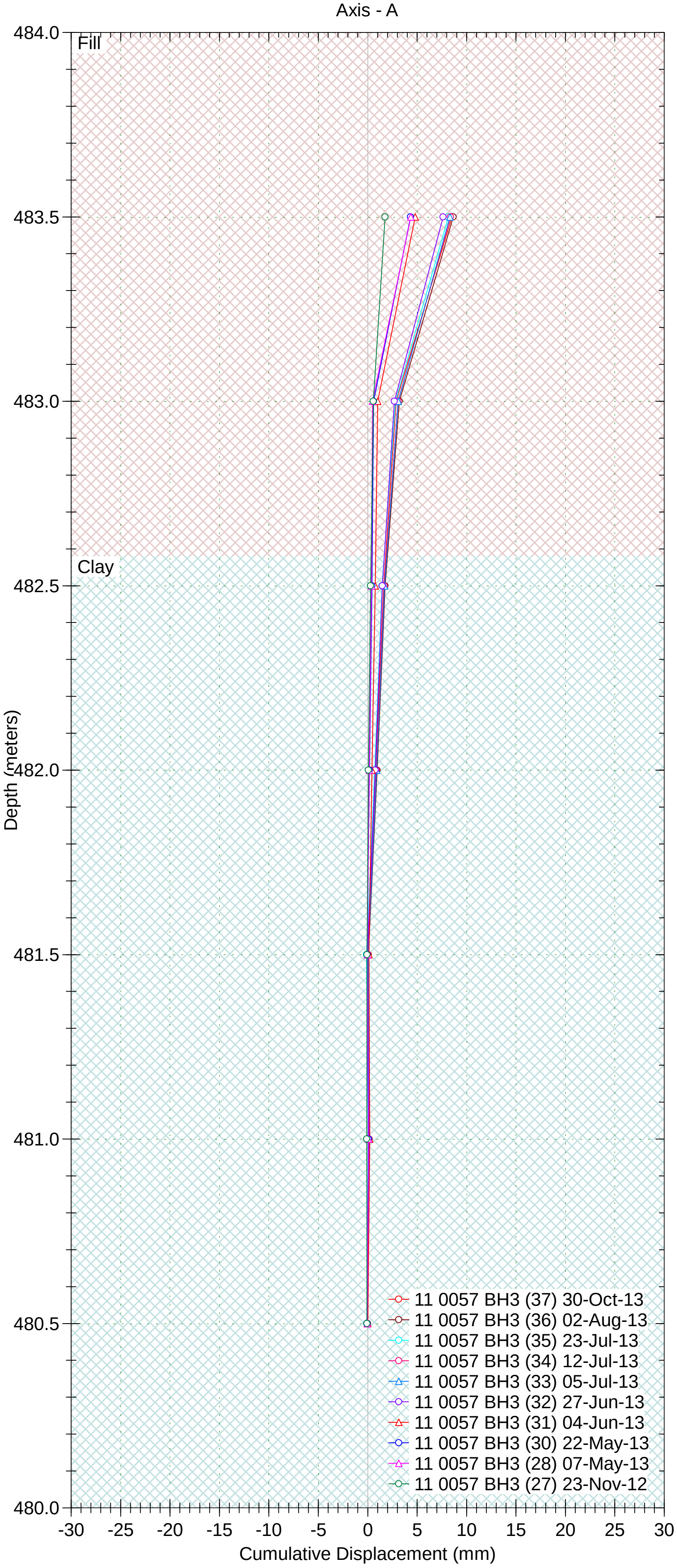
RST Instruments Ltd.

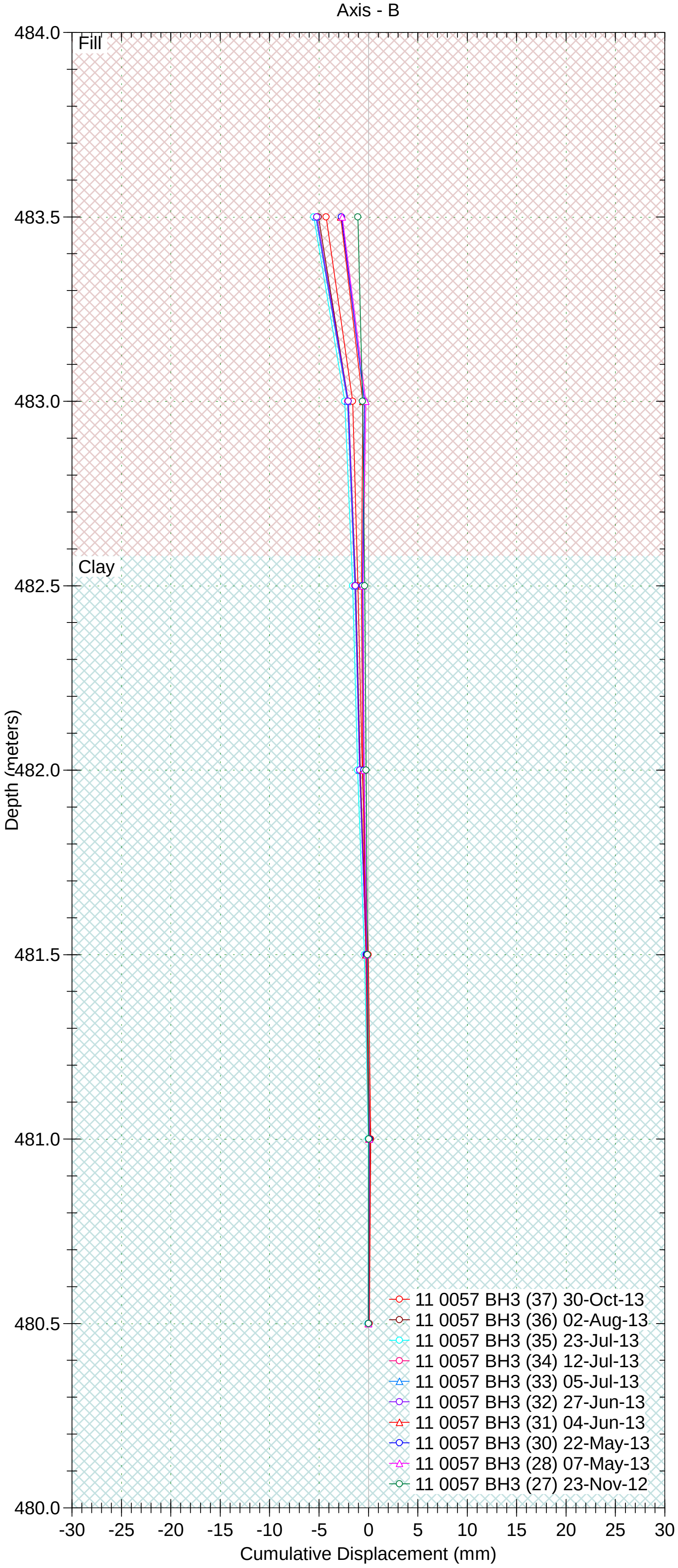
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.47.0

Borehole : BH 3
Project : 11-1362-0057 Cherry Lane
Location : Lane - 231 11th St E.
Northing : 5775623.7
Easting : 385980.0
Collar :

Spiral Correction : N/A
Collar Elevation : 484.0 meters
Borehole Total Depth : 3.5 meters
A+ Groove Azimuth :
Base Reading : 2012 Jun 25 10:17
Applied Azimuth : 0.0 degrees





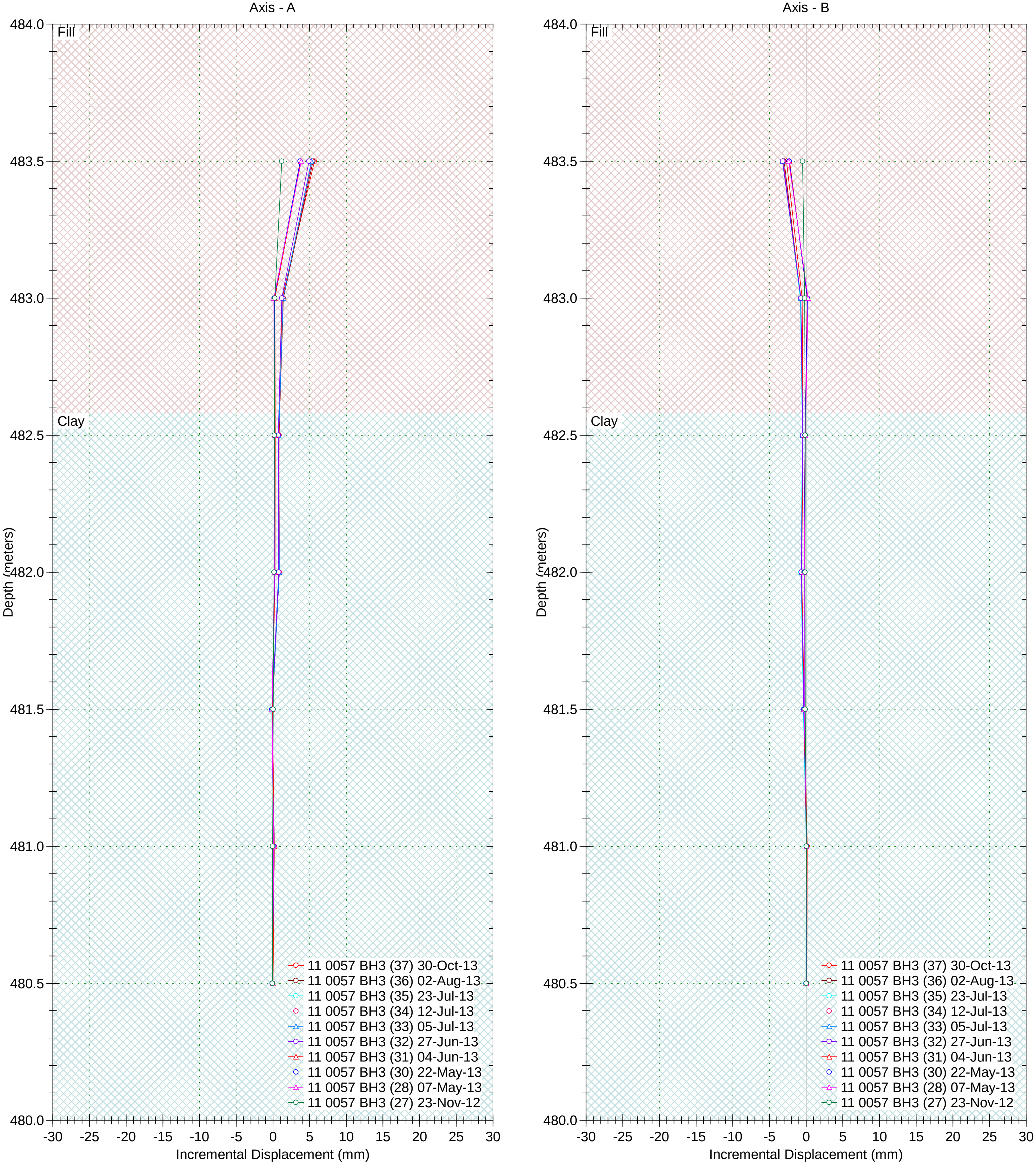
RST Instruments Ltd.

INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.47.0

Borehole : BH 3
Project : 11-1362-0057 Cherry Lane
Location : Lane - 231 11th St E.
Northing : 5775623.7
Easting : 385980.0
Collar :

Spiral Correction : N/A
Collar Elevation : 484.0 meters
Borehole Total Depth : 3.5 meters
A+ Groove Azimuth :
Base Reading : 2012 Jun 25 10:17
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

TIME PLOT

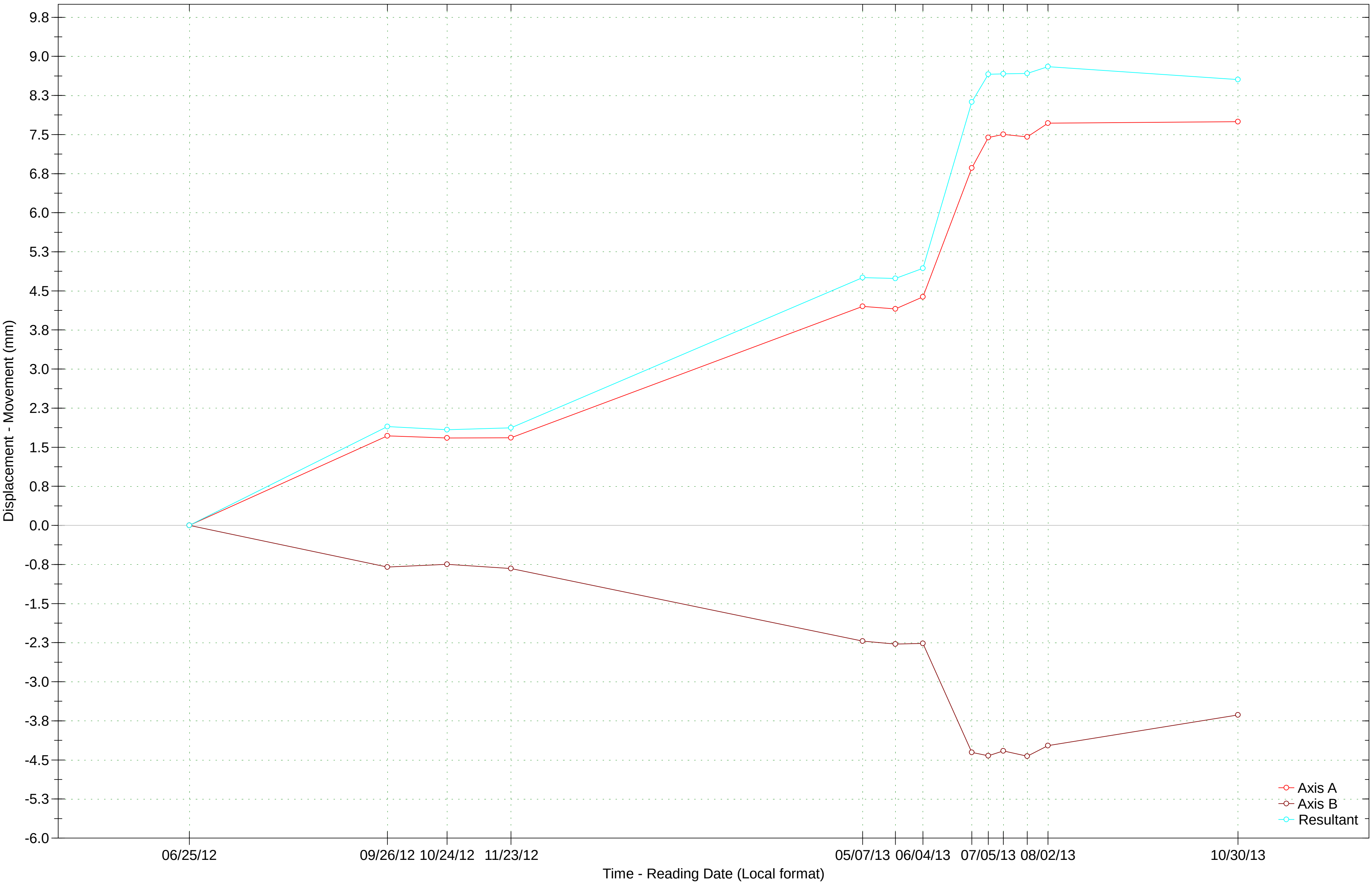
Displacement vs. Time

Inclinalysis v. 2.47.0

Borehole : BH 3
Project : 11-1362-0057 Cherry Lane
Location : Lane - 231 11th St E.
Northing : 5775623.7
Easting : 385980.0
Collar :
Collar Elev : 484.0 meters

Spiral Correction : N/A
Movement Depth : 0.5 - 1.5 meters
Borehole Total Depth : 3.5 meters
A+ Groove Azimuth :
Latest Reading : 2013 Oct 30 10:49
Initial Reading : 2012 Jun 25 10:17
Applied Azimuth : 0.0 degrees

Time Plot : 0.5 - 1.5 meters



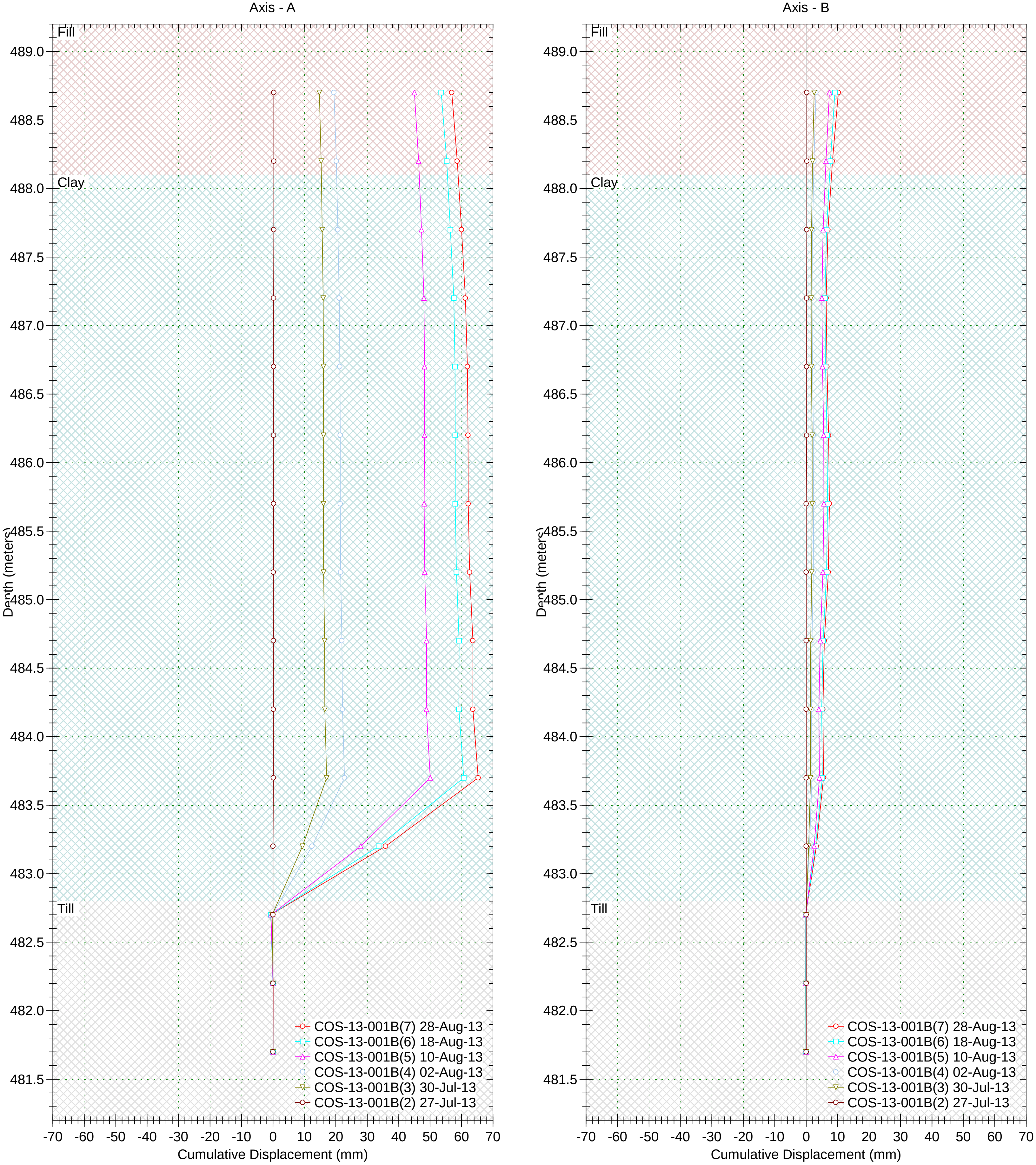
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.47.0

Borehole : COS-13-001B
Project : 11-1362-0057 Cherry Lane
Location : Lane - 306 SK. Cres. E.
Northing : 5775616.67
Easting : 386038.94
Collar : -0.109

Spiral Correction : N/A
Collar Elevation : 489.2 meters
Borehole Total Depth : 7.5 meters
A+ Groove Azimuth :
Base Reading : 2013 Jul 27 15:17
Applied Azimuth : 0.0 degrees



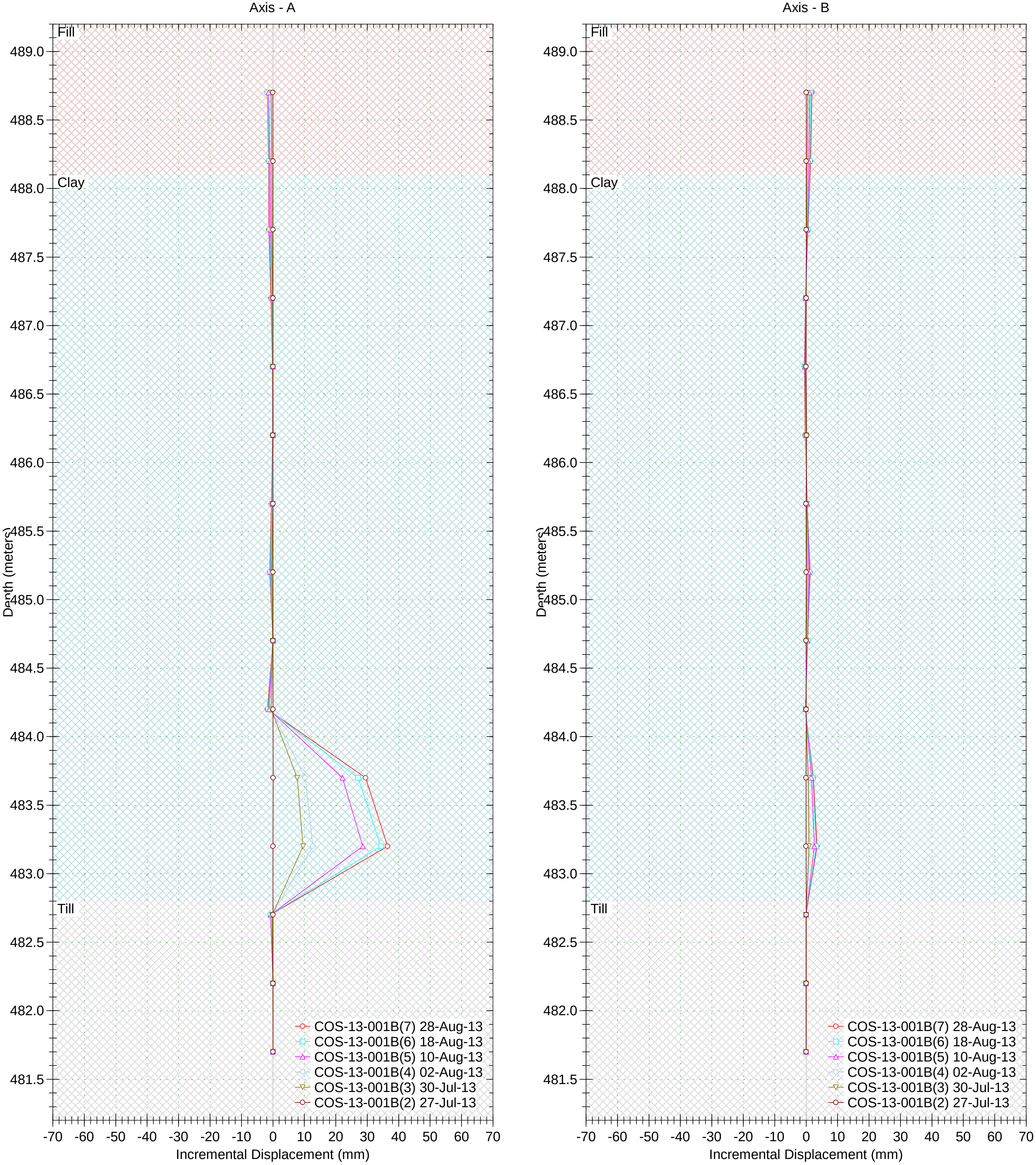
RST Instruments Ltd.

INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.47.0

Borehole : COS-13-001B
Project : 11-1362-0057 Cherry Lane
Location : Lane - 306 SK. Cres. E.
Northing : 5775616.67
Easting : 386038.94
Collar : -0.109

Spiral Correction : N/A
Collar Elevation : 489.2 meters
Borehole Total Depth : 7.5 meters
A+ Groove Azimuth :
Base Reading : 2013 Jul 27 15:17
Applied Azimuth : 0.0 degrees



RST Instruments Ltd.

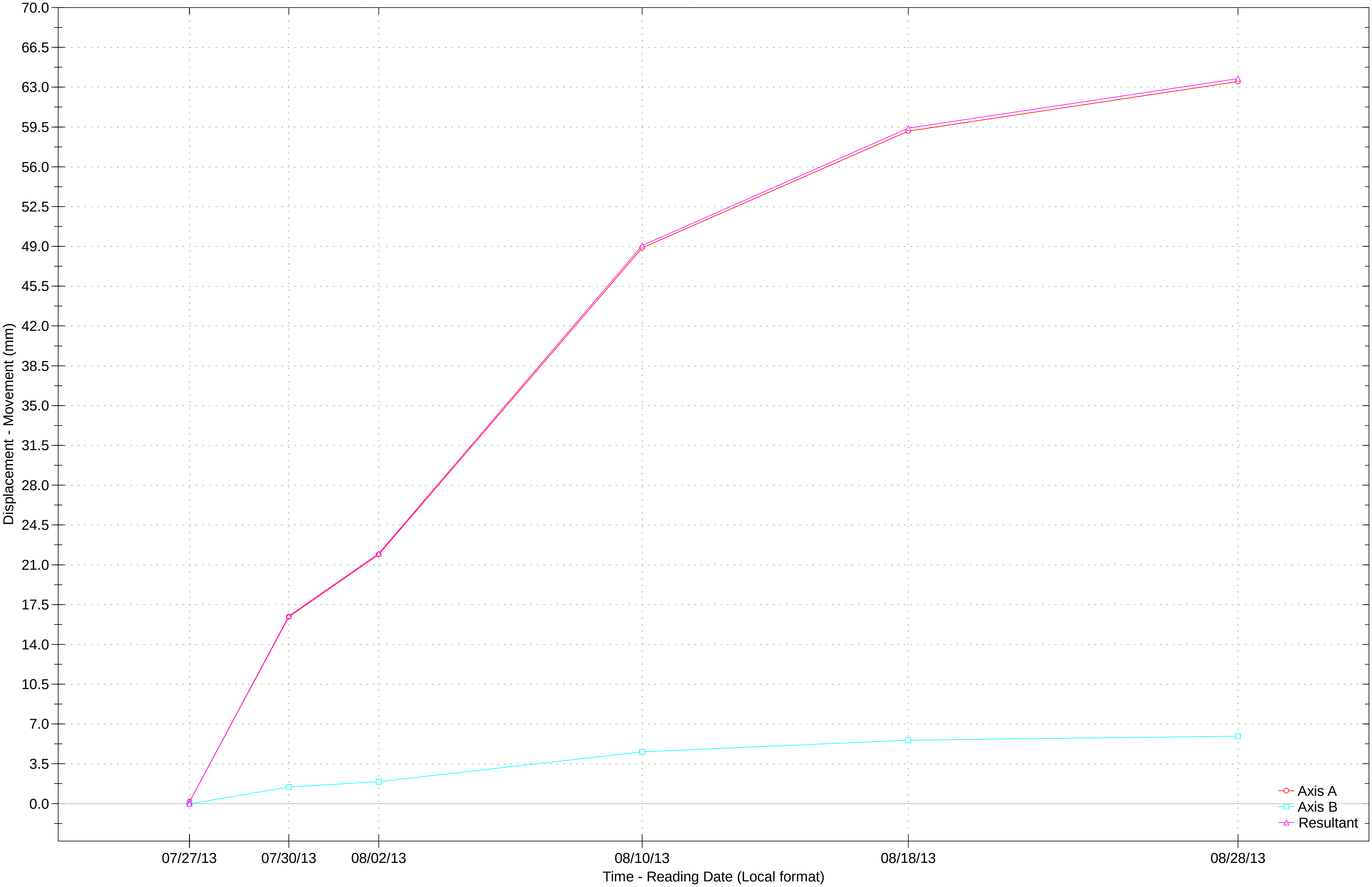
TIME PLOT
Displacement vs. Time

Inclinalysis v. 2.47.0

Borehole : COS-13-001B
Project : 11-1362-0057 Cherry Lane
Location : Lane - 306 SK. Cres. E.
Northing : 5775616.67
Easting : 386038.94
Collar : -0.109
Collar Elev : 489.2 meters

Spiral Correction : N/A
Movement Depth : 4.5 - 6.5 meters
Borehole Total Depth : 7.5 meters
A+ Groove Azimuth :
Latest Reading : 2013 Aug 28 08:05
Initial Reading : 2013 Jul 27 15:17
Applied Azimuth : 0.0 degrees

Time Plot : 4.5 - 6.5 meters



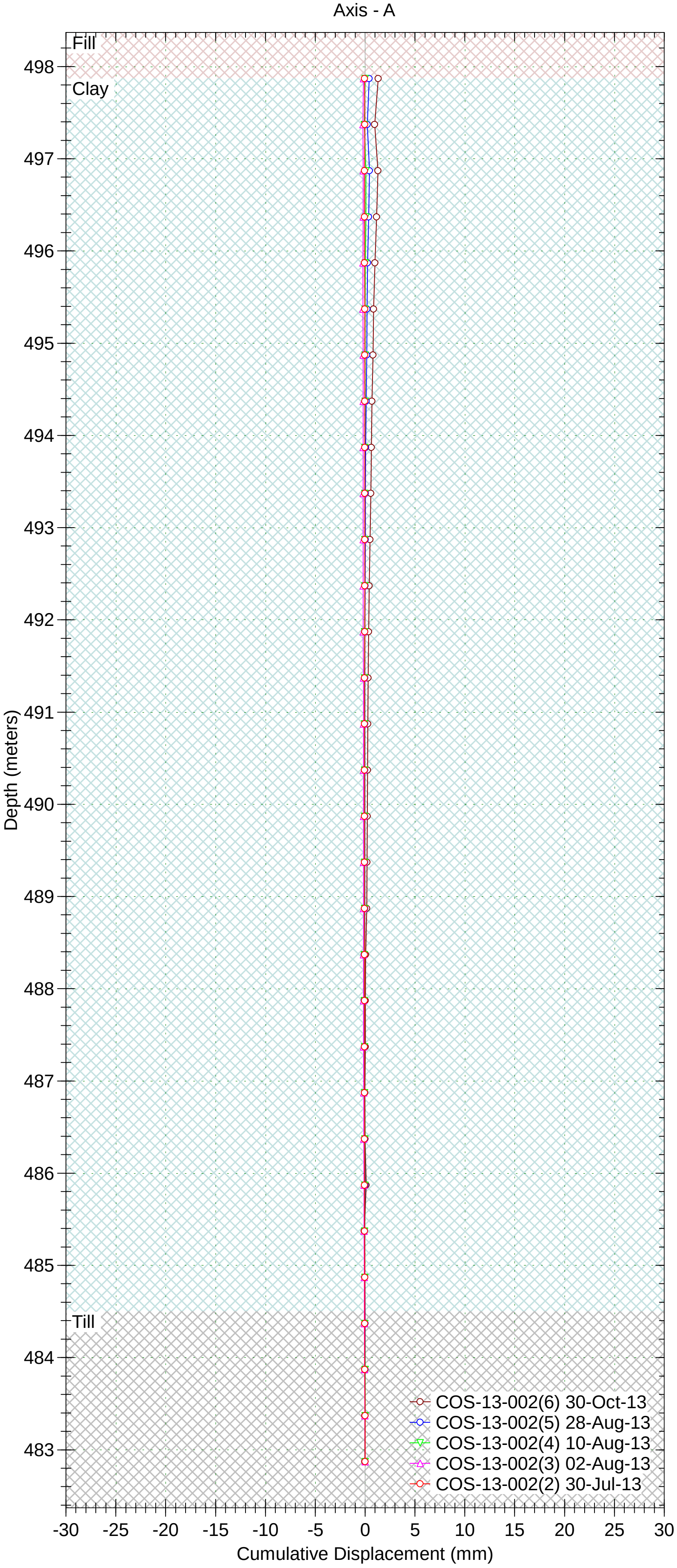
RST Instruments Ltd.

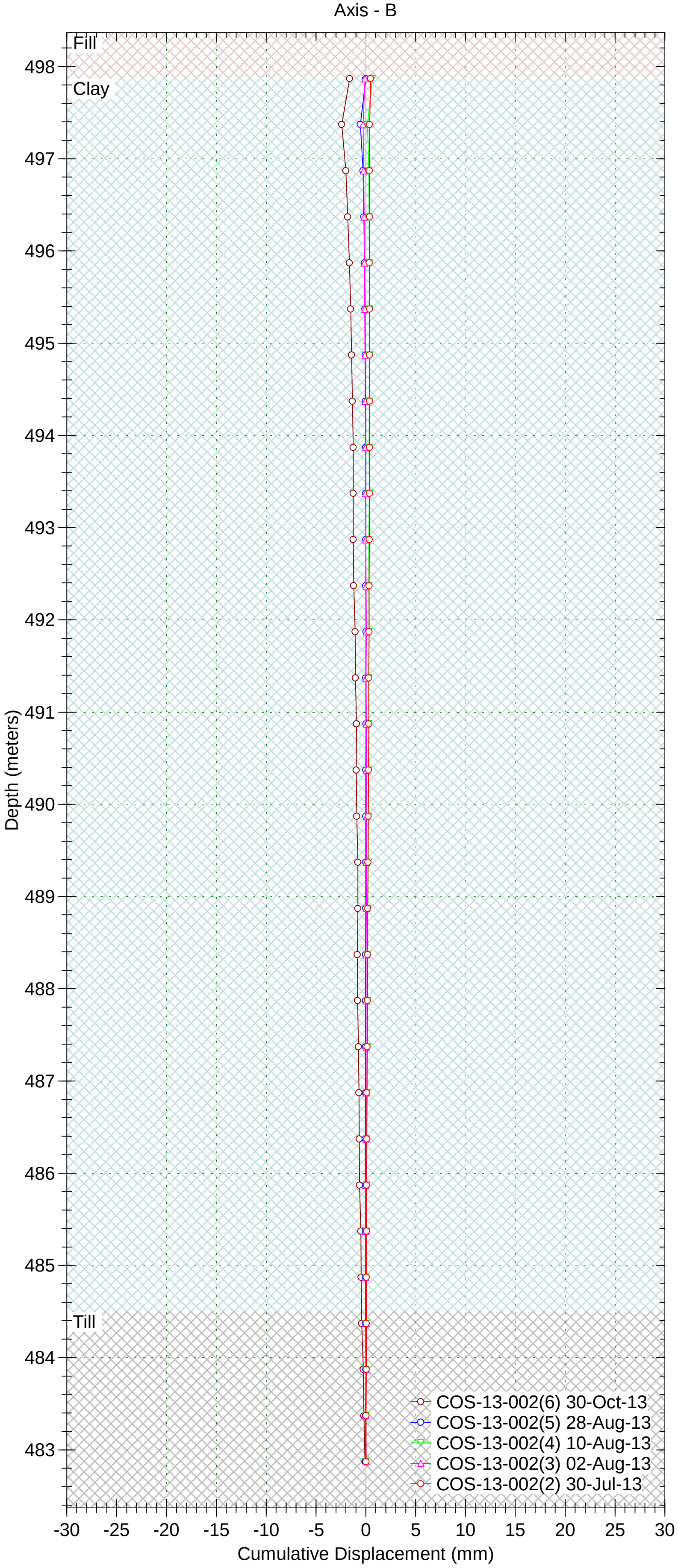
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.47.0

Borehole : COS-13-002
Project : 11-1362-0057 Cherry Lane
Location : 307 11th St. E. (Front)
Northing : 5775567.41
Easting : 386043.54
Collar : -0.113

Spiral Correction : N/A
Collar Elevation : 498.4 meters
Borehole Total Depth : 15.5 meters
A+ Groove Azimuth :
Base Reading : 2013 Jul 30 16:18
Applied Azimuth : 0.0 degrees





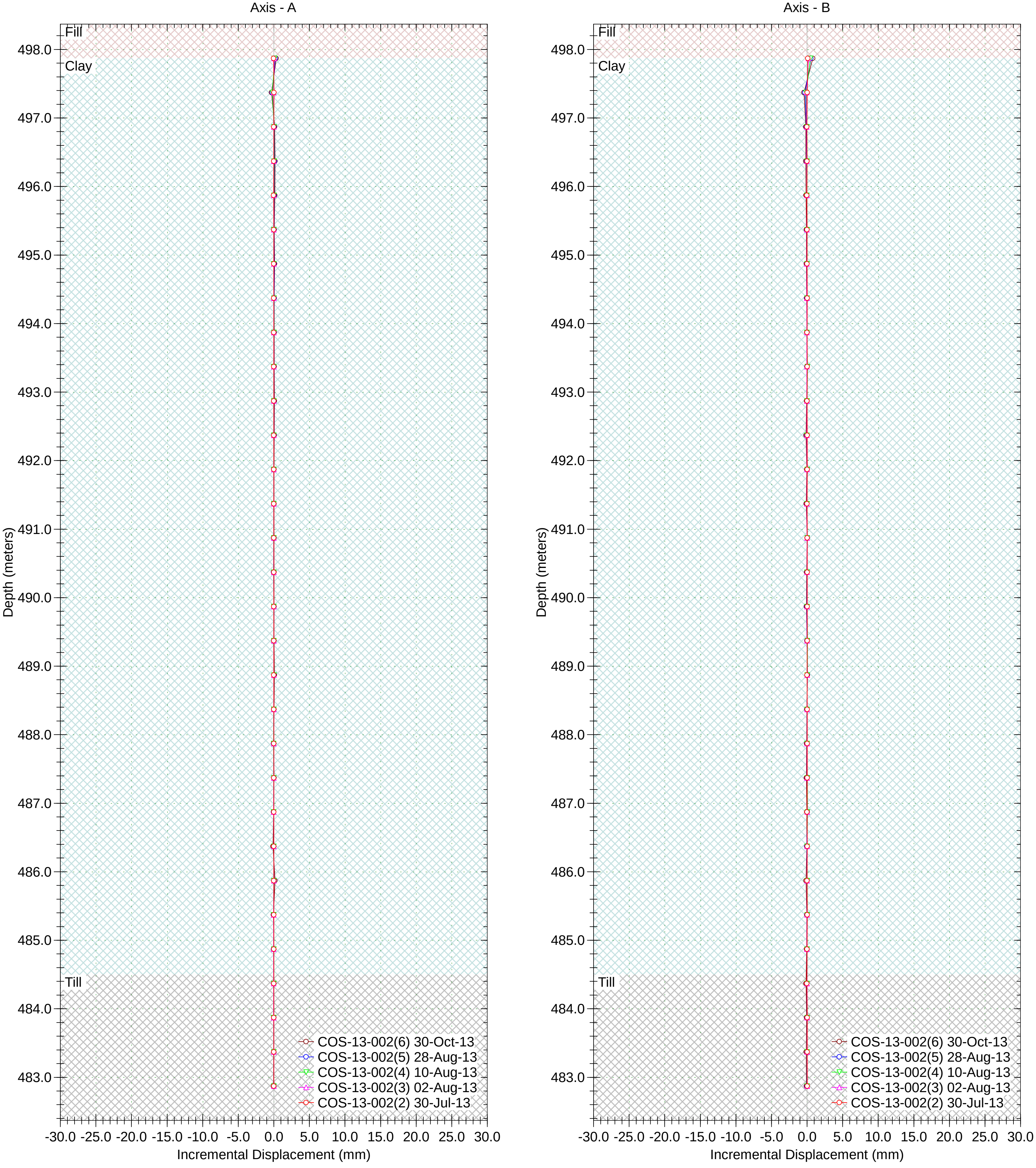
RST Instruments Ltd.

INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.47.0

Borehole : COS-13-002
Project : 11-1362-0057 Cherry Lane
Location : 307 11th St. E. (Front)
Northing : 5775567.41
Easting : 386043.54
Collar : -0.113

Spiral Correction : N/A
Collar Elevation : 498.4 meters
Borehole Total Depth : 15.5 meters
A+ Groove Azimuth :
Base Reading : 2013 Jul 30 16:18
Applied Azimuth : 0.0 degrees



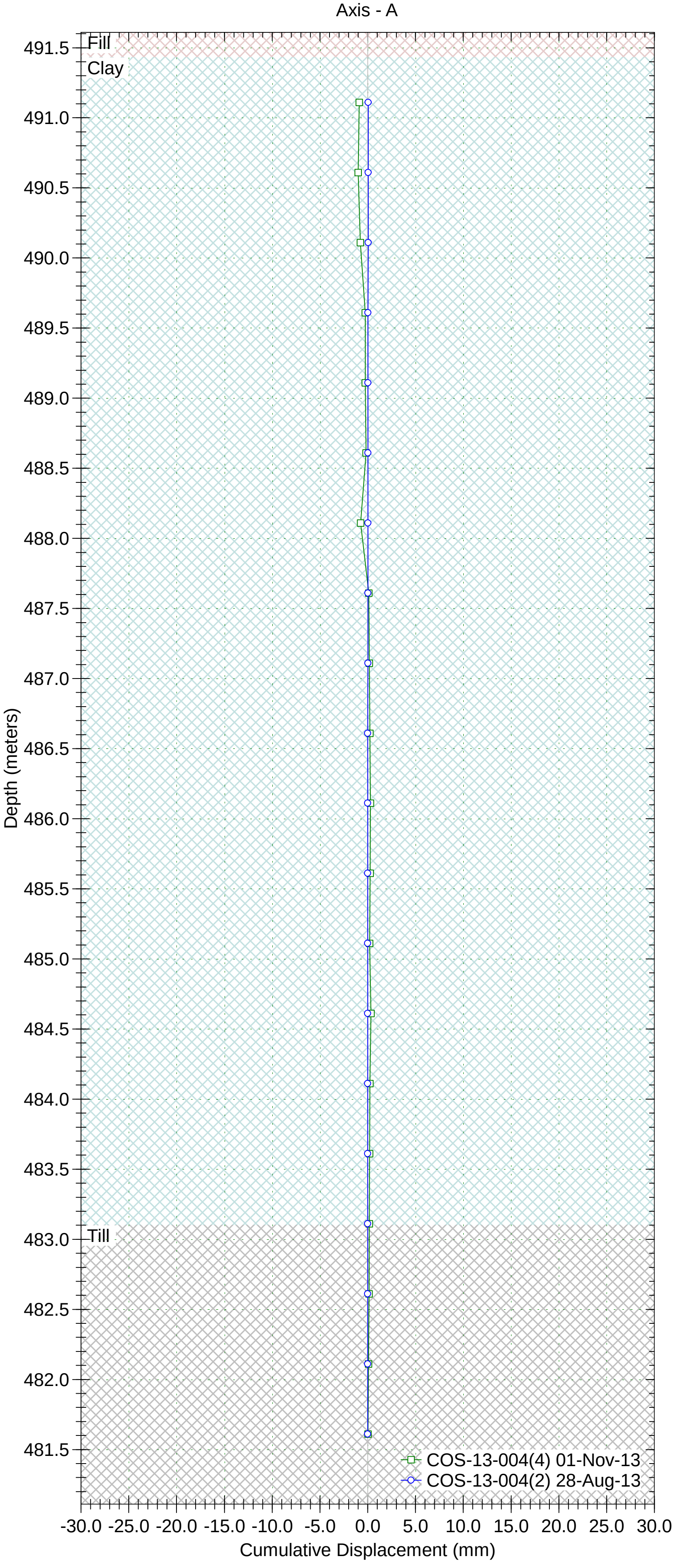
RST Instruments Ltd.

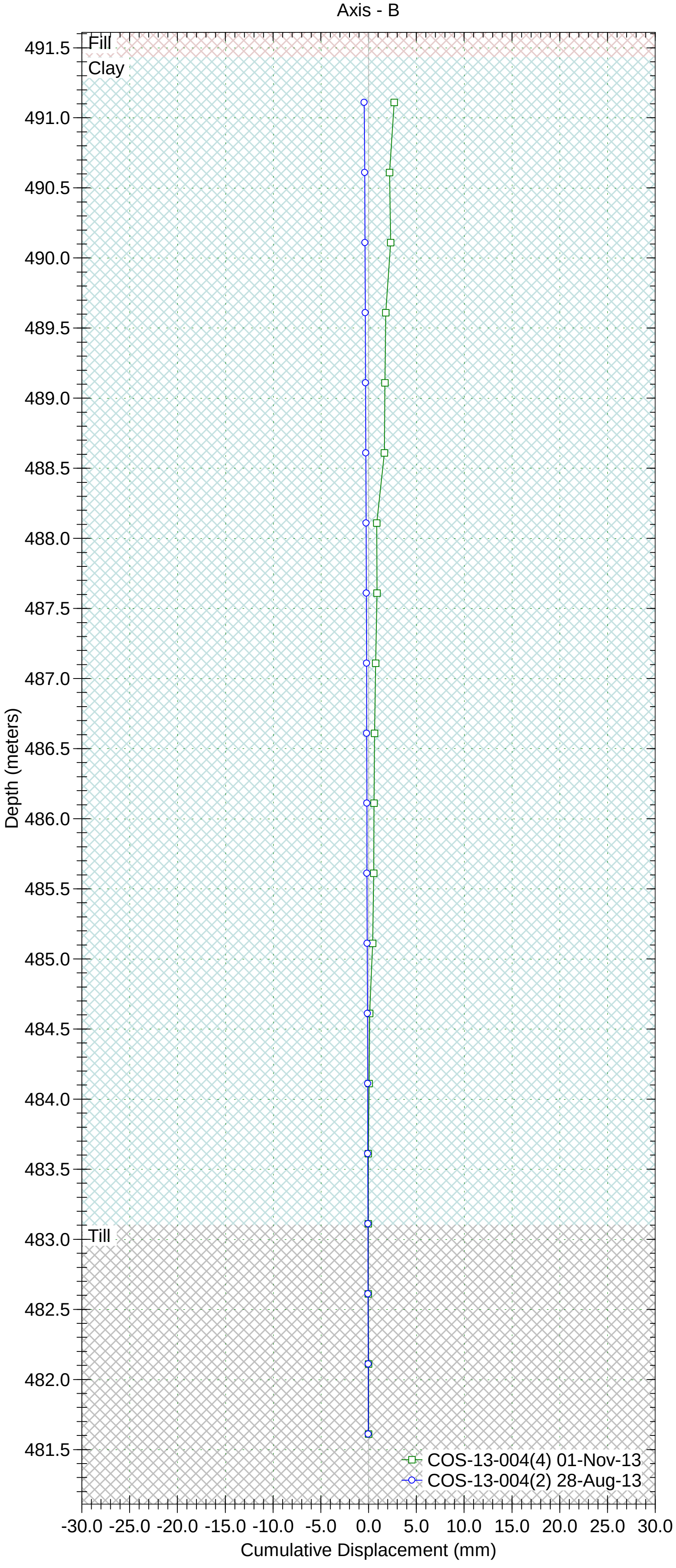
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.47.0

Borehole : COS-13-004
Project : 11-1362-0057 Cherry Lane
Location : 307 11th. St. E. (back)
Northing : 5775604.97
Easting : 386050.63
Collar : -0.677

Spiral Correction : N/A
Collar Elevation : 491.6 meters
Borehole Total Depth : 10.0 meters
A+ Groove Azimuth :
Base Reading : 2013 Aug 28 08:30
Applied Azimuth : 0.0 degrees





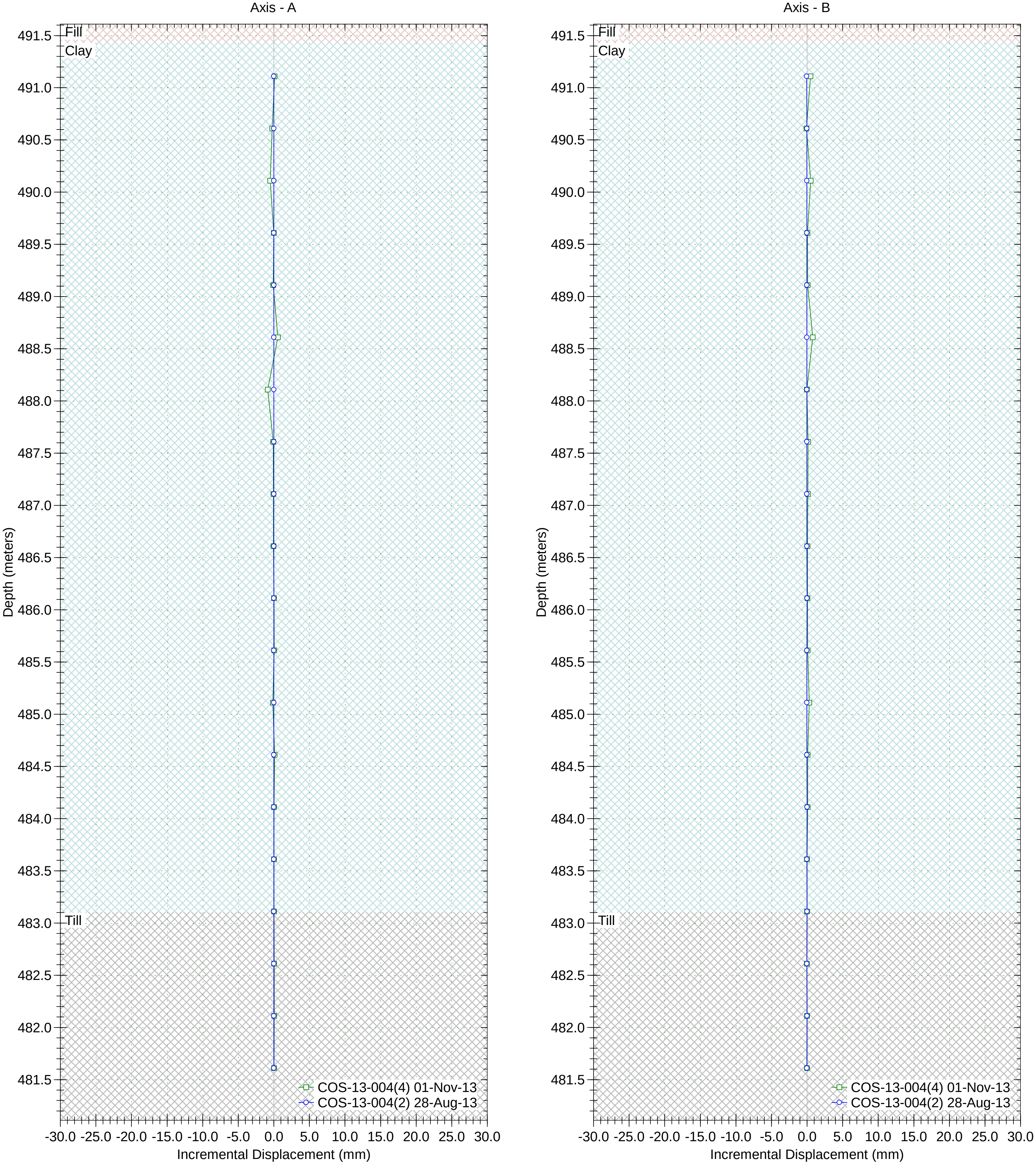
RST Instruments Ltd.

INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.47.0

Borehole : COS-13-004
Project : 11-1362-0057 Cherry Lane
Location : 307 11th. St. E. (back)
Northing : 5775604.97
Easting : 386050.63
Collar : -0.677

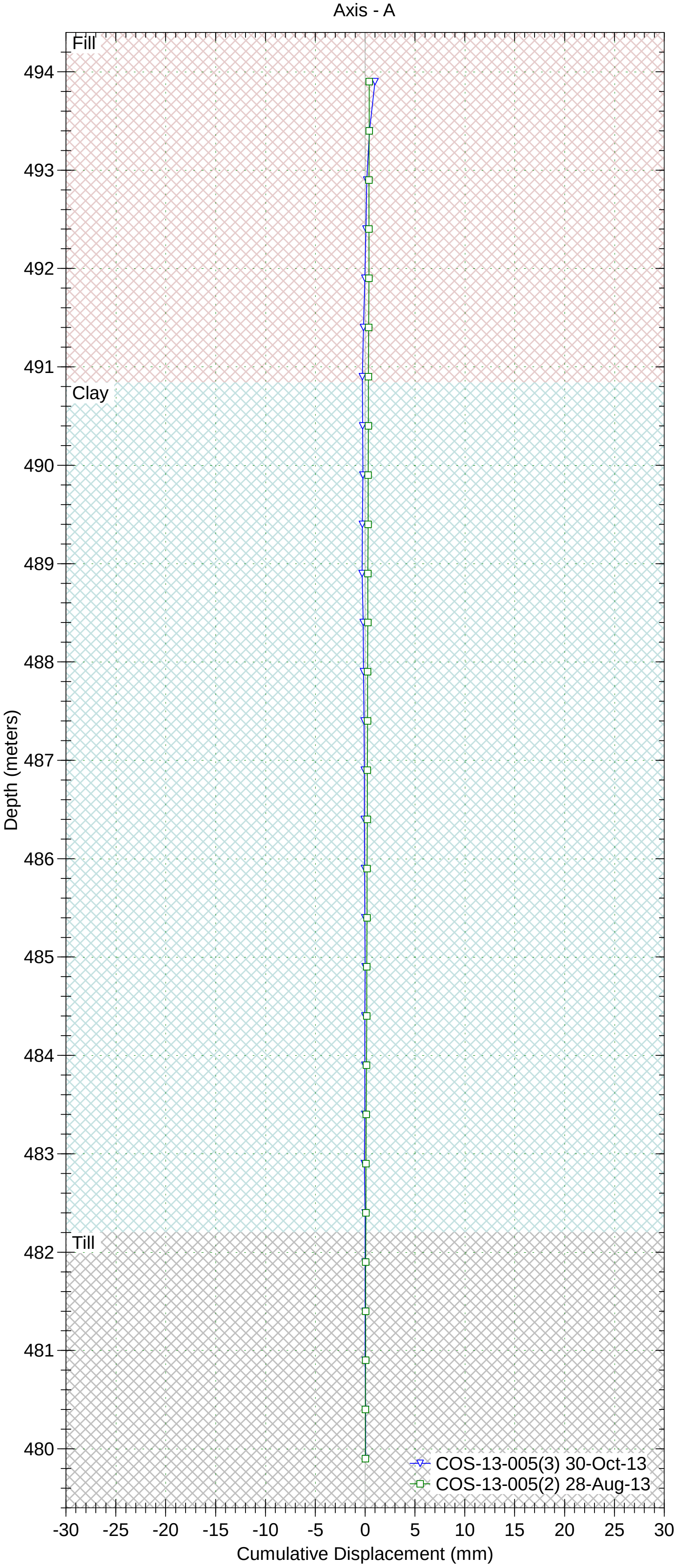
Spiral Correction : N/A
Collar Elevation : 491.6 meters
Borehole Total Depth : 10.0 meters
A+ Groove Azimuth :
Base Reading : 2013 Aug 28 08:30
Applied Azimuth : 0.0 degrees

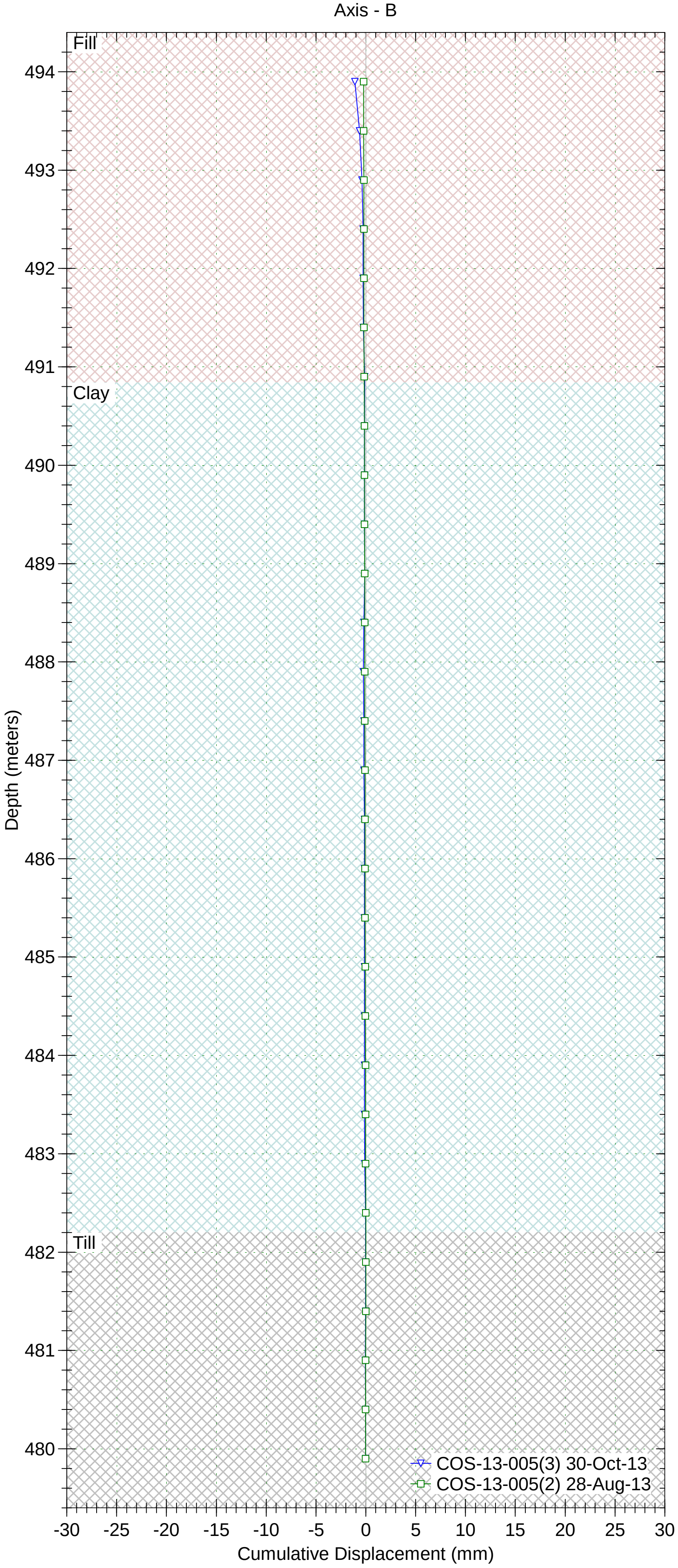


RST Instruments Ltd. CUMULATIVE DISPLACEMENT Inclinalysis v. 2.47.5

Borehole : COS-13-005
Project : 11-1362-0057 Cherry Lane
Location : 316 Sask. Cres. E.
Northing : 5775631.299
Easting : 386078.8467
Collar : -0.1

Spiral Correction : N/A
Collar Elevation : 494.4 meters
Borehole Total Depth : 14.5 meters
A+ Groove Azimuth :
Base Reading : 2013 Aug 28 09:11
Applied Azimuth : 0.0 degrees

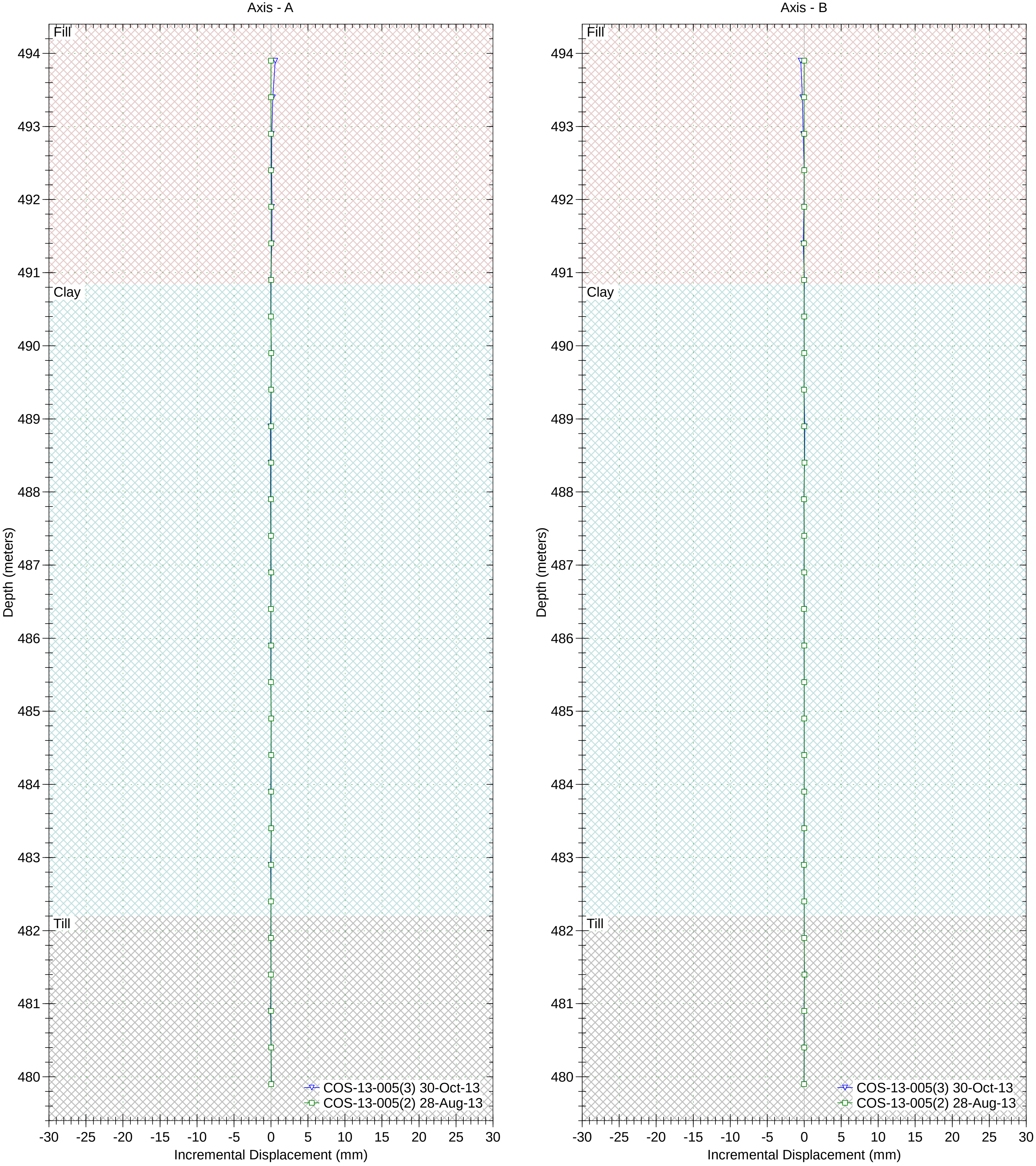




RST Instruments Ltd. INCREMENTAL DISPLACEMENT Inclinalysis v. 2.47.5

Borehole : COS-13-005
Project : 11-1362-0057 Cherry Lane
Location : 316 Sask. Cres. E.
Northing : 5775631.299
Easting : 386078.8467
Collar : -0.1

Spiral Correction : N/A
Collar Elevation : 494.4 meters
Borehole Total Depth : 14.5 meters
A+ Groove Azimuth :
Base Reading : 2013 Aug 28 09:11
Applied Azimuth : 0.0 degrees



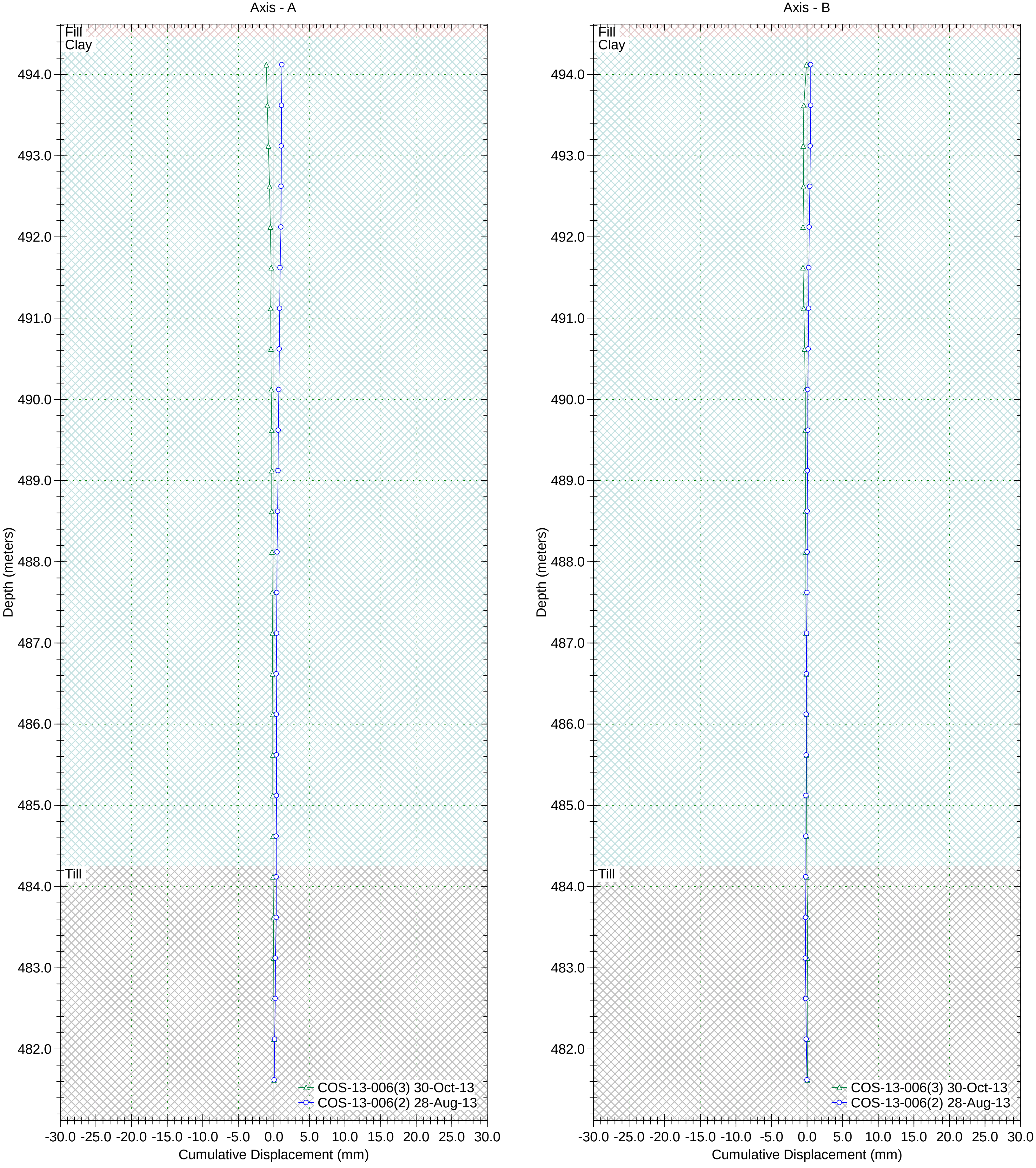
RST Instruments Ltd.

CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.47.0

Borehole : COS-13-006
Project : 11-1362-0057 Cherry Lane
Location : 231 11th St. E.
Northing : 5775572.72
Easting : 385959.21
Collar : -0.147

Spiral Correction : N/A
Collar Elevation : 494.6 meters
Borehole Total Depth : 13.0 meters
A+ Groove Azimuth :
Base Reading : 2013 Aug 28 13:13
Applied Azimuth : 0.0 degrees



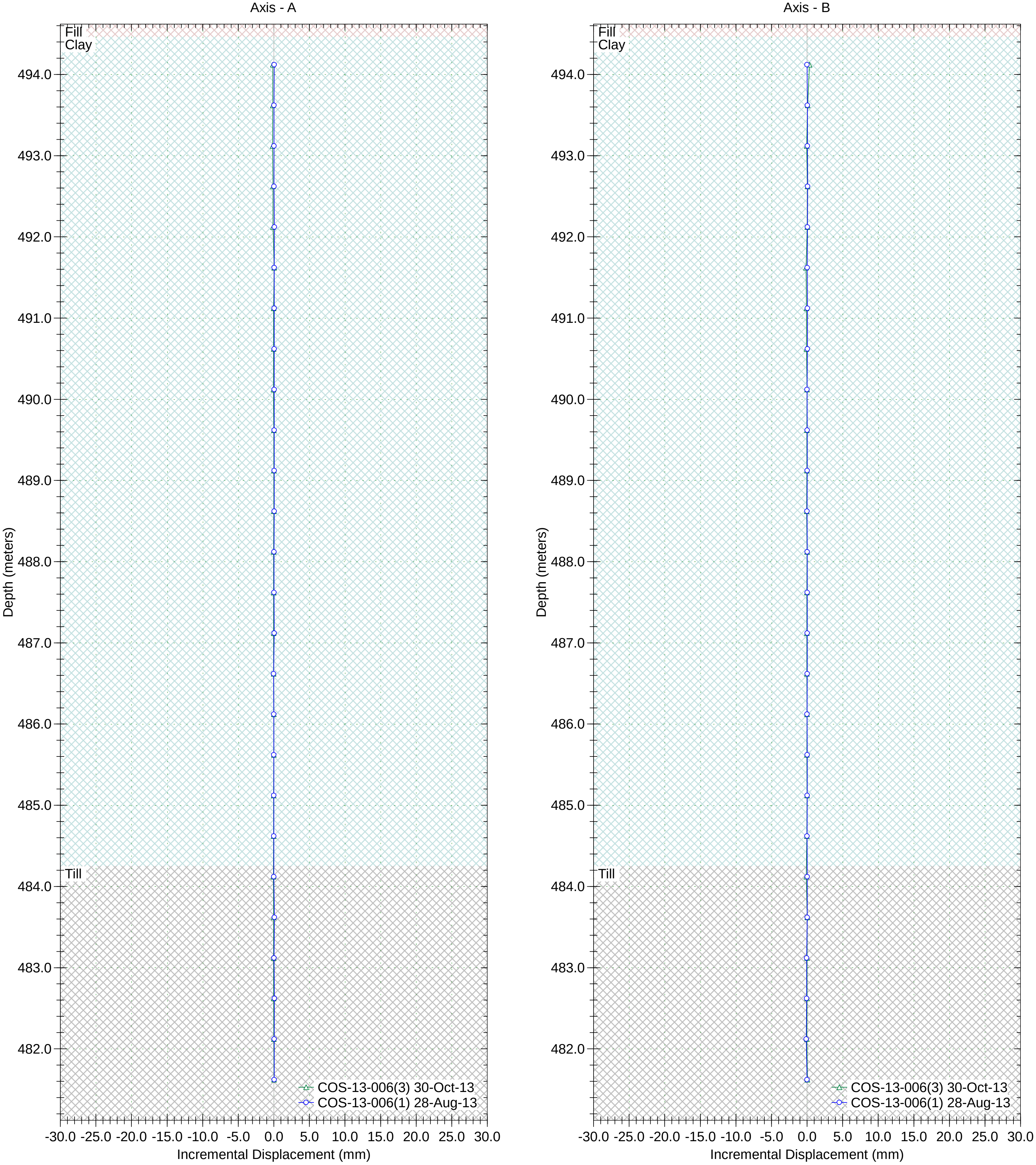
RST Instruments Ltd.

INCREMENTAL DISPLACEMENT

Inclinalysis v. 2.47.0

Borehole : COS-13-006
Project : 11-1362-0057 Cherry Lane
Location : 231 11th St. E.
Northing : 5775572.72
Easting : 385959.21
Collar : -0.147

Spiral Correction : N/A
Collar Elevation : 494.6 meters
Borehole Total Depth : 13.0 meters
A+ Groove Azimuth :
Base Reading : 2013 Aug 28 13:13
Applied Azimuth : 0.0 degrees



F.2. TELL-TALE CRACK MONITORS PHOTOS

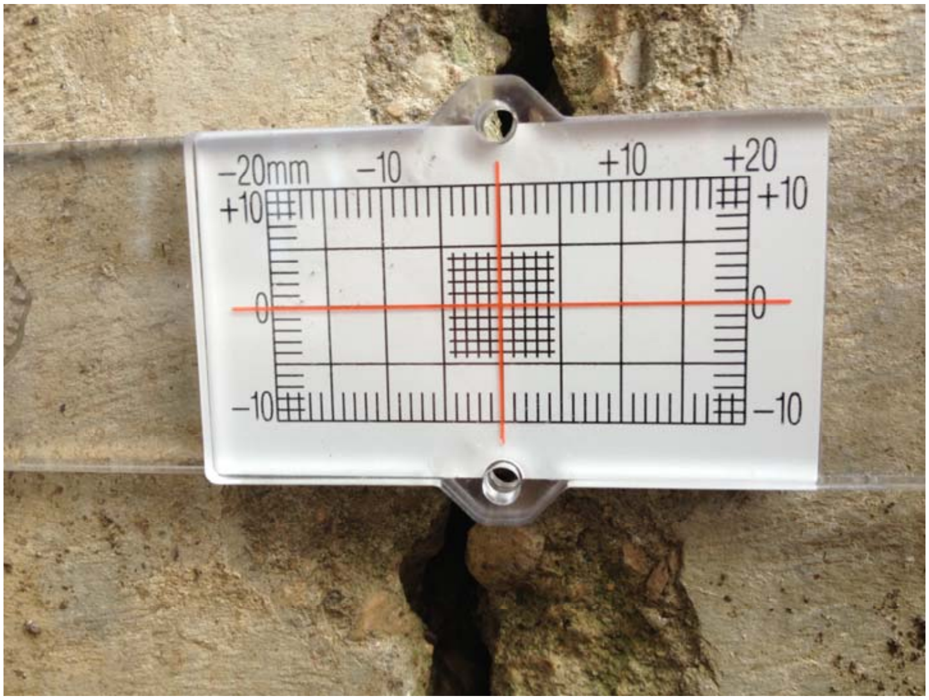


Photo F.1: Crack Meter Located on the Retaining Wall Behind 306 Sask. Cres. E. (CM1) (Aug 12, 2013)

Photo F.2: Crack Meter Located on the Retaining Wall Behind 306 Sask. Cres. E. (CM1) (Sept 18, 2013)

Photo F.3: Crack Meter Located on the East Face of the Retaining Wall Between 230 & 306 Sask. Cres. E. (CM2) (Aug 12, 2013)

Photo F.4: Crack Meter Located on the East Face of the Retaining Wall Between 230 & 306 Sask. Cres. E. (CM2) (Sept 18, 2013)

Photo F.5: Crack Meter Located on the West Face of the Retaining Wall Between 230 & 306 Sask. Cres. E. (CM3) (Aug 12, 2013)

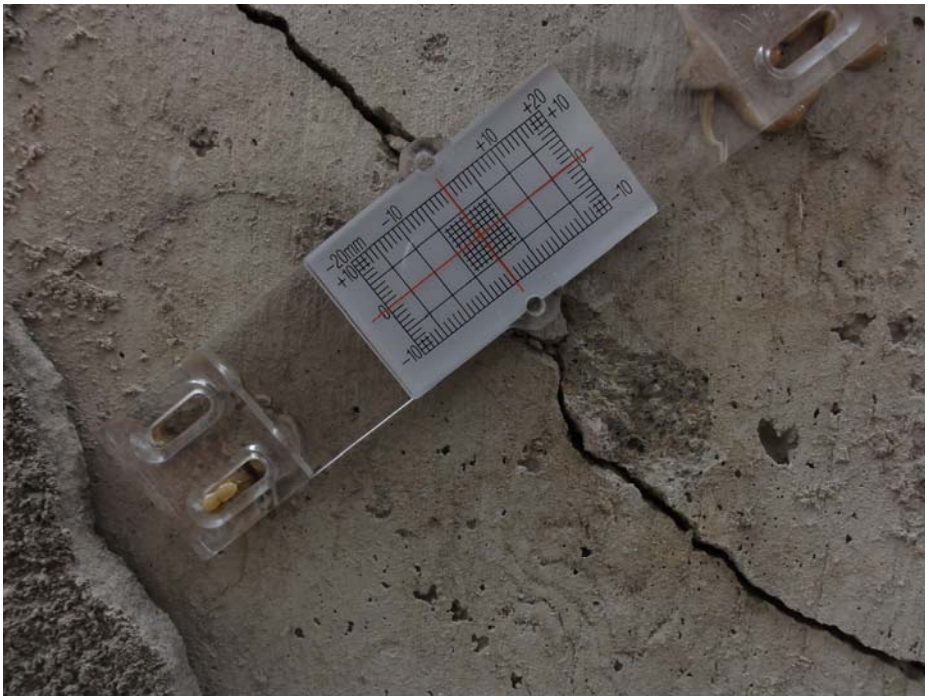


Photo F.6: Crack Meter Located on the West Face of the Retaining Wall Between 230 & 306 Sask. Cres. E. (CM3) (Sept 18, 2013)

F.3. SETTLEMENT POINT DATA

Cherry Lane - Settlement Point Data

Point ID	Description	Elevation (masl)			Settlement (mm)	
		29-Aug-13	18-Sep-13	28-Nov-13	18-Sep-13	28-Nov-13
PT03	BM2 - Sask. Cres./sidewalk	480.12	480.12	480.12	-2.15	-5.98
PT04	306 Sask. Cres. (NE corner)	479.95	479.95	479.95	-0.50	-3.17
PT05	306 Sask. Cres. (NW corner)	479.52	479.52	479.52	-0.35	-3.27
PT06	230 Sask. Cres. (NE corner)	479.60	479.60	479.60	-0.60	-4.26
PT07	230 Sask. Cres. (E side)	479.71	479.71	479.71	-1.24	-4.33
PT08	306 Sask. Cres. (SW corner)	481.70	481.70	481.69	-1.47	-5.71
PT09	306 Sask. Cres. (SE corner)	482.40	482.39	482.39	-1.01	-3.99
PT10	230 Sask. Cres. (SE corner)	487.62	487.62	487.62	-0.38	-3.99
PT11	230 Sask. Cres. (SW corner)	487.85	487.85	487.85	-0.22	-2.77
PT12	311/313 - 11th St. (NW corner)	494.82	494.82	494.82	0.07	-0.55
PT13	311/313 - 11th St. (drive-way)	495.48	495.48	495.48	-0.36	-1.47
PT14	**BM3 - Apt. 328 Sask. Cres. (SW corner)**	**496.41**	**496.41**	**496.41**	**0.00**	**0.00**
PT15	Apt. 328 Sask. Cres. (NW corner)	494.56	494.56	494.56	0.03	0.20
PT16	311/313 - 11th St. (SE corner)	499.14	499.14	499.14	-1.62	-0.56
PT17	311/313 - 11th St. (SW corner)	499.19	499.19	499.19	-1.85	-1.19
PT18	309 - 11th St. (NW corner)	496.60	496.60	496.60	-0.63	-0.19
PT19	307 - 11th St. (back deck)	496.72	496.72	496.72	-0.46	0.53
PT20	305 - 11th St. (NE corner)	497.06	497.06	497.06	-0.50	-0.54
PT21	305 - 11th St. (SE corner)	498.84	498.84	498.84	-0.31	4.00
PT22	303 - 11th St. (SW corner)	498.28	498.28	498.28	1.38	0.02
PT23	233/235 - 11th St. (drive-way)	497.13	497.13	497.12	-0.61	-3.80
PT24	233/235 - 11th St. (NW corner)	492.74	492.74	492.74	0.01	-1.86
PT25	233/235 - 11th St. (N side)	492.80	492.80	492.80	1.48	-0.43
PT26	237/239 - 11th St. (NW side)	494.85	494.85	494.85	0.74	-1.21
PT27	237/239 - 11th St. (NE side)	494.89	494.89	494.89	1.90	0.71
PT28	241 - 11th St. (NW corner)	495.83	495.84	495.83	1.87	1.44
PT29	237/239 - 11th St. (E side)	497.83	497.84	497.84	1.47	0.76
PT30	241 - 11th St. (NE corner)	495.41	495.41	495.41	2.14	0.53
PT31	303 - 11th St. (NE corner)	494.42	494.42	494.42	1.77	1.08

APPENDIX G

Laboratory Test Results

GENERAL TESTING RESULTS

Project #: 11-1362-0057 Phase : 5000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.H. Date: July 4, 2012

Sample Identification				Laboratory Test Results									
Borehole #	Sample #	Depth (m)	Sample Type	Water Content (%)	Plastic Limit	Liquid Limit	Plasticity Index	% Passing #200	SHT Group Index	ASTM Group Index	Dry Density (Kg/m^3)	Pocket Penetrometer (kPa)	Lab Vane (kPa)
11-0057-BH1	BH1-1	0.61-0.91	AS	36.2									
11-0057-BH1	BH1-2	1.22-1.52	AS	37.0									
11-0057-BH1	BH1-3	2.13-2.44	AS	33.9	20	39	19						
11-0057-BH1	BH1-4	2.44-2.74	AS	36.1									
11-0057-BH1	BH1-5	3.35-3.66	AS	36.3	22	62	40						
11-0057-BH1	BH1-6	3.96-4.27	AS	14.5									
11-0057-BH1	BH1-7	4.88-5.18	AS	15.7									
11-0057-BH1	BH1-8	6.40-6.71	AS	8.3									
11-0057-BH1P	BH1P-1	1.52-2.13	TO	34.6	21	43	22				1371		
11-0057-BH1P	BH1P-2	2.44-3.05	TO	31.1									
11-0057-BH1P	BH1P-3	3.05	TO	35.0	21	50	29				1405		
11-0057-BH2	BH2-1	0.91-1.22	AS	33.0									
11-0057-BH2	BH2-2	1.22-1.52	AS	31.8	24	55	31						
11-0057-BH2	BH2-3	1.83-2.13	AS	31.7									
11-0057-BH2	BH2-4	2.44-2.74	AS	30.4	25	48	23						
11-0057-BH2	BH2-5	3.35-3.66	AS	12.9	12	18	6						
11-0057-BH2	BH2-6	3.66-3.96	AS	9.1									
11-0057-BH2	BH2-7	4.57-4.88	AS	14.9									
11-0057-BH2P	BH2P-1	1.52-2.13	TO	34.9									
11-0057-BH2P	BH2P-2	2.44	TO	34.5	27	72	45				1415		
11-0057-BH2P	BH2P-3	2.74-3.35	TO	10.9									
11-0057-BH3	BH3-1	0.61-0.91	AS	22.2									
11-0057-BH3	BH3-2	1.22-1.52	AS	24.3	17	31	14						
11-0057-BH3	BH3-3	1.83-2.13	AS	28.4	18	28	10						
11-0057-BH3	BH3-4	2.44-3.05	AS	15.9									
11-0057-BH3	BH3-5	3.66-3.96	AS	13.6									

Reviewed by:

Golder Associates

GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

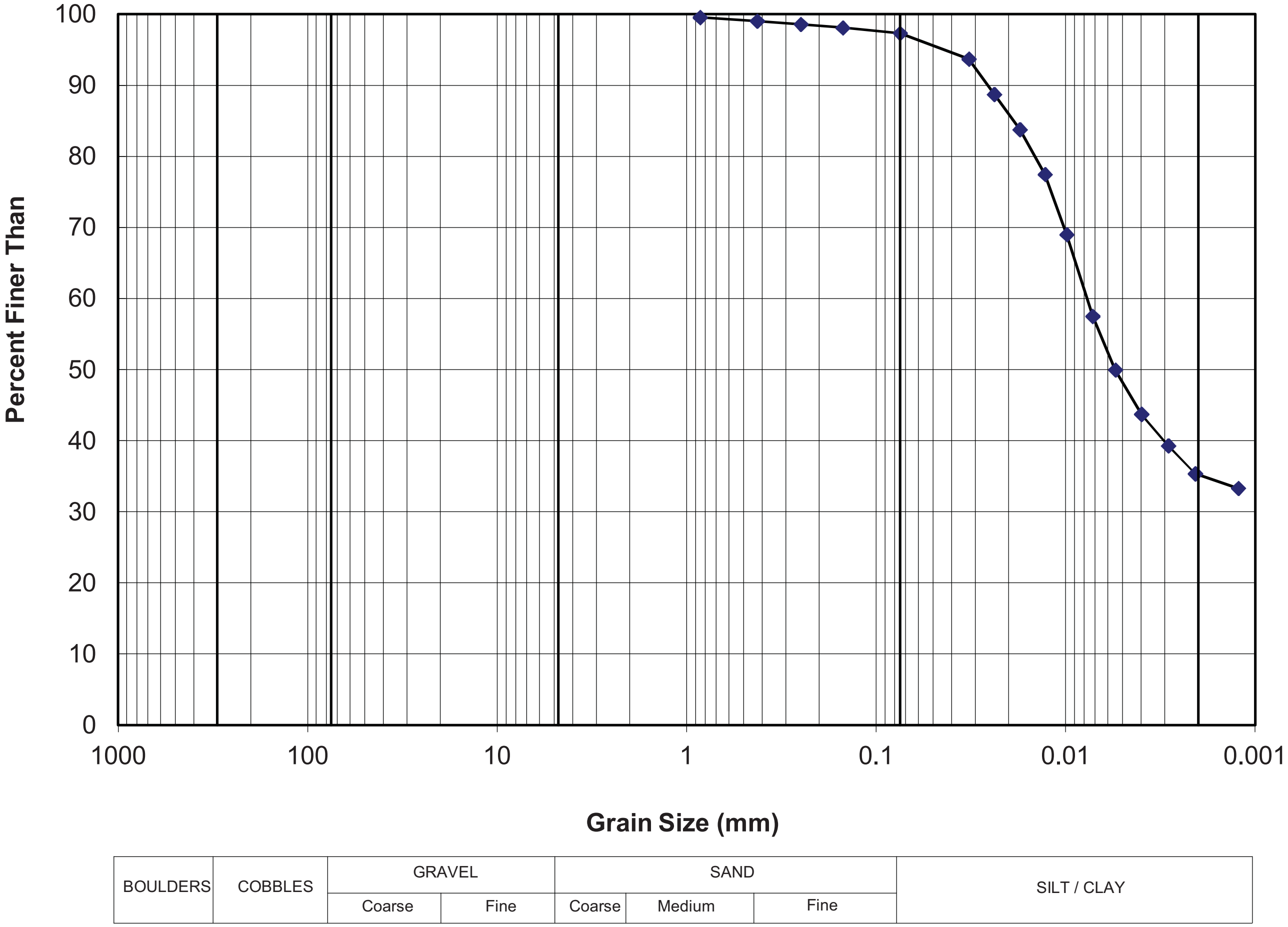
Project #:	11-1362-0057	Phase:	5000
Short Title:	COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK		
Tested by:	S.B. / P.E.	Date:	July 3, 2012

Borehole #: 11-0057-BH1 Sample #: BH1-5

Source:

Date Sample Received: June 25, 2012

Graphical Analysis



Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	100
2.00	100
0.850	100
0.425	99
0.250	99
0.150	98
0.075	97
0.032	94
0.024	89
0.017	84
0.013	77
0.010	69
0.007	58
0.005	50
0.004	44
0.003	39
0.002	35
0.001	33

Comments:

Reviewed by:

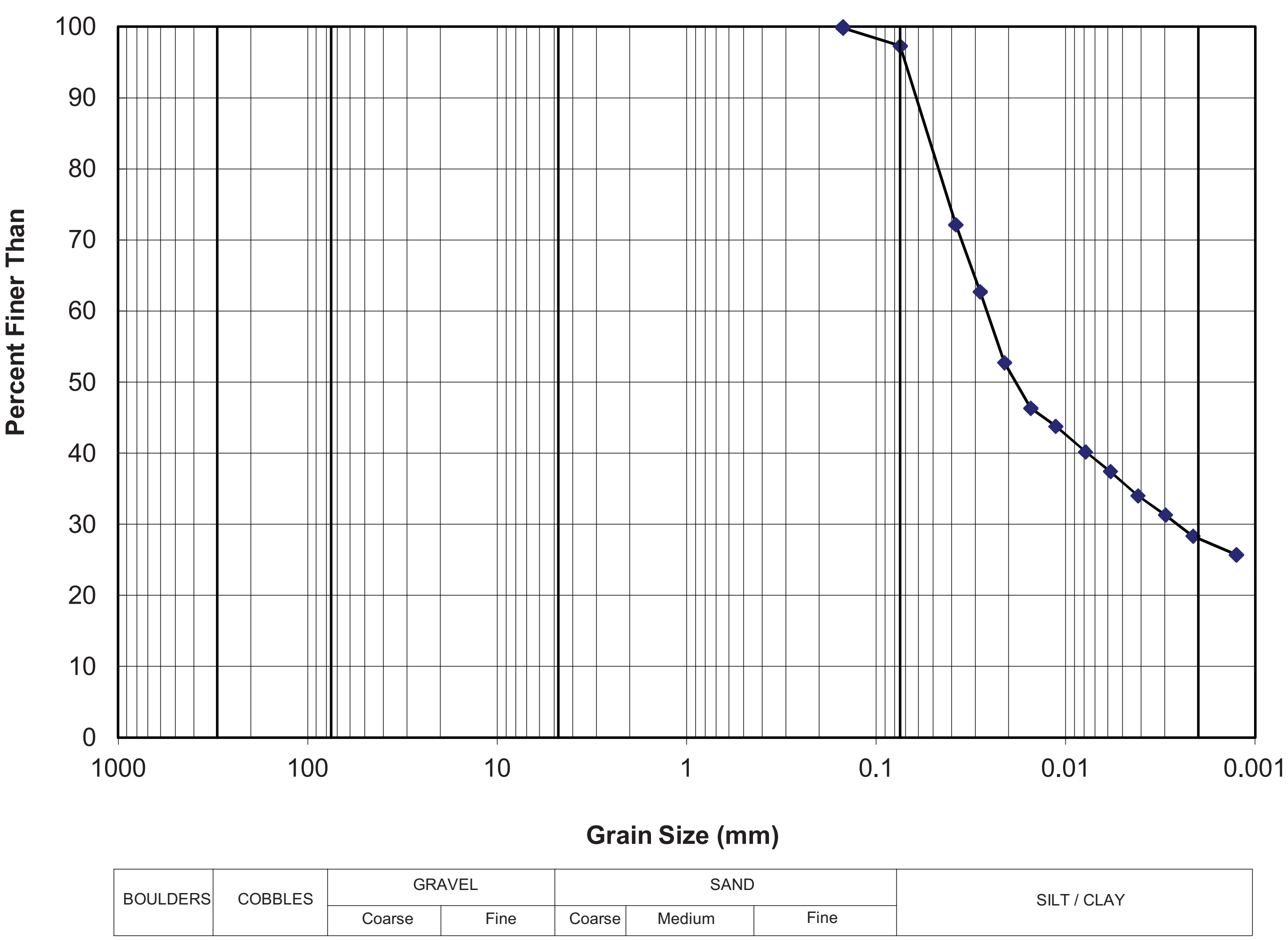
GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057 Phase: 5000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.B. / P.E. Date: July 3, 2012

Borehole #: 11-0057-BH1P Sample #: BH1P-1
Source:
Date Sample Received: June 25, 2012

Graphical Analysis



Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	100
2.00	100
0.850	100
0.425	100
0.250	100
0.150	100
0.075	97
0.038	72
0.028	63
0.021	53
0.015	46
0.011	44
0.008	40
0.006	37
0.004	34
0.003	31
0.002	28
0.001	26

Comments:

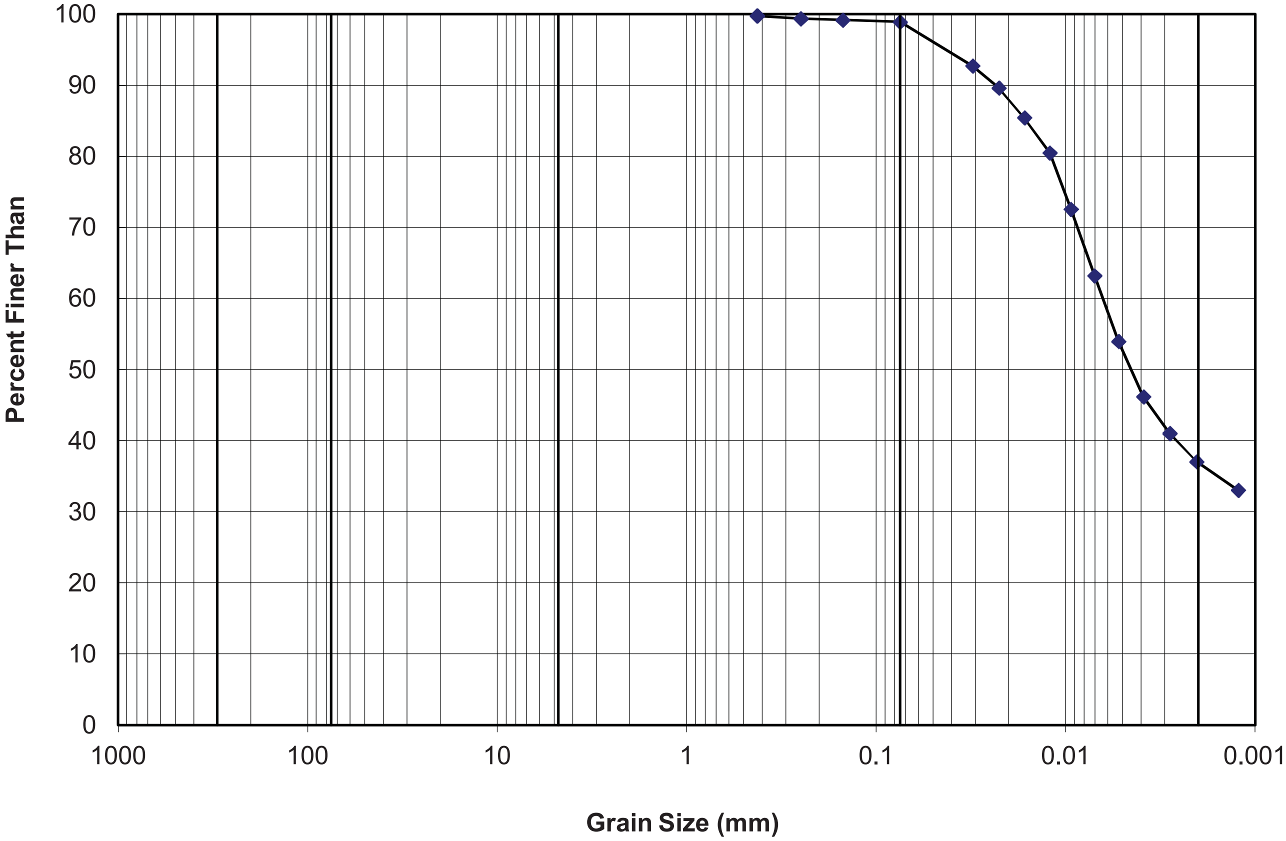
Reviewed by:

Golder Associates

GRAIN SIZE ANALYSIS - ASTM D422
(Mechanical & Hydrometer)

Project #: 11-1362-0057 Phase: 5000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.B. / P.E. Date: July 3, 2012
Borehole #: 11-0057-BH1P Sample #: BH1P-3
Source:
Date Sample Received: June 25, 2012

Graphical Analysis



BOULDERS	COBBLES	GRAVEL		SAND			SILT / CLAY
		Coarse	Fine	Coarse	Medium	Fine	

Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	100
2.00	100
0.850	100
0.425	100
0.250	99
0.150	99
0.075	99
0.031	93
0.023	90
0.016	85
0.012	80
0.009	73
0.007	63
0.005	54
0.004	46
0.003	41
0.002	37
0.001	33

Comments:

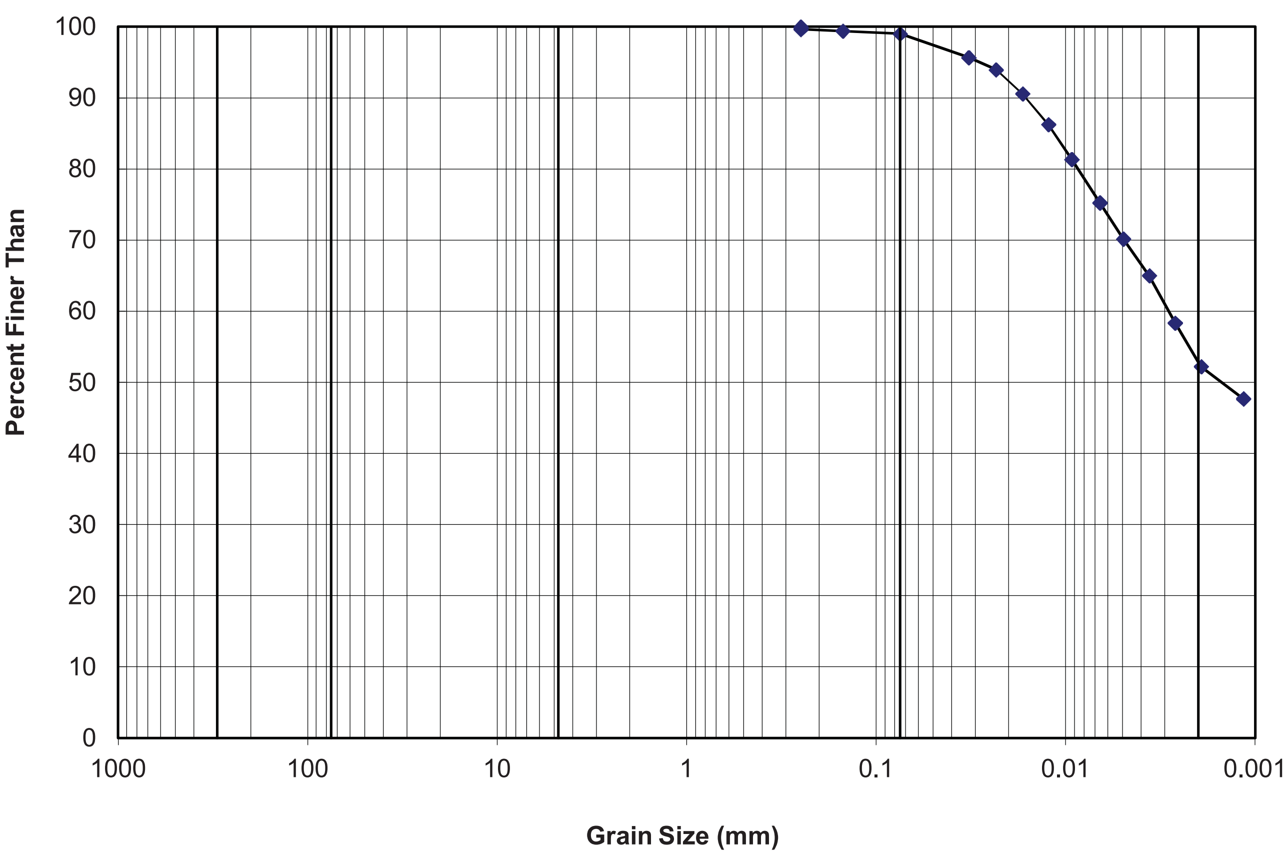
Reviewed by:___________

GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057 Phase: 5000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.B. / P.E. Date: July 3, 2012
Borehole #: 11-0057-BH2P Sample #: BH2P-2
Source:
Date Sample Received: June 25, 2012

Graphical Analysis



BOULDERS	COBBLES	GRAVEL		SAND			SILT / CLAY
		Coarse	Fine	Coarse	Medium	Fine	

Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	100
2.00	100
0.850	100
0.425	100
0.250	100
0.150	99
0.075	99
0.033	96
0.023	94
0.017	91
0.012	86
0.009	81
0.007	75
0.005	70
0.004	65
0.003	58
0.002	52
0.001	48

Comments:

Reviewed by:

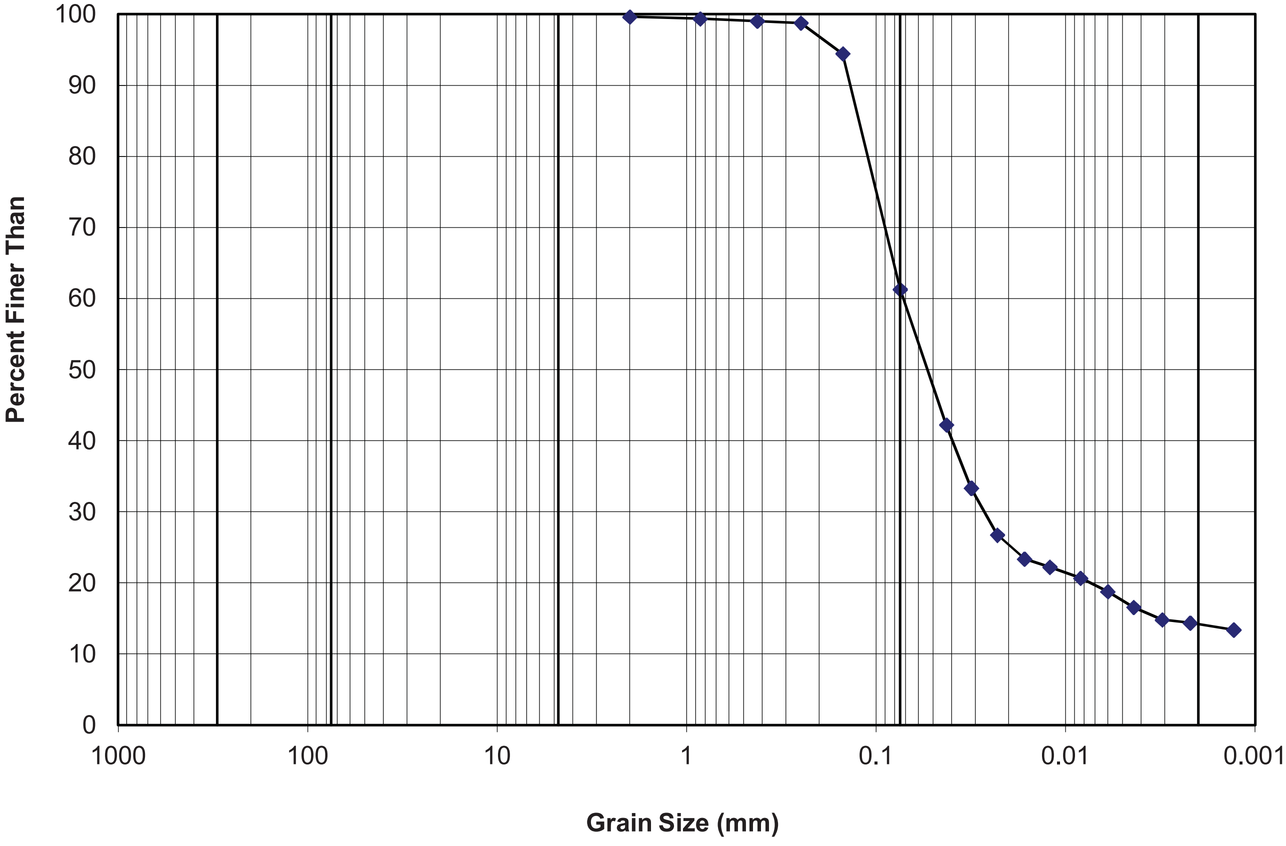
GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #:	11-1362-0057	Phase:	5000
Short Title:	COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK		
Tested by:	S.B. / P.E.	Date:	July 3, 2012

Borehole #: 11-0057-BH3 Sample #: BH3-3
Source:
Date Sample Received: June 25, 2012

Graphical Analysis



BOULDERS	COBBLES	GRAVEL		SAND			SILT / CLAY
		Coarse	Fine	Coarse	Medium	Fine	

Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	100
2.00	100
0.850	99
0.425	99
0.250	99
0.150	94
0.075	61
0.043	42
0.032	33
0.023	27
0.017	23
0.012	22
0.008	21
0.006	19
0.004	17
0.003	15
0.002	14
0.001	13

Comments:

Reviewed by:

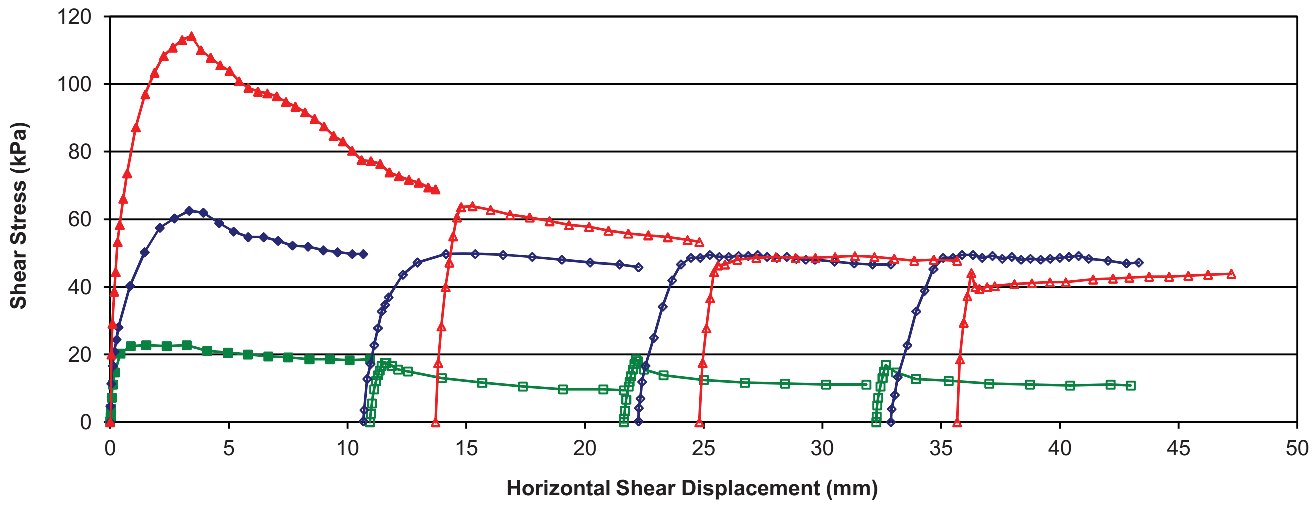
Golder Associates

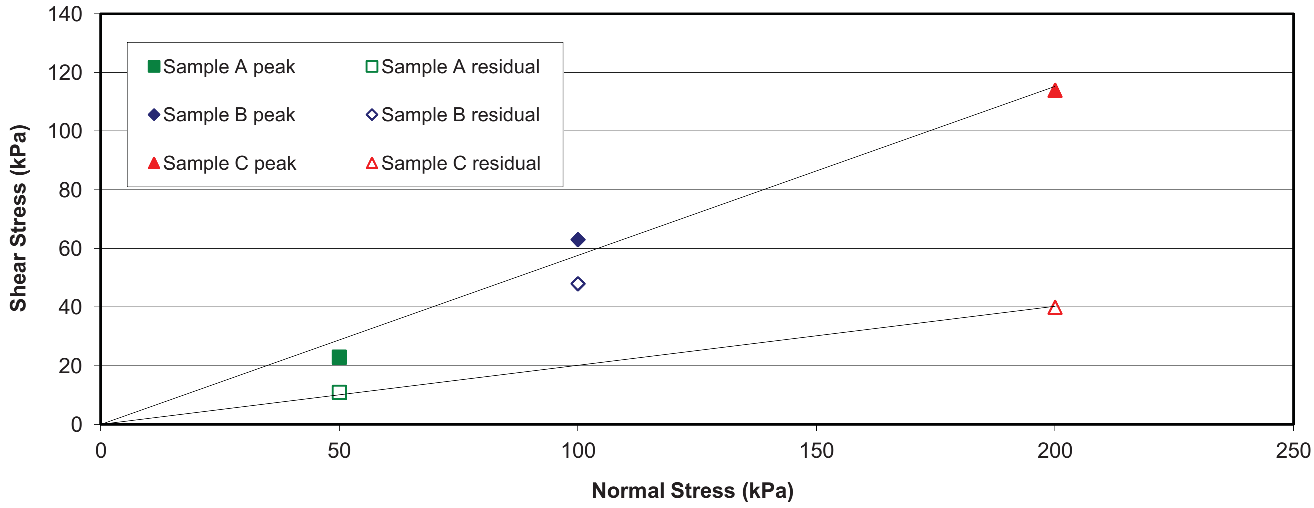
CONSOLIDATED DRAINED DIRECT SHEAR TEST-SUMMARY

Project #: 11-1362-0057 Phase: 5000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested By: D.B. Date: July 24, 2012

Sample	Normal Stress (kPa)	Shear Stress Peak (kPa)	Shear Stress Residual (kPa)
11-0057-BH1P BH1P-3	50	23	11
	100	63	48
	200	114	40

	Peak	Residual
Friction angle (degrees):	30.0	11.4
cohesion (kPa):	0	0





Comments:

1721 8th Street E.,
Saskatoon, Saskatchewan, S7H 0T4

Reviewed by:

CONSOLIDATED DRAINED DIRECT SHEAR TEST

Project #:	11-1362-0057	Phase:	5000
Short Title:	COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK		
Tested By:	D.B.	Date:	July 24, 2012
Sample:	11-0057-BH1P BH1P-3		

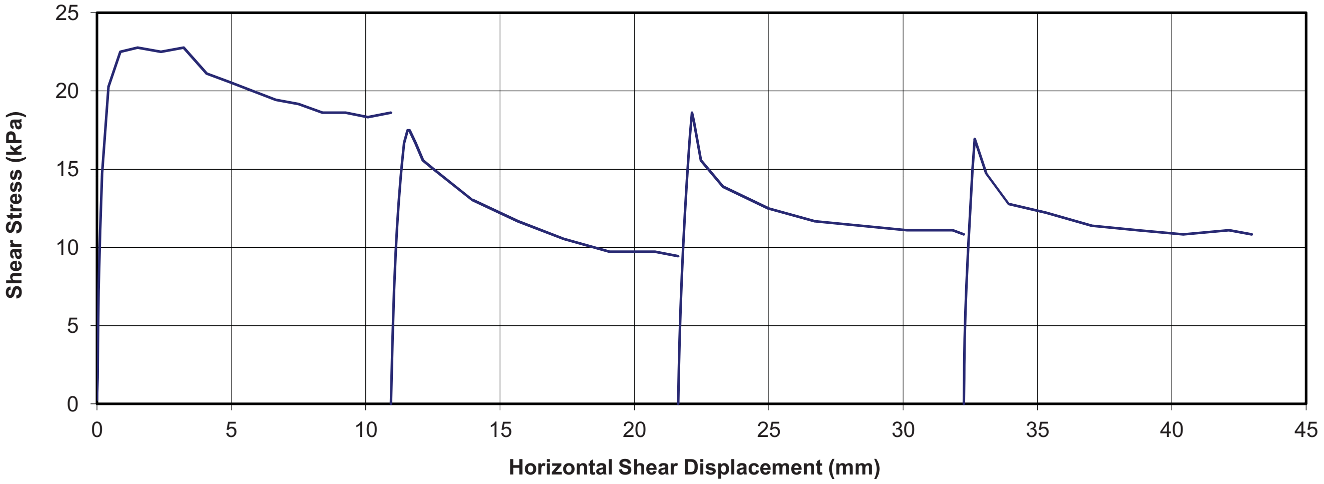
Effective Stress: 50 kPa

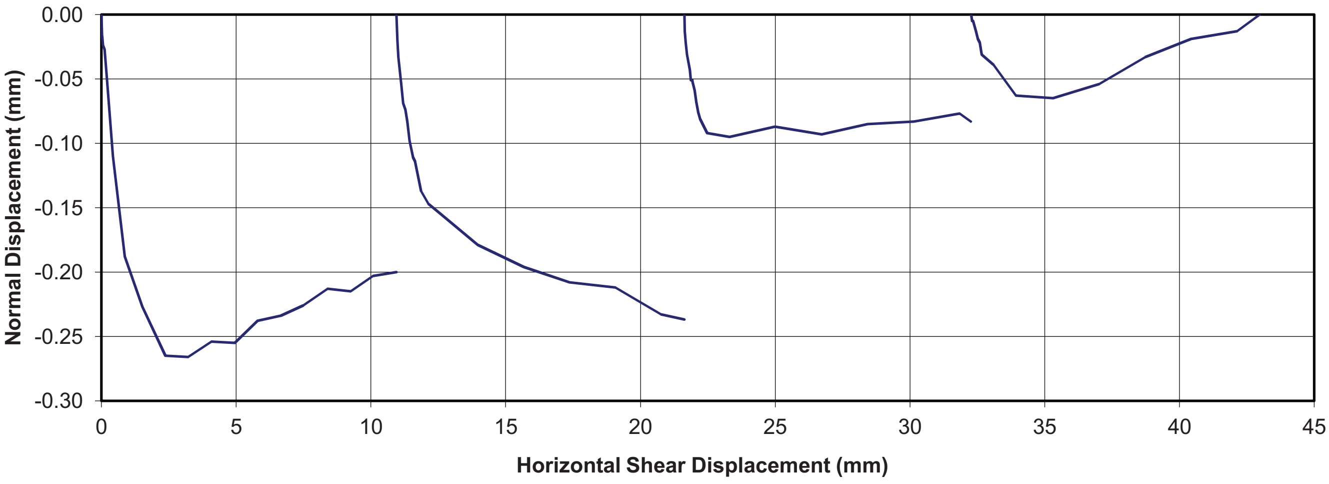
Sample Data:

Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	33.7	%
Initial Dry Density:	1372	kg/m^3
Final Water Content:	42.7	%

Peak Shear Stress:	23	kPa
Residual Shear Stress	11	kPa

Comments:





Reviewed by:

CONSOLIDATED DRAINED DIRECT SHEAR TEST

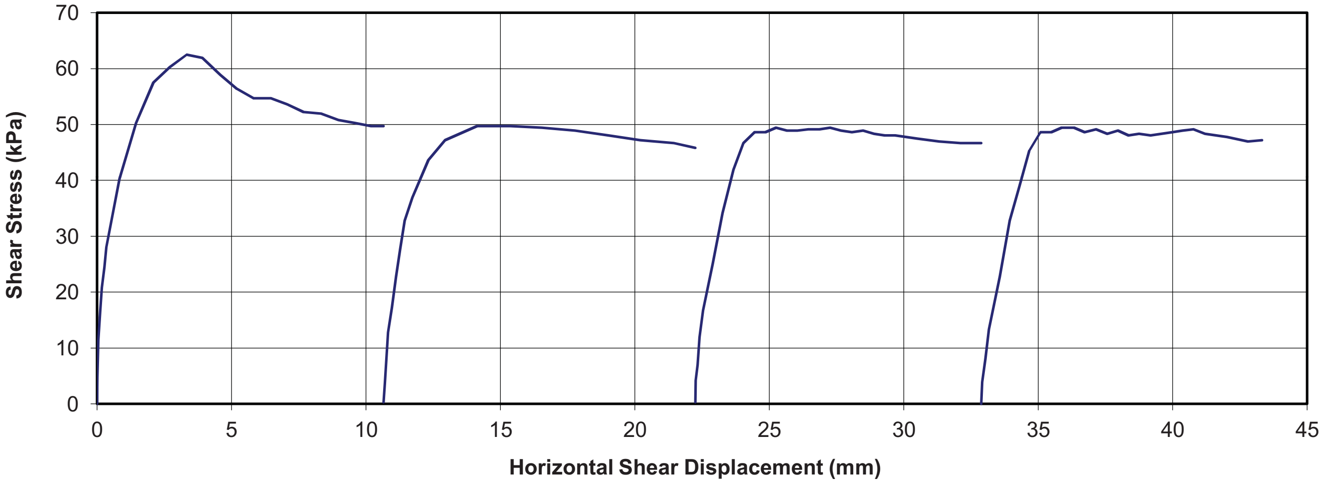
Project #: 11-1362-0057 Phase: 5000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested By: D.B. Date: July 24, 2012

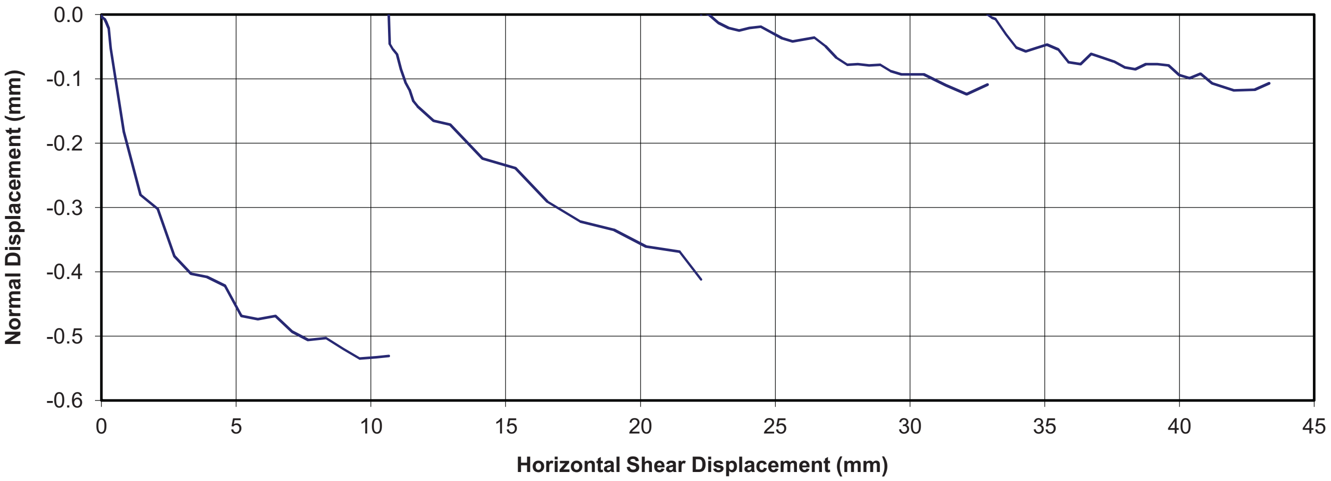
Sample: 11-0057-BH1P BH1P-3

Effective Stress:	100	kPa
Sample Data:		
Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	34.4	%
Initial Dry Density:	1416	kg/m^3
Final Water Content:	34.2	%

Peak Shear Stress:	63	kPa
Residual Shear Stress	48	kPa

Comments:





Reviewed by:

Golder Associates

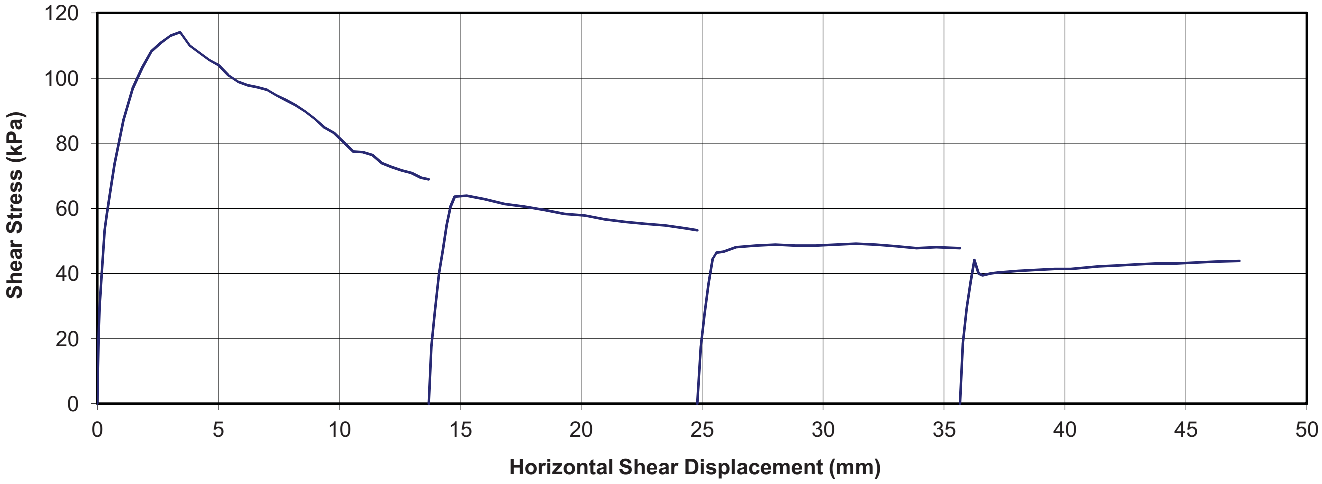
CONSOLIDATED DRAINED DIRECT SHEAR TEST

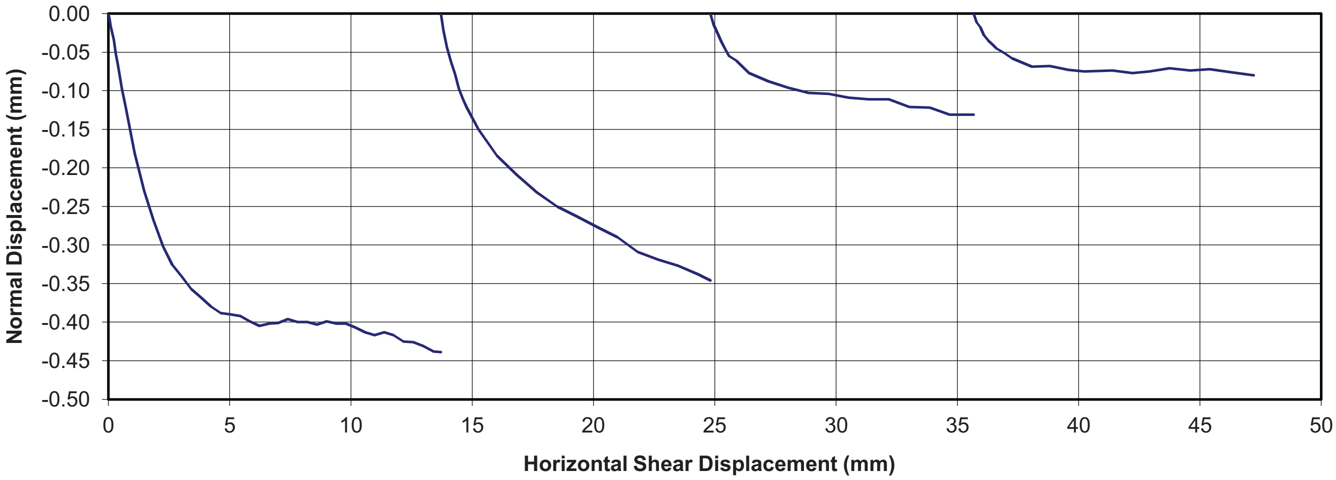
Project #:	11-1362-0057	Phase:	5000
Short Title:	COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK		
Tested By:	D.B.	Date:	July 24, 2012
Sample:	11-0057-BH1P BH1P-3		

Effective Stress:	200	kPa
Sample Data:		
Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	33.2	%
Initial Dry Density:	1386	kg/m^3
Final Water Content:	35.8	%

Peak Shear Stress:	114	kPa
Residual Shear Stress	40	kPa

Comments:





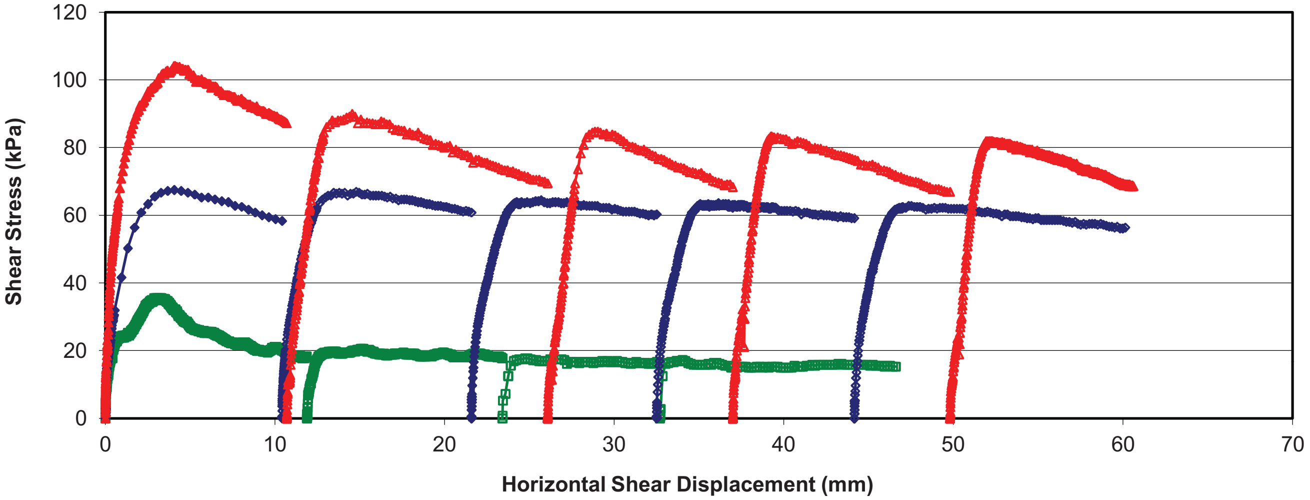
Reviewed by:

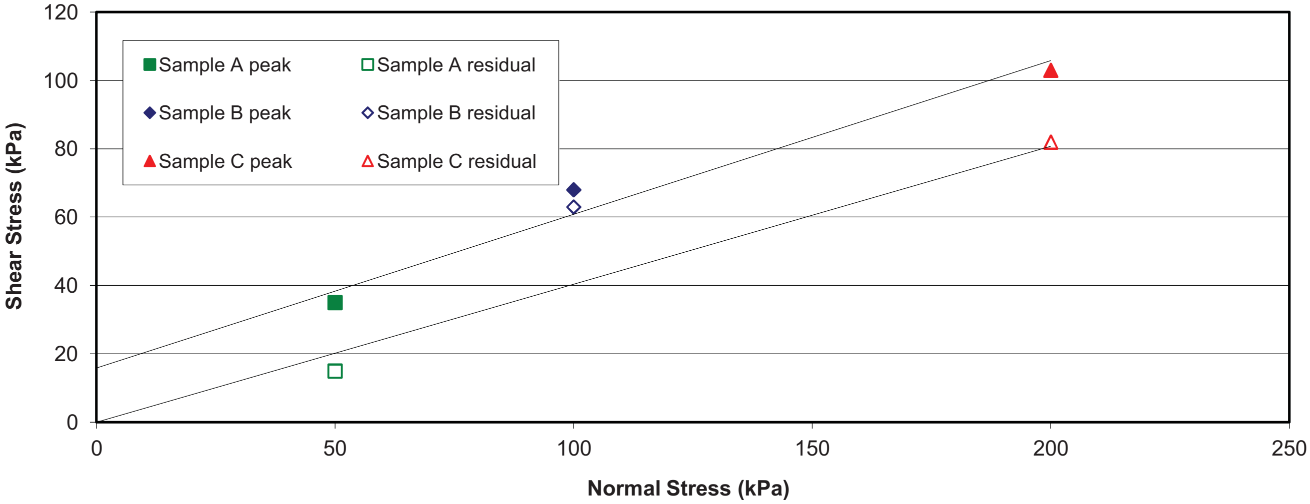
CONSOLIDATED DRAINED DIRECT SHEAR TEST-SUMMARY

Project #: 11-1362-0057 Phase: 5000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested By: D.B. Date: July 12, 2012

Sample	Normal Stress (kPa)	Shear Stress Peak (kPa)	Shear Stress Residual (kPa)
11-0057-BH2P BH2P-2	50	35	15
	100	68	63
	200	103	82

	Peak	Residual
Friction angle (degrees):	23.7	22.0
cohesion (kPa):	18	0





Comments:

Reviewed by:

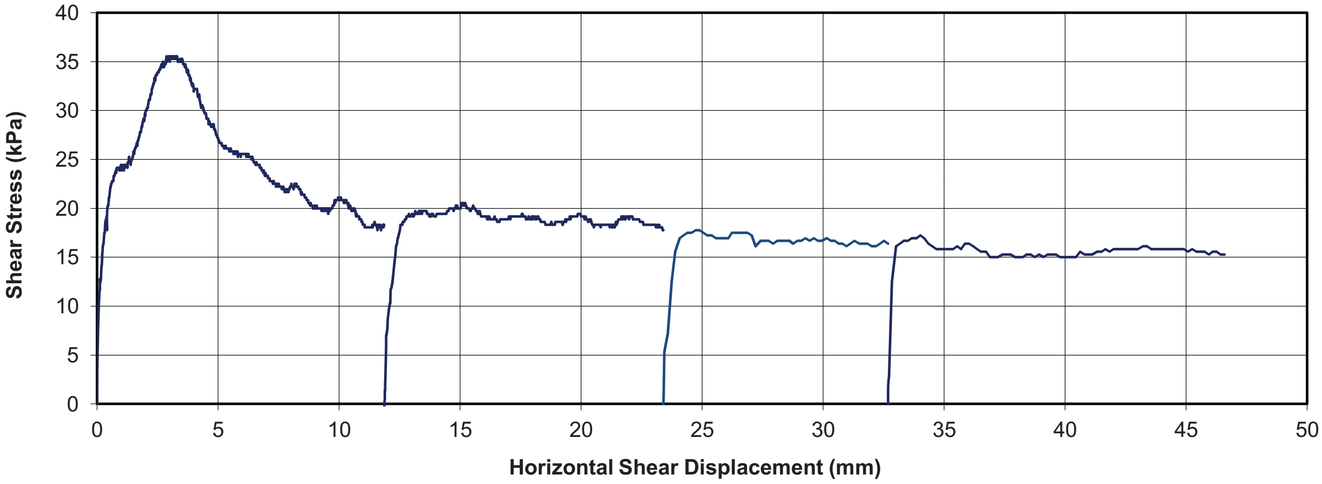
CONSOLIDATED DRAINED DIRECT SHEAR TEST

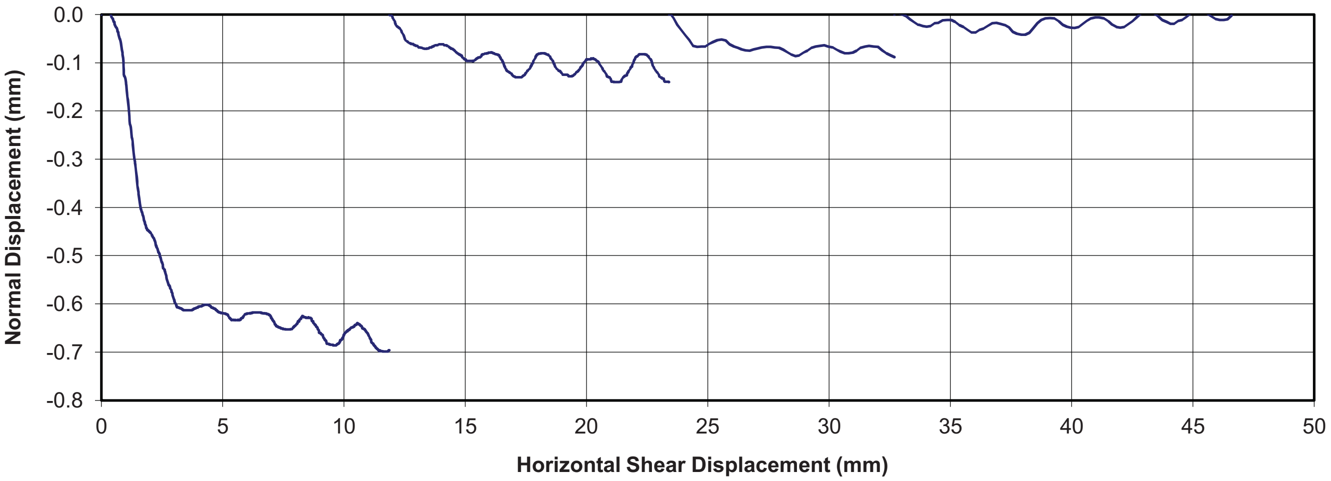
Project #: 11-1362-0057 Phase: 5000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested By: D.B. Date: July 12, 2012
Sample: 11-0057-BH2P BH2P-2

Effective Stress:	50	kPa
Sample Data:		
Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	34.8	%
Initial Dry Density:	1346	kg/m^3
Final Water Content:	40.3	%

Peak Shear Stress:	35	kPa
Residual Shear Stress	15	kPa

Comments:





Reviewed by:

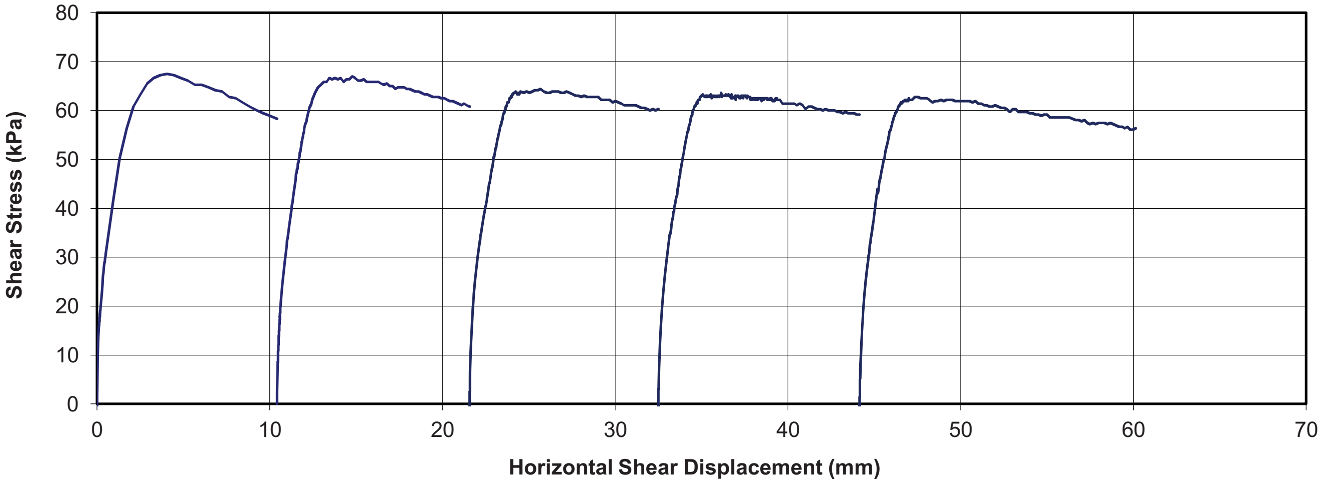
CONSOLIDATED DRAINED DIRECT SHEAR TEST

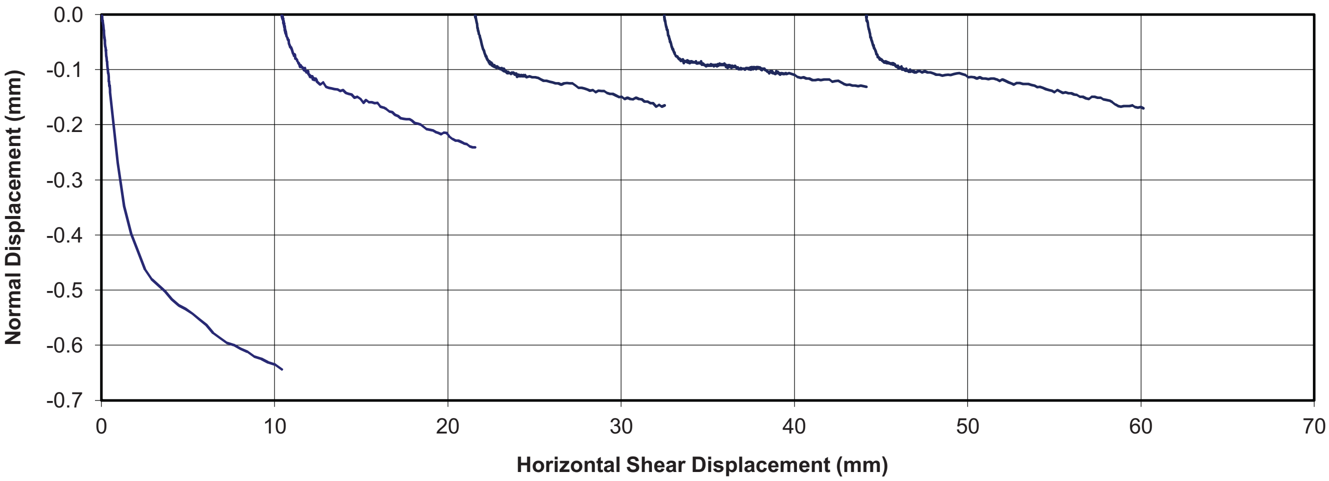
Project #:	11-1362-0057	Phase:	5000
Short Title:	COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK		
Tested By:	D.B.	Date:	July 12, 2012
Sample:	11-0057-BH2P BH2P-2		

Effective Stress:	100	kPa
Sample Data:		
Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	36.6	%
Initial Dry Density:	1336	kg/m^3
Final Water Content:	38.3	%

Peak Shear Stress:	68	kPa
Residual Shear Stress	63	kPa

Comments:





Reviewed by:

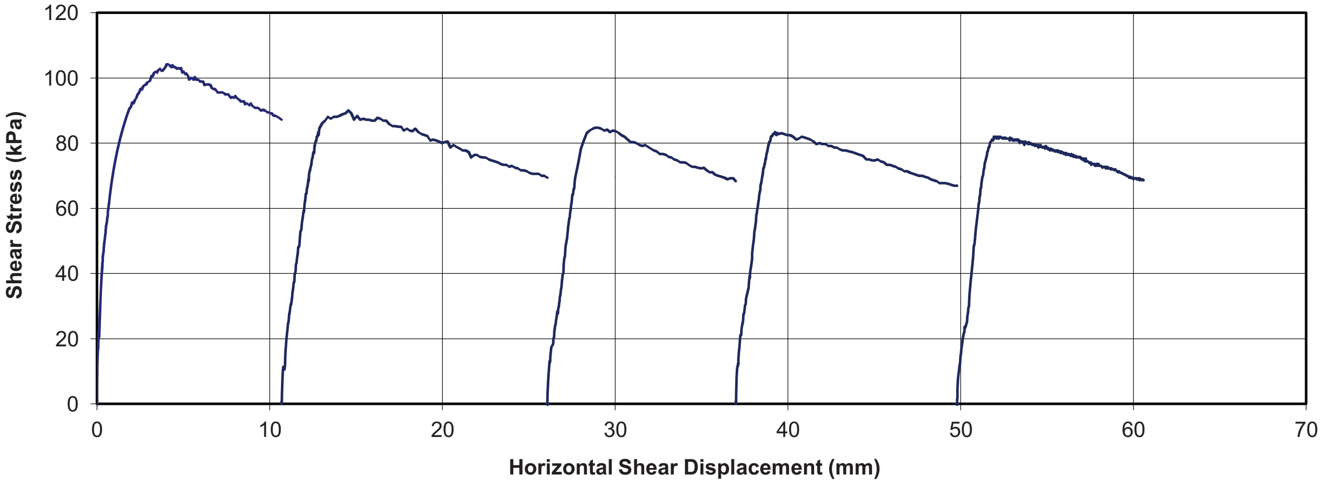
CONSOLIDATED DRAINED DIRECT SHEAR TEST

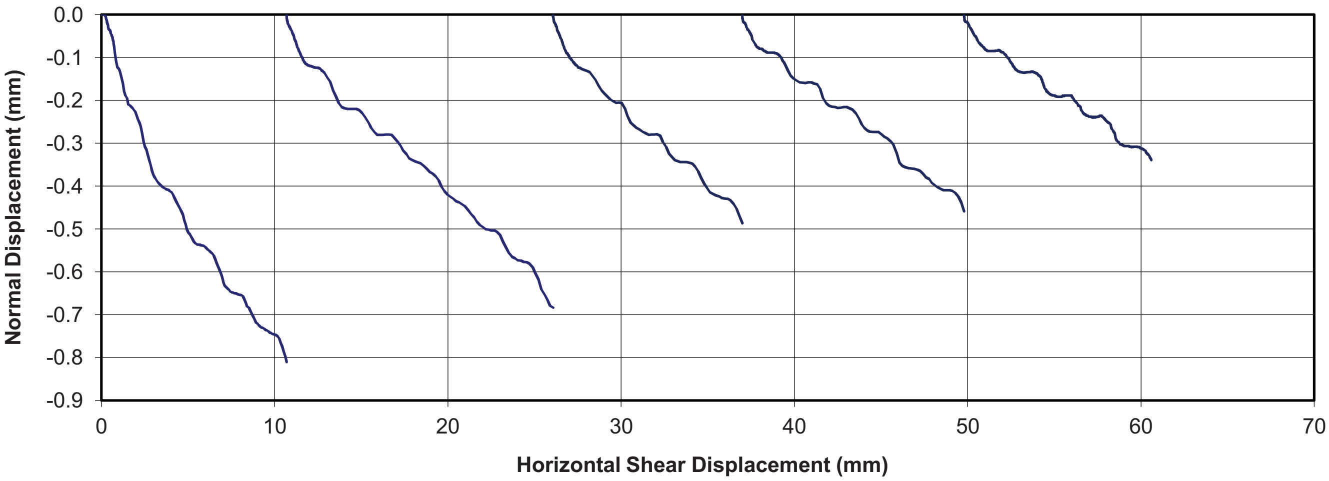
Project #:	11-1362-0057	Phase:	5000
Short Title:	COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK		
Tested By:	D.B.	Date:	July 12, 2012
Sample:	11-0057-BH2P BH2P-2		

Effective Stress:	200	kPa
Sample Data:		
Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	34.4	%
Initial Dry Density:	1359	kg/m^3
Final Water Content:	36.3	%

Peak Shear Stress:	103	kPa
Residual Shear Stress	82	kPa

Comments:





Reviewed by:

GENERAL TESTING RESULTS

Project #: 11-1362-0057 Phase: 5100
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.E. / J.F. / S.J.B. Date: August 15, 2013

Sample Identification				Laboratory Test Results									
Borehole #	Sample #	Depth (m)	Sample Type	Water Content (%)	Plastic Limit	Liquid Limit	Plasticity Index	% Passing #200	ASTM Group Index	Specific Gravity	Dry Density (Kg/m^3)	Pocket Penetrometer (kPa)	Lab Vane (kPa)
COS-13-001	001-1	0.61-0.91	AS	27.9									
COS-13-001	001-2	1.22-1.52	AS	37.4									
COS-13-001	001-3	2.44-2.74	AS	37.5									
COS-13-001	001-4	3.66-3.96	AS	34.7									
COS-13-001	001-5	4.27-4.57	AS	36.0									
COS-13-001	001-6	4.88-5.18	AS	33.9	18	56	38			2.63			
COS-13-001	001-7	5.79-6.10	AS	37.6									
COS-13-001	001-8	6.71-7.01	AS	12.1									
COS-13-001	001-9	7.92-8.23	AS	14.8									
COS-13-001	001-10	8.53-8.84	AS	9.7									
COS-13-001B	001B-1	5.18-5.87	TO	35.0									
COS-13-001B	001B-2	5.87-6.55	TO	32.1									
COS-13-001B	001B-3	6.55-7.24	TO	11.0	11	23	12				2057		
COS-13-002	002-1	0.00-0.15	AS	15.3									
COS-13-002	002-2	0.15-0.30	AS	14.0									
COS-13-002	002-3	0.30-0.61	AS	14.2									
COS-13-002	002-4	0.91-1.22	AS	25.9									
COS-13-002	002-5	1.52-1.83	AS	23.1									
COS-13-002	002-6	2.44-2.74	AS	30.1									
COS-13-002	002-7	3.35-3.66	AS	31.3									
COS-13-002	002-8	4.27-4.57	AS	32.2									
COS-13-002	002-9	5.49-5.79	AS	30.7									
COS-13-002	002-10	6.71-7.01	AS	32.1									
COS-13-002	002-11	7.62-7.92	AS	33.0									
COS-13-002	002-12	8.53-8.84	AS	30.2									
COS-13-002	002-13	9.75-10.06	AS	27.8									
COS-13-002	002-14	10.36-10.67	AS	32.5									
COS-13-002	002-15	11.58-11.89	AS	30.8									
COS-13-002	002-16	12.19-12.50	AS	33.7									
COS-13-002	002-17	13.11-13.41	AS	32.7	21	69	48			2.63			
COS-13-002	002-18	14.33-14.63	AS	15.4									
COS-13-002	002-19	16.15-16.46	AS	12.0									
COS-13-003	003-1	0.46-0.61	AS	18.4									
COS-13-003	003-2	0.91-1.22	AS	26.3									
COS-13-003	003-3	2.13-2.44	AS	20.7									
COS-13-003	003-4	3.96-4.27	AS	25.8									

Reviewed by:__________

GENERAL TESTING RESULTS

Project #: 11-1362-0057 Phase: 5100
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.E. / J.F. / S.J.B. Date: August 15, 2013

Sample Identification				Laboratory Test Results									
Borehole #	Sample #	Depth (m)	Sample Type	Water Content (%)	Plastic Limit	Liquid Limit	Plasticity Index	% Passing #200	ASTM Group Index	Specific Gravity	Dry Density (Kg/m^3)	Pocket Penetrometer (kPa)	Lab Vane (kPa)
COS-13-003	003-5	4.88-5.03	AS	32.3	19	57	38						
COS-13-003	003-6	5.49-5.79	AS	24.0									
COS-13-003	003-7	5.79-6.48	TO	24.2									
COS-13-003	003-8	7.32-7.62	AS	14.5									
COS-13-003	003-9	8.84-9.14	AS	17.7									

Reviewed by:__________

GENERAL TESTING RESULTS

Project #: 11-1362-0057 Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.E. / W.C. Date: September 6, 2013

Sample Identification				Laboratory Test Results									
Borehole #	Sample #	Depth (m)	Sample Type	Water Content (%)	Plastic Limit	Liquid Limit	Plasticity Index	% Passing #200	ASTM Group Index	Specific Gravity	Dry Density (Kg/m^3)	Pocket Penetrometer (kPa)	Lab Vane (kPa)
COS-13-004	004-1	0.00-0.15	AS	11.2									
COS-13-004	004-2	0.30-0.61	AS	32.5									
COS-13-004	004-3	1.22-1.37	DO	33.4									
COS-13-004	004-4	2.59-2.90	DO	33.4									
COS-13-004	004-5	4.42-4.72	DO	33.6	24	74	50						
COS-13-004	004-6	5.18-5.49	AS	31.6									
COS-13-004	004-7	5.79-6.10	TO	30.1						2.61	1699	72	80
COS-13-004	004-8	7.01-7.62	TO	33.7	21	46	25					120	99
COS-13-004	004-9	8.53-9.14	TO	27.2								168	188
COS-13-004	004-10	9.30-9.60	AS	10.2									
COS-13-004	004-11	9.75-10.06	AS	10.8	12	19	7						
COS-13-005	005-1	0.00-0.30	AS	8.9									
COS-13-005	005-2	1.07-1.22	DO	8.2									
COS-13-005	005-3	2.59-2.74	DO	7.5									
COS-13-005	005-4	4.11-4.27	DO	11.5	15	35	20						
COS-13-005	005-5	5.33-5.94	TO	23.2	20	49	29					180	91
COS-13-005	005-6	6.10-6.71	TO	8.4								>200	203
COS-13-005	005-7	6.86-7.47	TO	8.0									
COS-13-005	005-8	7.62-8.23	TO	29.5	22	38	16						
COS-13-005	005-9	8.38-8.99	TO	23.9						2.59	1306		
COS-13-005	005-10	9.14-9.75	TO	28.2	25	32	7						
COS-13-005	005-11	9.91-10.52	TO	33.0									
COS-13-005	005-12	10.67-11.28	TO	28.7	21	33	12						
COS-13-005	005-13	11.43-12.04	TO	29.3	19	34	15						
COS-13-005	005-14	12.19-12.34	TO	29.4	14	40	26						
COS-13-005	005-15	13.72-14.02	DO	9.0									
COS-13-006	006-1	0.15-0.30	AS	17.2									
COS-13-006	006-2	1.07-1.22	AS	28.7									
COS-13-006	006-3	1.83-1.98	AS	25.3	22	65	43						
COS-13-006	006-4	2.29-2.44	AS	24.6									
COS-13-006	006-5	2.90-3.05	AS	30.6									
COS-13-006	006-6	4.72-4.88	AS	29.6									
COS-13-006	006-7	5.33-5.49	AS	29.1									
COS-13-006	006-8	6.25-6.40	AS	34.0	23	72	49						
COS-13-006	006-9	7.62-7.77	AS	33.8									
COS-13-006	006-10	8.69-8.84	AS	29.5	13	41	28						

Reviewed by:__________

GENERAL TESTING RESULTS

Project #: 11-1362-0057 Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.E. / W.C. Date: September 6, 2013

Sample Identification				Laboratory Test Results										
Borehole #	Sample #	Depth (m)	Sample Type	Water Content (%)	Plastic Limit	Liquid Limit	Plasticity Index	% Passing #200	ASTM Group Index	Specific Gravity	Dry Density (Kg/m^3)	Pocket Penetrometer (kPa)	Lab Vane (kPa)
COS-13-006	006-11	10.06-10.21	AS	34.8									
COS-13-006	006-12	11.58-11.73	AS	13.0									
COS-13-006	006-13	12.19-12.34	AS	11.8									
COS-13-006	006-14	13.11-13.26	AS	10.3									

Reviewed by: David Palm

Golder Associates

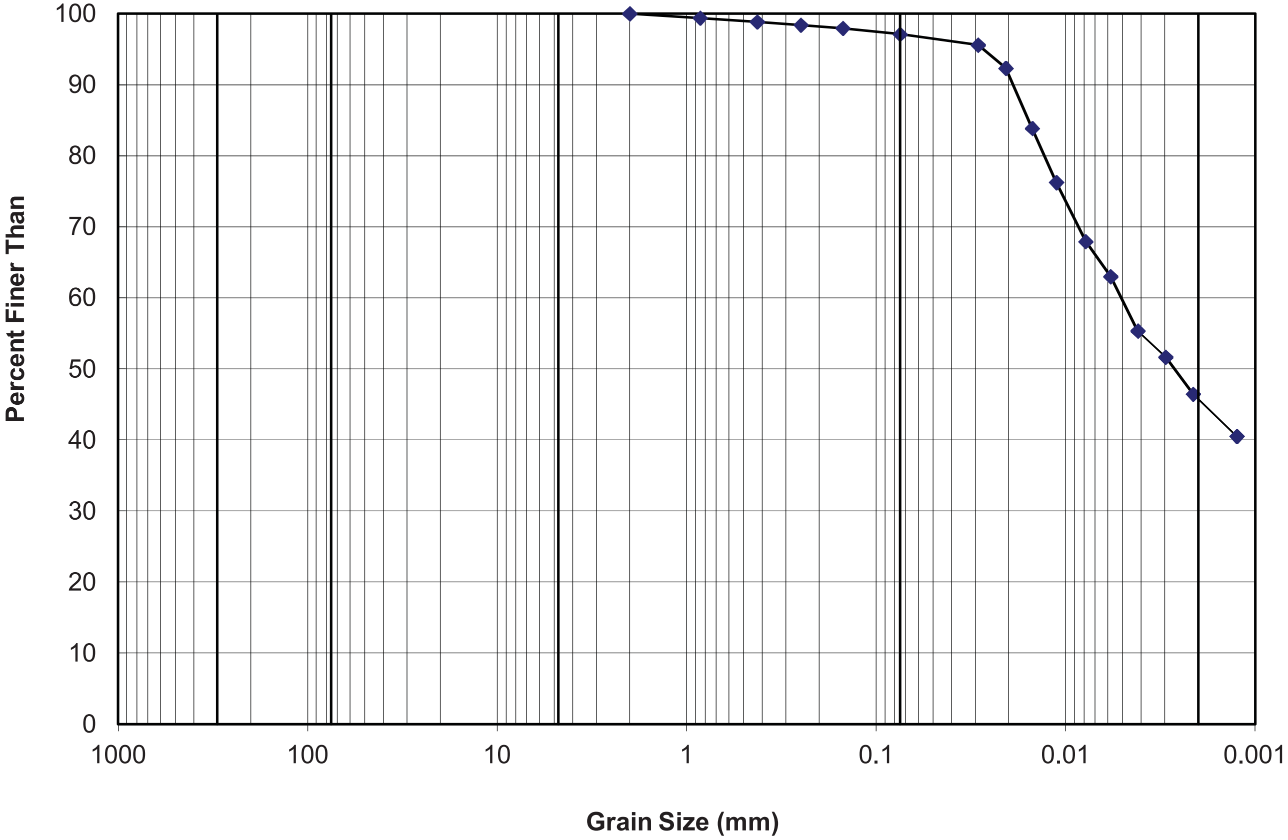
GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057 Phase: 5100
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon,
Tested by: S.H. / S.B. Date: August 9, 2013

Borehole #: COS-13-001 Sample #: 001-6
Source:
Date Sample Received: July 29, 2013

Graphical Analysis



BOULDERS	COBBLES	GRAVEL		SAND			SILT / CLAY
		Coarse	Fine	Coarse	Medium	Fine	

Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	100
2.00	100
0.850	99
0.425	99
0.250	98
0.150	98
0.075	97
0.029	96
0.021	92
0.015	84
0.011	76
0.008	68
0.006	63
0.004	55
0.003	52
0.002	46
0.001	41

Comments:

1721 8th Street E.,
Saskatoon, Saskatchewan, S7H 0T4

Reviewed by:

Golder Associates

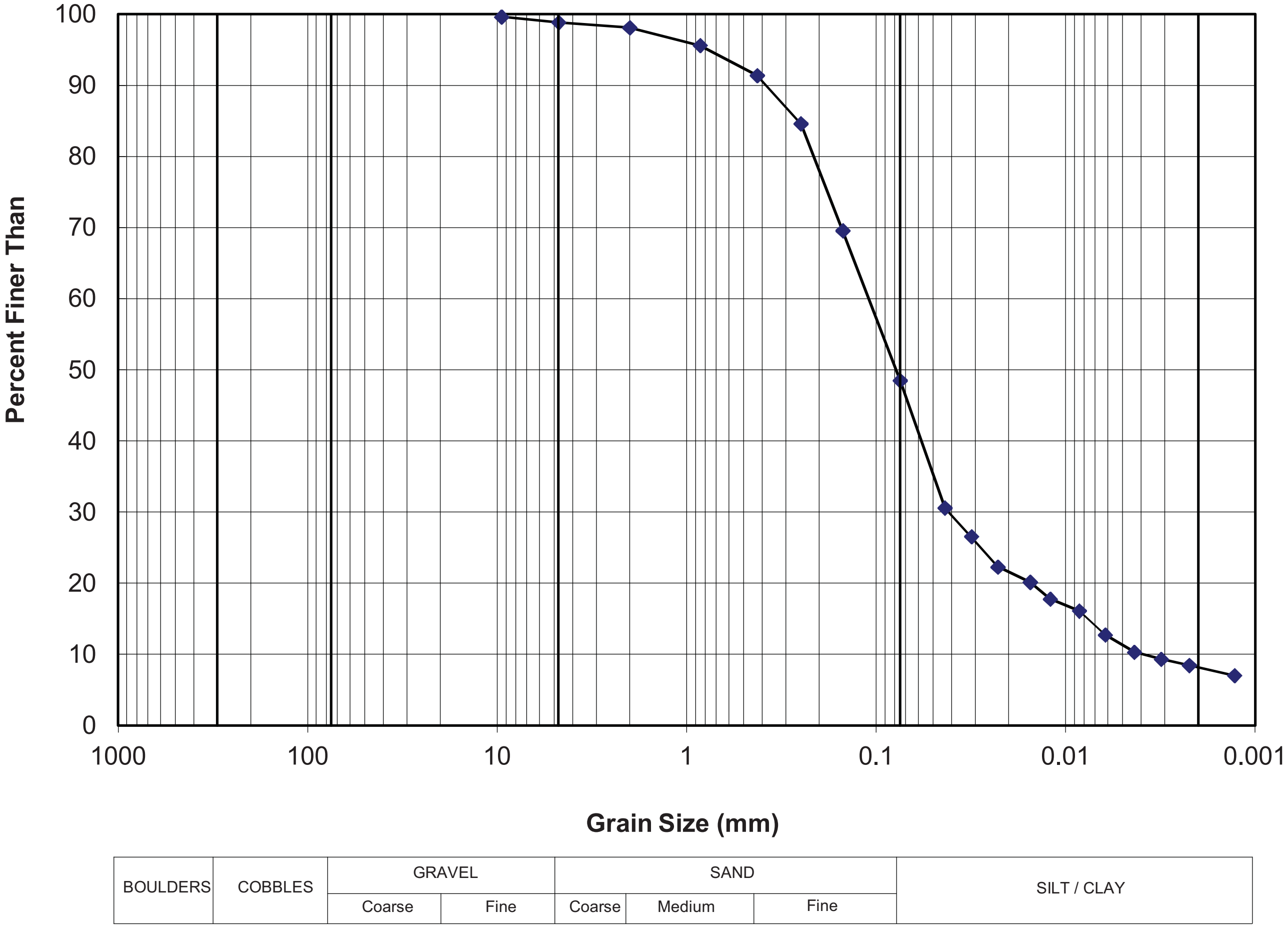
GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057 Phase: 5100
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon,
Tested by: S.H. / S.B. Date: August 9, 2013

Borehole #: COS-13-001 Sample #: 001-9
Source:
Date Sample Received: July 29, 2013

Graphical Analysis



Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	99
2.00	98
0.850	96
0.425	91
0.250	85
0.150	70
0.075	49
0.043	31
0.031	27
0.023	22
0.015	20
0.012	18
0.008	16
0.006	13
0.004	10
0.003	9.3
0.002	8.5
0.001	7.1

Comments:

Reviewed by:

Golder Associates

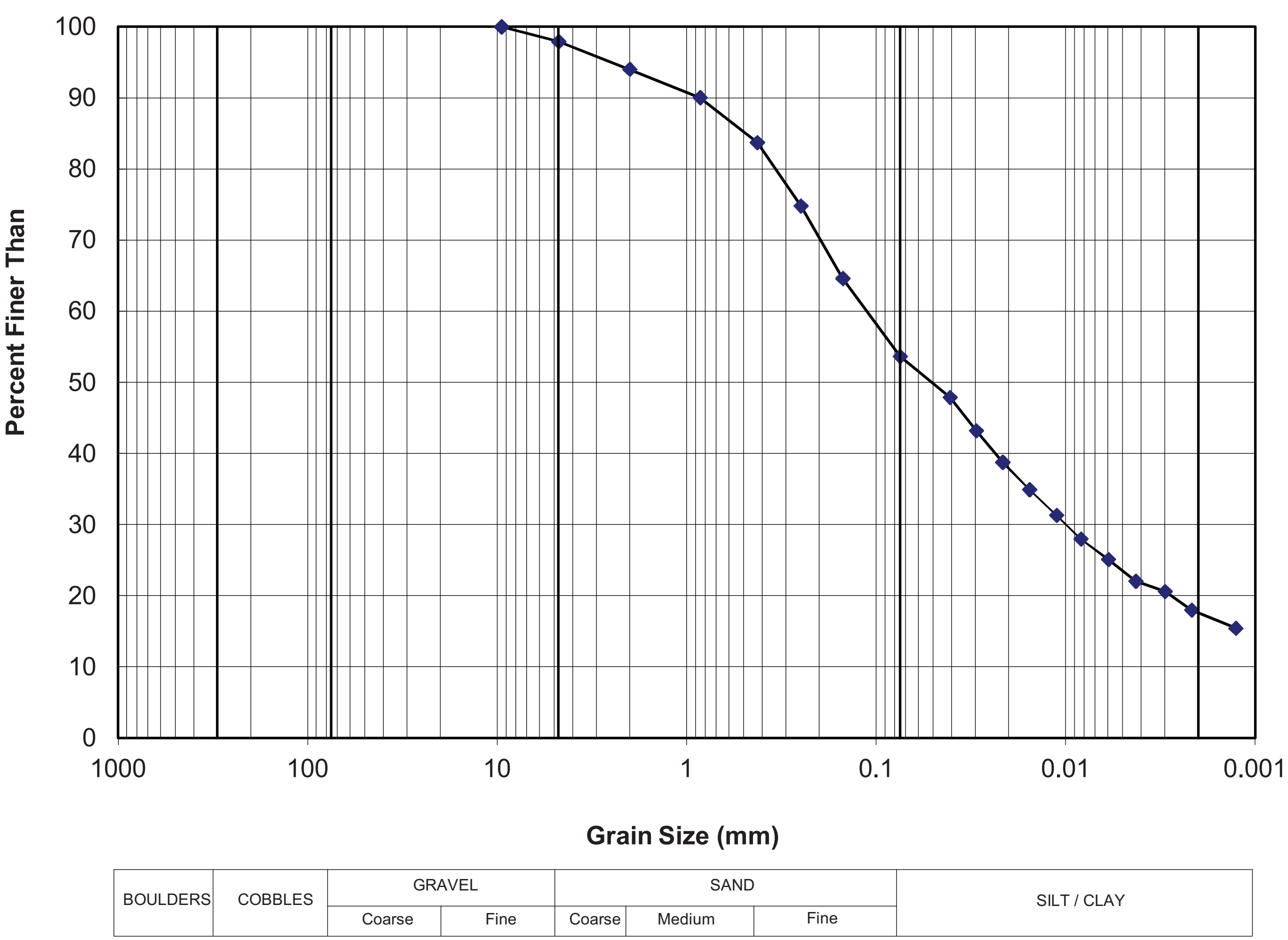
GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057 Phase: 5100
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon,
Tested by: S.J.B. / S.B. Date: August 10, 2013

Borehole #: CP-13-001B Sample #: 001B-3
Source:
Date Sample Received: July 29, 2013

Graphical Analysis



Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	98
2.00	94
0.850	90
0.425	84
0.250	75
0.150	65
0.075	54
0.041	48
0.030	43
0.022	39
0.016	35
0.011	31
0.008	28
0.006	25
0.004	22
0.003	21
0.002	18
0.001	15

Comments:

1721 8th Street E.,
Saskatoon, Saskatchewan, S7H 0T4

Reviewed by:___________

Golder Associates

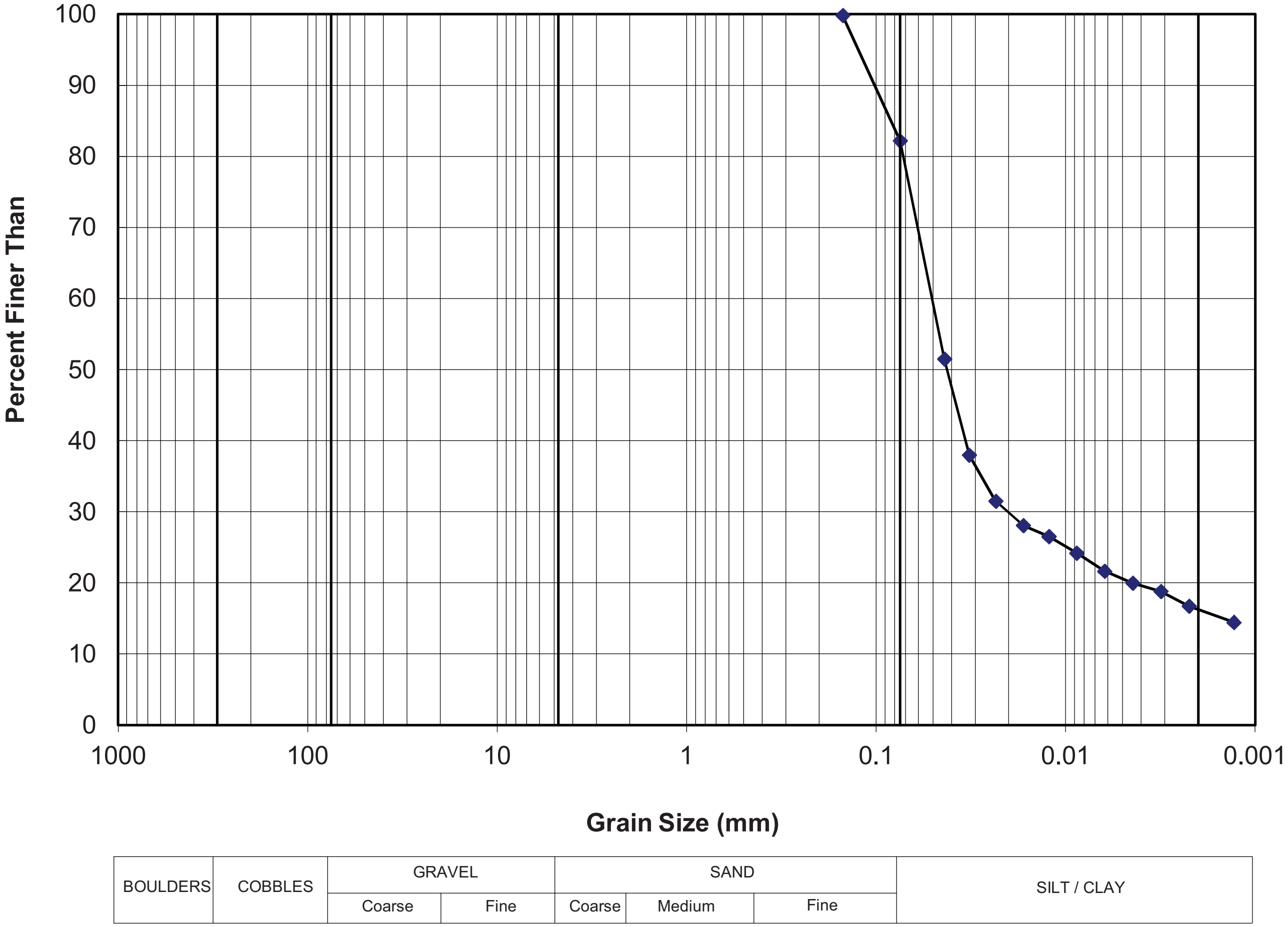
GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057 Phase: 5100
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon,
Tested by: S.J.B. / S.B. Date: August 10, 2013

Borehole #: COS-13-002 Sample #: 002-13
Source:
Date Sample Received: July 29, 2013

Graphical Analysis



Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	100
2.00	100
0.850	100
0.425	100
0.250	100
0.150	100
0.075	82
0.044	52
0.032	38
0.023	32
0.017	28
0.012	27
0.009	24
0.006	22
0.004	20
0.003	19
0.002	17
0.001	14

Comments:

1721 8th Street E.,
Saskatoon, Saskatchewan, S7H 0T4

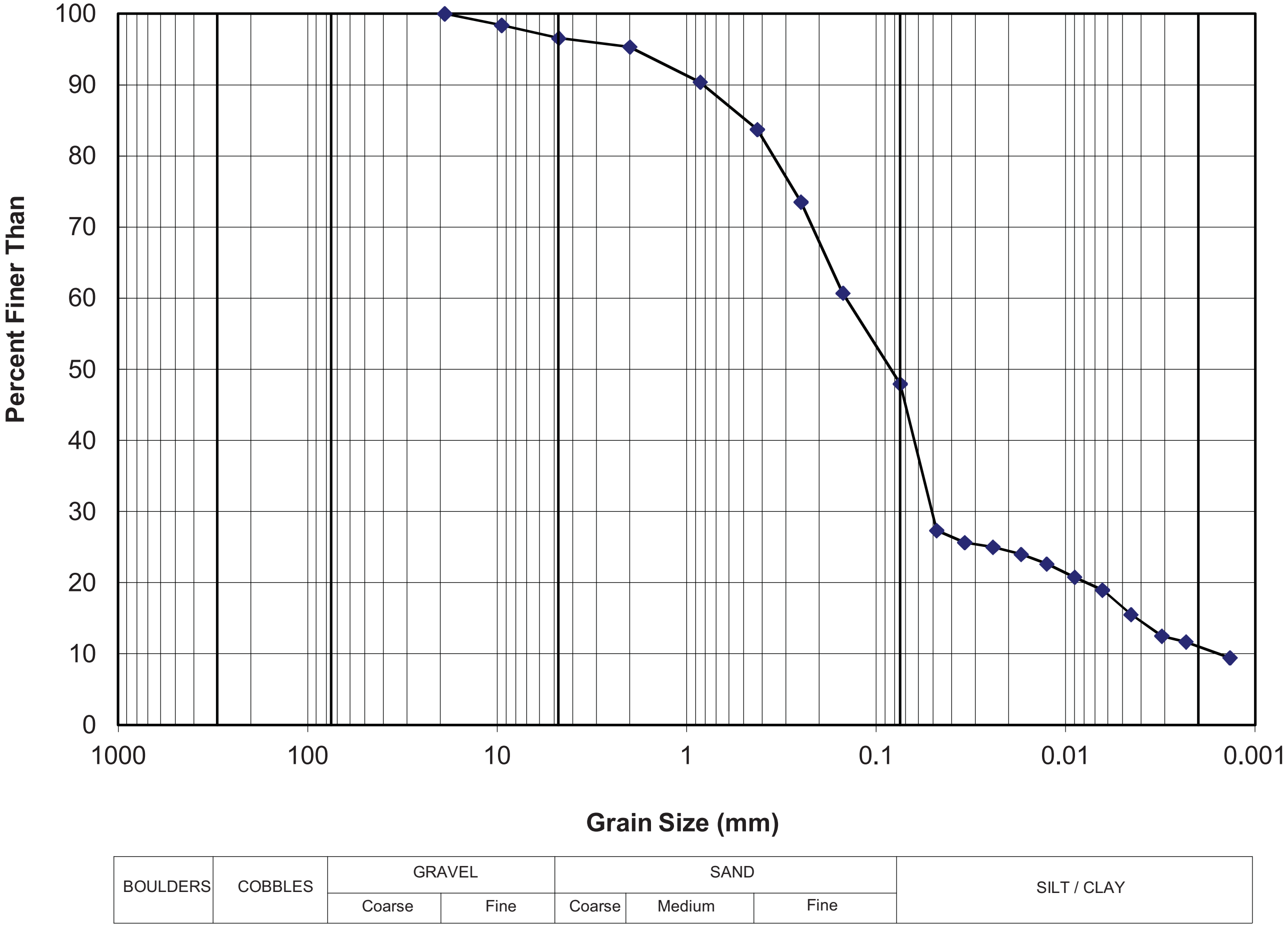
Reviewed by:

GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057
Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.E.
Date: September 16, 2013
Borehole #: COS-13-004
Sample #: 004-11
Source:
Date Sample Received: September 3, 2013

Graphical Analysis



Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	98
4.75	97
2.00	95
0.850	90
0.425	84
0.250	74
0.150	61
0.075	48
0.048	27
0.034	26
0.024	25
0.017	24
0.013	23
0.009	21
0.006	19
0.005	16
0.003	13
0.002	12
0.001	9.5

Comments:

Reviewed by:

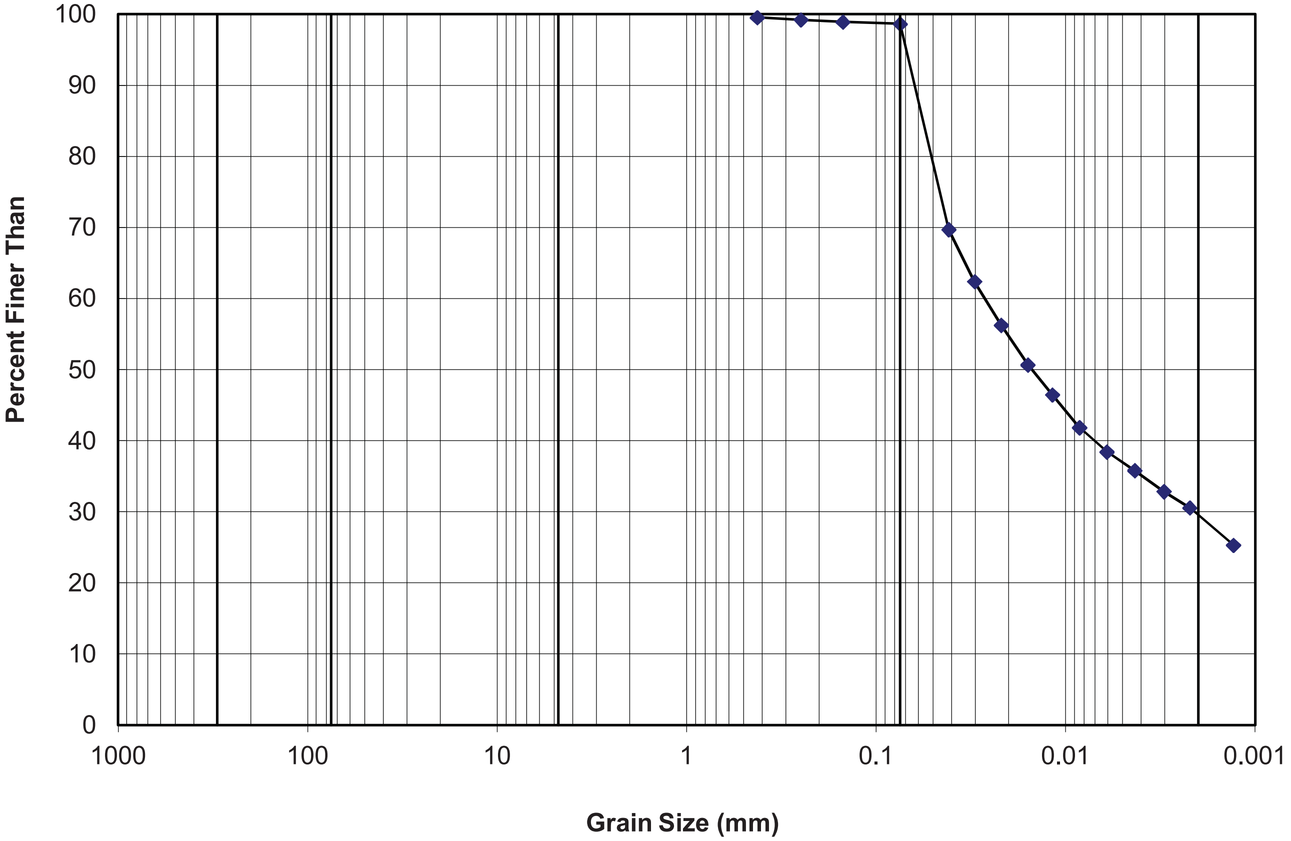
GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057 Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.E. Date: September 16, 2013

Borehole #: COS-13-004 Sample #: 004-2
Source:
Date Sample Received: September 3, 2013

Graphical Analysis



BOULDERS	COBBLES	GRAVEL		SAND			SILT / CLAY
		Coarse	Fine	Coarse	Medium	Fine	

Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	100
2.00	100
0.850	100
0.425	100
0.250	99
0.150	99
0.075	99
0.042	70
0.030	62
0.022	56
0.016	51
0.012	46
0.008	42
0.006	38
0.004	36
0.003	33
0.002	31
0.001	25

Comments:

1721 8th Street E.,
Saskatoon, Saskatchewan, S7H 0T4

Reviewed by:

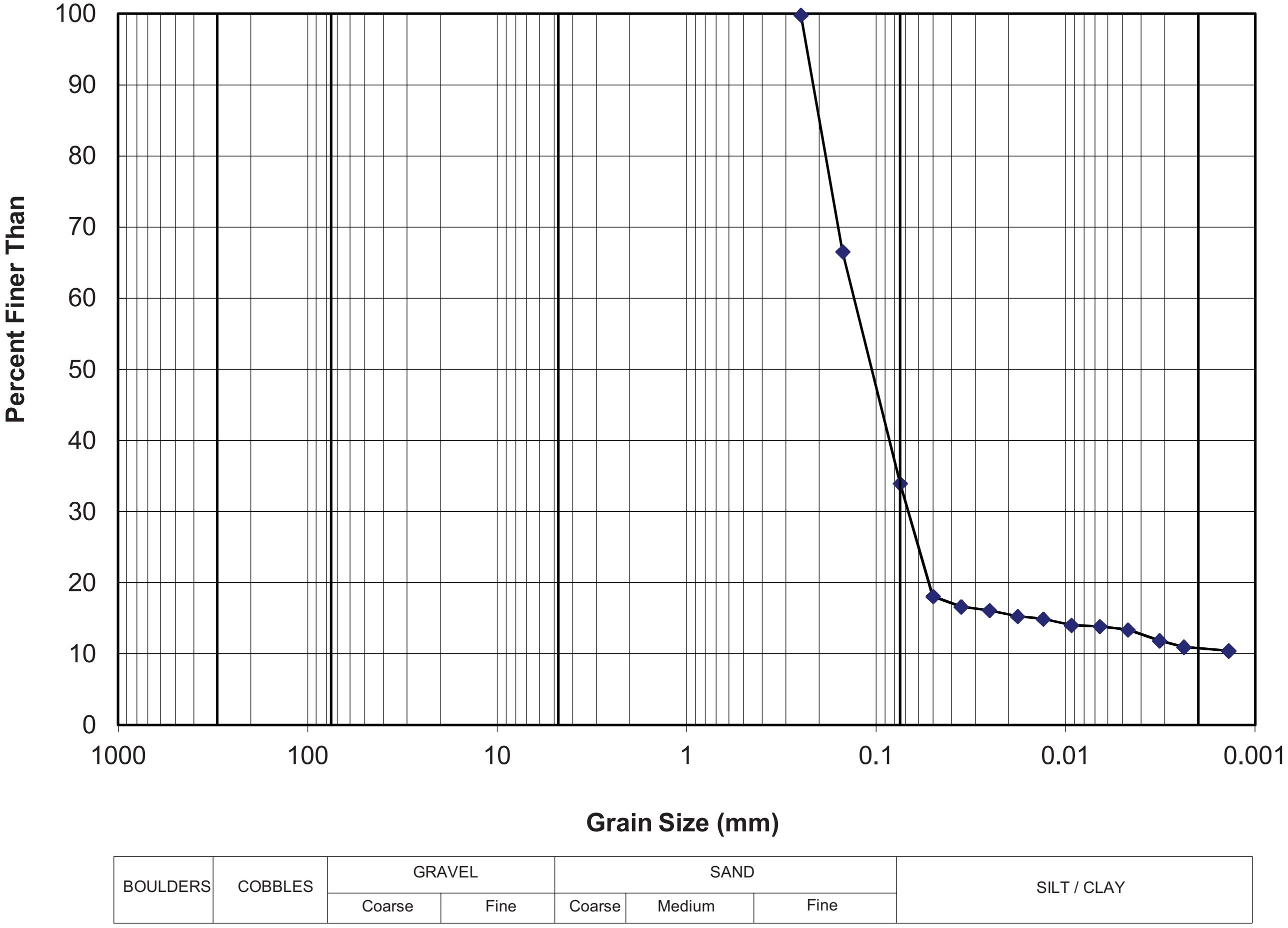
GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057 Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.E. Date: September 16, 2013

Borehole #: COS-13-005 Sample #: 005-1
Source:
Date Sample Received: September 3, 2013

Graphical Analysis



Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	100
2.00	100
0.850	100
0.425	100
0.250	100
0.150	67
0.075	34
0.050	18
0.036	17
0.025	16
0.018	15
0.013	15
0.009	14
0.007	14
0.005	13
0.003	12
0.002	11
0.001	10

Comments:

Reviewed by:

Golder Associates

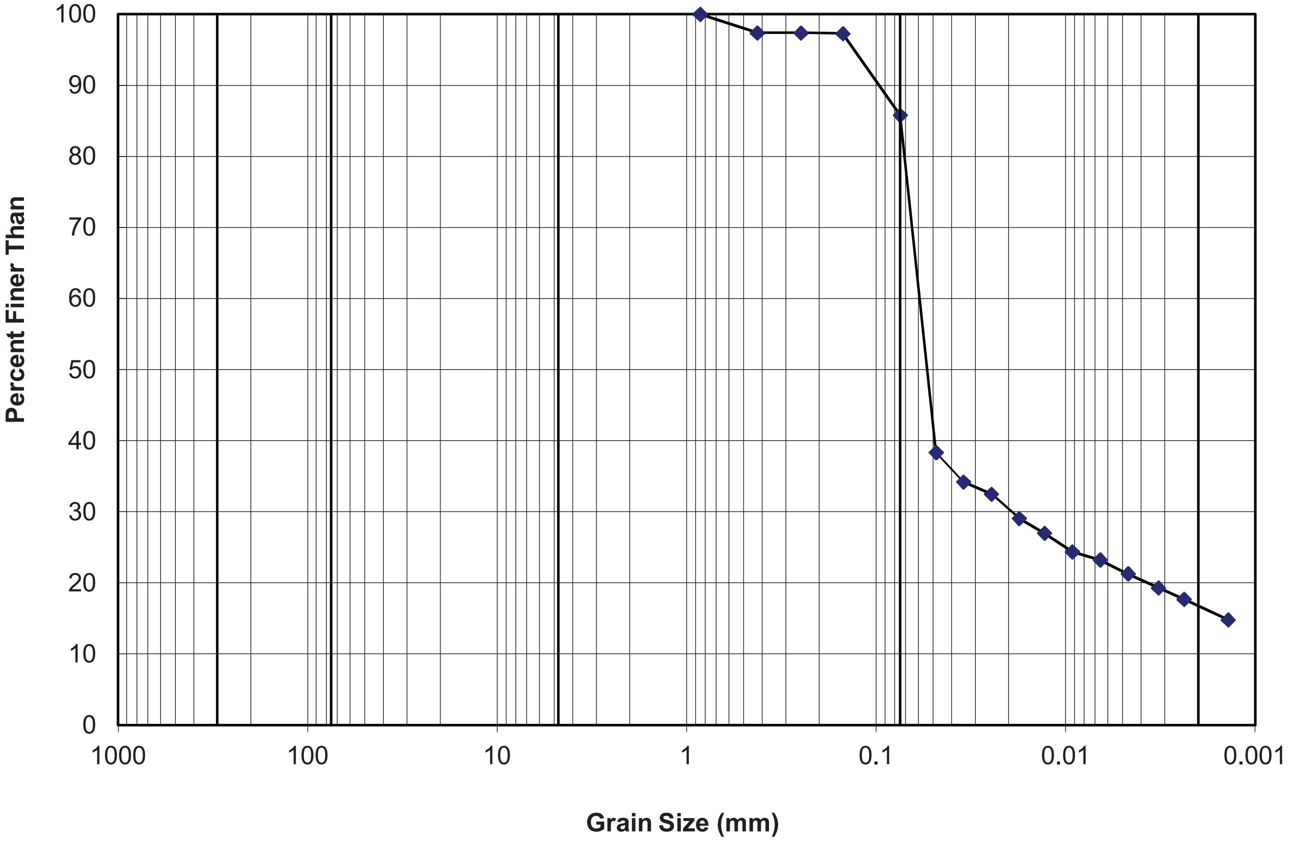
GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057 Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.E. Date: September 16, 2013

Borehole #: COS-13-005 Sample #: 005-10
Source:
Date Sample Received: September 3, 2013

Graphical Analysis



BOULDERS	COBBLES	GRAVEL		SAND			SILT / CLAY
		Coarse	Fine	Coarse	Medium	Fine	

Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	100
2.00	100
0.850	100
0.425	97
0.250	97
0.150	97
0.075	86
0.048	38
0.035	34
0.025	33
0.018	29
0.013	27
0.009	24
0.007	23
0.005	21
0.003	19
0.002	18
0.001	15

Comments:

1721 8th Street E.,
Saskatoon, Saskatchewan, S7H 0T4

Reviewed by:

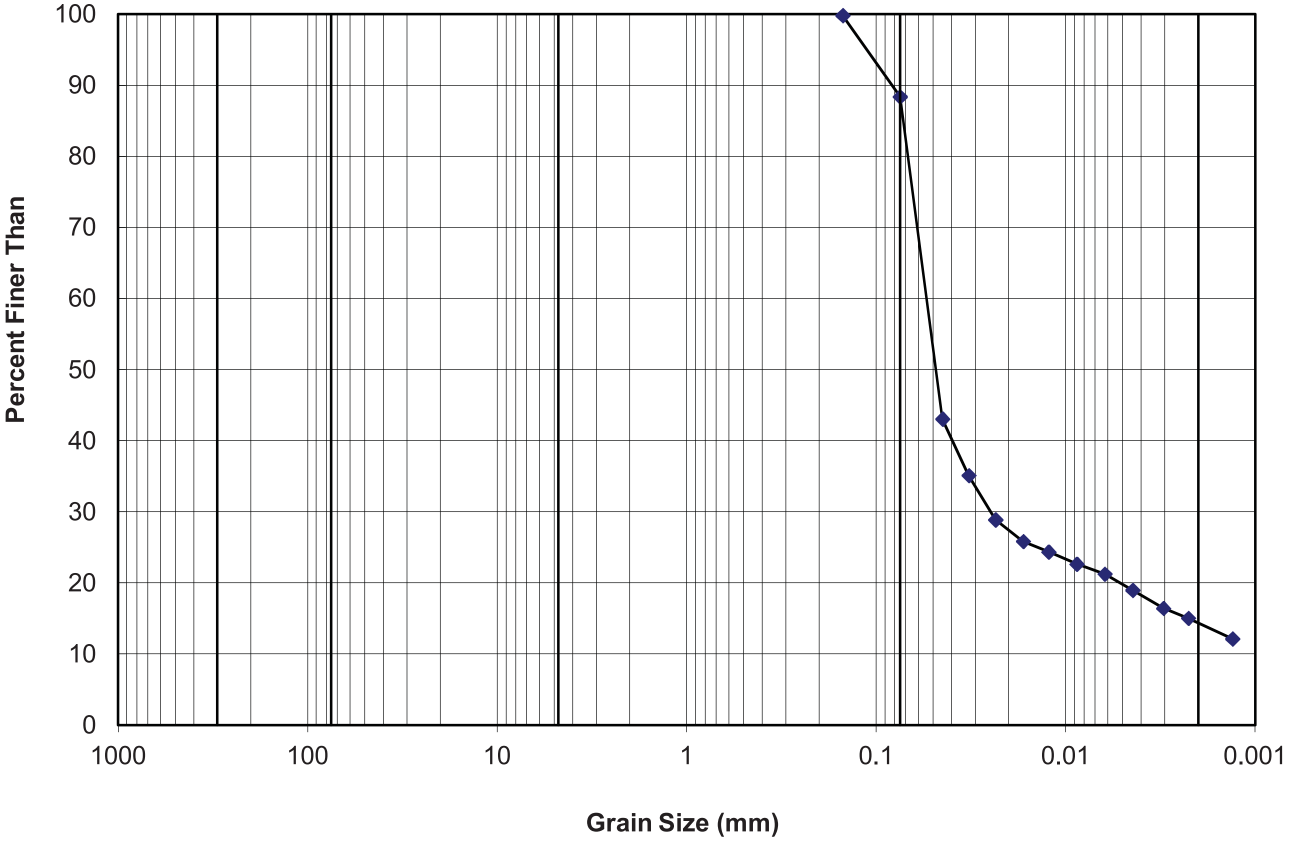
Golder Associates

GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057 Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.E. Date: September 16, 2013
Borehole #: COS-13-005 Sample #: 005-11
Source:
Date Sample Received: September 3, 2013

Graphical Analysis



BOULDERS	COBBLES	GRAVEL		SAND			SILT / CLAY
		Coarse	Fine	Coarse	Medium	Fine	

Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	100
2.00	100
0.850	100
0.425	100
0.250	100
0.150	100
0.075	88
0.045	43
0.032	35
0.023	29
0.017	26
0.012	24
0.009	23
0.006	21
0.004	19
0.003	16
0.002	15
0.001	12

Comments:

Reviewed by:____________

Golder Associates

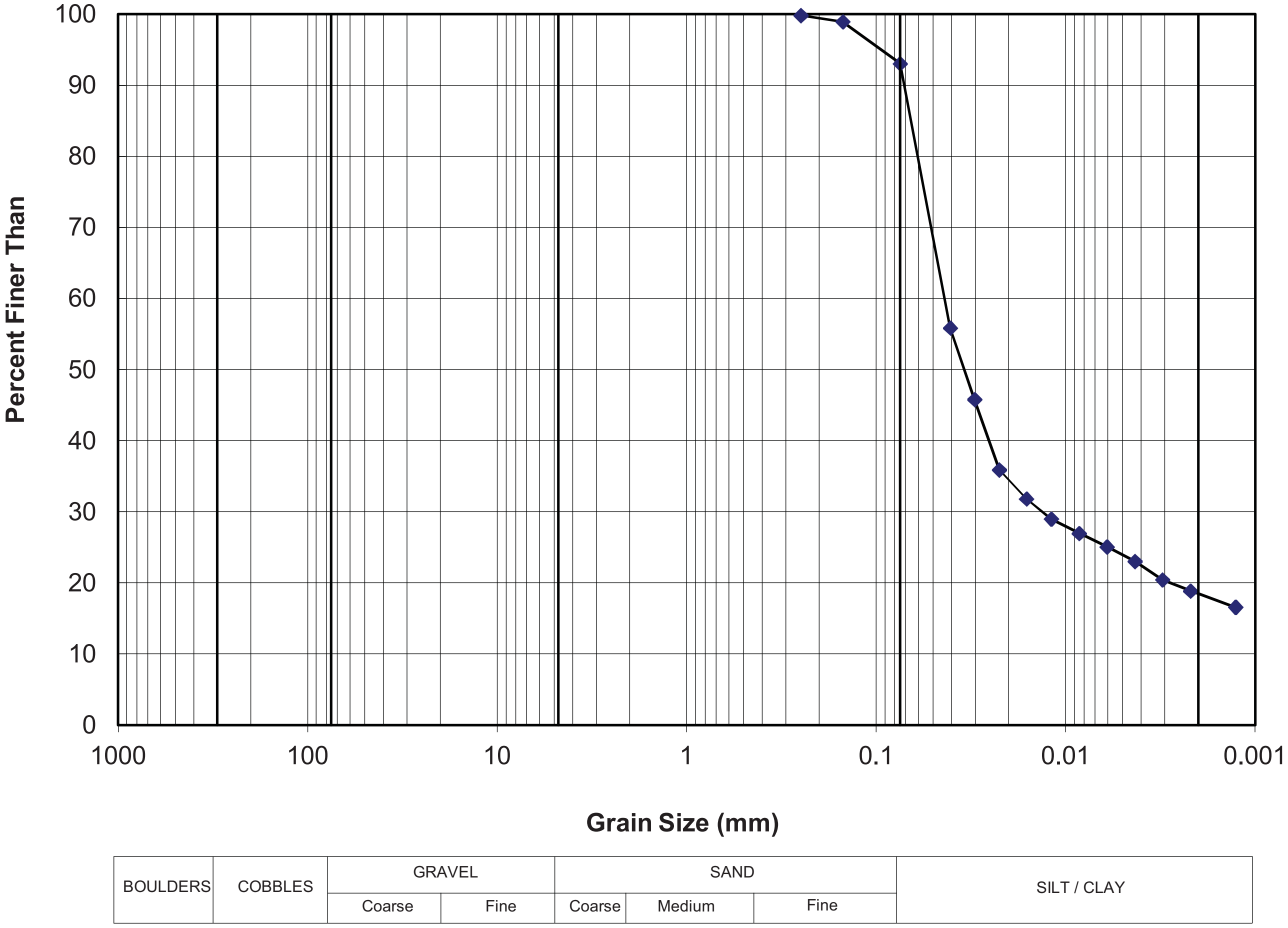
GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057 Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.E. Date: September 16, 2013

Borehole #: COS-13-005 Sample #: 005-12
Source:
Date Sample Received: September 3, 2013

Graphical Analysis



Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	100
2.00	100
0.850	100
0.425	100
0.250	100
0.150	99
0.075	93
0.041	56
0.030	46
0.022	36
0.016	32
0.012	29
0.009	27
0.006	25
0.004	23
0.003	20
0.002	19
0.001	17

Comments:

Reviewed by:

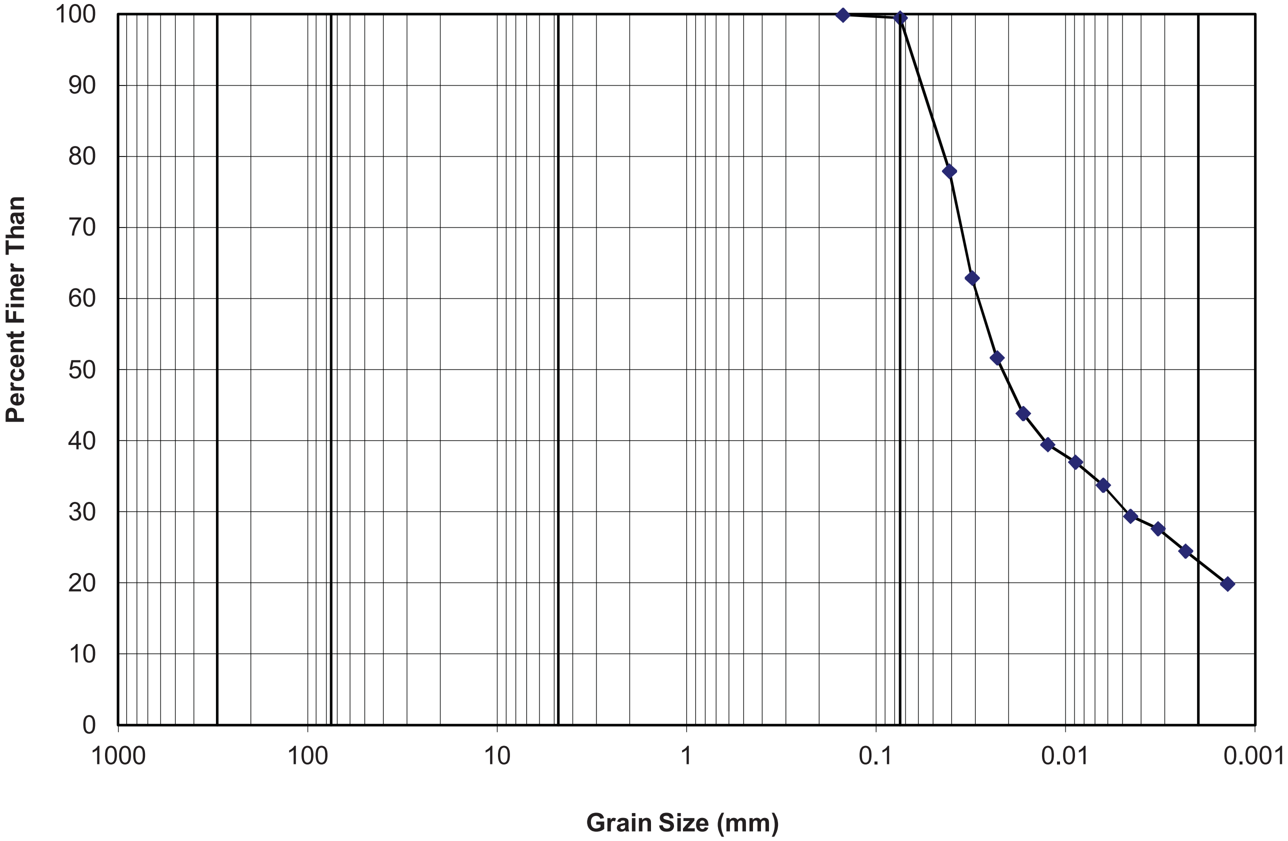
GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057 Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.E. Date: September 16, 2013

Borehole #: COS-13-005 Sample #: 005-8
Source:
Date Sample Received: September 3, 2013

Graphical Analysis



BOULDERS	COBBLES	GRAVEL		SAND			SILT / CLAY
		Coarse	Fine	Coarse	Medium	Fine	

Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	100
2.00	100
0.850	100
0.425	100
0.250	100
0.150	100
0.075	99
0.041	78
0.031	63
0.023	52
0.017	44
0.012	39
0.009	37
0.006	34
0.005	29
0.003	28
0.002	25
0.001	20

Comments:

Reviewed by:____________

Golder Associates

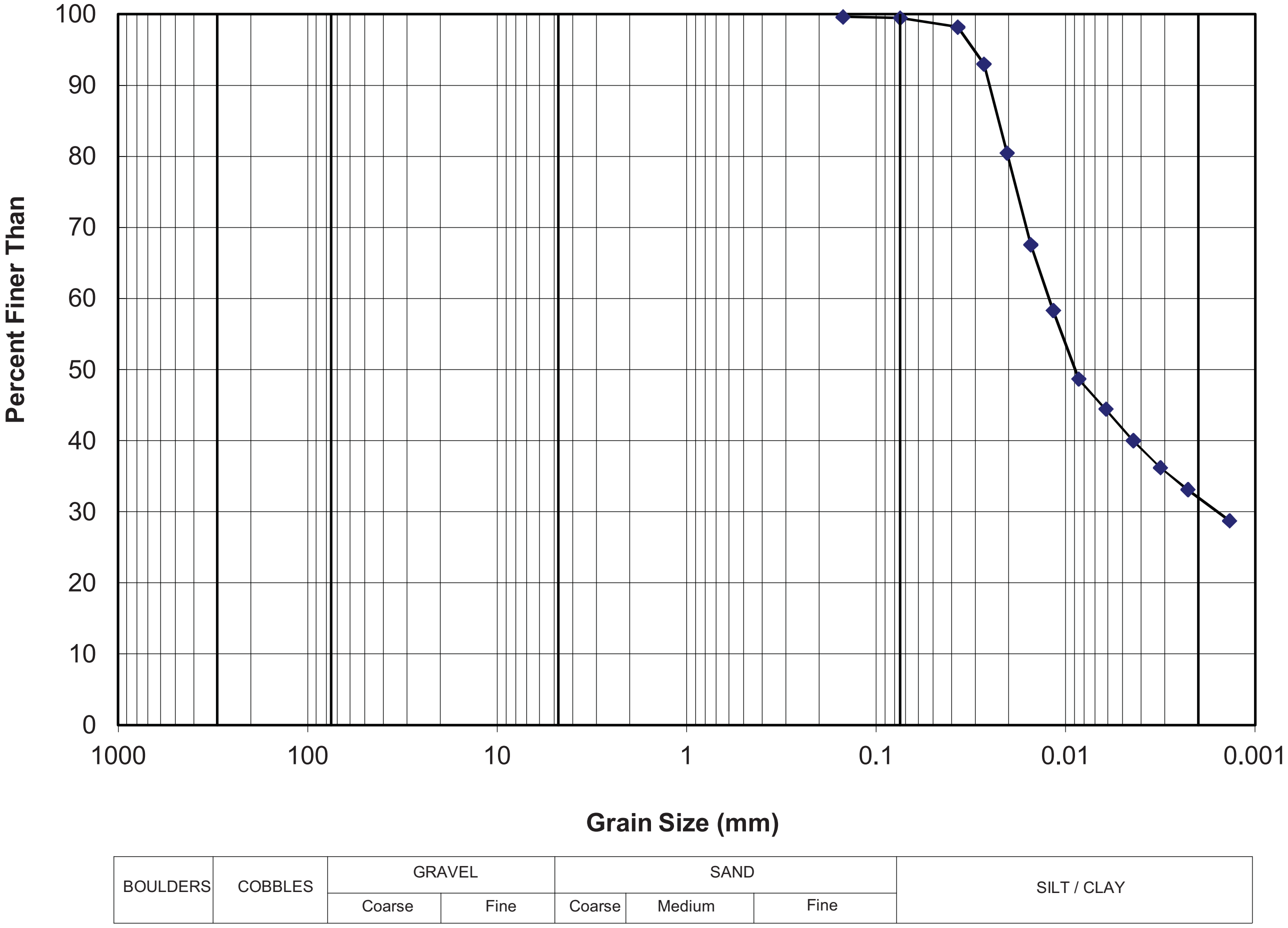
GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057
Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.E.
Date: September 16, 2013

Borehole #: COS-13-006 Sample #: 006-10
Source:
Date Sample Received: September 3, 2013

Graphical Analysis



Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	100
2.00	100
0.850	100
0.425	100
0.250	100
0.150	100
0.075	99
0.037	98
0.027	93
0.020	80
0.015	68
0.012	58
0.009	49
0.006	44
0.004	40
0.003	36
0.002	33
0.001	29

Comments:

Reviewed by:

Golder Associates

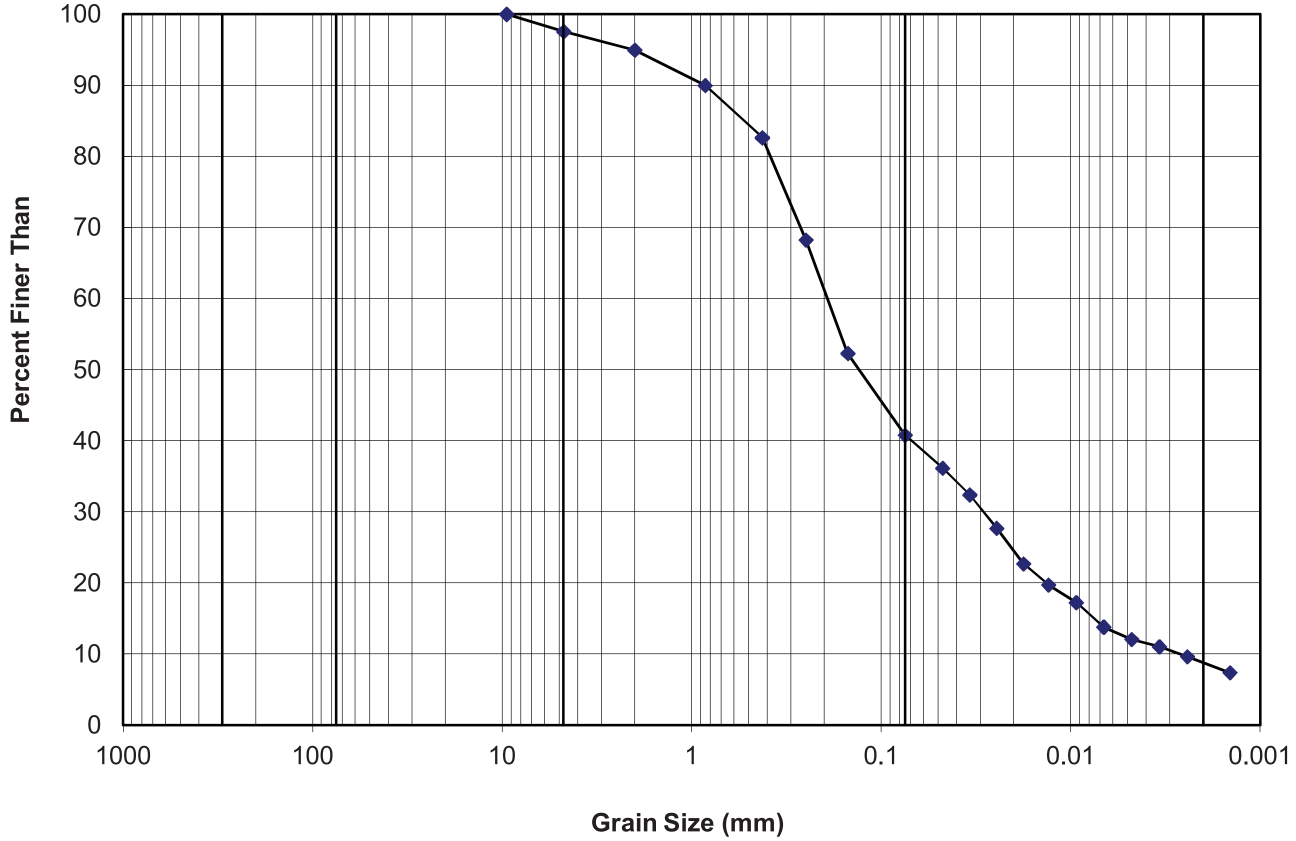
GRAIN SIZE ANALYSIS - ASTM D422

(Mechanical & Hydrometer)

Project #: 11-1362-0057
Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested by: S.E.
Date: September 16, 2013

Borehole #: COS-13-006
Sample #: 006-13
Source:
Date Sample Received: September 3, 2013

Graphical Analysis



BOULDERS	COBBLES	GRAVEL		SAND			SILT / CLAY
		Coarse	Fine	Coarse	Medium	Fine	

Grain Size Analysis Results:

Opening (mm)	Percent Passing (%)
152	100
76	100
38	100
19	100
9.5	100
4.75	98
2.00	95
0.850	90
0.425	83
0.250	68
0.150	52
0.075	41
0.047	36
0.034	32
0.025	28
0.018	23
0.013	20
0.009	17
0.007	14
0.005	12
0.003	11
0.002	9.6
0.001	7.4

Comments:

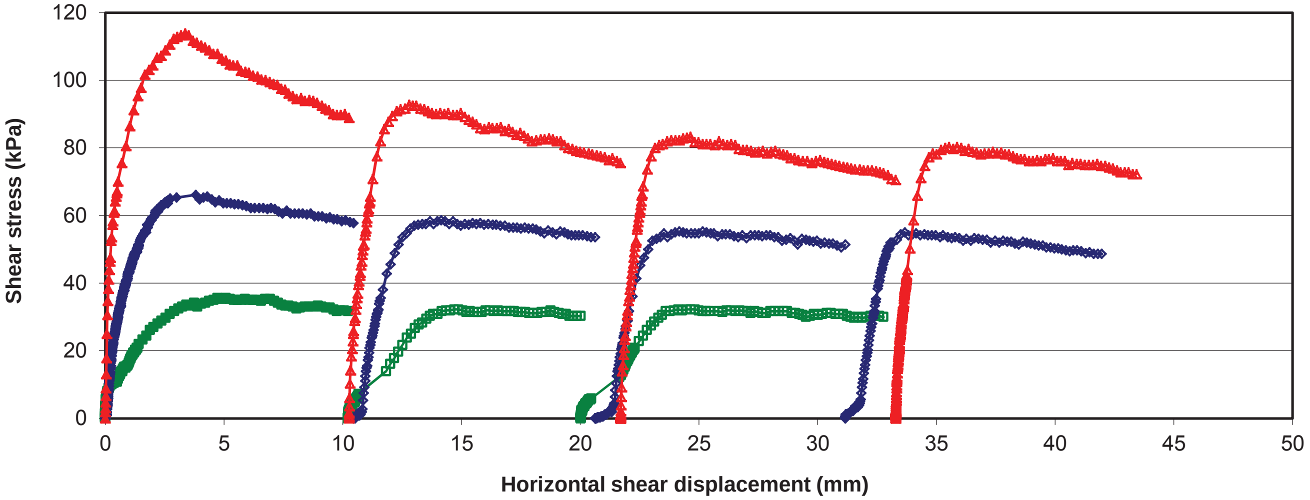
Reviewed by:

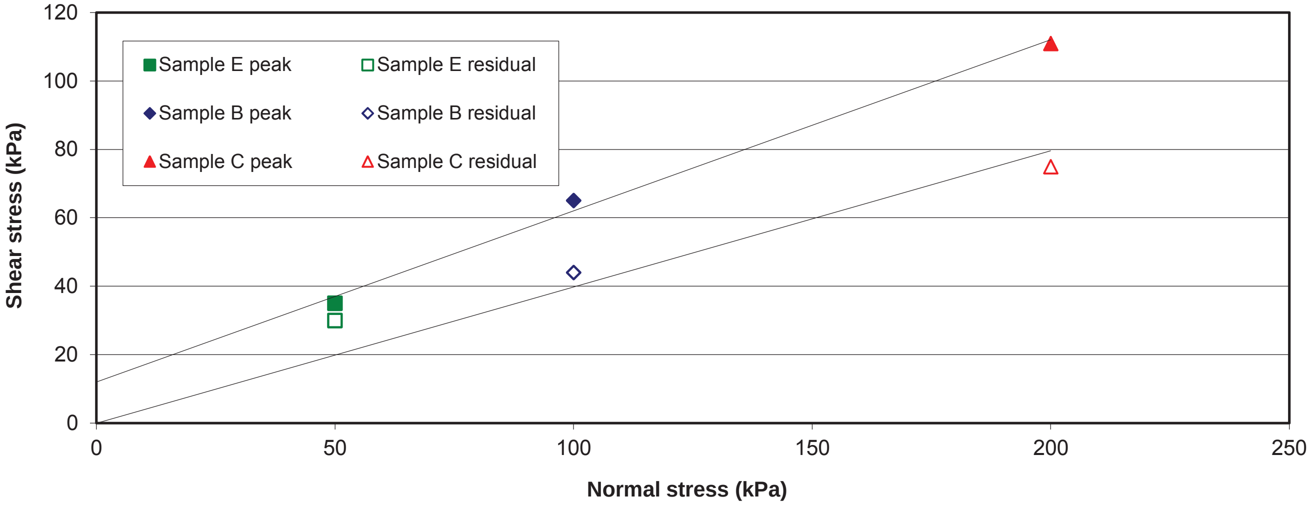
CONSOLIDATED DRAINED DIRECT SHEAR TEST-SUMMARY

Project #:	11-1362-0057	Phase:	5100
Short Title:	COS East Riverbank / Cherry Lane - Geotech Investigation Saskatoon, SK		
Tested By:	B.Y. / D.B.	Date:	August 29, 2013

Sample	Normal Stress (kPa)	Shear Stress Peak (kPa)	Residual (kPa)
	50	35	30
COS-13-001B 001B-1	100	65	44
	200	111	75

	Peak	Residual
Friction angle (degrees):	26.6	21.7
cohesion (kPa):	12	0





Comments:

Reviewed by:

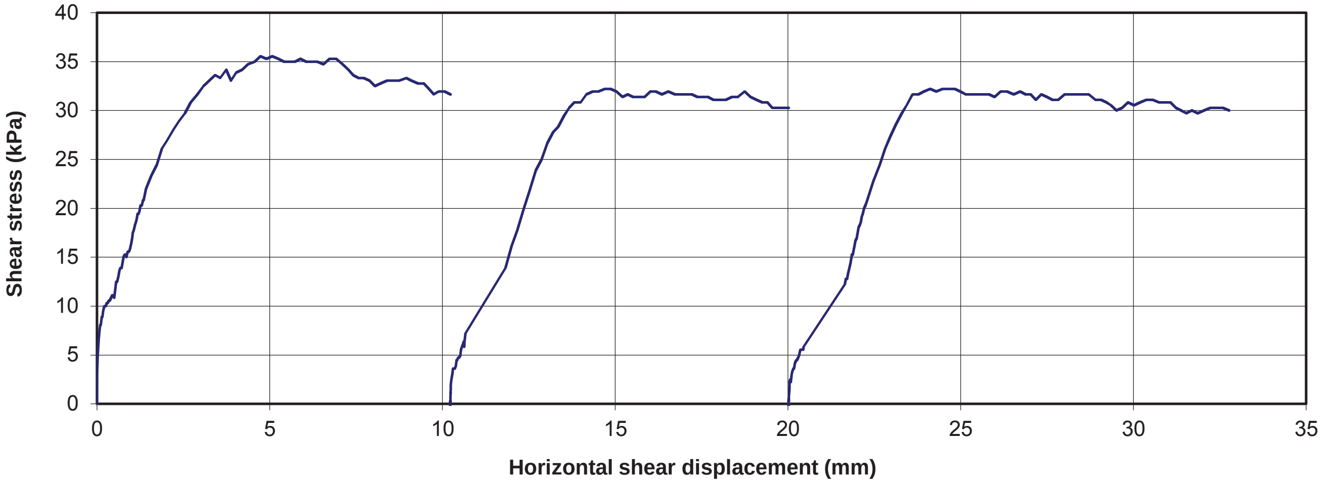
CONSOLIDATED DRAINED DIRECT SHEAR TEST

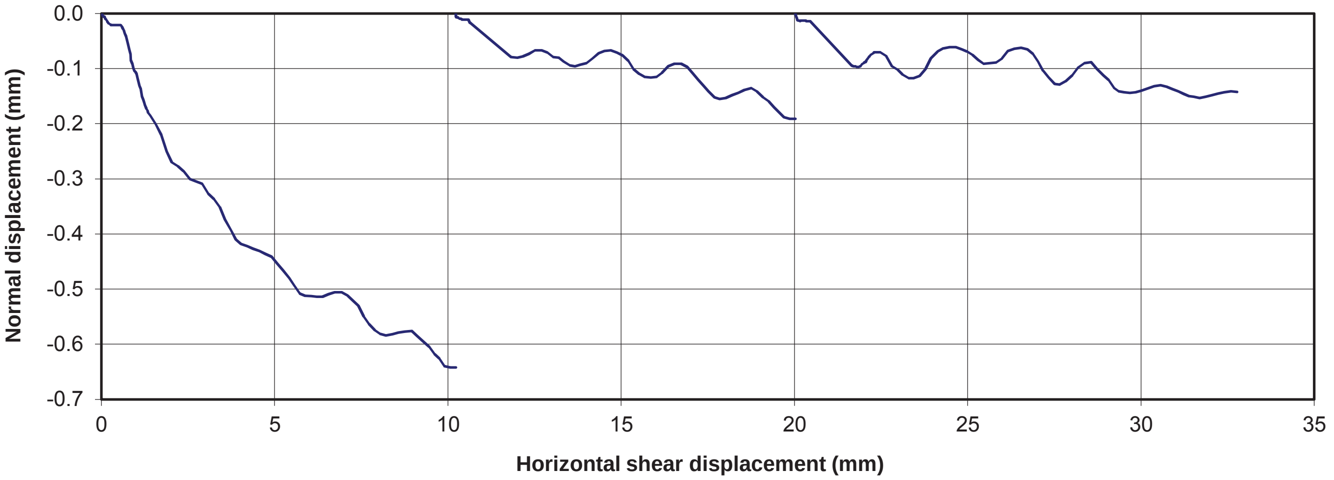
Project #:	11-1362-0057	Phase:	5100
Short Title:	COS East Riverbank / Cherry Lane - Geotech Investigation Saskatoon, SK		
Tested By:	B.Y. / D.B.	Date:	August 29, 2013
Sample:	COS-13-001B 001B-1 (REDO#2)		

Effective Stress:	50	kPa
Sample Data:		
Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	35.4	%
Initial Dry Density:	1319	kg/m^3
Final Water Content:	42.6	%

Peak Shear Stress:	35	kPa
Residual Shear Stress	30	kPa

Comments:





Reviewed by:

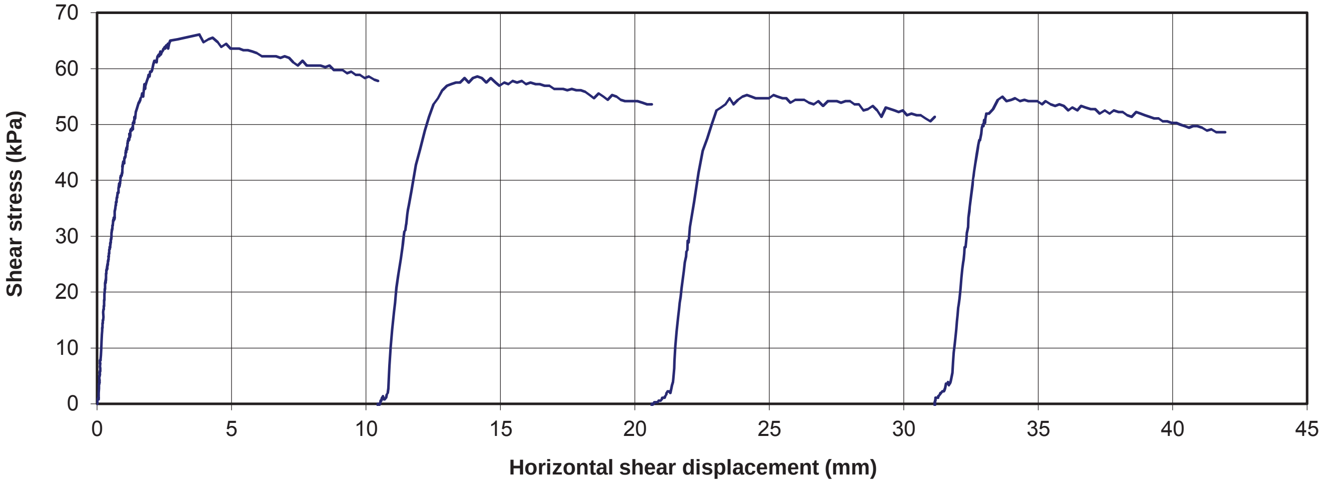
CONSOLIDATED DRAINED DIRECT SHEAR TEST

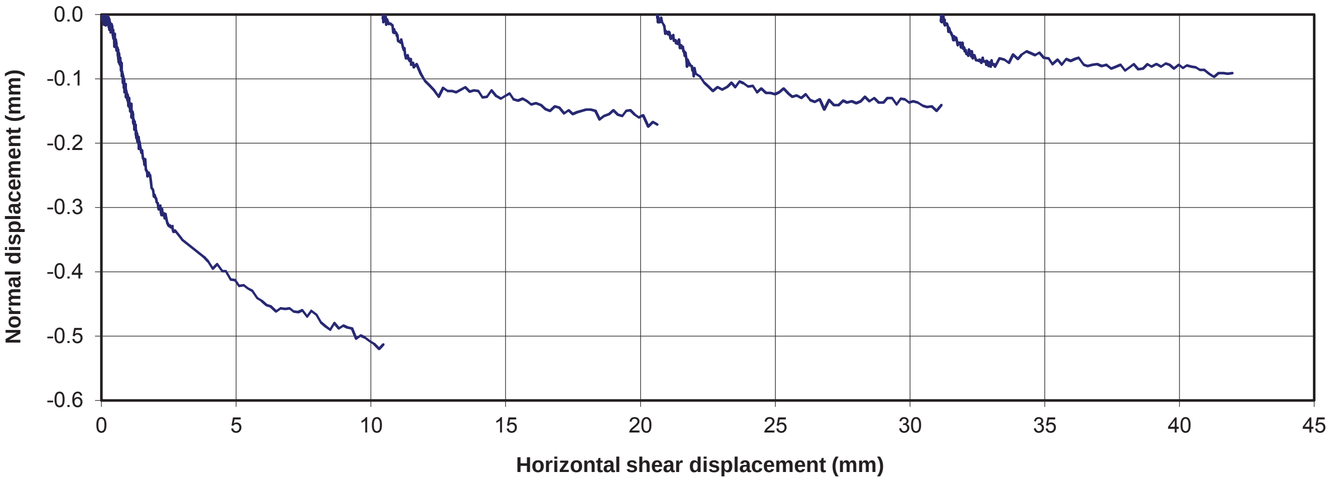
Project #:	11-1362-0057	Phase:	5100
Short Title:	COS East Riverbank / Cherry Lane - Geotech Investigation Saskatoon, SK		
Tested By:	B.Y. / D.B.	Date:	August 29, 2013
Sample:	COS-13-001B 001B-1		

Effective Stress:	100	kPa
Sample Data:		
Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	35.0	%
Initial Dry Density:	1349	kg/m^3
Final Water Content:	40.5	%

Peak Shear Stress:	65	kPa
Residual Shear Stress	44	kPa

Comments:





Reviewed by:

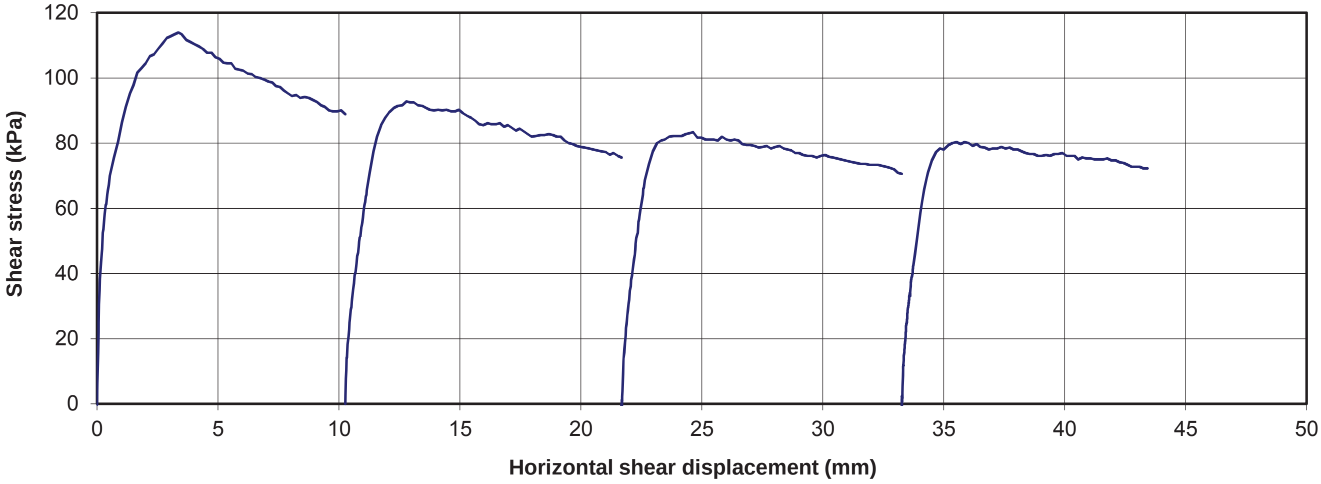
CONSOLIDATED DRAINED DIRECT SHEAR TEST

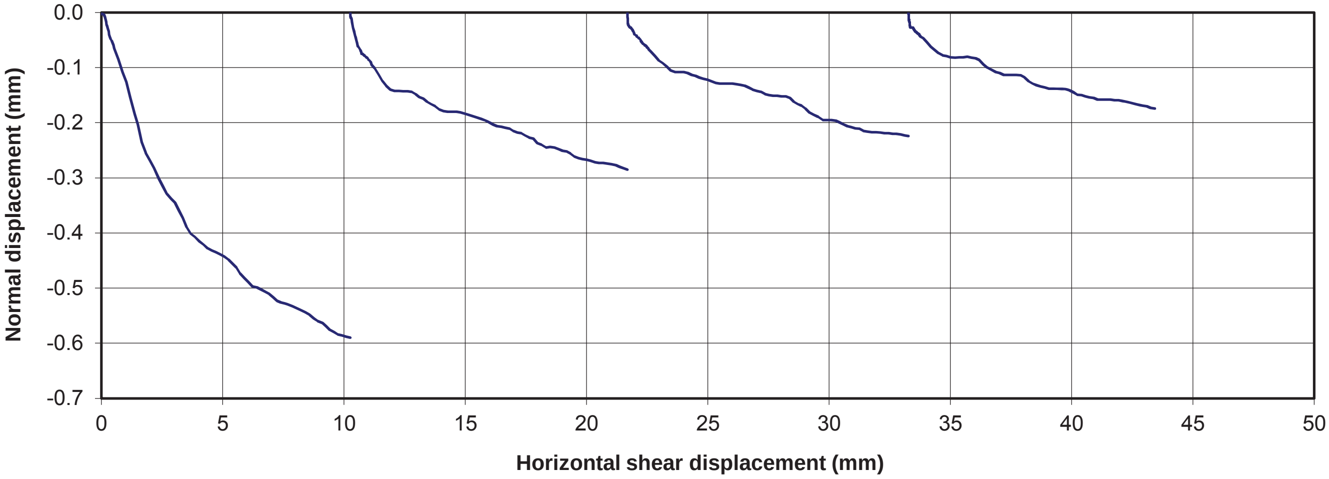
Project #:	11-1362-0057	Phase:	5100
Short Title:	COS East Riverbank / Cherry Lane - Geotech Investigation Saskatoon, SK		
Tested By:	B.Y. / D.B.	Date:	August 29, 2013
Sample:	COS-13-001B 001B-1		

Effective Stress:	200	kPa
Sample Data:		
Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	36.4	%
Initial Dry Density:	1337	kg/m^3
Final Water Content:	35.0	%

Peak Shear Stress:	111	kPa
Residual Shear Stress	75	kPa

Comments:





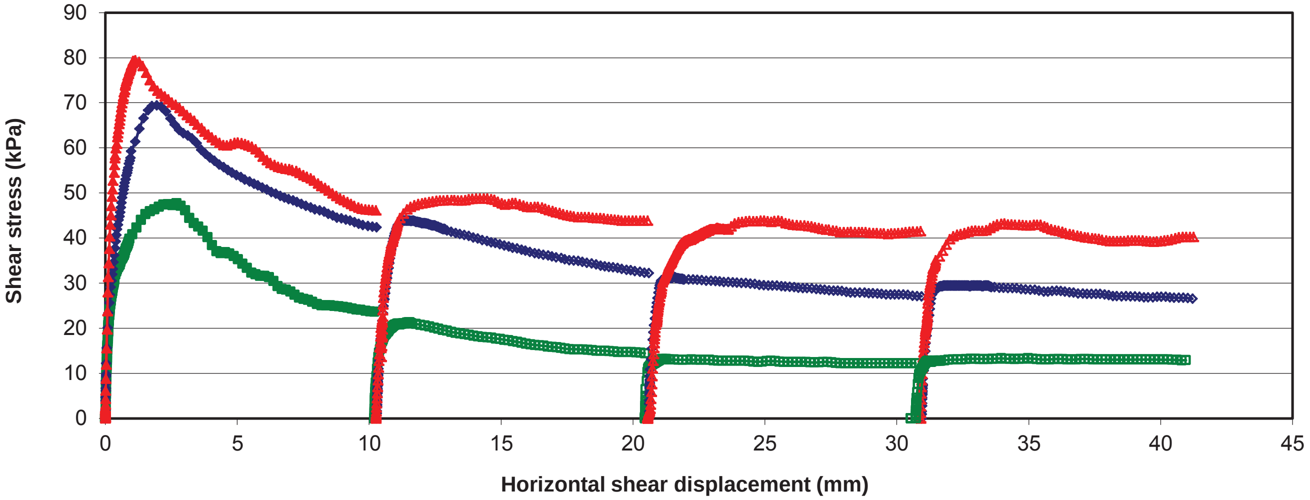
Reviewed by:

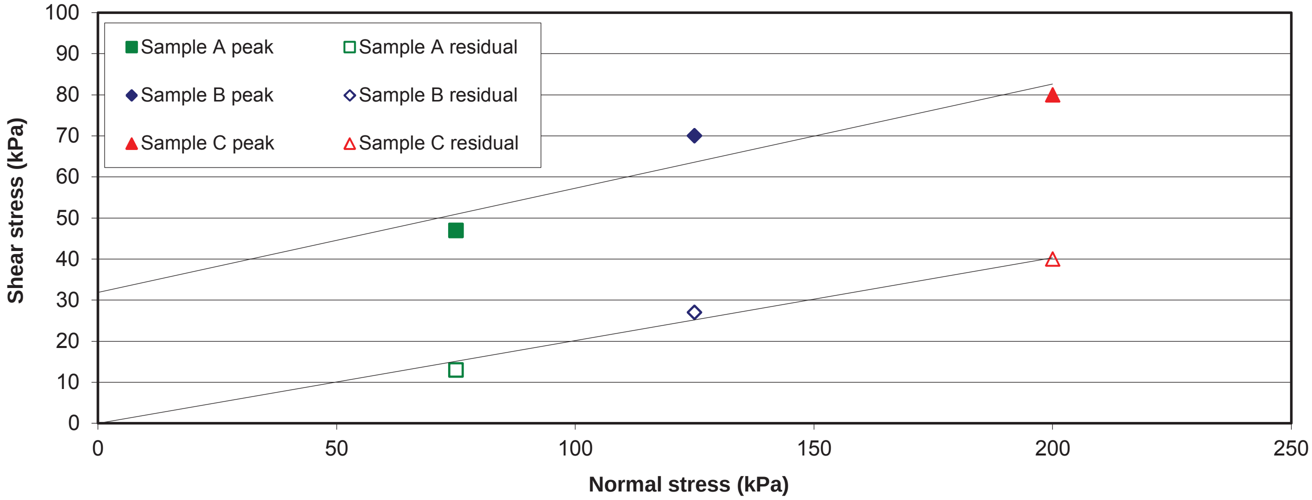
CONSOLIDATED DRAINED DIRECT SHEAR TEST-SUMMARY

Project #: 11-1362-0057 Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested By: B.Y. / D.B. Date: November 10, 2013

Sample	Normal Stress (kPa)	Shear Stress Peak (kPa)	Shear Stress Residual (kPa)
	75	47	13
COS-13-004 004-8 7.01-7.62 m depth	125	70	27
	200	80	40

	Peak	Residual
Friction angle (degrees):	14.2	11.4
cohesion (kPa):	32	0





Comments:

Reviewed by:

Golder Associates

CONSOLIDATED DRAINED DIRECT SHEAR TEST

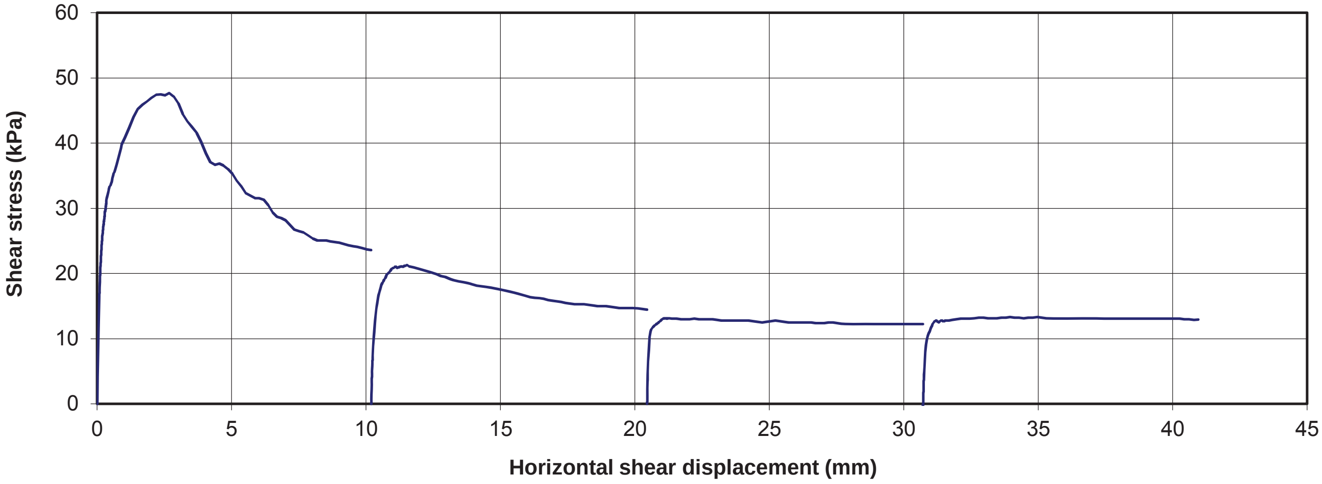
Project #: 11-1362-0057 Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested By: B.Y. / D.B. Date: November 10, 2013

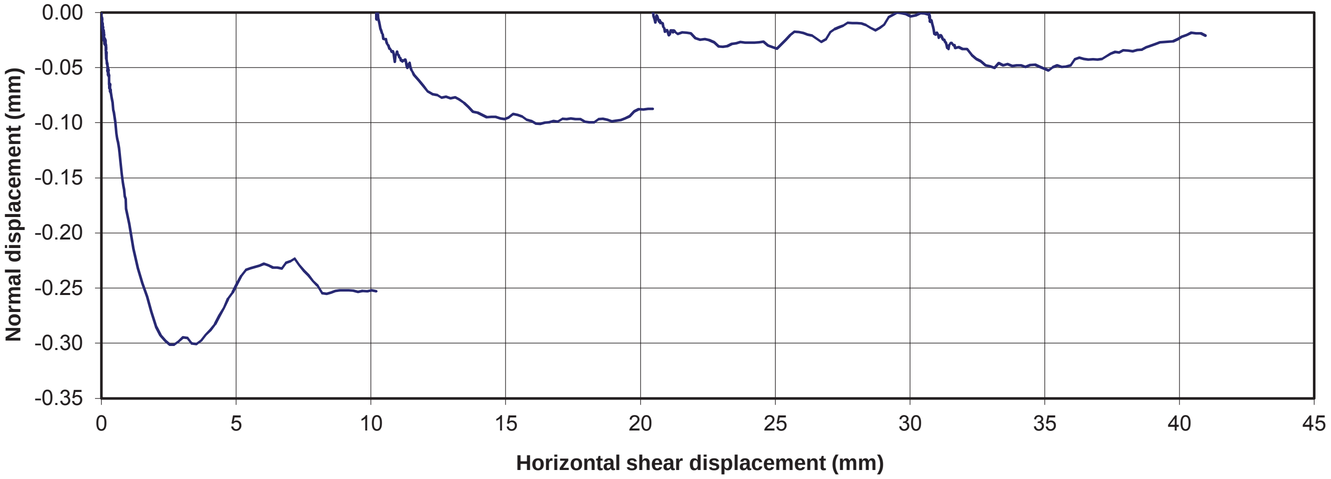
Sample: COS-13-004 004-8 7.01-7.62 m depth

Effective Stress:	75	kPa
Sample Data:		
Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	36.8	%
Initial Dry Density:	1329	kg/m^3
Final Water Content:	43.6	%

Peak Shear Stress:	47	kPa
Residual Shear Stress	13	kPa

Comments:





Reviewed by:

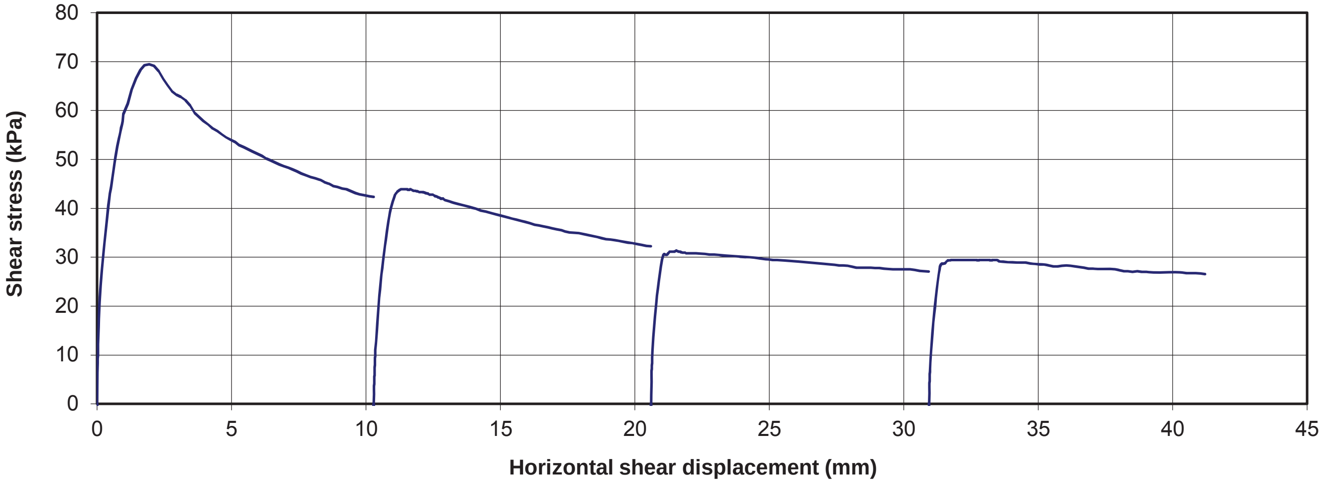
CONSOLIDATED DRAINED DIRECT SHEAR TEST

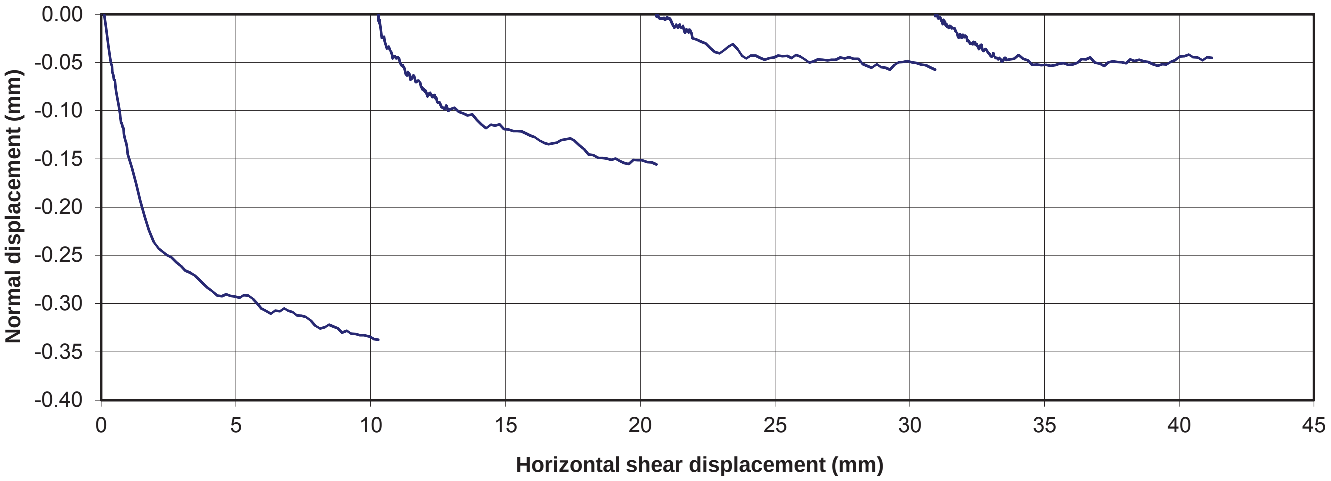
Project #: 11-1362-0057 Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested By: B.Y. / D.B. Date: November 10, 2013
Sample: COS-13-004 004-8 7.01-7.62 m depth

Effective Stress:	125	kPa
Sample Data:		
Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	35.0	%
Initial Dry Density:	1368	kg/m^3
Final Water Content:	38.6	%

Peak Shear Stress:	70	kPa
Residual Shear Stress	27	kPa

Comments:





Reviewed by:

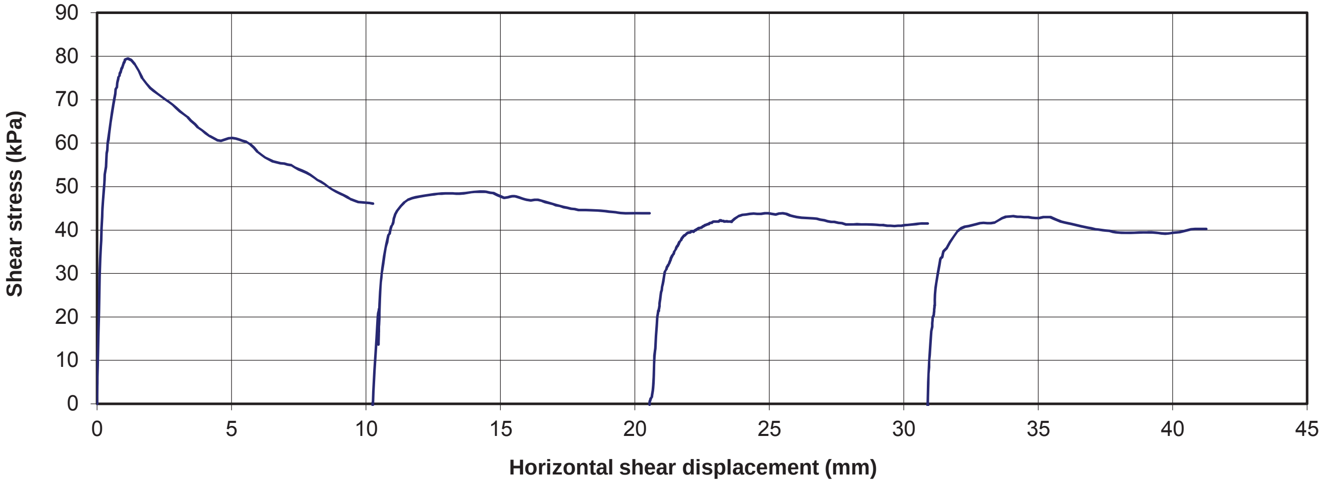
CONSOLIDATED DRAINED DIRECT SHEAR TEST

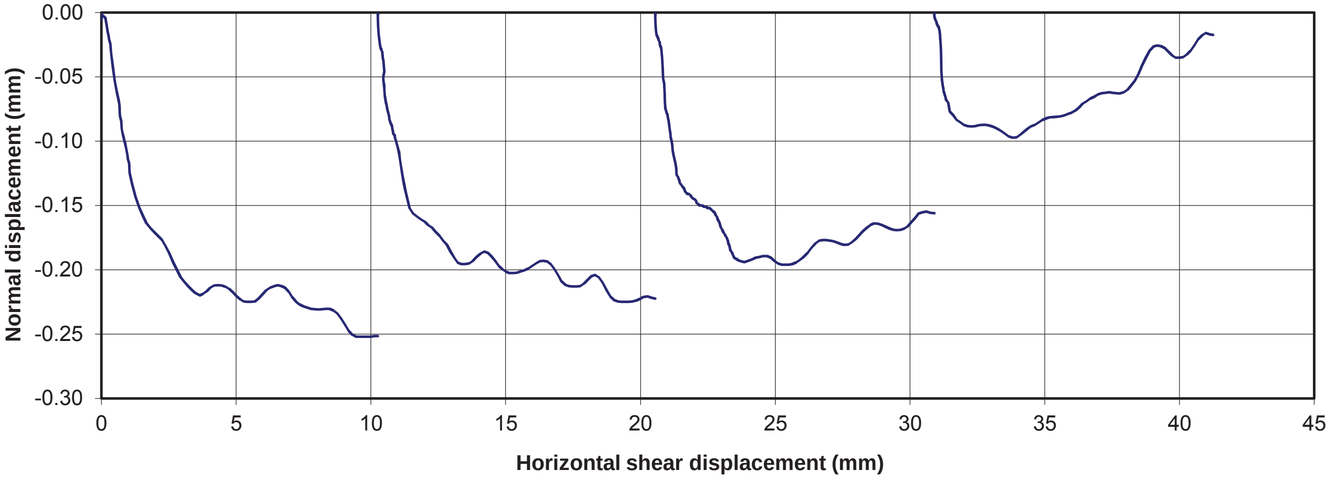
Project #:	11-1362-0057	Phase:	5100 / 4000
Short Title:	COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK		
Tested By:	B.Y. / D.B.	Date:	November 10, 2013
Sample:	COS-13-004 004-8 7.01-7.62 m depth		

Effective Stress:	200	kPa
Sample Data:		
Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	36.8	%
Initial Dry Density:	1356	kg/m^3
Final Water Content:	39.0	%

Peak Shear Stress:	80	kPa
Residual Shear Stress	40	kPa

Comments:





Reviewed by:

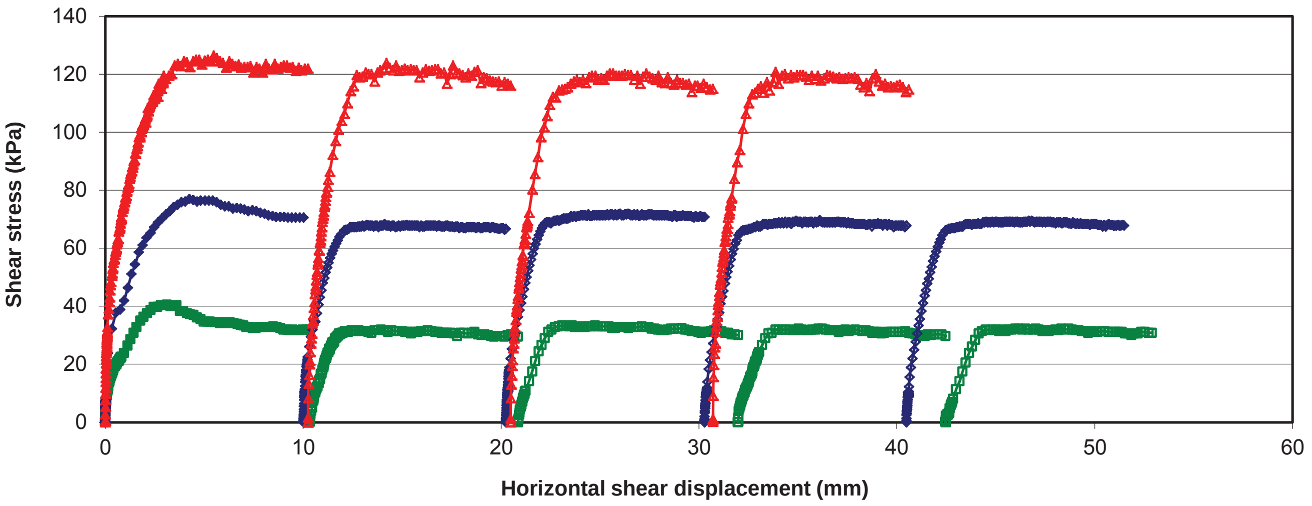
Golder Associates

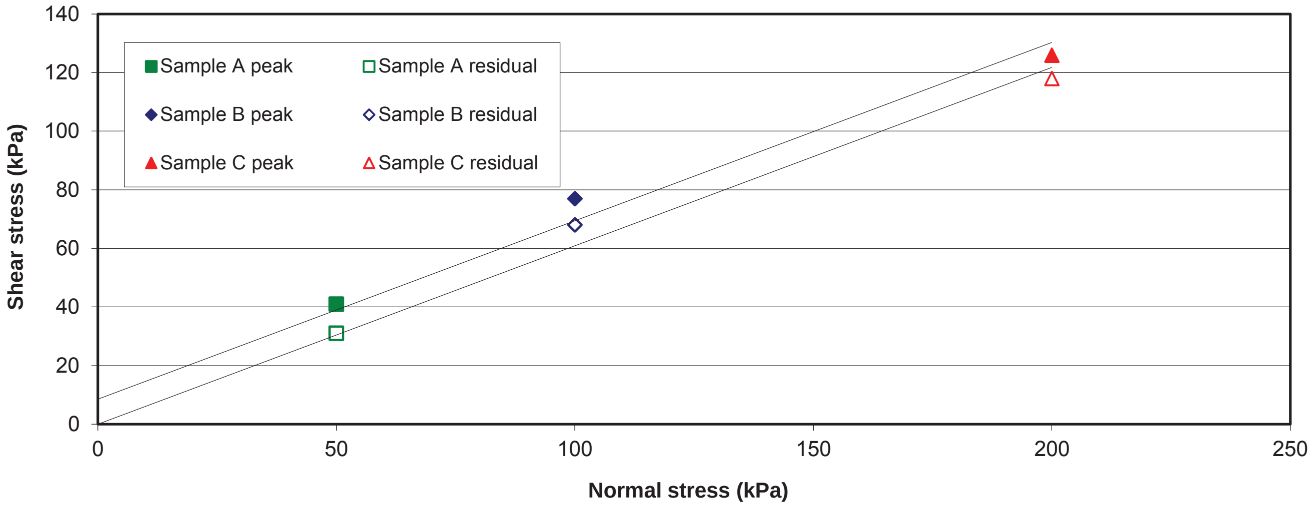
CONSOLIDATED DRAINED DIRECT SHEAR TEST-SUMMARY

Project #: 11-1362-0057 Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested By: B.Y. / D.B. Date: October 22, 2013

	Normal	Shear Stress	
Sample	Stress	Peak	Residual
	(kPa)	(kPa)	(kPa)
COS-13-005 005-13 11.43-12.04 m depth	50	41	31
	100	77	68
	200	126	118

	Peak	Residual
Friction angle (degrees):	31.3	31.3
cohesion (kPa):	9	0





Comments:

1721 8th Street E.,
Saskatoon, Saskatchewan, S7H 0T4

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Golder Associates

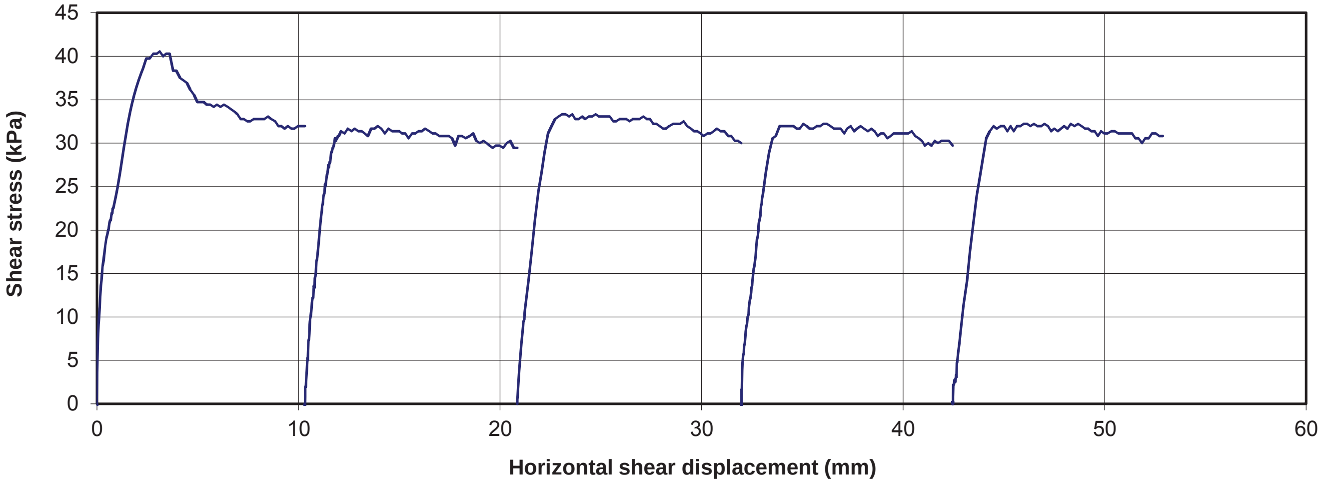
CONSOLIDATED DRAINED DIRECT SHEAR TEST

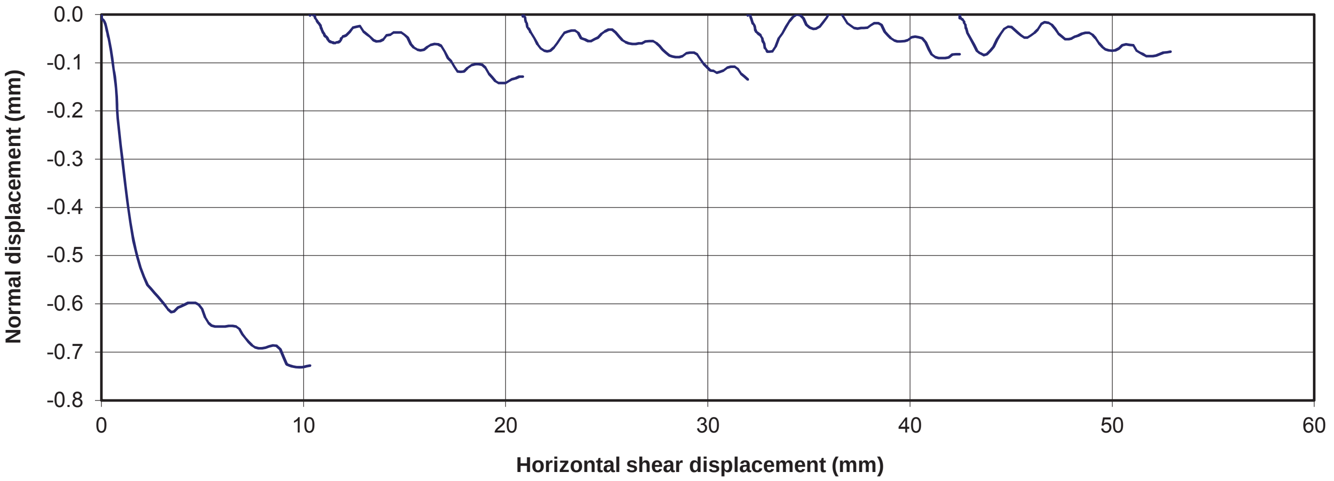
Project #:	11-1362-0057	Phase:	5100 / 4000
Short Title:	COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK		
Tested By:	B.Y. / D.B.	Date:	October 22, 2013
Sample:	COS-13-005 005-13 11.43-12.04 m depth		

Effective Stress:	50	kPa
Sample Data:		
Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	26.2	%
Initial Dry Density:	1512	kg/m^3
Final Water Content:	30.9	%

Peak Shear Stress:	41	kPa
Residual Shear Stress	31	kPa

Comments:





Reviewed by:

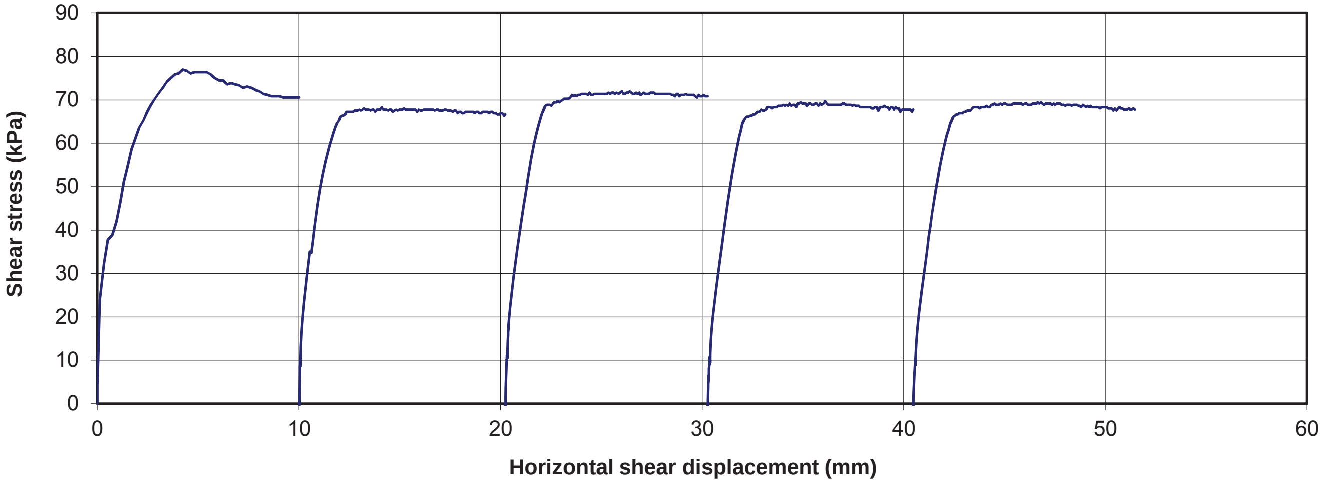
CONSOLIDATED DRAINED DIRECT SHEAR TEST

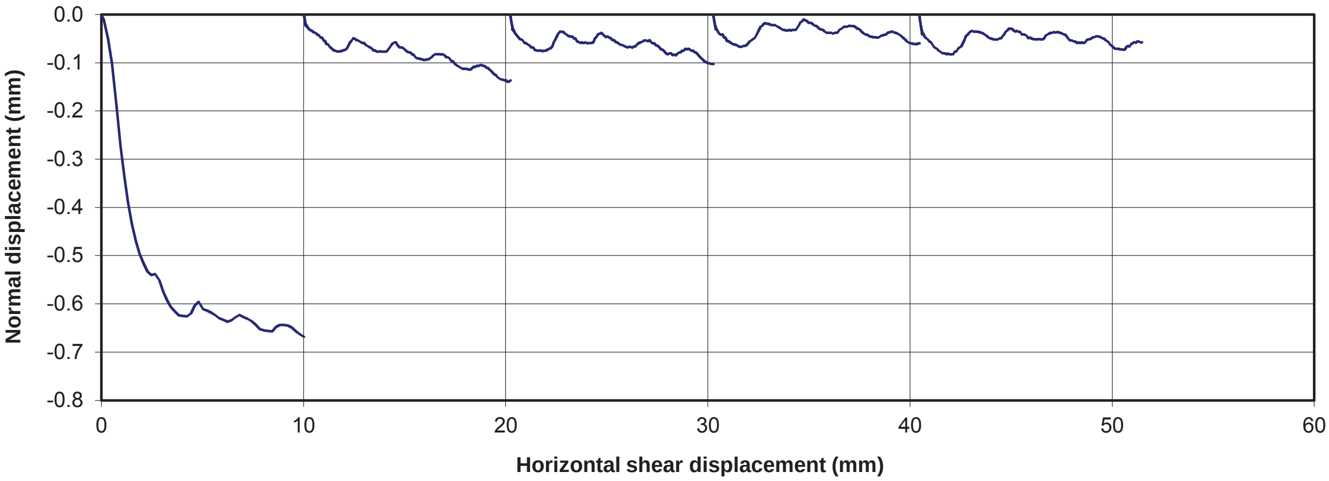
Project #: 11-1362-0057 Phase: 5100 / 4000
Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK
Tested By: B.Y. / D.B. Date: October 22, 2013
Sample: COS-13-005 005-13 11.43-12.04 m depth

Effective Stress:	100	kPa
Sample Data:		
Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	27.2	%
Initial Dry Density:	1507	kg/m^3
Final Water Content:	30.2	%

Peak Shear Stress:	77	kPa
Residual Shear Stress	68	kPa

Comments:





Reviewed by:

CONSOLIDATED DRAINED DIRECT SHEAR TEST

Project #: 11-1362-0057 Phase: 5100 / 4000

Short Title: COS East Riverbank / Cherry Lane - Geotech Investigation / Saskatoon, SK

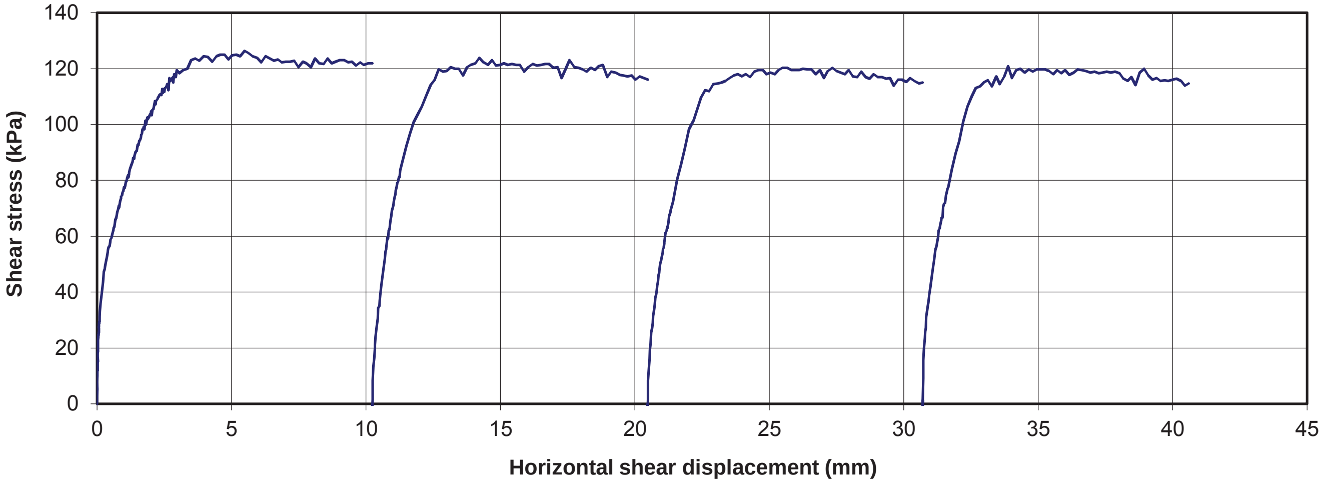
Tested By: B.Y. / D.B. Date: October 22, 2013

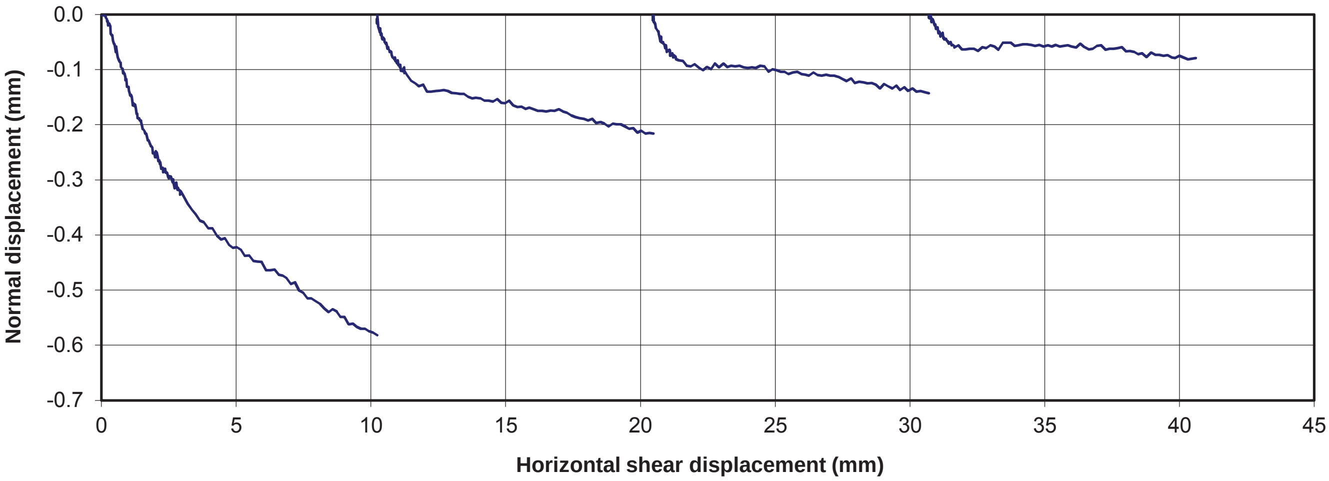
Sample: COS-13-005 005-13 11.43-12.04 m depth

Effective Stress:	200	kPa
Sample Data:		
Sample Length:	60.0	mm
Initial Height:	20.0	mm
Initial Water Content:	26.4	%
Initial Dry Density:	1507	kg/m^3
Final Water Content:	28.5	%

Peak Shear Stress:	126	kPa
Residual Shear Stress	118	kPa

Comments:





Reviewed by:

APPENDIX H

Cost Estimates for Conceptual Remediation Options

Conceptual Option	Description	Estimated Cost	Engineering (5-10%)	Monitoring (5%)	Contingency (50%)	Estimated Total Cost	Estimate Assumption (Average Dimensions)	Estimate Basis
1	Do Nothing							
2A	Dewatering - 11th St	$ 1,760,000	$ 180,000	$ 90,000	$ 880,000	$ 2,910,000	150 m long x 10 m deep	COS 17th Street (2013) ~$325K for drainage trench and street repairs, 80 m long x 4 m deep
2B	Dewatering - Cherry Lane	$ 880,000	$ 90,000	$ 50,000	$ 440,000	$ 1,460,000	150 m long x 5 m deep	COS 17th Street (2013) ~$325K for drainage trench and street repairs, 80 m long x 4 m deep
3	Slope Re-grading w/ drainage	$ 4,000,000	$ 200,000	$ 200,000	$ 2,000,000	$ 6,400,000	135 m long x 40 m2	COS 17th Street (2013) ~$880K for selective site demolition, 2 drainage trenches, landscaping, excavation, 80 m long x 4 m deep x 15 m wide. Does not include purchase or demolition of residential property
4A	Shear Zone Modification - CSM w/ drainage	$ 5,810,000	$ 300,000	$ 300,000	$ 2,905,000	$ 9,315,000	10 m long x 6 m deep x 4 m wide; 50 m long x 5 m deep x 13 m wide; 60 m long x 7 m deep x 4 m wide	CSM Slurry Wall ~$250/m2 or $2.5M/km (0.9 m wide trench), assume cement cost is 1.8:1 for bentonite, not including platform construction. COS 17th Street (2013) ~$580K selective site demo, drainage systems and landscaping.
4B	Shear Zone Modification - Shear Key w/drainage	$ 6,520,000	$ 330,000	$ 330,000	$ 3,260,000	$ 10,440,000	10 m long x 6 m deep x 4 m wide; 50 m long x 5 m deep x 13 m wide; 60 m long x 7 m deep x 4 m wide	Cosmo Park (2009) ~$2M for shear key construction, 150 m long x 5 m deep x 6 m wide, assume 7% inflation. COS 17th Street (2013) ~$500K for 2 drainage systems. Assume $1.35M for temporary shoring

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Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

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