P. MACHIBRODA ENGINEERING LTD.

CONSULTING
GEOTECHNICAL
GEOENVIRONMENTAL
ENGINEERS AND
GEOSCIENTISTS

SASKATOON
806 – 48TH STREET EAST
SASKATOON, SK
S7K 3Y4

PHONE:
(306) 665-8444
FAX:
(306) 652-2092

E-MAIL:
pmel.sk@machibroda.com

WEB:
www.machibroda.com

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GEOTECHNICAL INVESTIGATION AND SLOPE STABILITY STUDY EAST BANK SOUTH SASKATCHEWAN RIVER OUTLOOK, SASKATCHEWAN

PMEL FILE NO. 9551
AUGUST 31, 2015

PREPARED FOR:

TOWN OF OUTLOOK
BOX 518
OUTLOOK, SASKATCHEWAN
S0L 2N0

ATTENTION: MR. TRENT MICHELMAN

EXECUTIVE SUMMARY

P. Machibroda Engineering Ltd. (PMEL) was authorized by the Town of Outlook to complete a slope stability study for the East Bank of the South Saskatchewan River, proximate the Skytrail Bridge, in Outlook, Saskatchewan.

The existing East Bank of the South Saskatchewan River was a historical landslide and recent slope movement has been due to the reactivation of the historical landslide. The slope movement has damaged the Skytrail Bridge, residential homes and other infrastructure on the slope or near the crest of slope.

The primary cause that initiated the recent movement is difficult to determine due to the complexity of the slope. It is likely due to a combination of factors, including (but not limited too), erosion along the river (i.e., change of river flow), increase in groundwater level (i.e., irrigation, increase precipitation, etc.), and surcharge loading on slope and at crest of slope (i.e., fill placement, bridge piers, etc.).

A geotechnical investigation and instrumentation installation was carried out to determine the soil and groundwater conditions, location of shear plane, and rate of slope movement. The slope monitoring measured an active shear plane at a geodetic elevation of approximately 475 to 476 metres (approximately 60 metres below crest of slope and 20 meters below the river elevation). Slope movement of approximately 25 and 43 mm was measured between April, 2015 and August 2015 in SI 15-1 and SI 15-2 respectively.

Based on the investigation and monitoring it was theorized that the slope was at or slightly less than equilibrium. A number of remedial options were considered to increase the stability of the slope. Due to the size of the landslide and depth of the slip plane, lowering of the groundwater table was considered as the only feasible option for increasing the stability of the slope. Further investigation and analysis would be required to determine the feasibility of this remedial option.

If efforts are not made to stabilize the slope, the slope movement will likely to continue and potentially regress further upslope of the crest of slope and impact properties and infrastructure. A comprehensive monitoring program is recommended to continue monitoring slope movement and provide the necessary information to stakeholders to make decisions regarding infrastructure and properties.

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1.0 INTRODUCTION

1.1 General

The following report has been prepared on the results of a geotechnical investigation and slope stability study conducted for the East Bank of the South Saskatchewan River, proximate the Skytrail Bridge, in Outlook, Saskatchewan.

Authorization to proceed with this investigation was provided on September 16, 2015 via the signed Consulting Agreement. The Terms of Reference for this investigation were presented in P. Machibroda Engineering Ltd. (PMEL) Proposal No. 0510-6655REV2, dated September 16, 2014.

The field test drilling and sampling were conducted between December 11 and 12, 2014, March 24 and 25, 2015, and April 6, 7 and 9, 2015. Groundwater level monitoring and slope inclinometer readings were conducted between January 23, 2015 and August 20, 2015.

1.2 Background Information

PMEL completed a slope stability study of the East Bank of the South Saskatchewan River within the area of the Skytrail Bridge in 2008 (refer to PMEL File No. S08-6559, report dated November 19, 2008. The purpose of the study was to assess the slope stability of the slope and quantify the risk to existing infrastructure.

The study theorized that the slope was meta-stable (i.e., at or near a Factory of Safety of 1.0) the probable failure mode was a deep seated composite surface. It was recommended that a slope inclinometer(s) be installed to accurately determine the elevation of the slip plane and determine the rate of lateral slope movement.

PMEL also completed a slope stability study in 1986/1987 as part of the geotechnical investigation for the existing swimming pool located immediately south of the Bridge (refer to PMEL File No. S87-1123, dated January 8, 1987). The study identified that the pool was located on a historical landslide that had marginally stabilized due to deposition of river alluvium. The report also noted that surficial slumping had occurred along the river banks and at the crest of slope (due to placement of fill on residential properties), and slight changes in the slope conditions could re-initiate slope movement.

1.3 Visual Site Review

Mr. Graham Baxter, P.Eng. of PMEL conducted a visual site inspection of the subject site on June 30, 2014. It was observed that there had been continual slope movement (as originally noted in PMEL's initial slope stability study) within the area of the Skytrail Bridge. Additional slope movement and instability (in the form of tension cracks and leaning trees) was observed along the crest of the slope to the north and south of the Skytrail Bridge. The Bridge had been damaged and closed to pedestrian traffic due to movement of the Bridge piers based on the slope.

Evidence of slope instability affecting properties along Tufts Crescent, in the form of tension cracking, leaning tress and downward movement of residential houses (resulting breakage of a sanitary sewer line of one property and differential downward movement of another), was also observed. It is suspected that the houses are within a secondary failure block that is developing.

2.0 FIELD INVESTIGATION

Four (4) test holes, located as shown on the Site Plan, Drawing No. 9551-1, were drilled using our powered auger equipment. Test Hole Nos. SI 14-1 and 14-1A were 150 mm in diameter, dry drilled using our truck-mounted continuous flight auger drilling equipment and extended to depths of 40.5 and 8.5 below existing ground surface, respectively. Test Hole Nos. SI 15-1 and SI 15-2 were 100 mm in diameter, drilled using our track-mounted air rotary drilling equipment and extended to depths of 61.5 and 67 metres below existing ground surface, respectively.

Test hole drill logs were compiled during test drilling to record the soil stratification, the groundwater conditions, the position of unstable sloughing soils and the depths at which cobblestones and/or boulders were encountered.

Both disturbed and undisturbed samples were collected during test drilling. Disturbed samples of auger cuttings and drill cuttings, collected during test drilling, were sealed in plastic bags to minimize moisture loss. The soil samples were taken to our laboratory for analysis. Undisturbed soil samples were collected by hydraulically pushing a thin walled (Shelby) tube into the bottom of the test hole as drilling advanced. The Shelby tubes were sealed in polyethylene to minimize moisture loss.

A standpipe piezometer (slotted, 50 mm PVC pipe) was installed in Test Hole No. 14-1A, to monitor groundwater levels.

Slope inclinometer casing (85 mm diameter) was installed in Test Hole Nos. SI 14-1, SI 15-1 and SI 15-2 to monitor horizontal ground movement.

3.0 FIELD DRILL LOGS

The field drill logs recorded during test drilling have been shown plotted on Drawing Nos. 9551-2 to 5A, inclusive.

A survey of the subject site was completed by PMEL on July 9, 2015 using handheld Global Positioning Equipment (Trimble, Model No. GeoXH 6000).

3.1 Soil Profile

In general, the subgrade soil conditions consisted of a silt and/or sand deposit overlying glacial till followed by clay shale, which extended to a depth of at least 67 metres below existing grade, the maximum depth explored with our test holes at this site. A silt and sand deposit was encountered between the depths of approximately 49 and 64 metres below existing grade in Test Hole No. SI 15-2.

3.2 Groundwater Conditions and Sloughing

Groundwater seepage and sloughing conditions were encountered during test drilling. The depths at which groundwater seepage and sloughing conditions were encountered have been shown on the field drill logs, as shown on Drawing Nos. 9551-2 to 5E, inclusive. A summary of the groundwater levels recorded in the standpipe piezometers installed during this investigation and the 2008 investigation has been presented in Table I.

TABLE I. RECORDED GROUNDWATER LEVELS

Test Hole No.	Piezometer Rim Elevation* (metres)	Ground Surface Elevation* (metres)	Recorded Groundwater Levels (metres)			
			November 17, 2008	June 4, 2015	July 9, 2015	August 20, 2015
08-1*	513.0	512.0	496.5	506.8	506.7	506.7
08-4*	507.5	506.7	498.7	498.7	498.5	498.5
14-1A	537.7	536.7	--	532.4	532.5	532.9

*Piezometers installed in PMEL's 2008 investigation (S08-6559)

Based on the results of the groundwater monitoring, the groundwater table was situated between approximately 3.8 to 7 metres below existing grade on August 20, 2015. Higher water levels should be expected during and/or following spring snowmelt and/or periods of precipitation.

A comparison of the 2008 and 2015 water levels recorded in Test Hole Nos. 08-1 and 08-4 revealed that the groundwater levels have remained unchanged in Test Hole No. 08-4. However, the groundwater levels have risen approximately 10 metres in the last 7 years in Test Hole No. 08-1.

3.3 Cobblestones and Boulders

The glacial till consisted of a heterogeneous mixture of gravel, sand, silt and clay-sized particles. A random distribution of larger particle sizes in the cobblestone range (60 to 200 mm) and boulder-sized range (larger than 200 mm) should be expected at the subject site.

It should be recognized that the statistical probability of encountering cobblestones and/or boulders in the four small diameter Test Holes conducted at this large site was low. Intertill deposits of cobblestones, boulders, boulder pavements and isolated deposits of saturated sand or gravel should be anticipated. The frequency of encountering such deposits will increase proportionately with the number of piles installed or volume of soil excavated.

3.4 Slope Inclinometer Survey

The results of the slope inclinometer readings have been shown plotted in Appendix B. The baseline slope inclinometer readings for Slope Inclinometer No. SI 14-1 was on January 23, 2015 and four (4) subsequent readings were conducted between April 29, 2015 and August 20, 2015. The baseline slope inclinometer readings for SI Nos. 15-1 and 15-2 were April 29, 2015, and three (3) subsequent readings were conducted between June 4, 2015 and August 20, 2015.

The summarized cumulative displacement and incremental change of the slope indicator readings have been presented as “Profile Change” and “Tilt Change” on the slope inclinometer plots, respectively.

An examination of the SI 15-1 and 15-2 plots revealed that some slope movement (total cumulative displacement of approximately 25 mm and 43 mm, respectively) has occurred between April 29, 2015 and August 20, 2015. SI 15-1 has recorded approximately 25 mm of lateral movement in the northwest direction and SI 15-2 has recorded approximately 43 mm movement in the west - southwest direction. The plots revealed that the slip plane was located approximately 32 and 36.5 metres below existing grade (Geodetic Elevations of 475.7 and 476.5 metres) in SI 15-1 and 15-2 respectively.

An examination of the SI 14-1 plots revealed some slight movement recorded between January 23, 2015 and August 20, 2015. However, the magnitude of movement was nearly indiscernible and no clear slip plane was captured at this location. SI 14-1 may not have been installed deep enough to accurately capture a slip plane.

4.0 LABORATORY ANALYSIS

The soil classification and index tests performed during this investigation consisted of a visual classification of the soil, water contents, unconfined compressive strength, Atterberg limits, unit weight and direct shear strength testing.

The results of soil classification and index tests conducted on representative samples of soil recovered from this site have been plotted alongside the depth at which the samples were recovered as shown on Drawing Nos. 9551-2 to 5E, inclusive.

The results of the direct shear strength testing and grain size distribution analysis have been presented in Appendix C.

5.0 SLOPE STABILITY ANALYSIS

5.1 Possible Cause of Slope Movement

The East Bank of the South Saskatchewan River along the west side of the Town of Outlook was a historical landslide. The recent observed slope movement has been due to the reactivation of the historical landslide. The reasons for reactivation of the landslide are difficult to determine, due to the complexity of the slope and was likely a result of a number of different conditions impacting the slope. Conditions that could have impacted the stability of the slope include, but not limited to, erosion along the river, increase in groundwater conditions and urban development. Due to the size of the landslide and the marginal stability of the slope, as noted in the past, slight changes in the slope conditions can re-initiate slope movement.

Based on historical aerial photographs, the flow of the South Saskatchewan River has changed significantly since 1949. Sometime between 1960 and 1965 a dyke (extended sometime after 1970) was constructed upstream of the west bridge abutment of the Skytrail Bridge. The dyke extends approximately 350 metres perpendicular across the river from the west bank. Since the construction of the dyke the river flow has narrowed against the east bank of the river likely causing some erosion of the river bank and removal of alluvium deposits in the bed of the river. This unloading of material at the toe of the slope would have negatively impacted the stability of the slope, however the magnitude of erosion and its impact is difficult to quantify.

A rise of the groundwater level in the slope would negatively impact the stability of the slope. Fluctuations in the groundwater level are typically attributed to climate changes (i.e., increase or decrease in precipitation and snowmelt), urban development (i.e., irrigation) and changes in upland land use.

A comparison of the water levels in the 2008 piezometers revealed no change in the groundwater level of Test Hole 08-4, but a significant rise (10 metres) was noted in Test Hole 08-1 since 2008. No monitoring of the piezometers was conducted between 2008 and 2015. As such, it is difficult to establish trends in the groundwater conditions in the slope.

The construction of residential lots and roadways, bridges and utilities, on and at the crest of the slope could impact the stability of the slope. This type of development affects slope stability by, but not limited to, altering drainage paths, groundwater discharge or recharge, removal of vegetation (affects infiltration rate of surface water into the soil) and site grading (adding fill to crest of slope or removal of soil from toe of slope).

5.2 Theoretical Slope Stability Analysis

The theoretical slope stability analysis was performed using the SLOPE/W computer program available through Geo-Slope International Ltd.[1] The Morgenstern-Price Method of slices was used for all analysis (utilizing a half-sine side force function).

5.2.1 Surface Geometry

The surface geometry of the subject site was interpreted from elevation locations surveyed by PMEL on July 9, 2015 using handheld Global Positioning Equipment (Trimble, Model No. GeoXH 6000).

The slope was approximately 45 metres in height with an average slope gradient of approximately 5 to 7 degrees.

[1] Geo-Slope International Ltd., 2007. Slope/W User's Manual, A Comprehensive Program for Slope Stability Analysis, Geo-Slope International Ltd., Calgary, Alberta.

5.2.2 Soil Stratigraphy

The stratigraphic units as well as the lithologic boundaries were interpreted based on the results of the drilling investigations conducted by PMEL. The slope was analyzed for circular and composite failures.

5.2.3 Piezometric Conditions

The piezometric conditions used for the slope stability analysis were inferred from the groundwater levels recorded during this investigation. A hydrostatic pore pressure condition was used for the analysis.

It should be noted that the inferred groundwater conditions in the slope analysis was simplified and may not reflect actual conditions. The modelled groundwater conditions assumed one groundwater level impacting the entire soil profile.

5.2.4 Soil Properties

The soil properties obtained during this investigation as well as the design strength parameters used for the theoretical slope stability analysis have been presented in Table II. The soil strength parameters selected for analysis were based on published strength parameters, laboratory testing on soil samples collected during this investigation and a back analysis of the historical slope failure (see Section 5.3).

TABLE II. SOIL PARAMETERS FOR ANALYSIS

Material Type	Total Unit Weight (kN/m^3)	Effective Unit Cohesion (kPa)	Effective Internal Angle of Friction (Degrees)
Silt/Sand	18.5	0	30
Glacial Till	21.5	25	25
Clay Shale	18.5	25	25
Residual Clay Shale*	18.5	0	6
Bedrock - Impenetrable	--	--	--

5.3 Back Analysis

The Factor of Safety of a slope is defined as the ratio of the available shear strength of the soil, to the minimum shear strength required to maintain stability. A Factor of Safety of less than or equal to 1.0 would indicate the potential for slope failure.

Based on the size of the landslide and measured movement of the slope, it is assumed that the slope is at or slightly less than equilibrium (active creep movement), indicated by a Factor of Safety of 1 or slightly less. A back analysis of the slope was performed to assess the soil strength properties of the soil in order to assess the feasibility of possible stabilization (remedial) methods. It was assumed that the clay shale along the shear plane was at or near residual shear strength. The depth and thickness of the shear plane was interpreted from the SI readings in SI 15-1 and 15-2.

Based on the back analysis, the slope at Section A-A' (Skytrail Bridge) and Section B-B' (Truft Crescent) had Factors of Safety of slightly less than 1.0 and 0.9, respectively. This indicates that the slope is at slightly less than equilibrium. The results of the back analysis have been shown on Drawing Nos. D-1 and D-2.

5.4 Remedial Options

A number of conceptual remedial options were considered to stabilize the slope, these included, slope flattening, lowering the groundwater table, shear key, toe loading (i.e., buttress), erosion control (i.e., river bank armouring) and shear zone reinforcement (i.e., shear piles).

Due to the size of the landslide and depth of the slip plane, slope flattening, construction of a shear key, placement of a buttress, and/or shear zone reinforcement are not considered feasible or possible options to stabilize the slope (both from an economic or constructability standpoint). Lowering the groundwater table, via the installation of sub-horizontal drains, could be a feasible option for increasing the slope stability.

Erosion control (i.e., river bank armouring) would likely not be sufficient to increasing stability of the slope, but should be considered to prevent further erosion along the river embankment. As further erosion would change the conditions of the slope and lower the probability, of any remedial option, in stabilizing the slope.

To analyze the effectiveness of lowering the groundwater in improving the Factor of Safety of the slope, Stratigraphic Section A-A' and B-B' were both modelled by lowering the water table 20 metres below the measured groundwater level at the crest of slope. The 20 metre drop in the groundwater elevation was based on a reasonable drop using a passive drainage system (i.e., gravity drained). Based on the analyses, the Factor of Safety of the slope would increase from 1.0 to 1.2 (a 20% increase).

Factors of Safety of 1.3 to 1.5 are typically acceptable Factors of Safety for the long-term stabilization of a slope. A Factor of Safety of 1.5 is typically recommended for permanent buildings such as houses. As such, lowering the groundwater to a reasonable level may not increase the Factor of Safety of the slope to a typical acceptable level. However, considering the size of the slope, a Factor of Safety of 1.2 could be sufficient in minimizing further slope movement enough to extend the service life of existing structures and utilities on the slope. Additionally it may also lessen the risk of the landslide regressing further upland and potentially damaging further properties and infrastructure.

An alternative to stabilization is the "do nothing" approach. Based on the stability analysis, the slope will continue to move. There is a high probability the slope movement may regress upslope and further impact properties and infrastructure. If no stabilization option is implement it is highly recommended that a comprehensive slope monitoring program is implement. The purpose of the monitoring program would be to regularly monitor movement of the slope via the slope inclinometers (more would be need to be installed) and survey monuments installed across the slope and on existing infrastructure. This will provide the necessary information to stakeholders to make decisions on infrastructure and properties (i.e., repairs to accommodate movement or location of new infrastructure).

5.5 Further Investigation and Analysis

A full year of readings of the slope inclinometers is recommended to establish the yearly movement rate of the slope at the location of the inclinometers. A deeper inclinometer is recommended at the crest of slope near Tuft Crescent.

Further recommendations have been summarized below for determining the feasibility of the above described dewatering remedial option, and what further instrumentation may be required to implement a long-term monitoring program.

5.5.1 Dewatering Remedial Option

The following further investigation, instrumentation and analysis are recommended to determine the feasibility of the recommended remedial option.

Installation of nested piezometers within the vicinity of the areas proposed to be stabilized. At a minimum one set at the crest of slope and one set mid-slope. Nested piezometers are monitoring wells that are installed at different depths at one location. The purpose of the nested piezometers is to determine if the groundwater conditions differ through the soil profile (i.e., perched conditions, confined aquifer, recharge area, etc.) and to perform slug tests to estimate the hydraulic conductivity of the soil profile. Slug tests consist of pumping the groundwater water level down in the piezometer and measuring the recovery rate to estimate the rate at which water moves through the soil profile.

Based on the results of the slug tests, a groundwater seepage analysis would be completed to determine the most feasible dewatering design.

PMEL can provide a detailed scope of work and budget cost estimate, for the above recommendations upon request.

5.5.2 Long-Term Monitoring Program

If a long-term monitoring program is implemented the following installation of instrumentation is recommended.

- Slope inclinometers (with vibrating water piezometers) at different locations on the slope to monitor the rate of slope movement;
- Survey monuments/settlement plates near and on existing infrastructure to measure vertical and horizontal movement; and
- Tilt plates and/or crack meters on existing infrastructure.

The extent and amount of instrumentation required will be dependent on the size of the area and type of infrastructure that would be encompassed in the monitoring program. PMEL can provide a scope of work and budget cost estimate upon request.

6.0 LIMITATIONS

The presentation of the summary of the field drill logs, geotechnical investigation and slope stability analysis has been completed as authorized. Four, 100/150 mm diameter test holes were completed at this site. A field drill log was compiled for each Test Hole during test drilling which, we believe, was representative of the subsurface conditions at the Test Hole locations at the time of test drilling.

Variations in the subsurface conditions from that shown on the drill logs at locations other than the exact Test Hole locations should be anticipated. If conditions should differ from those reported here, then we should be notified immediately in order that we may examine the conditions in the field and reassess our recommendations in the light of any new findings.

No detectable evidence (odor or staining) of environmentally sensitive materials was detected during the actual time of the field test drilling program. If, on the basis of any knowledge, other than that formally communicated to us, there is reason to suspect that environmentally sensitive materials may exist, then additional test holes should be drilled and samples recovered for chemical analysis.

The subsurface investigation necessitated the drilling of deep test holes. Instrumentation was installed in each test hole and the hole annulus was backfilled at the completion of test drilling. Please be advised that some settlement of the backfill materials will occur which may leave a depression or an open hole. It is the responsibility of the client to inspect the site and backfill, as required, to ensure that the ground surface at each Test Hole location is maintained level with the existing grade.

This report has been prepared for the exclusive use of Town of Outlook and their agents for specific application to the slope stability study conducted for the East Bank of the South Saskatchewan River, proximate the Skytrail Bridge, in Outlook, Saskatchewan. It has been prepared in accordance with generally accepted geotechnical engineering practices and no other warranty, express or implied, is made.

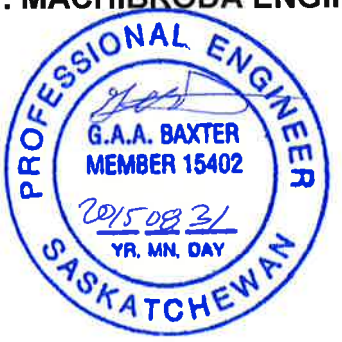
Any use which a Third Party makes of this report, or any reliance on decisions to be made based on it, is the responsibility of such Third Party. Governing Agencies such as municipal, provincial, or federal agencies having jurisdictions with respect to this development and/or construction of the facilities described herein have full jurisdiction with respect to the described development. Any other unspecified subsequent development would be considered Third Party and would, therefore, require prior review by PMEL. PMEL accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

The acceptance of responsibility for the design/construction recommendations presented in this report are contingent on adequate and/or full time inspection (as required, based on site conditions at the time of construction) by a representative of the Geotechnical Consultant. P. Machibroda Engineering Ltd. (PMEL) will not accept any responsibility on this project for any unsatisfactory performance if adequate and/or full time inspection is not performed by a representative of PMEL.

If this report has been transmitted electronically, it has been digitally signed and secured with personal passwords to lock the document. Due to the possibility of digital modification, only originally signed reports and those reports sent directly by PMEL can be relied upon without fault.

We trust that this report fulfills your requirements for this project. Should you require additional information, please contact us.

P. MACHIBRODA ENGINEERING LTD.



Graham Baxter, P.Eng.

K. Pardoski

Kelly Pardoski, P. Eng.

GB:KP:zz

Association of Professional Engineers & Geoscientists of Saskatchewan
CERTIFICATE OF AUTHORIZATION
P. MACHIBRODA ENGINEERING LTD.
Number 172
Permission to Consult held by:

Discipline	SK. Reg. No.	Signature
Geotechnical	15402	2015-08-31

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ENGINEERS

DRAWINGS

NOTE:
1. THIS DRAWING IS FOR CONCEPTUAL PURPOSES ONLY. ACTUAL LOCATIONS MAY VARY AND NOT ALL STRUCTURES ARE SHOWN.
2. THIS DRAWING WAS COMPILED FROM GOOGLE EARTH ©2014, IMAGE ©2014 DIGITALGLOBE, (IMAGERY DATE: (10/09/13).
3. SITE WAS SURVEYED BY PMEL ON DECEMBER 11, 2014; MARCH 24, 25 2015; APRIL 6, 7, 29, 2015 USING TRIMBLE GEO XH6000 GEOEXPLORER GPS EQUIPMENT.

LEGEND

- PMEL TEST HOLE (PIEZOMETER INSTALLED) (S08–6559)
- PMEL TEST HOLE (PIEZOMETER INSTALLED)
- PMEL SLOPE INCLINOMETER

P. MACHIBRODA ENGINEERING LTD.

CONSULTING
GEOENVIRONMENTAL
GEOTECHNICAL
ENGINEERS

806 – 48th STREET EAST
SASKATOON, SK
S7K 3Y4

DRAWING TITLE:
SITE PLAN - TEST HOLE LOCATIONS

PROJECT:
SLOPE STABILITY STUDY - EAST BANK
SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

APPROVED BY:	DRAWN BY:
GB	TP
DATE: JULY, 2015	DRAWING NUMBER: 9551-1
SCALE: AS SHOWN	

INCLINOMETER. ELEV.= 537.7 m
ROADBOX

TEST HOLE SI 14-1

ELEV: 536.7 m

DEPTH (m)	N	U	γ_w	Pw	Lw	w	
0		pp					**TOPSOIL,** organic, moist, brownish black, rootlets.
							SILT, some clay, stiff, low plastic, moist, brown.
1						13.9	
							GLACIAL TILL, clay, some silt, some sand, trace gravel, very stiff, medium plastic, moist, brown.
2							—oxide staining 1.6 m to 8.0 m.
							CEMENT/BENTONITE GROUT
3						10.4	
4							—very stiff below 4.0 m.
						11.2	
							85 mm diam. SLOPE INCLINOMETER
5							
6						12.2	
7							
8						12.1	
						21.8	**SAND,** loose, poorly graded, fine to medium grained, wet, brown, seepage, sloughing.
9						16.4	**GLACIAL TILL,** clay, some silt, some sand, trace gravel, very stiff, medium plastic, moist, brownish grey.
							—oxide staining 8.7 m to 37.0 m.
10						16.3	
11							
	14	43				17.8	—hard below 12.0 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

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

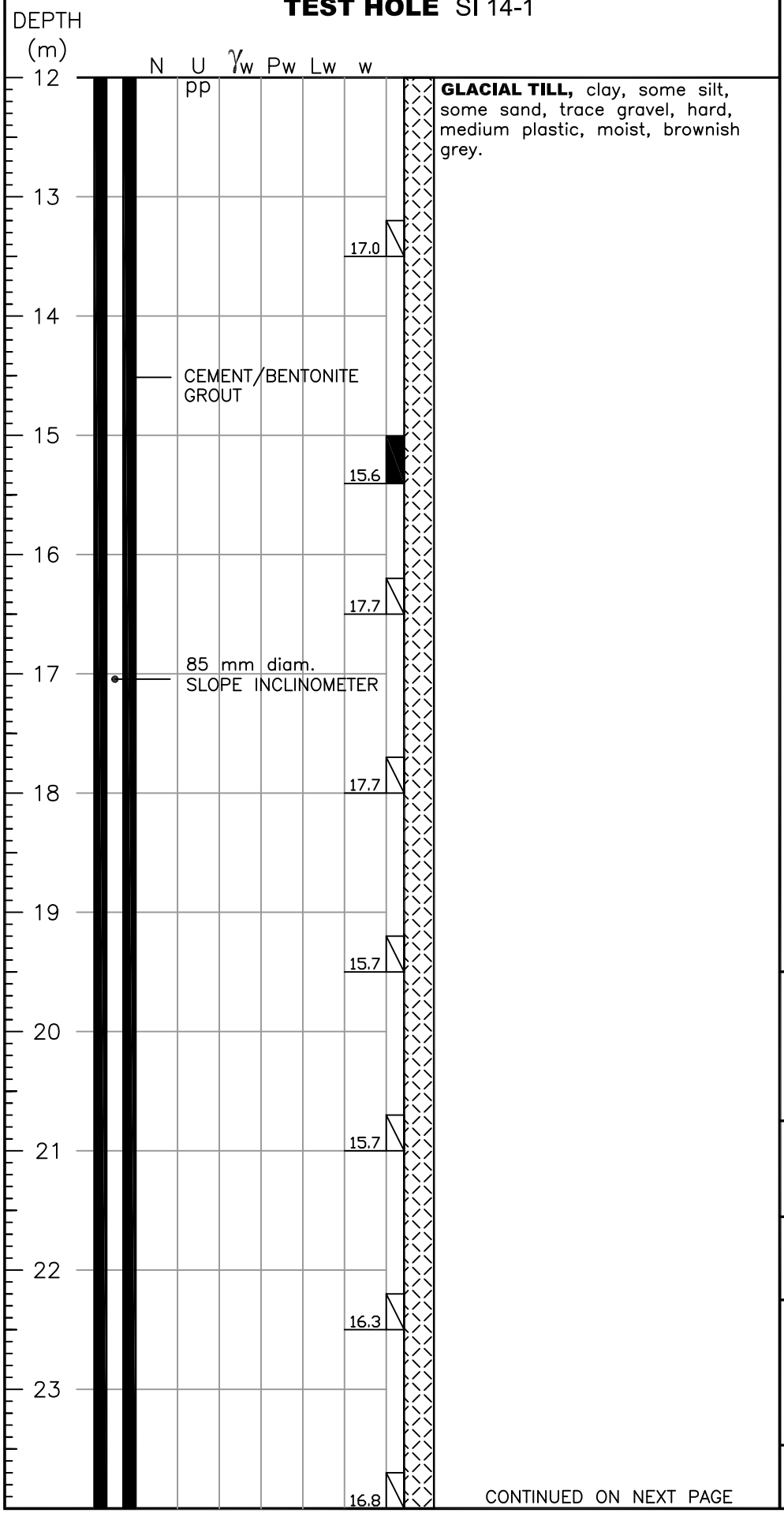
PROJECT:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	**DRAWING NUMBER:**
DEC 11/14	9551-2

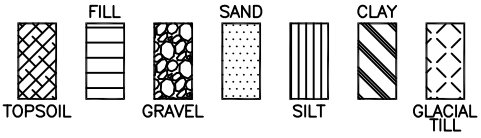
TEST HOLE SI 14-1



GLACIAL TILL, clay, some silt, some sand, trace gravel, hard, medium plastic, moist, brownish grey.

CONTINUED ON NEXT PAGE

LEGEND:



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)

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

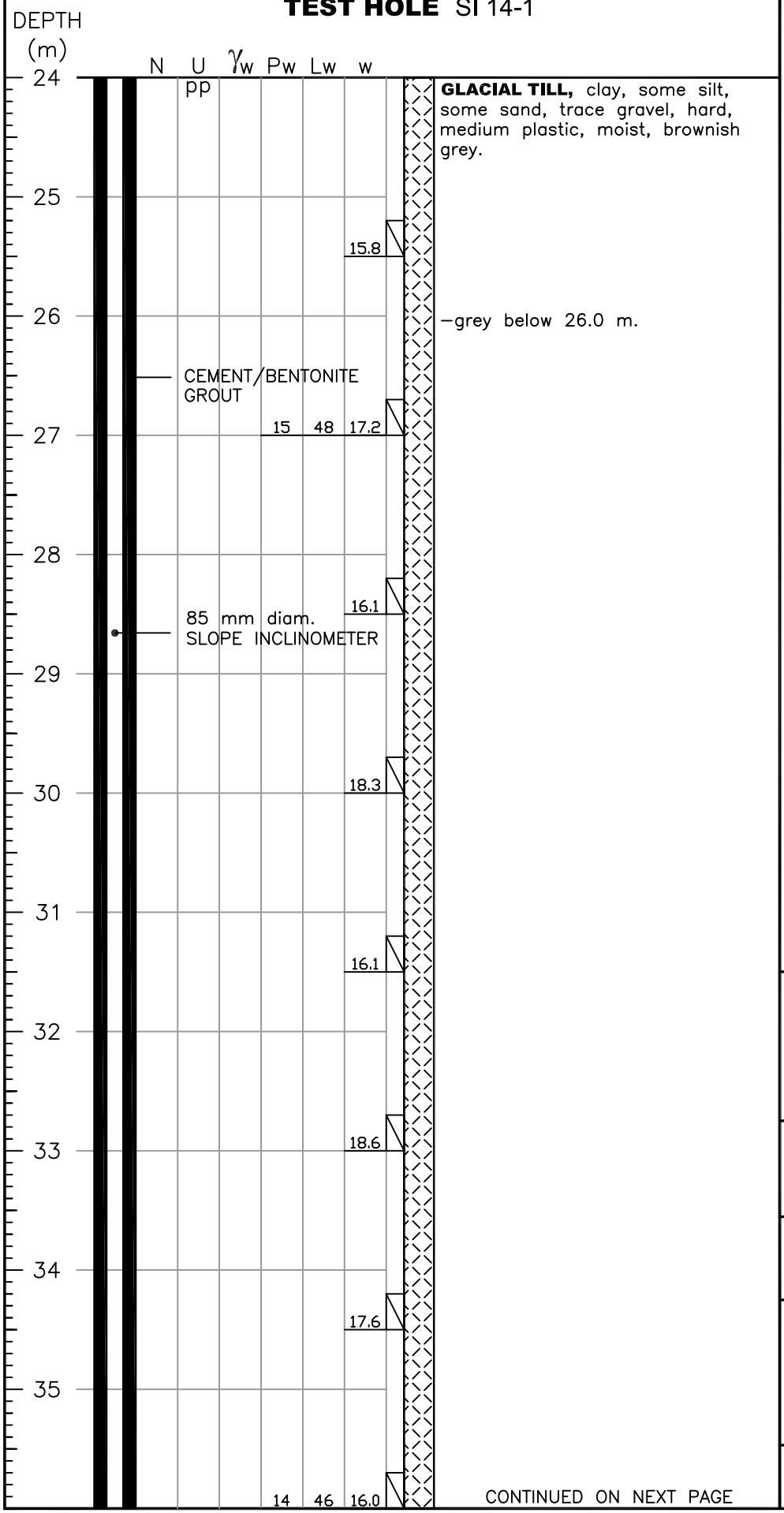
PROJECT:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

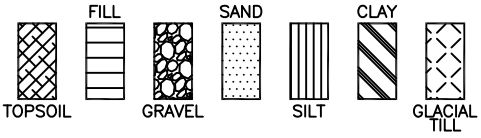
NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
DEC 11/14	9551-2A

TEST HOLE SI 14-1



LEGEND:



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)

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

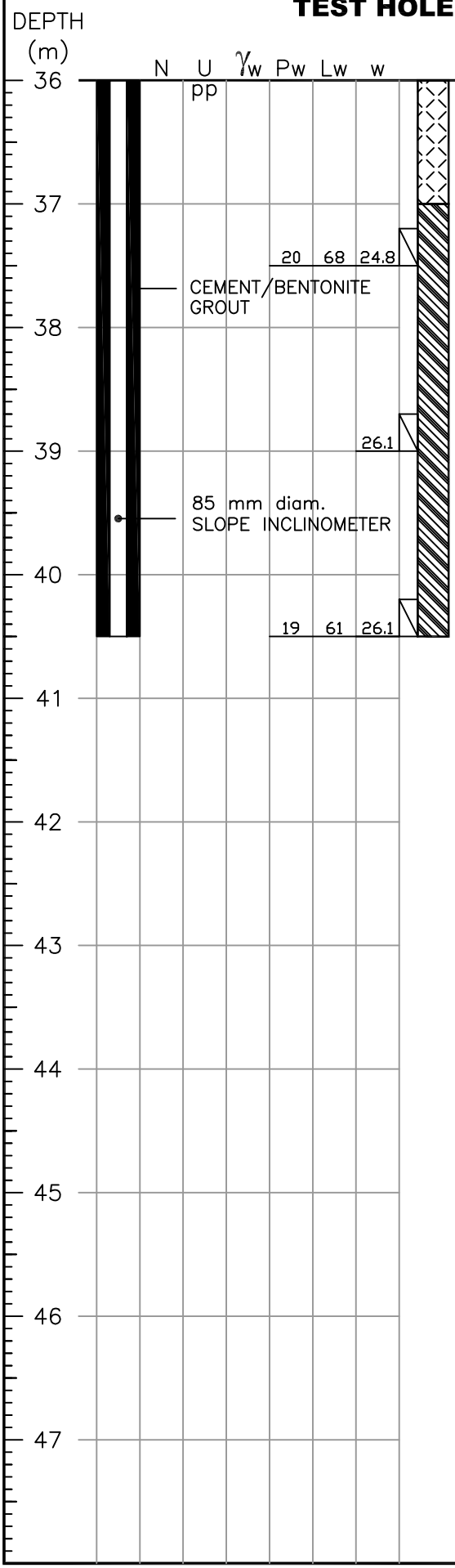
PROJECT:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	**DRAWING NUMBER:**
DEC 11/14	9551-2B

TEST HOLE 14-1

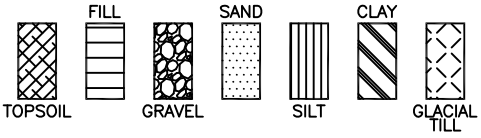


GLACIAL TILL, clay, some silt, some sand, trace gravel, hard, medium plastic, moist, grey.

CLAY SHALE, clay, some silt, hard, highly plastic, moist, mottled brown.

NOTE:
1. Test Hole open to 4.5 m I.A.D.
2. Hollow stem to 10.5 m.

LEGEND:



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)

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.

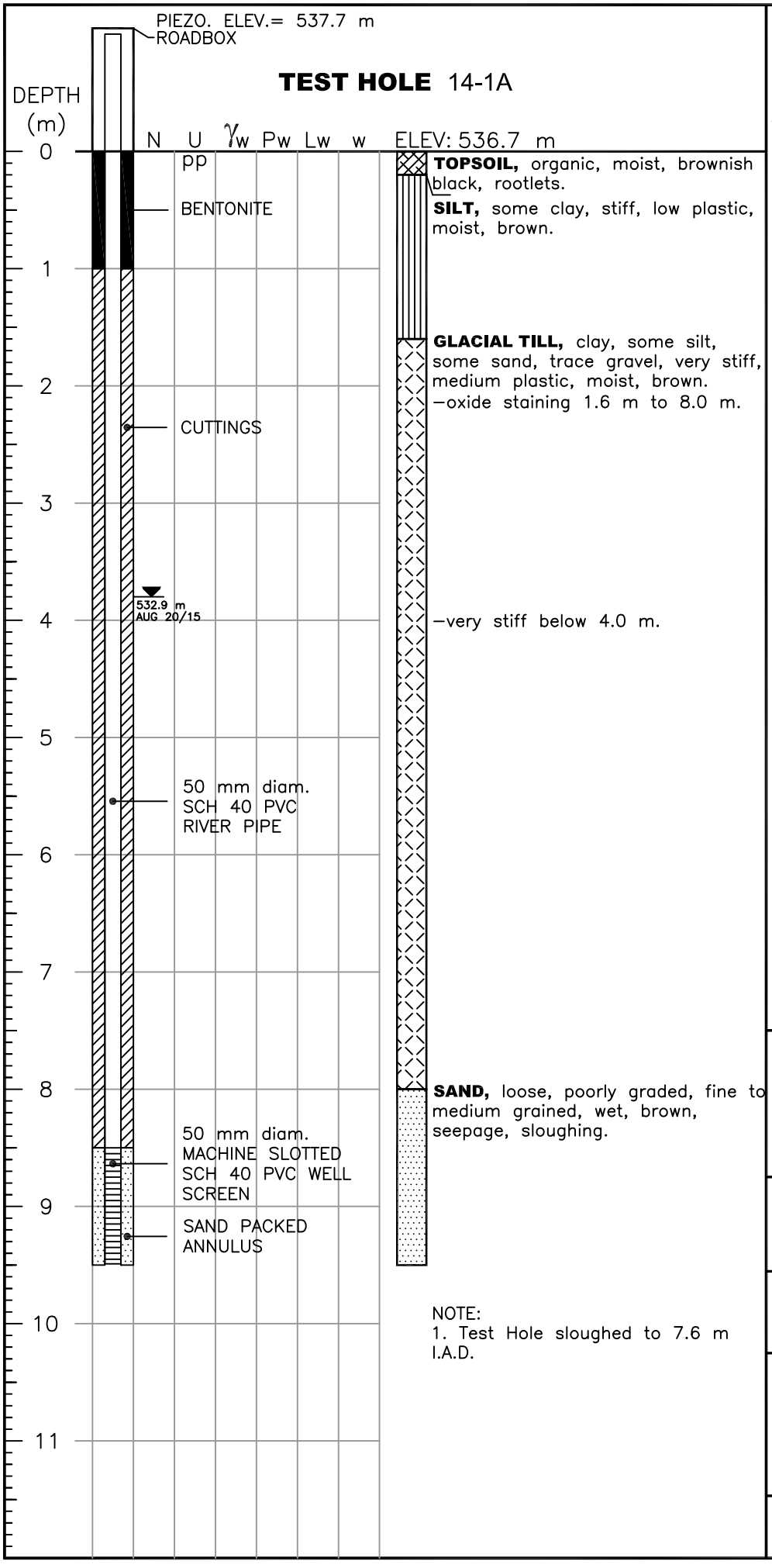
FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
DEC 11/14	9551-2C



NOTE:
1. Test Hole sloughed to 7.6 m I.A.D.

LEGEND:

FILL, SAND, CLAY
TOPSOIL, GRAVEL, SILT, 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:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	**DRAWING NUMBER:**
DEC 11/14	9551-3

INCLINOMETER ELEV.= 507.7 m
ROADBOX

TEST HOLE SI 15-1

ELEV: 506.7 m

DEPTH (m)	N	U	γ_w	Pw	Lw	w	
		pp					
0							**SAND,** silty, trace gravel, loose to compact, well graded, fine to coarse grained, moist, brown.
1						8.4	
2							CEMENT/BENTONITE GROUT
3						9.7	
4							85 mm diam. SLOPE INCLINOMETER
5						6.5	
6						5.3	**GLACIAL TILL,** clay, some silt, some sand, trace gravel, stiff to hard, medium plastic, moist, brown.
7						13.2	85 mm diam. SLOPE INCLINOMETER
8							
9						8.9	
10						12.1	
11						13.6	

CONTINUED ON NEXT PAGE

LEGEND:

FILL, SAND, CLAY
TOPSOIL, GRAVEL, SILT, 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

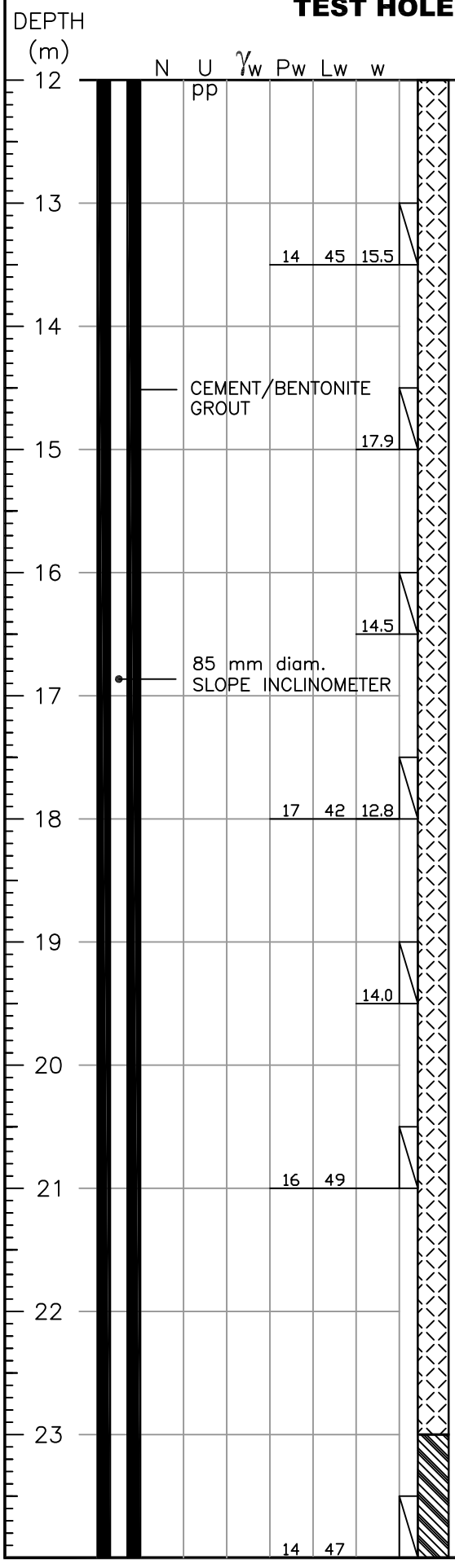
PROJECT:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: 5706357 **EASTING:** 356347

DATE DRILLED:	DRAWING NUMBER:
MAR 24,25/15	9551-4

TEST HOLE SI 15-1



GLACIAL TILL, clay, some silt, some sand, trace gravel, stiff to hard, medium plastic, moist, brown.

CLAY SHALE, silty to some silt, trace sand, hard, medium to highly plastic, grey.

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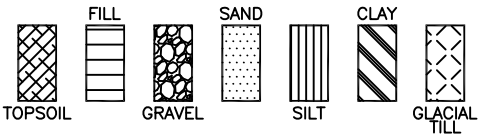
LEGEND:



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

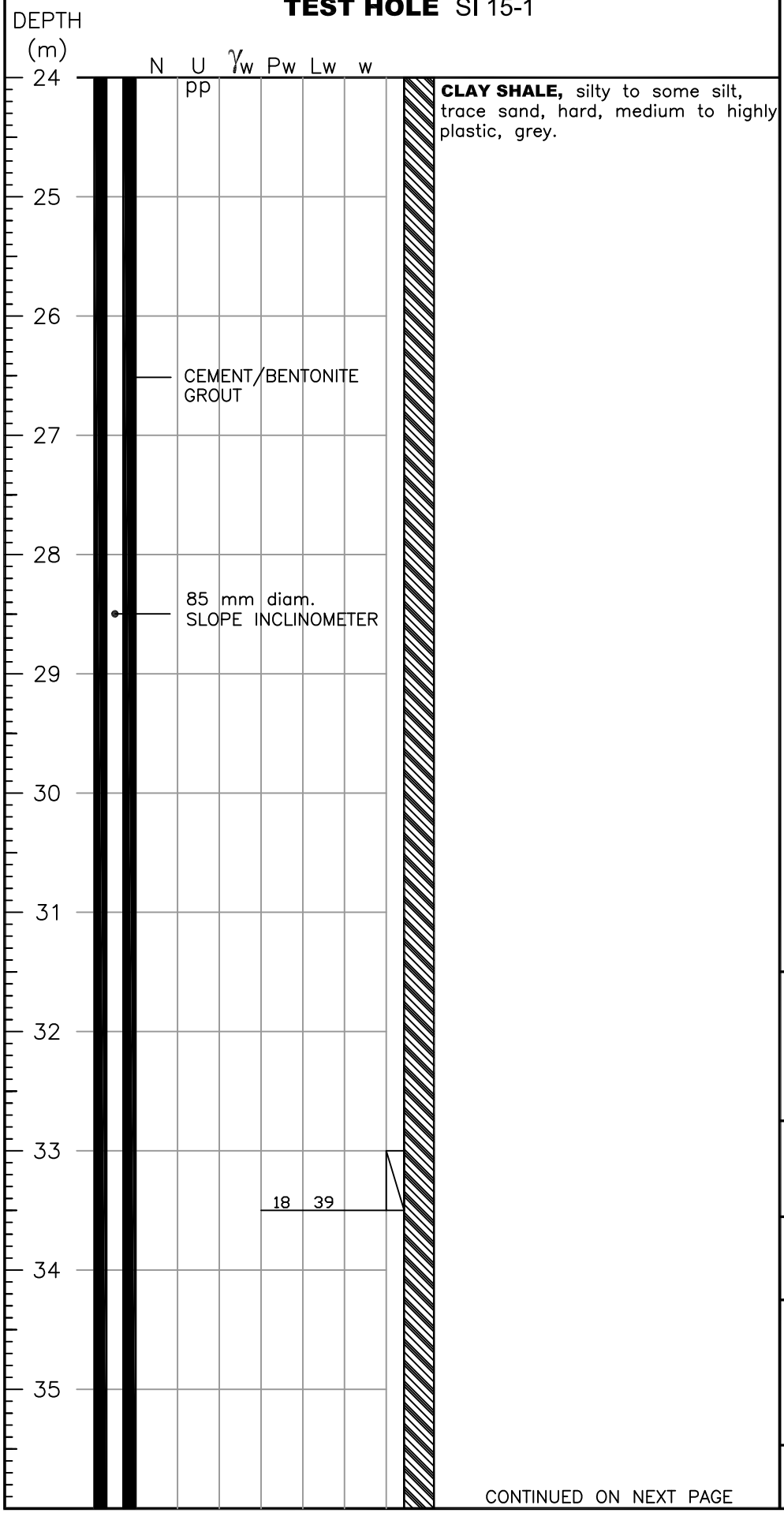
PROJECT:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: 5706357 **EASTING:** 356347

DATE DRILLED:	DRAWING NUMBER:
MAR 24,25/14	9551-4A

TEST HOLE SI 15-1



CLAY SHALE, silty to some silt, trace sand, hard, medium to highly plastic, grey.

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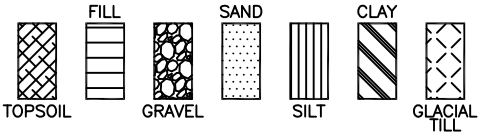
LEGEND:



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)

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

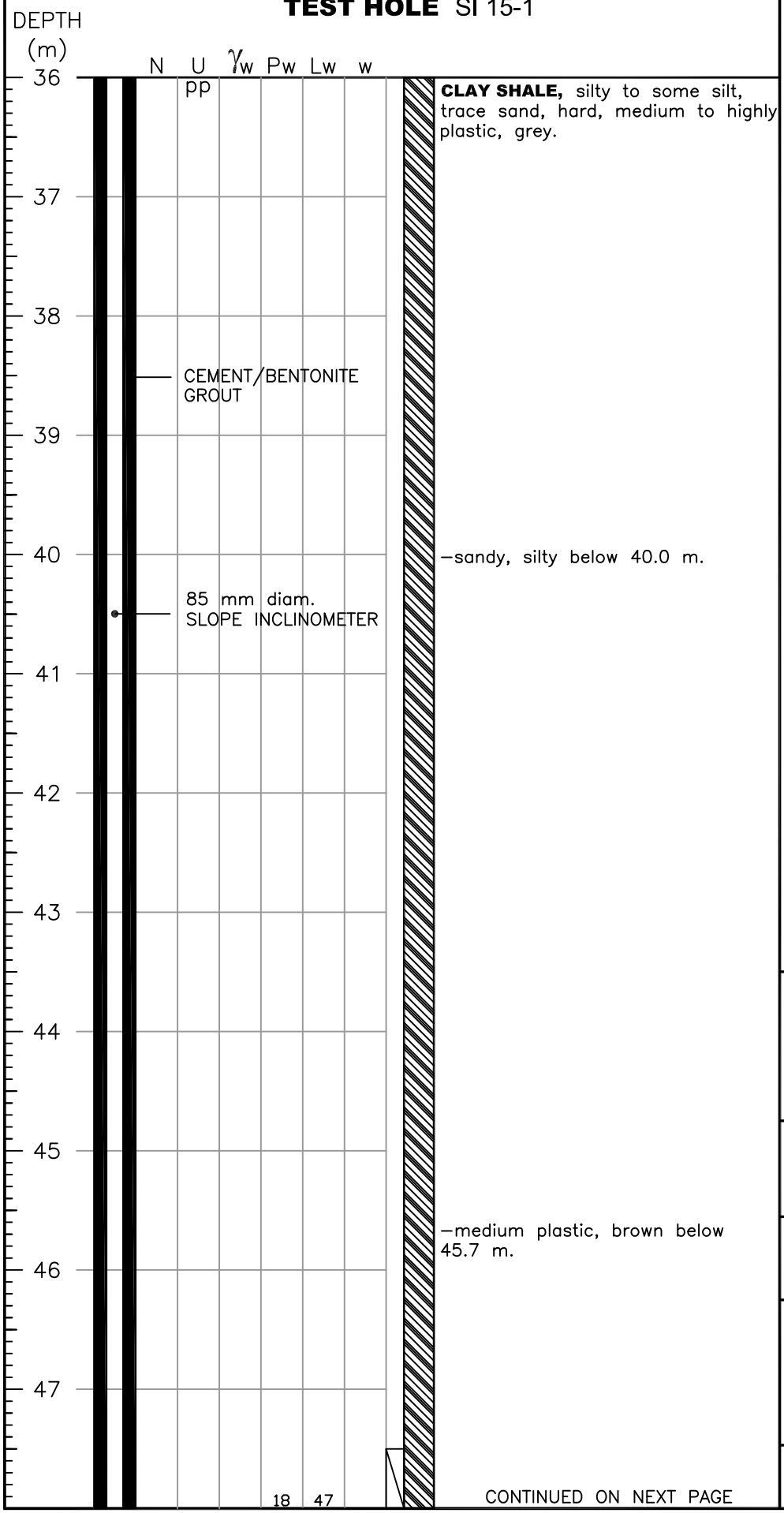
PROJECT:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: 5706357 **EASTING:** 356347

DATE DRILLED:	DRAWING NUMBER:
MAR 24,25/15	9551-4B

TEST HOLE SI 15-1



CLAY SHALE, silty to some silt, trace sand, hard, medium to highly plastic, grey.

—sandy, silty below 40.0 m.

—medium plastic, brown below 45.7 m.

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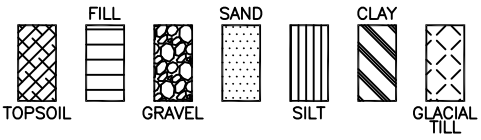
LEGEND:



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)

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

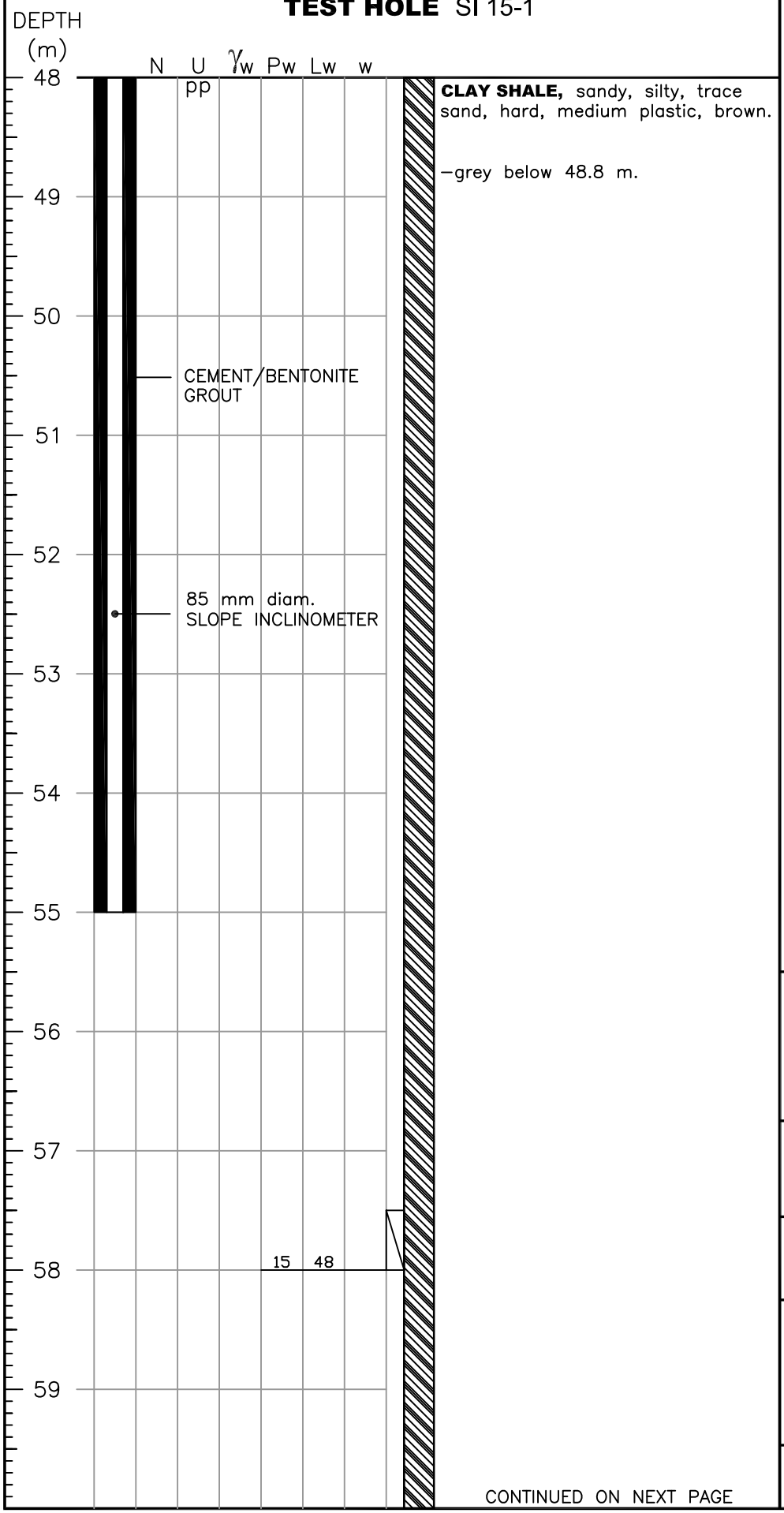
PROJECT:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: 5706357 **EASTING:** 356347

DATE DRILLED:	DRAWING NUMBER:
MAR 24,25/15	9551-4C

TEST HOLE SI 15-1



CLAY SHALE, sandy, silty, trace sand, hard, medium plastic, brown.

–grey below 48.8 m.

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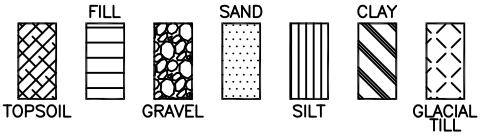
LEGEND:



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)

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:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: 5706357 **EASTING:** 356347

DATE DRILLED:	DRAWING NUMBER:
MAR 24,25/15	9551-4D

TEST HOLE SI 15-1

DEPTH (m)	N	U pp	γ_w	Pw	Lw	w
60						
61						
62						
63						
64						
65						
66						
67						
68						
69						
70						
71						

CLAY SHALE, sandy, silty, trace sand, hard, medium plastic, brown.

NOTE:
1. Test Hole sloughed to 55.0 m I.A.D.
2. Soil samples collected from drill cuttings every 1.5 m between 0 to 31.5 m, every 3.0 m between 31.5 m to 61.5 m.

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:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: 5706357 **EASTING:** 356347

DATE DRILLED:	DRAWING NUMBER:
MAR 24,25/15	9551-4E

INCLINOMETER ELEV.= 513.0 m
ROADBOX

TEST HOLE SI 15-2

ELEV: 512.0 m

DEPTH (m)	N	U pp	γ_w	Pw	Lw	w
0						
1						5.8
2						
3						10.8
4						12.0
5						
6						15.9
7						23.4
8						
9						18.6
10						18.3
11						18.2

CEMENT/BENTONITE GROUT

85 mm diam. SLOPE INCLINOMETER

SAND, silty, trace clay, compact, poorly graded, fine grained, brown.

GLACIAL TILL, clay, some silt, some sand, trace gravel, stiff to hard, medium plastic, moist, grey, cobbles and boulders.

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

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

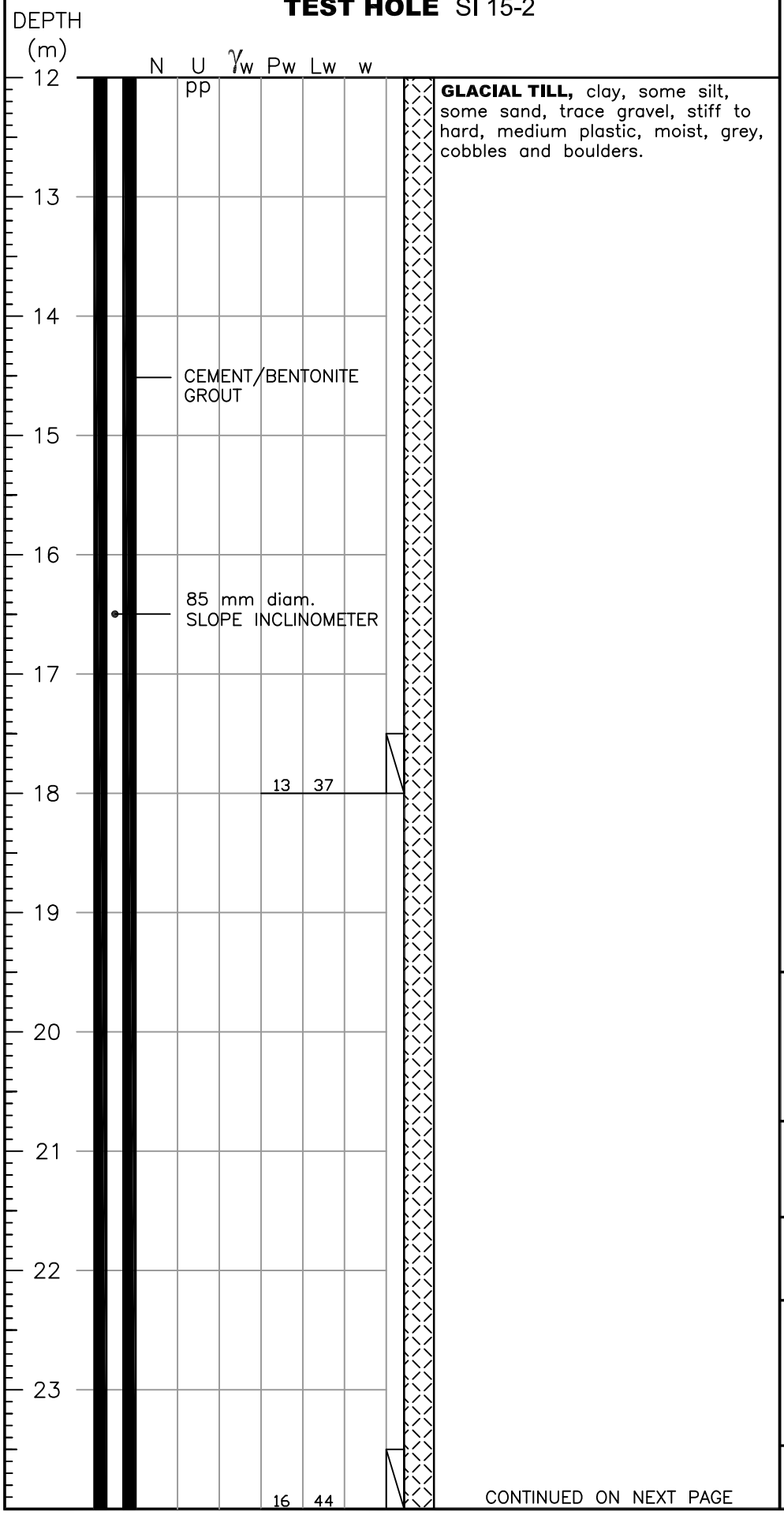
PROJECT:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
APR 6,7,29/15	9551-5

TEST HOLE SI 15-2



GLACIAL TILL, clay, some silt, some sand, trace gravel, stiff to hard, medium plastic, moist, grey, cobbles and boulders.

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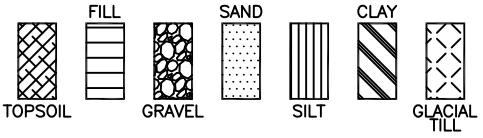
LEGEND:



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)

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

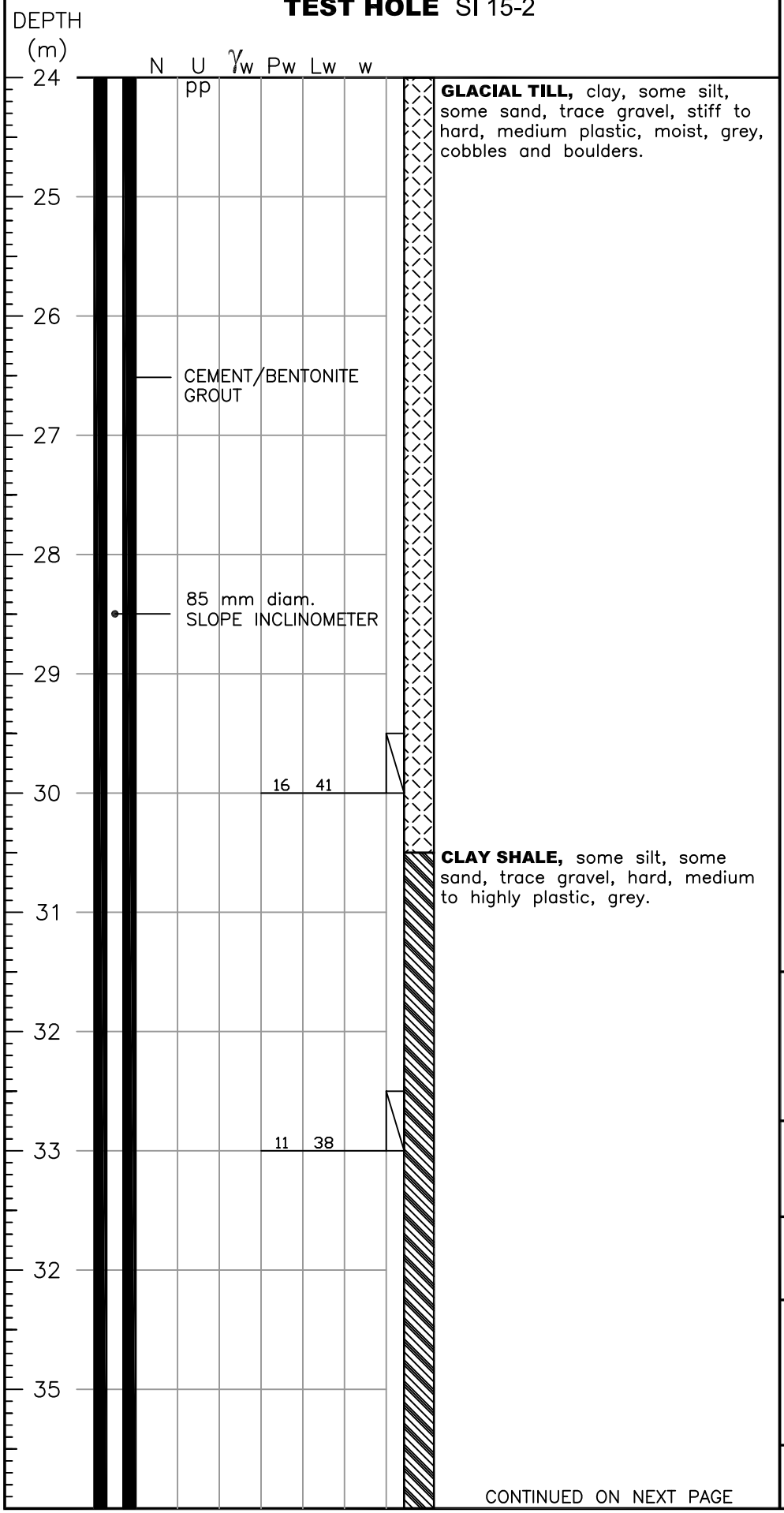
PROJECT:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	**DRAWING NUMBER:**
APR 6,7,29/15	9551-5A

TEST HOLE SI 15-2



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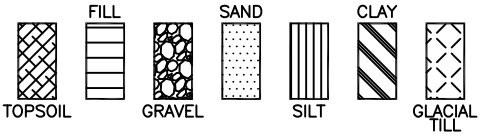

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m^3)

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

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P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

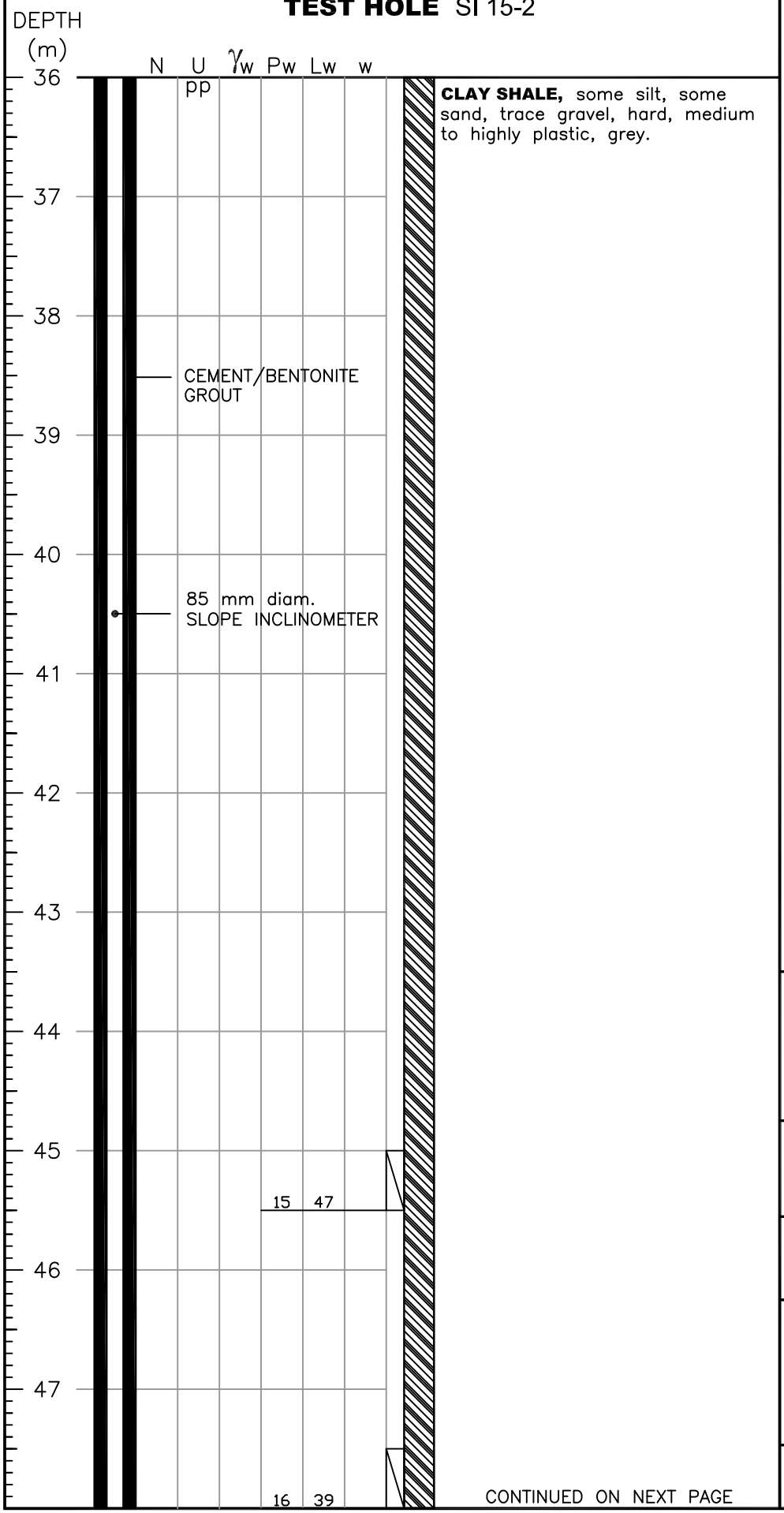
PROJECT:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
APR 6,7,29/15	9551-5B

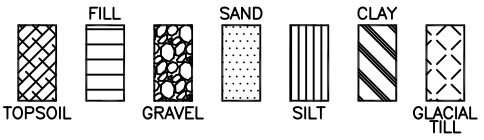
TEST HOLE SI 15-2



CLAY SHALE, some silt, some sand, trace gravel, hard, medium to highly plastic, grey.

CONTINUED ON NEXT PAGE

LEGEND:



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)

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

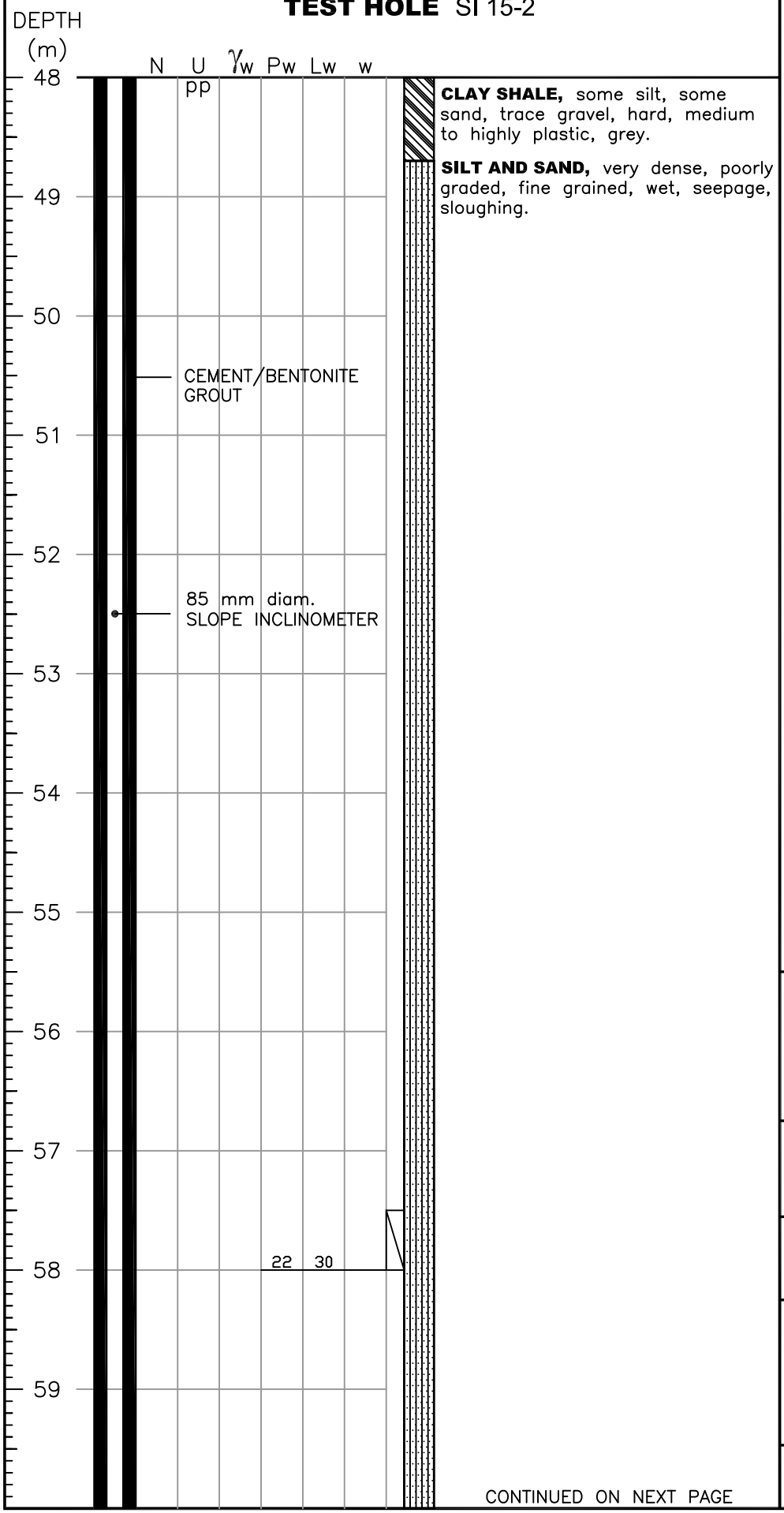
PROJECT:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	**DRAWING NUMBER:**
APR 6,7,29/15	9551-5C

TEST HOLE SI 15-2



CLAY SHALE, some silt, some sand, trace gravel, hard, medium to highly plastic, grey.

SILT AND SAND, very dense, poorly graded, fine grained, wet, seepage, sloughing.

CONTINUED ON NEXT PAGE

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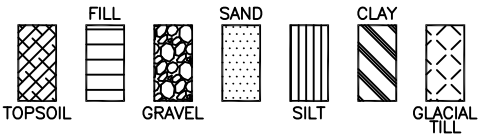

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m^3)

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

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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)

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

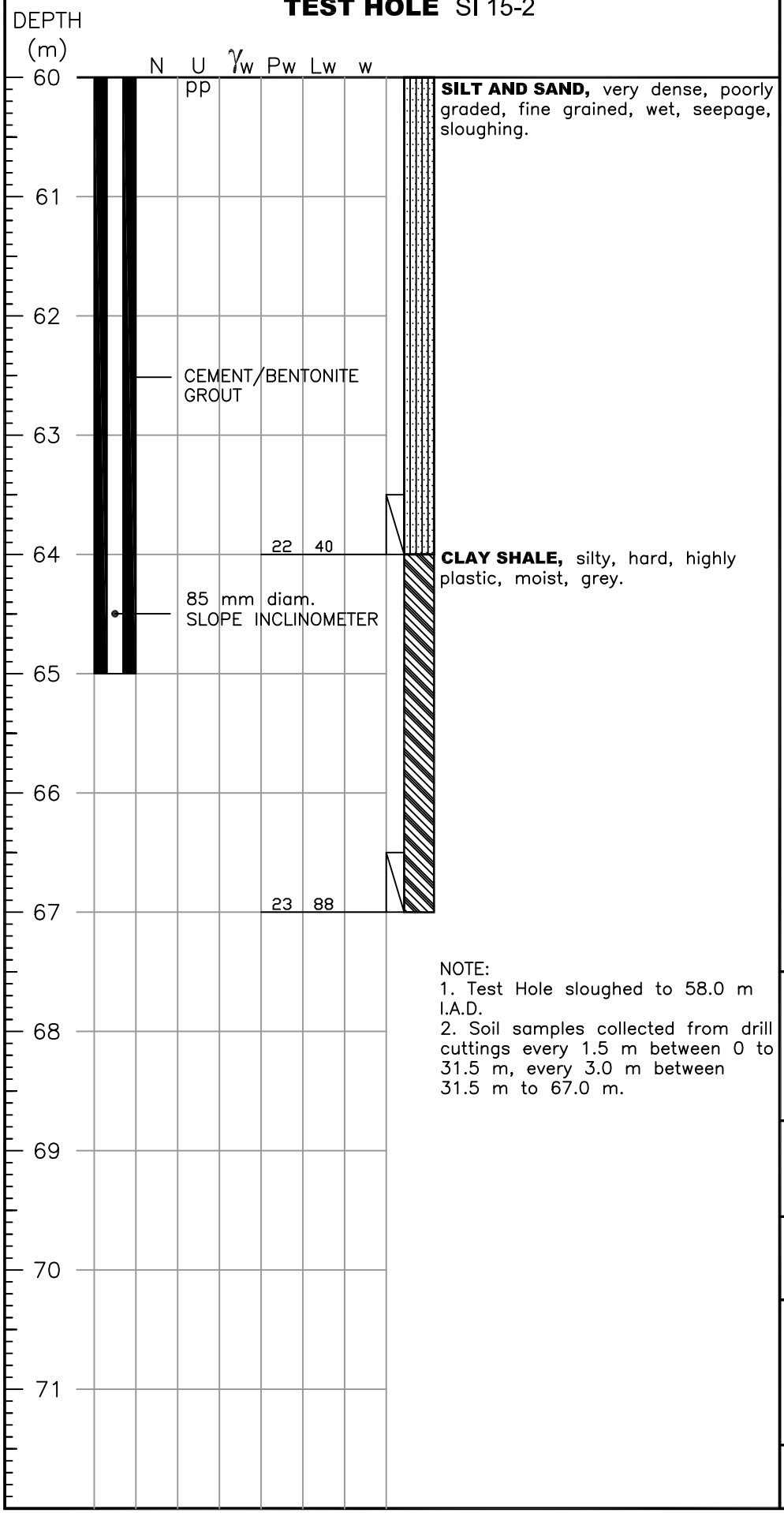
PROJECT:
SLOPE STABILITY STUDY

LOCATION:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: **EASTING:**

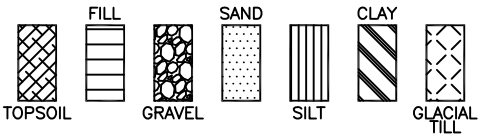
DATE DRILLED:	**DRAWING NUMBER:**
APR 6,7,29/15	9551-5D

TEST HOLE SI 15-2



NOTE:
1. Test Hole sloughed to 58.0 m I.A.D.
2. Soil samples collected from drill cuttings every 1.5 m between 0 to 31.5 m, every 3.0 m between 31.5 m to 67.0 m.

LEGEND:



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)

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:
EAST BANK SOUTH SASKATCHEWAN RIVER, OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
APR 6,7,29/15	9551-5E

APPENDIX A

EXPLANATION OF TERMS ON TEST HOLE LOGS

CLASSIFICATION OF SOILS

Coarse-Grained Soils: Soils containing particles that are visible to the naked eye. They include gravels and sands and are generally referred to as cohesionless or non-cohesive soils. Coarse-grained soils are soils having more than 50 percent of the dry weight larger than particle size 0.080 mm.

Fine-Grained Soils: Soils containing particles that are not visible to the naked eye. They include silts and clays. Fine-grained soils are soils having more than 50 percent of the dry weight smaller than particle size 0.080 mm.

Organic Soils: Soils containing a high natural organic content.

Soil Classification By Particle Size

Clay – particles of size	< 0.002 mm
Silt – particles of size	0.002 – 0.060 mm
Sand – particles of size	0.06 – 2.0 mm
Gravel – particles of size	2.0 – 60 mm
Cobbles – particles of size	60 – 200 mm
Boulders – particles of size	>200 mm

TERMS DESCRIBING CONSISTENCY OR CONDITION

Coarse-grained soils: Described in terms of compactness condition and are often interpreted from the results of a Standard Penetration Test (SPT). The standard penetration test is described as the number of blows, N, required to drive a 51 mm outside diameter (O.D.) split barrel sampler into the soil a distance of 0.3 m (from 0.15 m to 0.45 m) with a 63.5 kg weight having a free fall of 0.76 m.

Compactness Condition	SPT N-Index (blows per 0.3 m)
Very loose	0-4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	Over 50

Fine-Grained Soils: Classified in relation to undrained shear strength.

Consistency	Undrained Shear Strength (kPa)	N Value (Approximate)	Field Identification
Very Soft	<12	0-2	Easily penetrated several centimetres by the fist.
Soft	12-25	2-4	Easily penetrated several centimetres by the thumb.
Firm	25-50	4-8	Can be penetrated several centimetres by the thumb with moderate effort.
Stiff	50-100	8-15	Readily indented by the thumb, but penetrated only with great effort.
Very Stiff	100-200	15-30	Readily indented by the thumb nail.
Hard	>200	>30	Indented with difficulty by the thumbnail.

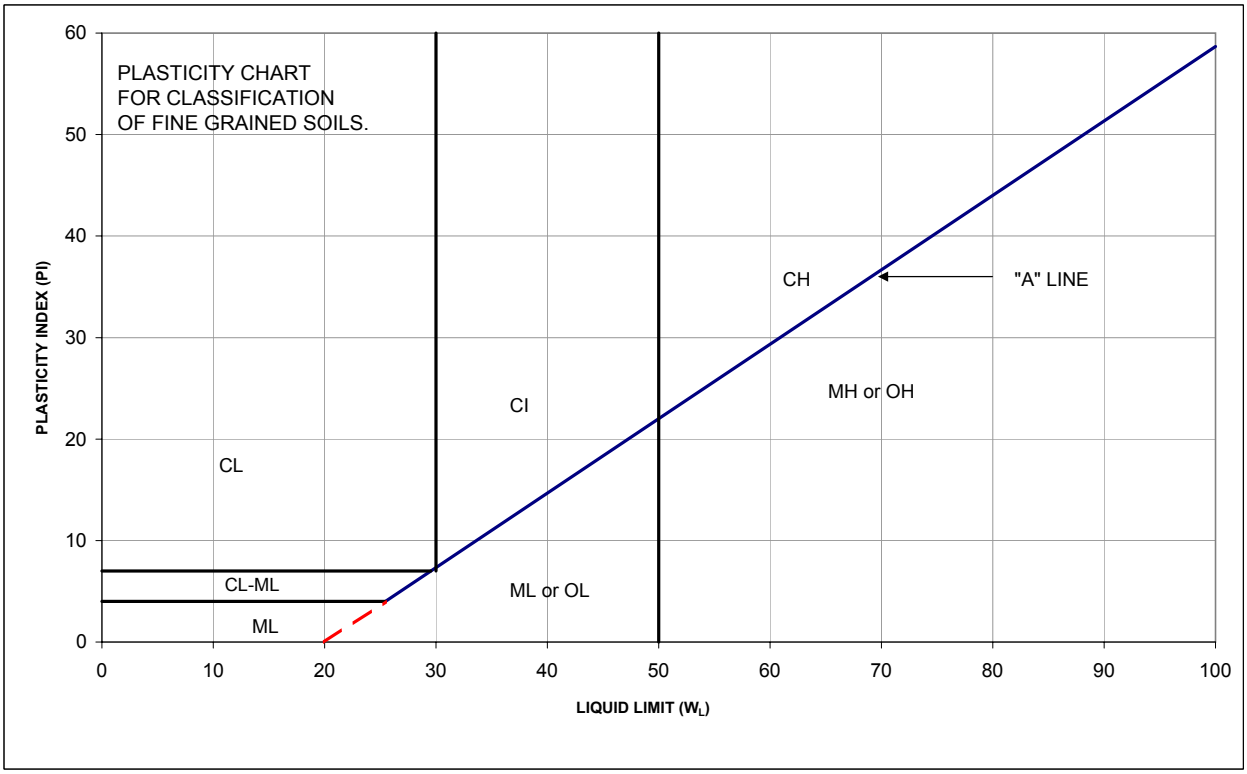
Organic Soils: Readily identified by colour, odour, spongy feel and frequently by fibrous texture.

DESCRIPTIVE TERMS COMMONLY USED TO CHARACTERIZE SOILS

Poorly Graded	- predominance of particles of one grain size.
Well Graded	- having no excess of particles in any size range with no intermediate sizes lacking.
Mottled	- marked with different coloured spots.
Nuggety	- structure consisting of small prismatic cubes.
Laminated	- structure consisting of thin layers of varying colour and texture.
Slickensided	- having inclined planes of weakness that are slick and glossy in appearance.
Fissured	- containing shrinkage cracks.
Fractured	- broken by randomly oriented interconnecting cracks in all 3 dimensions.

SOIL CLASSIFICATION SYSTEM (MODIFIED U.S.C.)

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA
HIGHLY ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR AND OFTEN FIBROUS TEXTURE
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO. 200 SIEVE SIZE)	GRAVELS More than half coarse fraction larger than No. 4 sieve size	CLEAN GRAVELS	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES <5% FINES	$C_u = \frac{D_{60}}{D_{10}} > 4 \quad C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}} = 1 \text{ to } 3$
			GP	POORLY-GRADED GRAVELS AND GRAVEL-SAND MIXTURES <5% FINES	NOT MEETING ALL ABOVE REQUIREMENTS FOR GW
		DIRTY GRAVELS	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES >12% FINES	ATTERBERG LIMITS BELOW "A" LINE OR PI < 4
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES >12% FINES	ATTERBERG LIMITS ABOVE "A" LINE WITH PI > 7
	SANDS More than half coarse fraction smaller than No. 4 sieve size	CLEAN SANDS	SW	WELL-GRADED SANDS, GRAVELLY SANDS MIXTURES <5% FINES	$C_u = \frac{D_{60}}{D_{10}} > 6 \quad C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}} = 1 \text{ to } 3$
			SP	POORLY-GRADED SANDS OR GRAVELLY SANDS <5% FINES	NOT MEETING ALL GRADATION REQUIREMENTS FOR SW
		DIRTY SANDS	SM	SILTY SANDS, SAND-SILT MIXTURES >12% FINES	ATTERBERG LIMITS BELOW "A" LINE OR PI < 4
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES >12% FINES	ATTERBERG LIMITS ABOVE "A" LINE WITH PI >7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSING NO. 200 SIEVE SIZE)	SILTS Below "A" line on plasticity chart; negligible organic content		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	$W_L < 50$
			MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	$W_L > 50$
	CLAYS Above 'A" line on plasticity chart; negligible organic content		CL	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS	$W_L < 30$
			CI	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS	$W_L > 30 < 50$
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	$W_L > 50$
	ORGANIC SILTS & ORGANIC CLAYS Below "A" line on plasticity chart		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	$W_L < 50$
			OH	ORGANIC CLAYS OF HIGH PLASTICITY	$W_L > 50$



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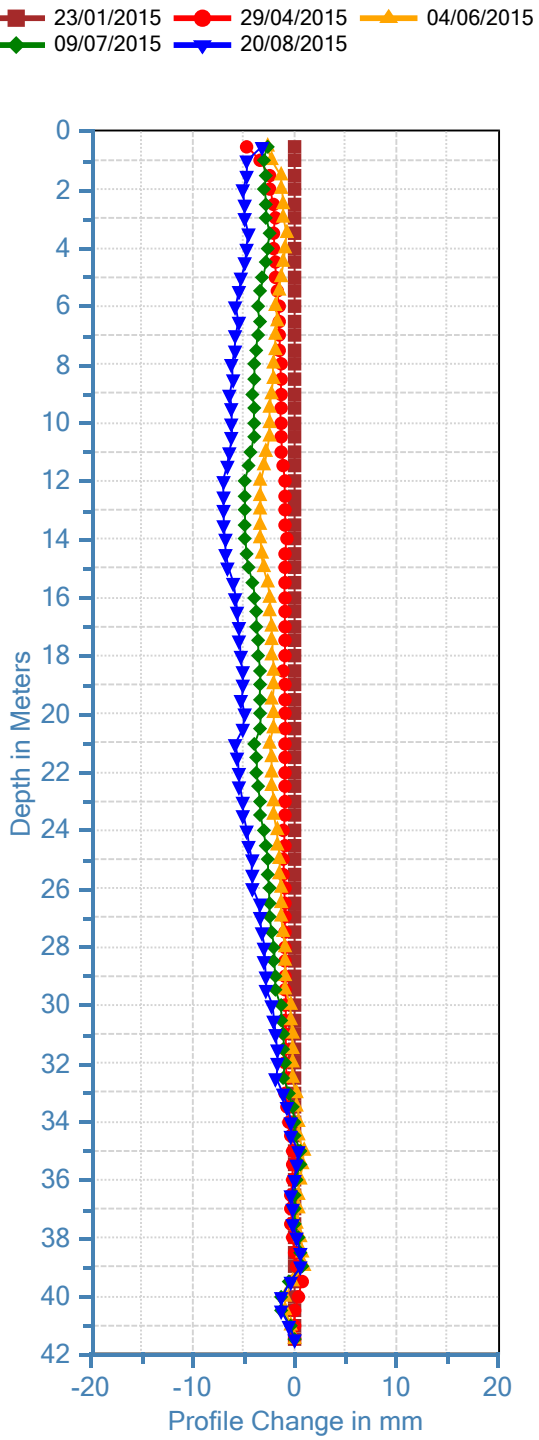
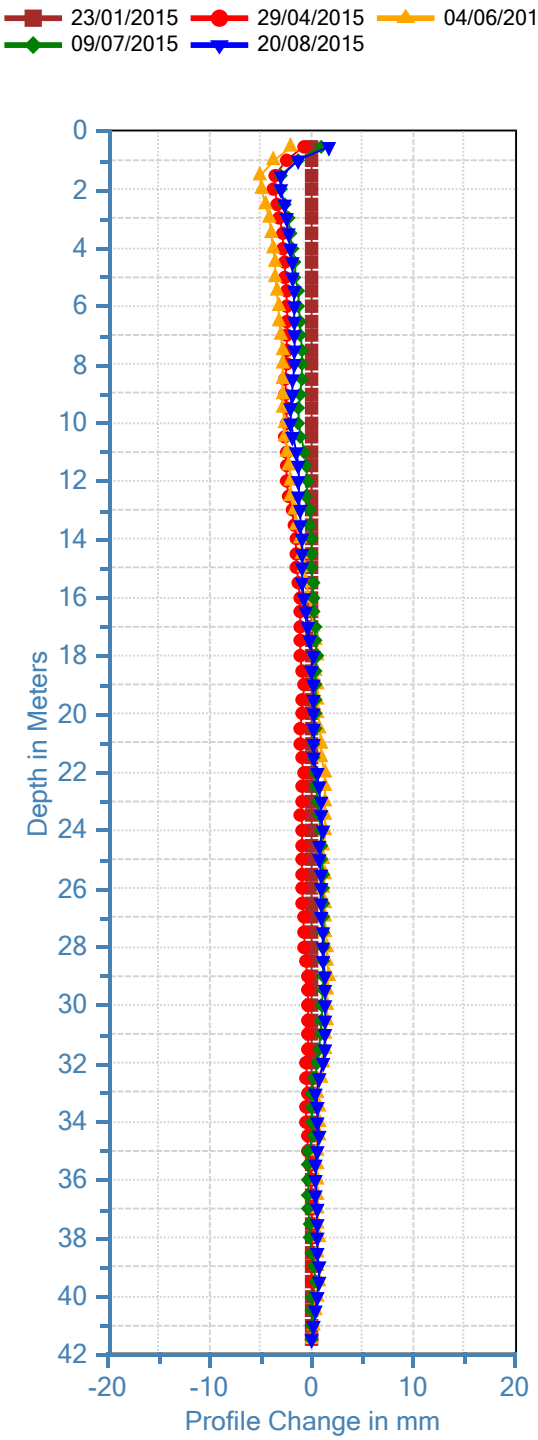
APPENDIX B

SLOPE INCLINOMETER PLOTS

9551 14-1 A

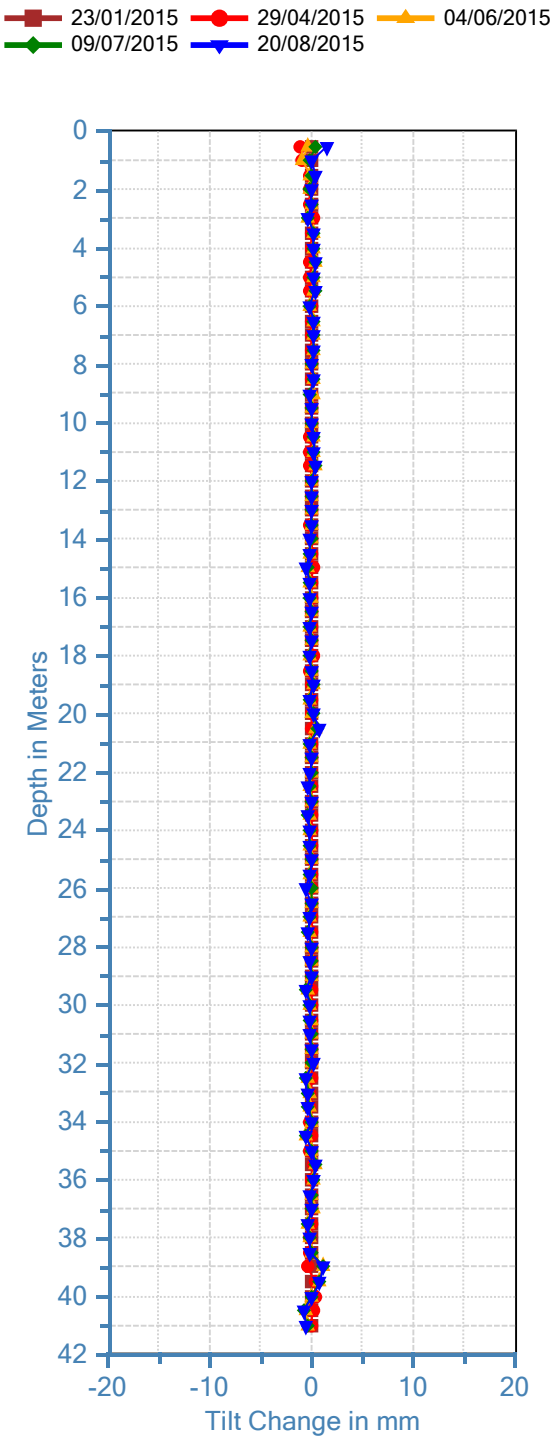


9551 14-1 B



Project No.:	9551
Project Name:	Outlook Slope Stability
Location:	Outlook, Saskatchewan
Test Hole No.	14-1
Drawing No.	Appendix B1

9551 14-1 A



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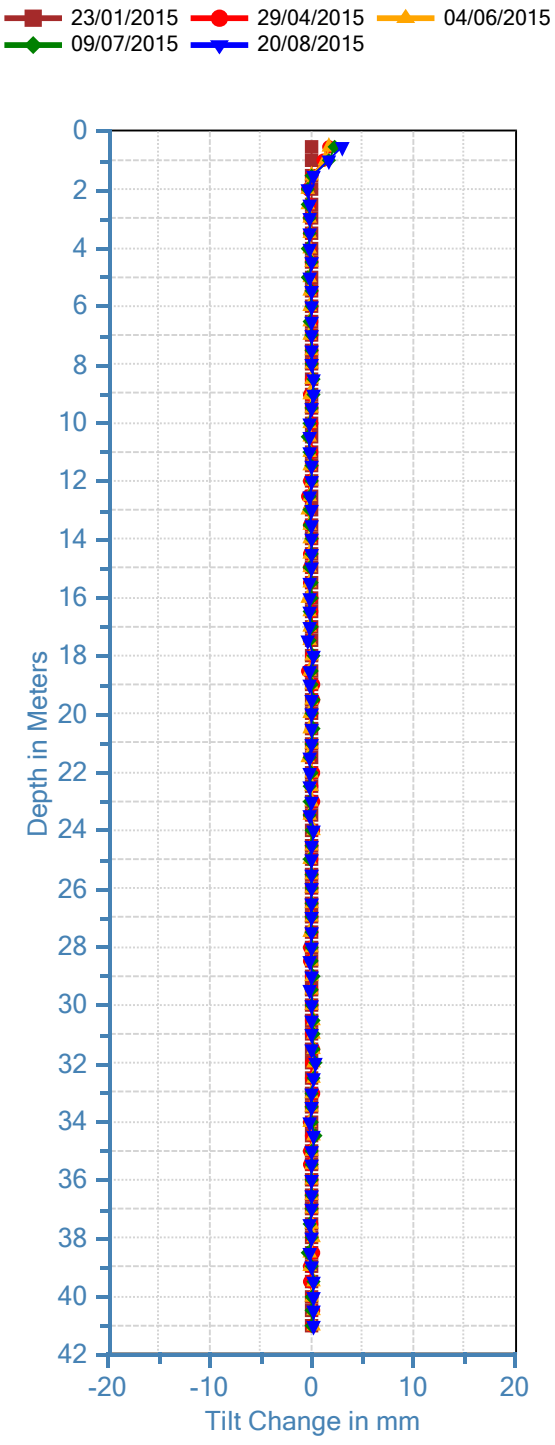
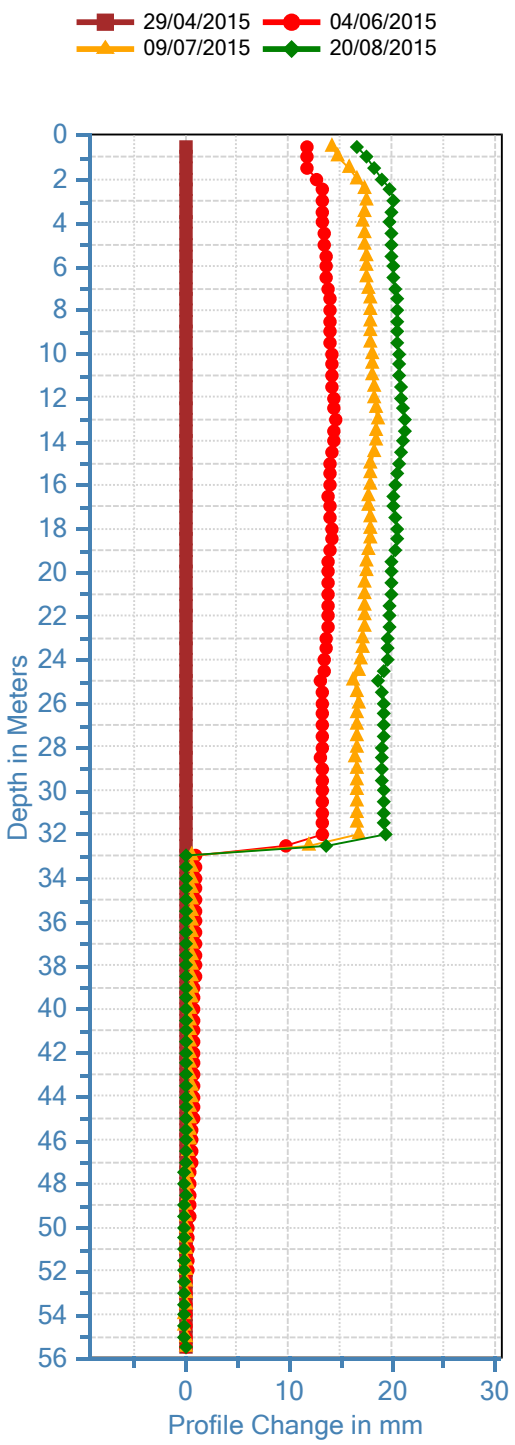


Project No.:	9551
Project Name:	Outlook Slope Stability
Location:	Outlook, Saskatchewan
Test Hole No.	14-1
Drawing No.	Appendix B2

9551 15-1 A



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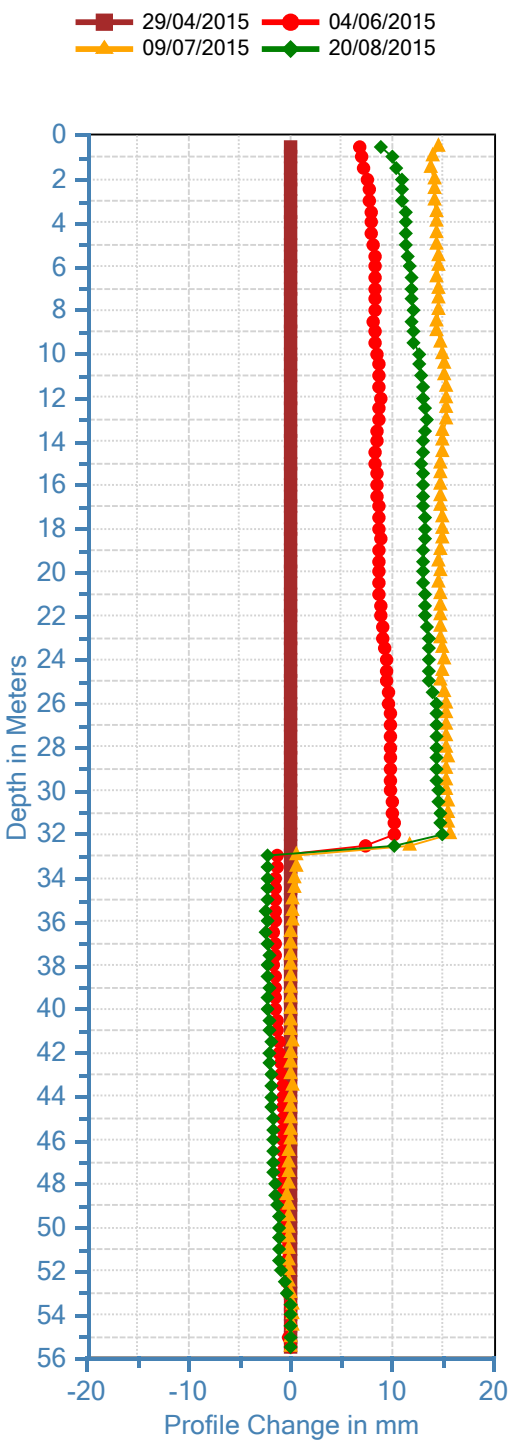
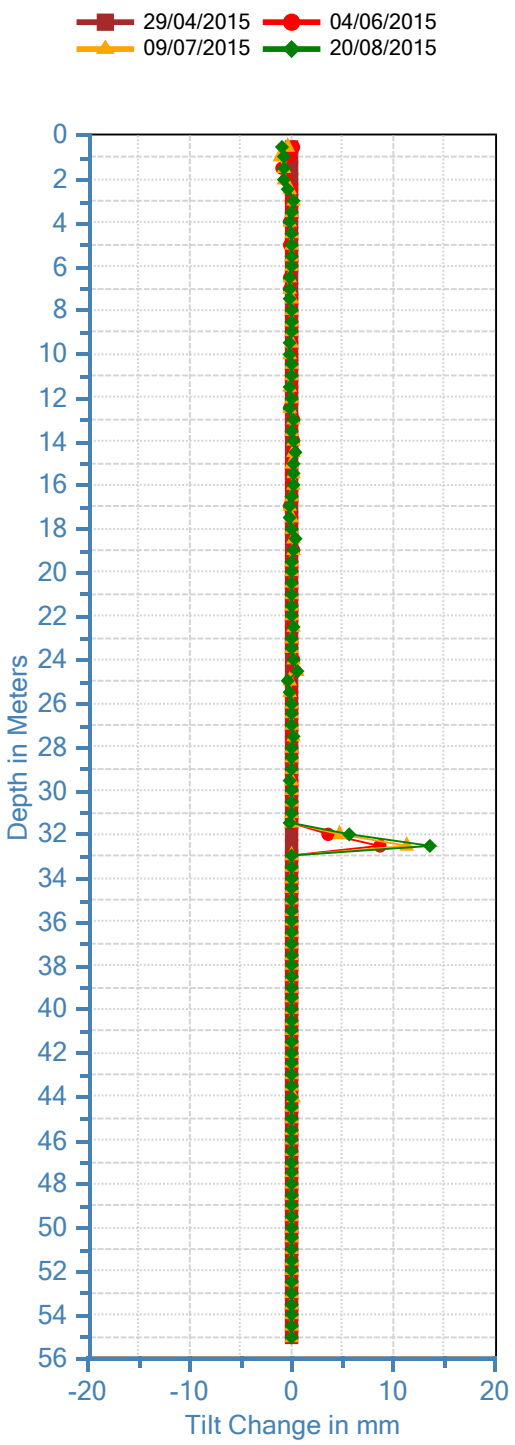


Project No.:	9551
Project Name:	Outlook Slope Stability
Location:	Outlook, Saskatchewan
Test Hole No.	15-1
Drawing No.	Appendix B3

9551 15-1 A



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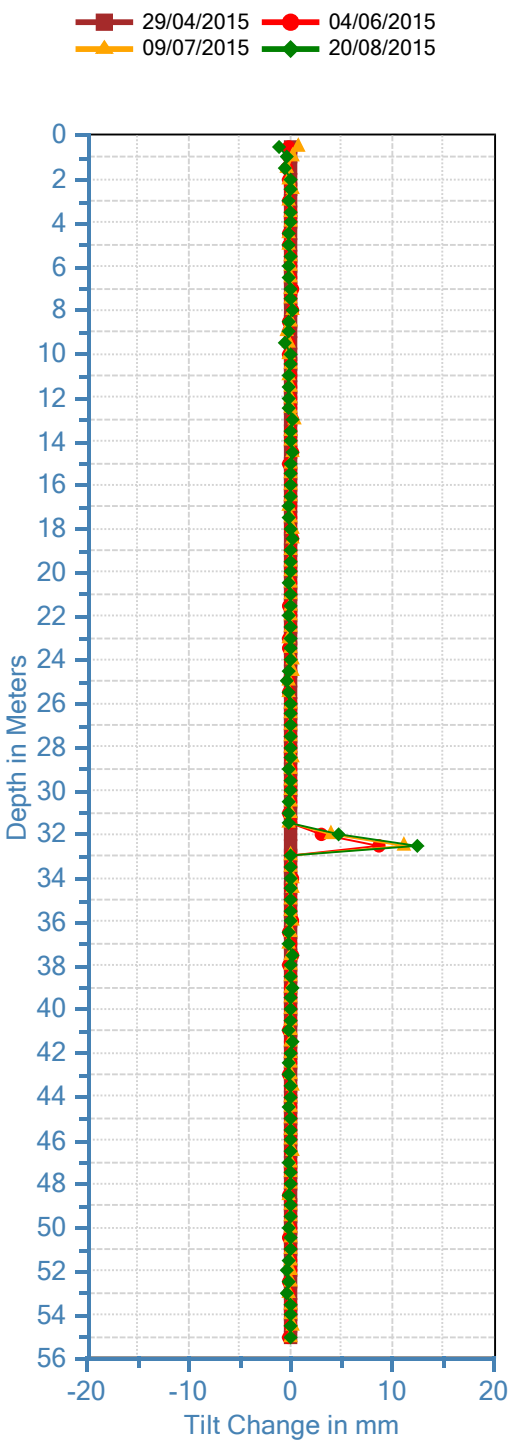
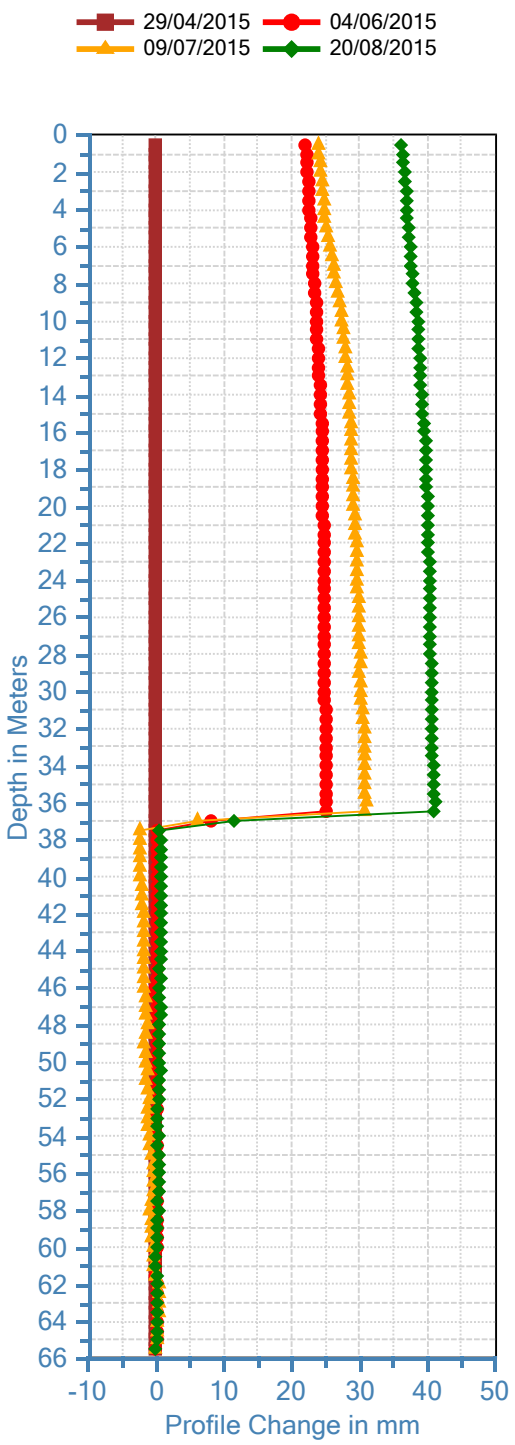


Project No.:	9551
Project Name:	Outlook Slope Stability
Location:	Outlook, Saskatchewan
Test Hole No.	15-1
Drawing No.	Appendix B4

9551 15-2 A



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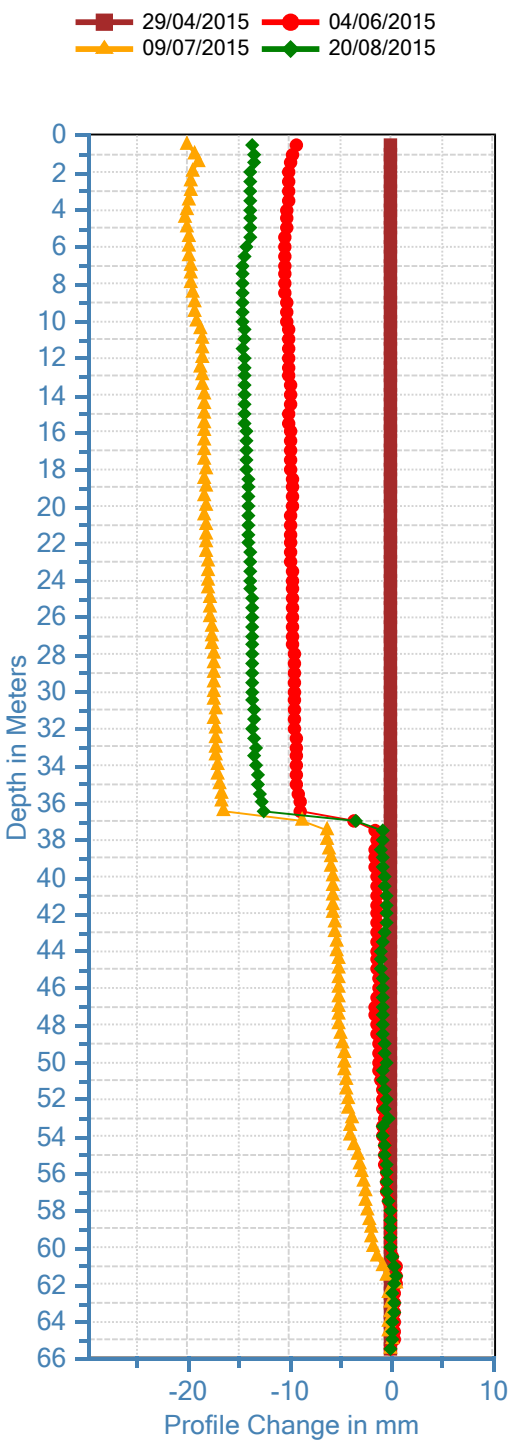
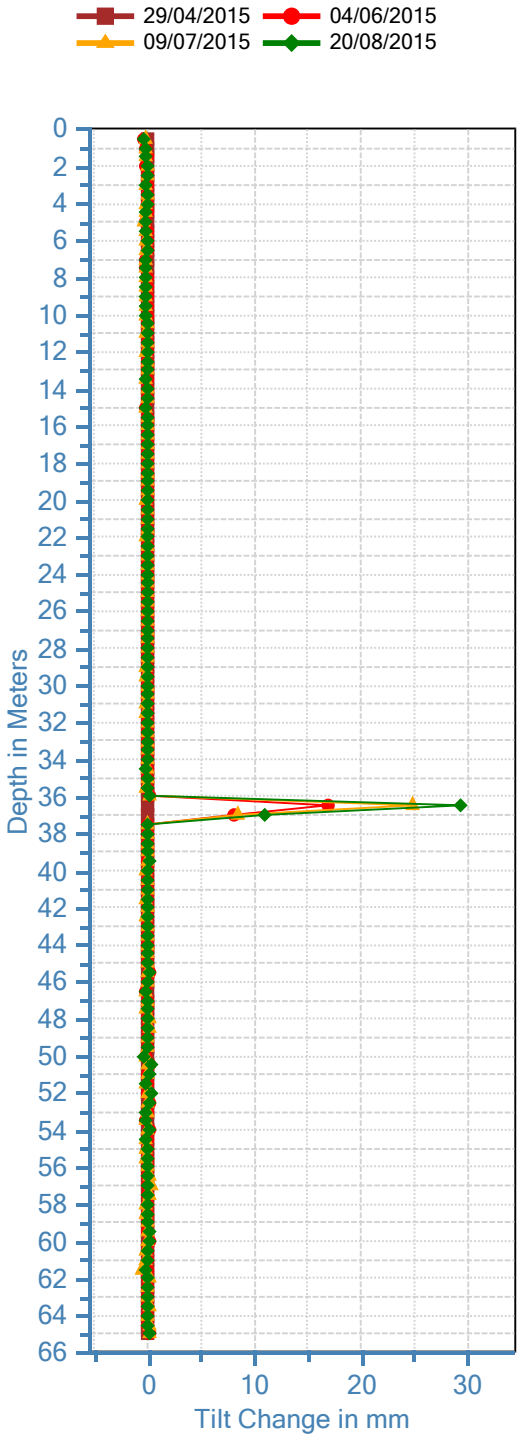


Project No.:	9551
Project Name:	Outlook Slope Stability
Location:	Outlook, Saskatchewan
Test Hole No.	15-2
Drawing No.	Appendix B5

9551 15-2 A



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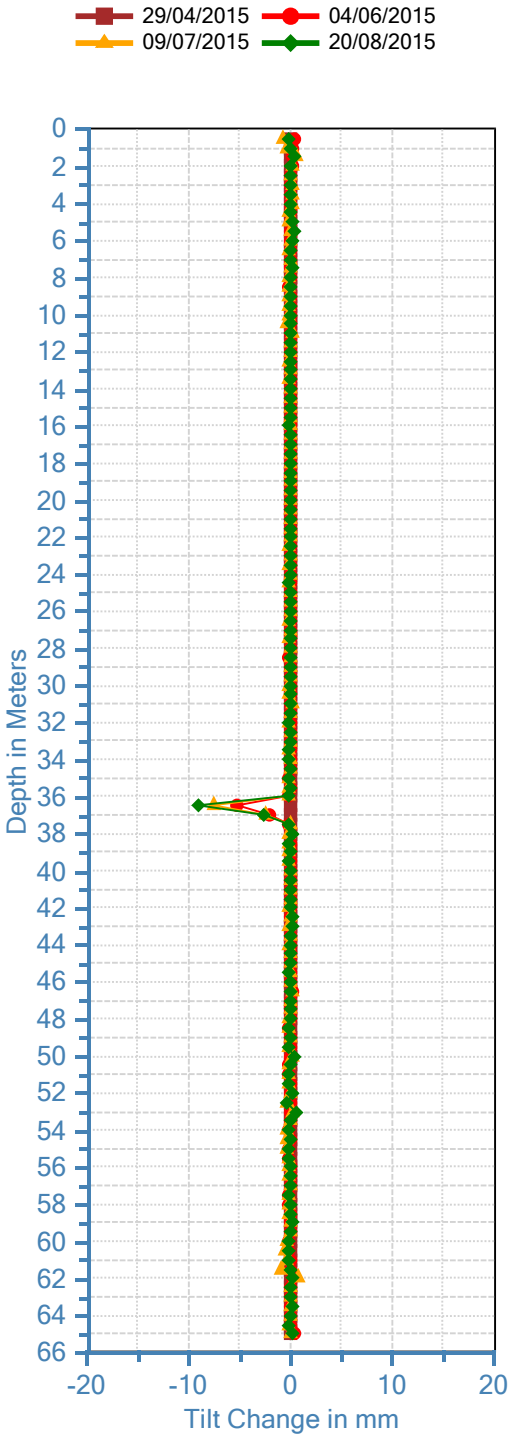


Project No.:	9551
Project Name:	Outlook Slope Stability
Location:	Outlook, Saskatchewan
Test Hole No.	15-2
Drawing No.	Appendix B6

APPENDIX C
LABORATORY RESULTS

GRAIN SIZE DISTRIBUTION TEST REPORT

Project: Slope Stability Study - East Bank South Saskatchewan River
Outlook , Saskatchewan

Project No.: 9551

Date Tested: April 13, 2015

Test Hole No.: 15-1

Sample No.: 2

Depth (m): 3.0

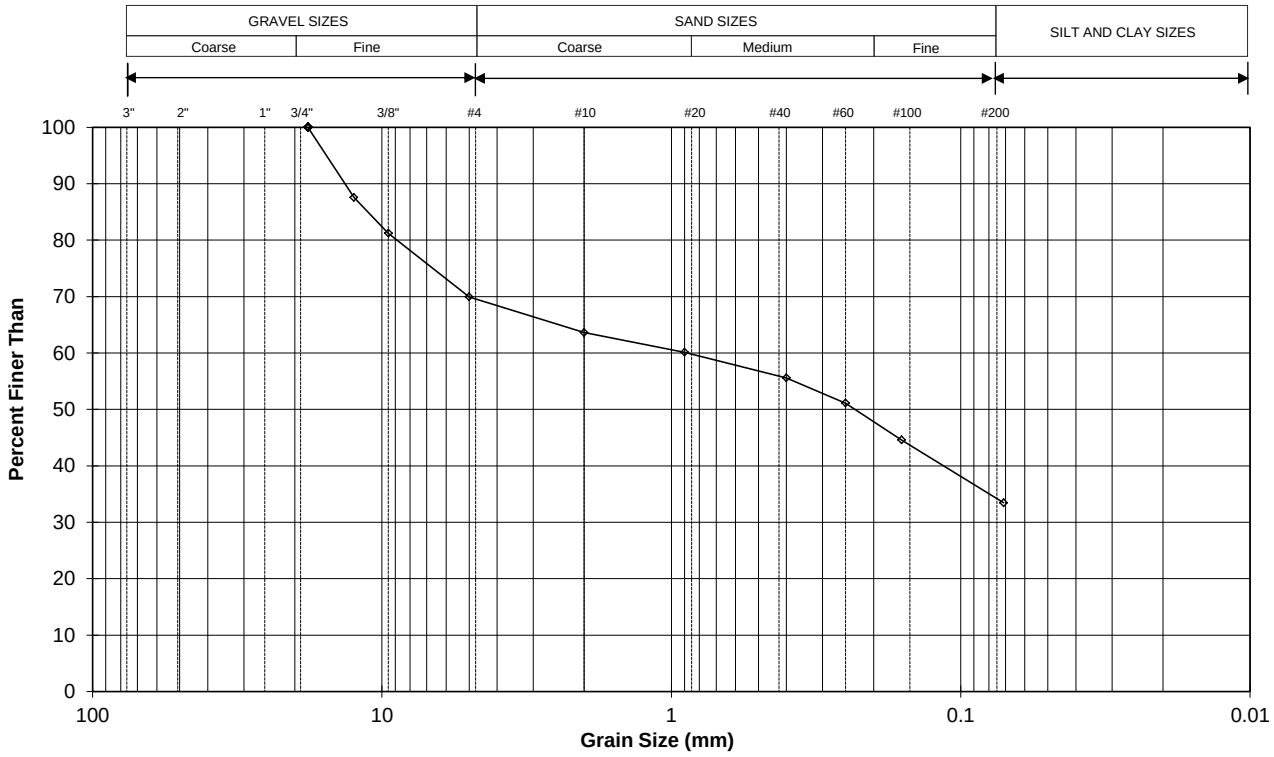
Sieve Analysis:

Sieve	Diameter mm	% Finer	Specification Max	Specification Min
	100.000	100		
	76.200	100		
	50.000	100		
	37.500	100		
	25.000	100		
	18.000	100		
	12.500	88		
	9.500	81		
	5.000	70		
	2.000	64		
	0.900	60		
	0.400	56		
	0.250	51		
	0.160	45		
	0.071	33		

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt and Clay Sizes
30	37	33

Remarks:



P. MACHIBRODA ENGINEERING LTD.

DRAWING NO.

Appendix C-2

GRAIN SIZE DISTRIBUTION TEST REPORT

Project: Slope Staiblity Study - East Bank South Saskatchewan River
Outlook , Saskatchewan

Project No.: 9551

Date Tested: April 13, 2015

Test Hole No.: 15-2

Sample No.: 2

Depth (m): 3.0

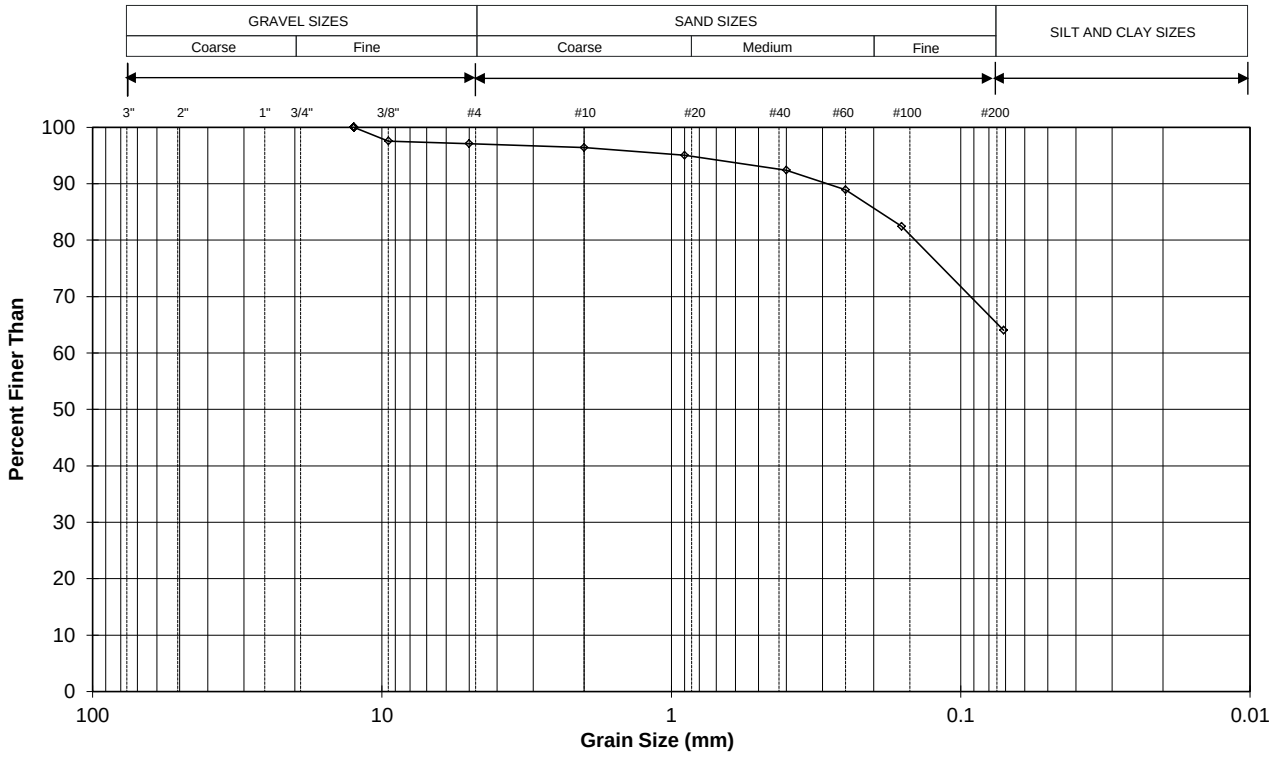
Sieve Analysis:

Sieve	Diameter mm	% Finer	Specification Max	Specification Min
	100.000	100		
	76.200	100		
	50.000	100		
	37.500	100		
	25.000	100		
	18.000	100		
	12.500	100		
	9.500	98		
	5.000	97		
	2.000	96		
	0.900	95		
	0.400	92		
	0.250	89		
	0.160	82		
	0.071	64		

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt and Clay Sizes
3	33	64

Remarks:



P. MACHIBRODA ENGINEERING LTD.

DRAWING NO.

Appendix C-2

ASTM D422: GRAIN SIZE ANALYSIS OF SOIL

Project: Slope Stability Study - East Bank South Saskatchewan River
Outlook, Saskatchewan

Project No.: 9551

Date Tested: April 14, 2015

Test Hole No.: 15-2

Sample No.: 19

Depth (m): 28.5

Sieve Analysis:

Sieve	Diameter mm	% Finer
1.5"	38.1	100
1"	25.4	100
3/4"	19.1	100
1/2"	12.7	100
3/8"	9.5	100
# 4	4.75	99
# 10	2	99
# 20	0.85	97
# 40	0.425	92.8
#60	0.25	87.4
# 100	0.15	81.2
# 200	0.075	73.1

Hydrometer Analysis:

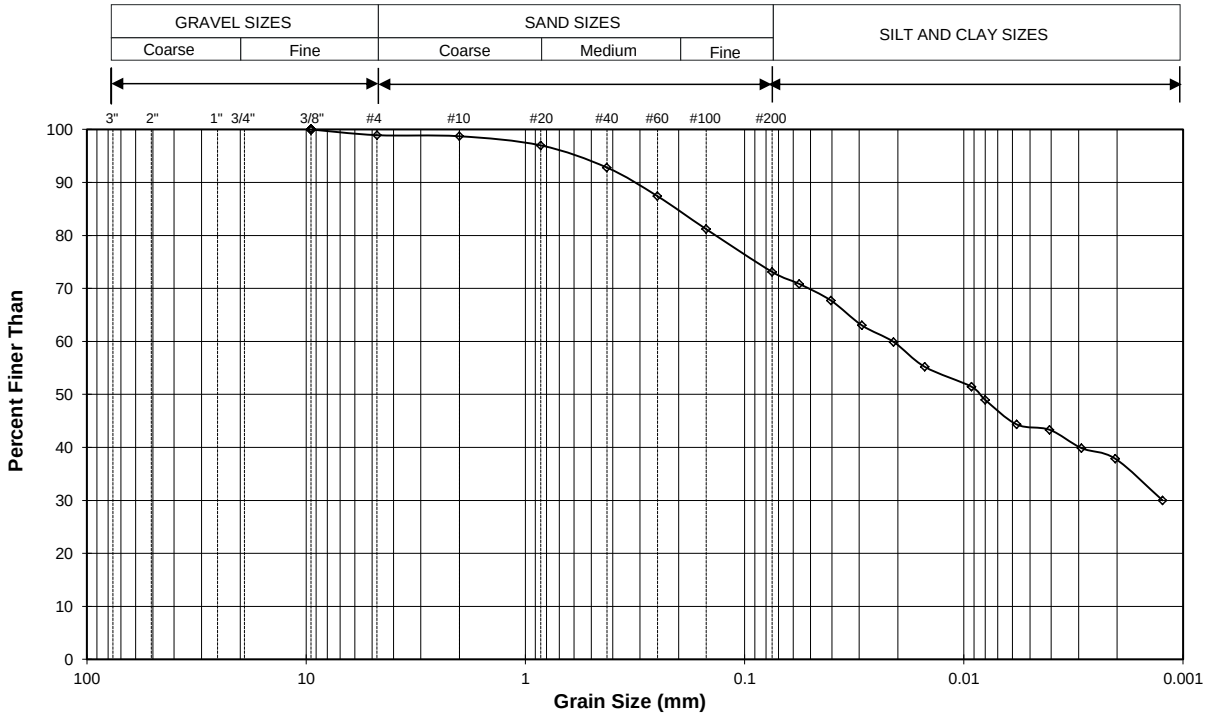
Dispersing Agent:
Sodium Hexametaphosphate

Diameter mm	% Finer
0.0564	70.9
0.0404	67.7
0.0292	63.0
0.0209	59.9
0.0151	55.2
0.0092	51.5
0.0080	48.9
0.0057	44.3
0.0041	43.3
0.0029	39.9
0.0020	37.9
0.0012	30.0

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt Sizes	% Clay Sizes
1	26	35	38

Remarks:



P. MACHIBRODA ENGINEERING LTD.

DRAWING NO.

Appendix C-3

ASTM D422: GRAIN SIZE ANALYSIS OF SOIL

Project: Slope Stability Study - East Bank South Saskatchewan River
Outlook, Saskatchewan

Project No.: 9551

Date Tested: April 14, 2015

Test Hole No.: 15-2

Sample No.: 29

Depth (m): 57.0

Sieve Analysis:

Sieve	Diameter mm	% Finer
1.5"	38.1	100
1"	25.4	100
3/4"	19.1	100
1/2"	12.7	100
3/8"	9.5	100
# 4	4.75	100
# 10	2	100
# 20	0.85	100
# 40	0.425	99.7
#60	0.25	93.4
# 100	0.15	59.3
# 200	0.075	36.3

Hydrometer Analysis:

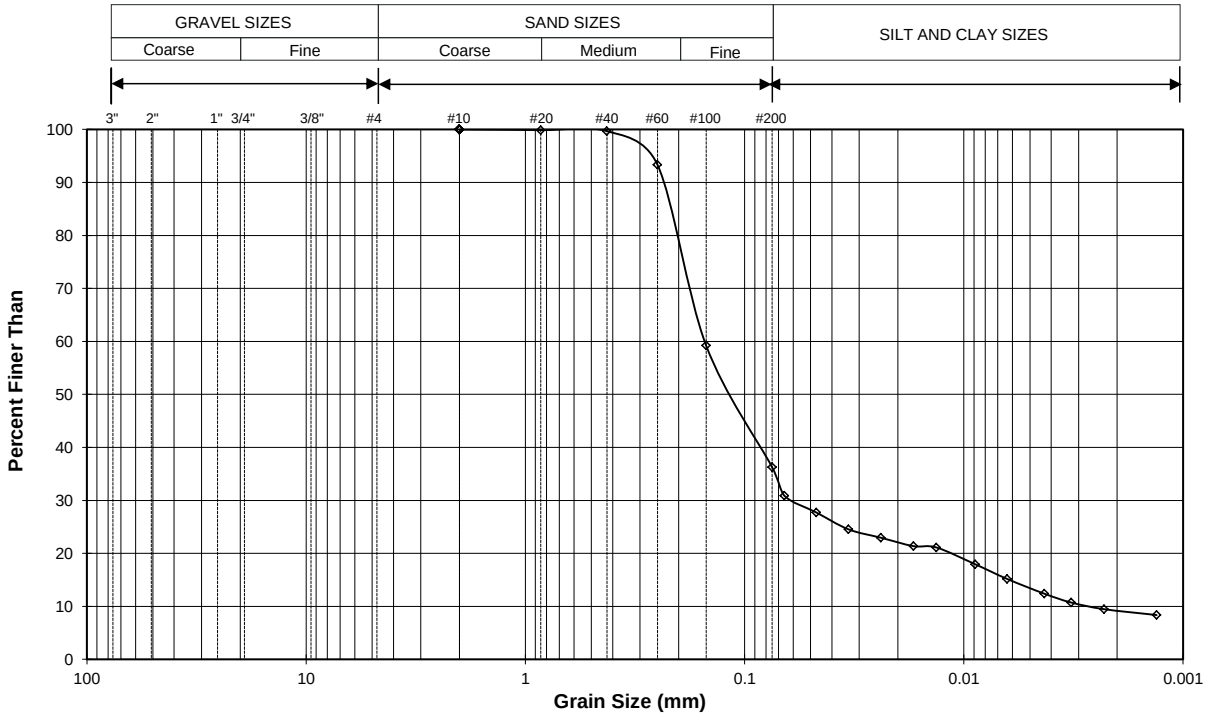
Dispersing Agent:
Sodium Hexametaphosphate

Diameter mm	% Finer
0.0659	30.9
0.0471	27.7
0.0336	24.5
0.0239	23.0
0.0170	21.4
0.0134	21.1
0.0089	18.0
0.0064	15.2
0.0043	12.4
0.0032	10.7
0.0023	9.5
0.0013	8.4

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt Sizes	% Clay Sizes
0	64	27	9

Remarks:



P. MACHIBRODA ENGINEERING LTD.

DRAWING NO.

Appendix C-4

ASTM D422: GRAIN SIZE ANALYSIS OF SOIL

Project: Slope Stability Study - East Bank South Saskatchewan River
Outlook, Saskatchewan

Project No.: 9551

Date Tested: April 24, 2015

Test Hole No.: 15-6

Sample No.:

Depth (m): 67.0

Sieve Analysis:

Sieve	Diameter mm	% Finer
1.5"	38.1	100
1"	25.4	100
3/4"	19.1	100
1/2"	12.7	100
3/8"	9.5	100
# 4	4.75	100
# 10	2	100
# 20	0.85	100
# 40	0.425	99.5
#60	0.25	99.1
# 100	0.15	96.6
# 200	0.075	90.6

Hydrometer Analysis:

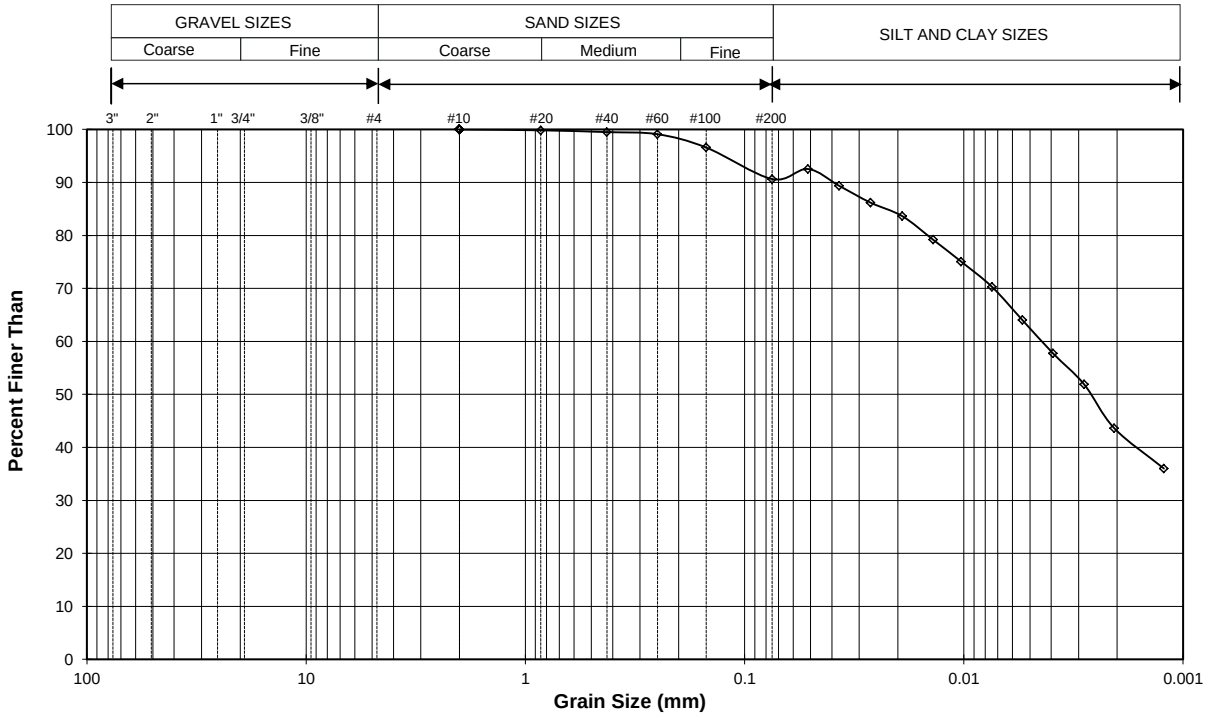
Dispersing Agent:
Sodium Hexametaphosphate

Diameter mm	% Finer
0.0515	92.5
0.0371	89.4
0.0267	86.2
0.0191	83.6
0.0138	79.2
0.0103	75.1
0.0074	70.3
0.0054	64.0
0.0039	57.8
0.0028	51.9
0.0021	43.6
0.0012	36.0

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt Sizes	% Clay Sizes
0	9	47	44

Remarks:



P. MACHIBRODA ENGINEERING LTD.

DRAWING NO.

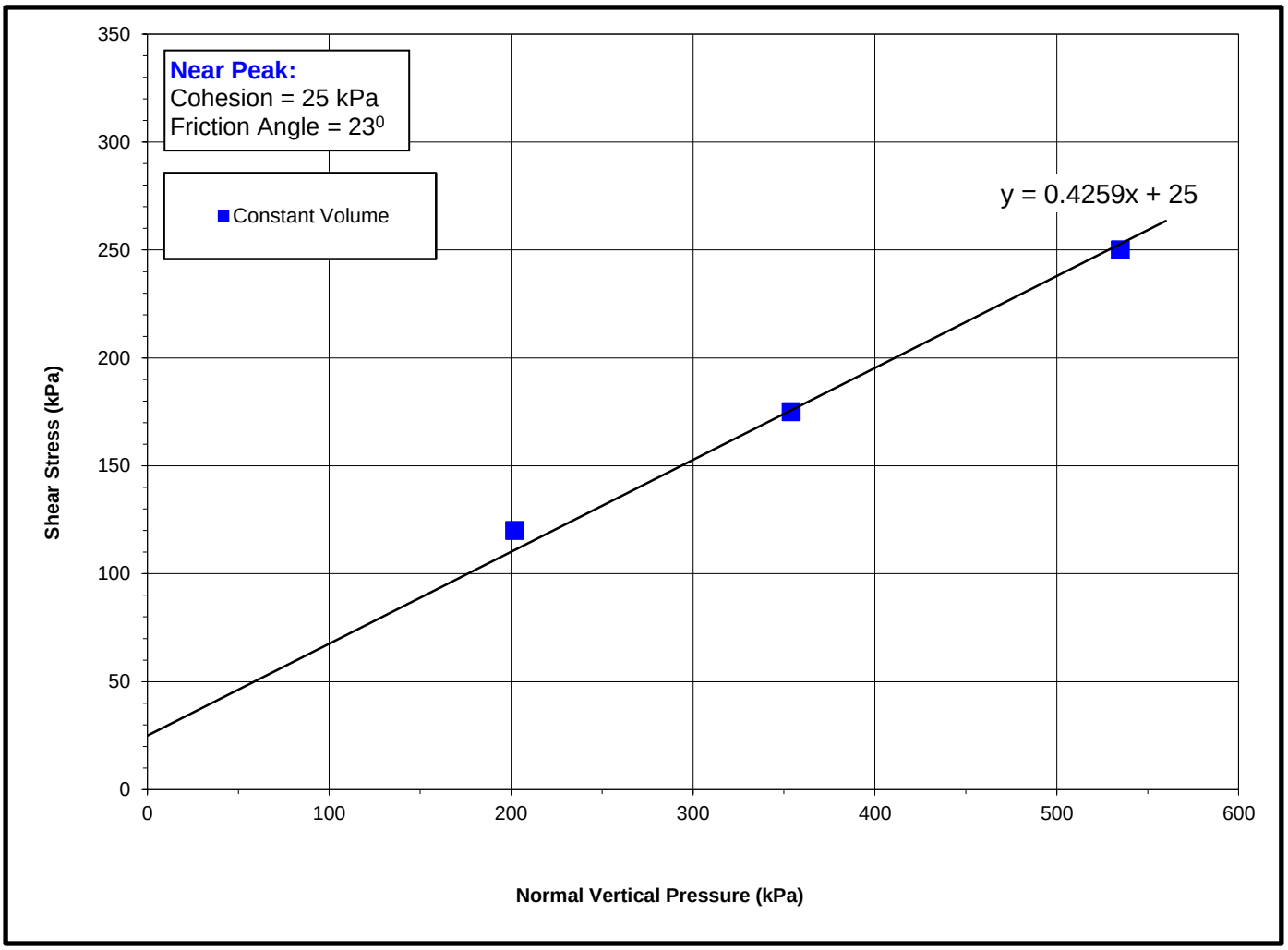
Appendix C-5

P. MACHIBRODA ENGINEERING LTD.
806 - 48th Street East, Saskatoon, SK, S7K 6K9
Phone: (306) 665-8444 Fax: (306)652-2092
Web: www.machibroda.com

DIRECT SHEAR TEST (ASTM D3080-04)

Job No.:	9551
Project:	Slope Stability Study - East Bank South Saskatchewan River
Location:	Outlook, Saskatchewan
Test Hole No.:	14-1
Sample No	8
Depth (m):	15-15.4 m
Soil Description:	Glacial Till
Tested By:	AP
Date:	15-Jan-15

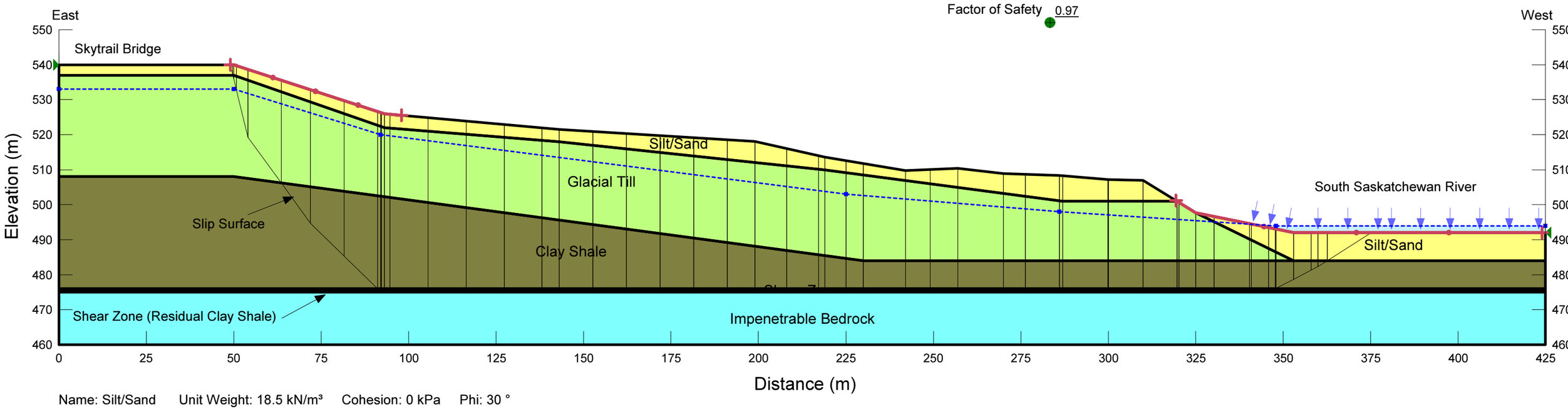
	Load 1	Load 2	Load 3
Normal Vertical Pressure (kPa)	202	354	535
Peak Shear Stress (kPa)	120	175	250
Residual Shear Stress (kPa)			



APPENDIX D

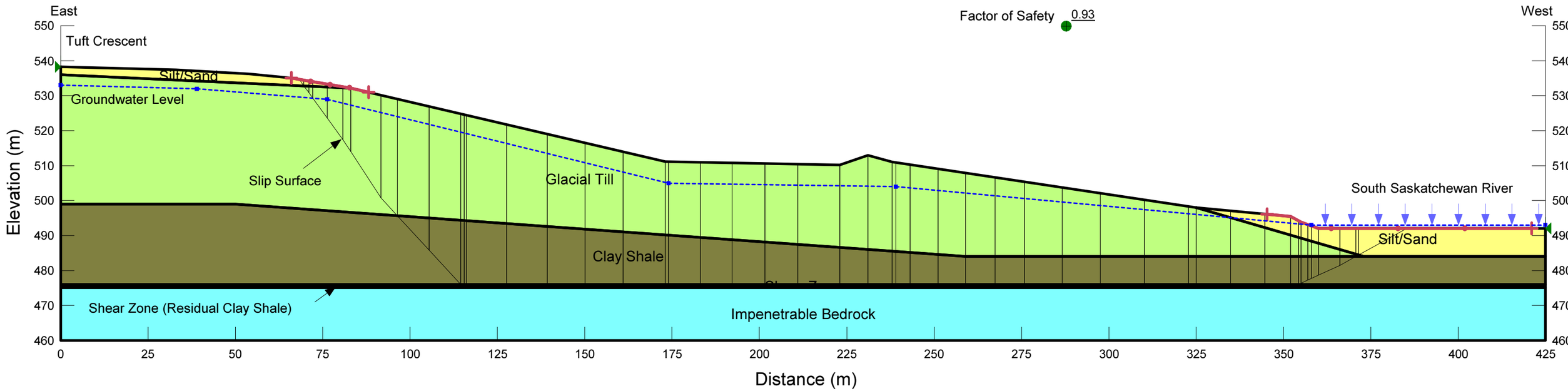
TYPICAL SLOPE STABILITY PLOTS

STRATGRAPHIC SECTION A-A' - BACK ANALYSIS



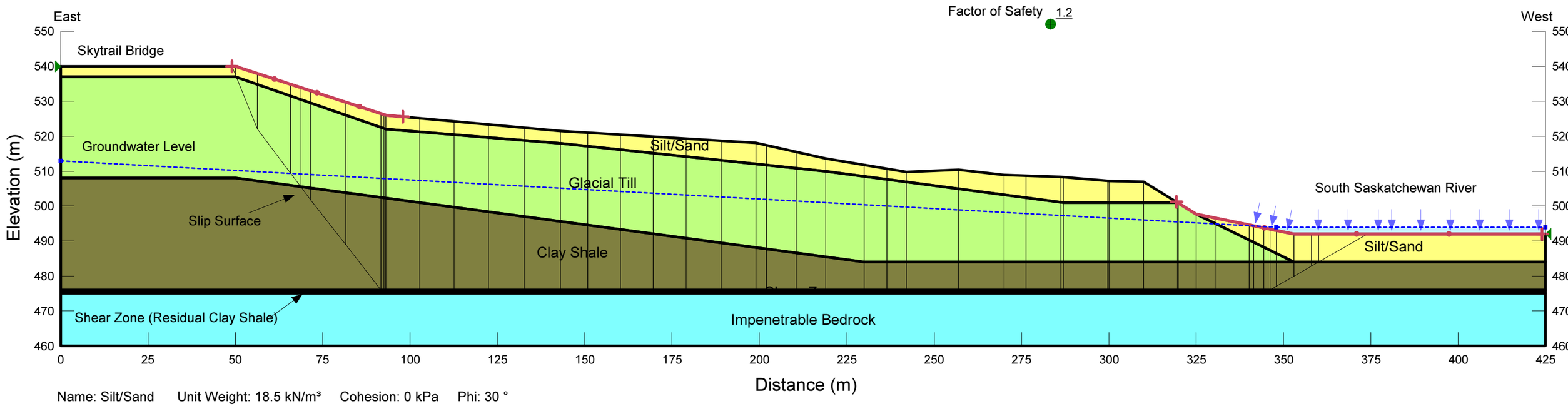
Name: Silt/Sand Unit Weight: 18.5 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Glacial Till Unit Weight: 21.5 kN/m³ Cohesion: 25 kPa Phi: 25 °
Name: Clay Shale Unit Weight: 18.5 kN/m³ Cohesion: 25 kPa Phi: 25 °
Name: Shear Zone Unit Weight: 18 kN/m³ Cohesion: 0 kPa Phi: 6 °
Name: Impenetrable Bedrock

STRATAGRAPHIC SECTION B-B' - BACK ANALYSIS



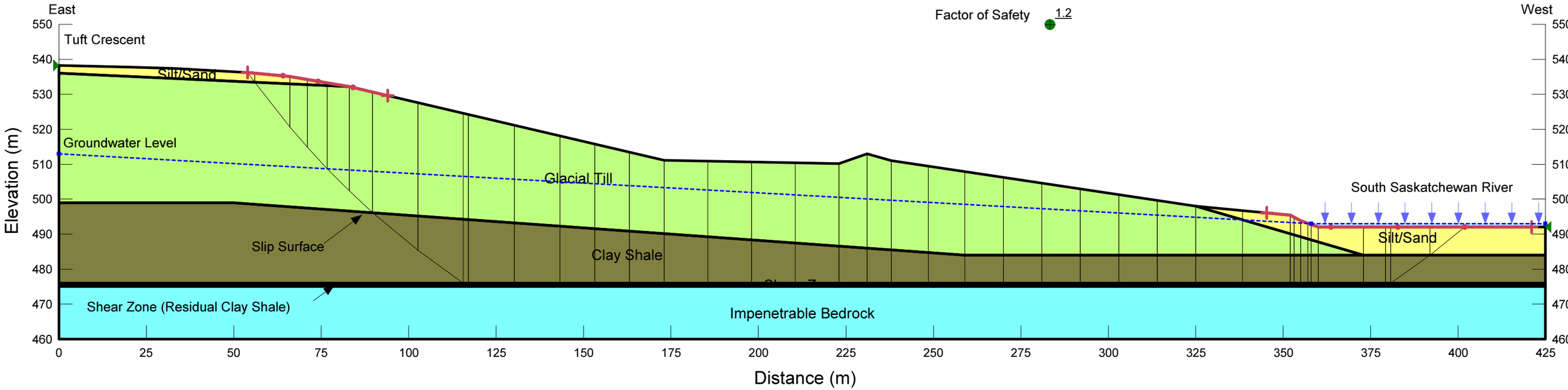
Name: Silt/Sand Unit Weight: 18.5 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Glacial Till Unit Weight: 21.5 kN/m³ Cohesion: 25 kPa Phi: 25 °
Name: Clay Shale Unit Weight: 18.5 kN/m³ Cohesion: 25 kPa Phi: 25 °
Name: Shear Zone Unit Weight: 18 kN/m³ Cohesion: 0 kPa Phi: 6 °
Name: Impenetrable Bedrock

STRATGRAPHIC SECTION A-A' - 20 METRE LOWER GROUNDWATER LEVEL



Name: Silt/Sand Unit Weight: 18.5 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Glacial Till Unit Weight: 21.5 kN/m³ Cohesion: 25 kPa Phi: 25 °
Name: Clay Shale Unit Weight: 18.5 kN/m³ Cohesion: 25 kPa Phi: 25 °
Name: Shear Zone Unit Weight: 18 kN/m³ Cohesion: 0 kPa Phi: 6 °
Name: Impenetrable Bedrock

STRATAGRAPHIC SECTION B-B' - 20 METRE LOWER GROUNDWATER LEVEL



Name: Silt/Sand Unit Weight: 18.5 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Glacial Till Unit Weight: 21.5 kN/m³ Cohesion: 25 kPa Phi: 25 °
Name: Clay Shale Unit Weight: 18.5 kN/m³ Cohesion: 25 kPa Phi: 25 °
Name: Shear Zone Unit Weight: 18 kN/m³ Cohesion: 0 kPa Phi: 6 °
Name: Impenetrable Bedrock

APPENDIX E

TEST HOLE LOGS FROM PMEL REPORT NO. S08-6559

PIEZO. ELEV.= 501.2 m

TEST HOLE 08-1

ELEV: 500.2 m

DEPTH (m)	N	U	γ_w	Pw	Lw	w	
0		pp					**SILT,** some clay, trace sand, stiff, medium plastic, moist, brown.
							BENTONITE SEAL
1						8.1	
2							**GLACIAL TILL,** clay, some silt, some sand, trace gravel, very stiff to hard, medium plastic, moist, brown, oxide stained, gypsum crystals.
							CUTTINGS
3						12.9	
							50 mm diam. SCH 40, PVC RISER PIPE
4							
	15	46				14.5	
5							
6							
	20.7					15.1	
7						15.2	
8							
9						17.4	
10							
						19.5	
11							

488.7 m NOV 17/08

CONTINUED ON NEXT PAGE

LEGEND:

TOPSOIL, GRAVEL, SAND, SILT, CLAY, CLAY SHALE, 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:

SLOPE STABILITY STUDY

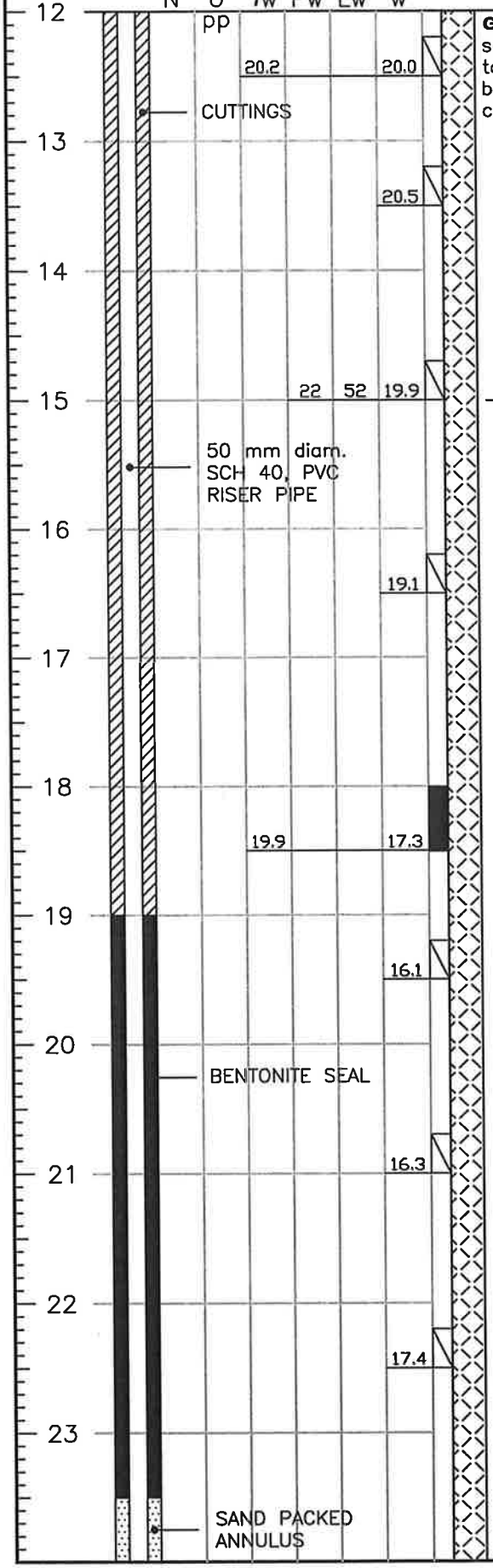
LOCATION:

EAST BANK
SOUTH SASKATCHEWAN RIVER
OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
AUG 13/08	S08-6559-2

TEST HOLE 08-1

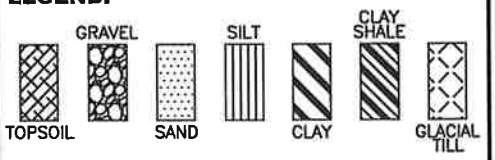


GLACIAL TILL, clay, some silt, some sand, trace gravel, very stiff to hard, medium plastic, moist, brown, oxide stained, gypsum crystals.

–grey below 15.0 m.

CONTINUED ON NEXT PAGE

LEGEND:



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:

SLOPE STABILITY STUDY

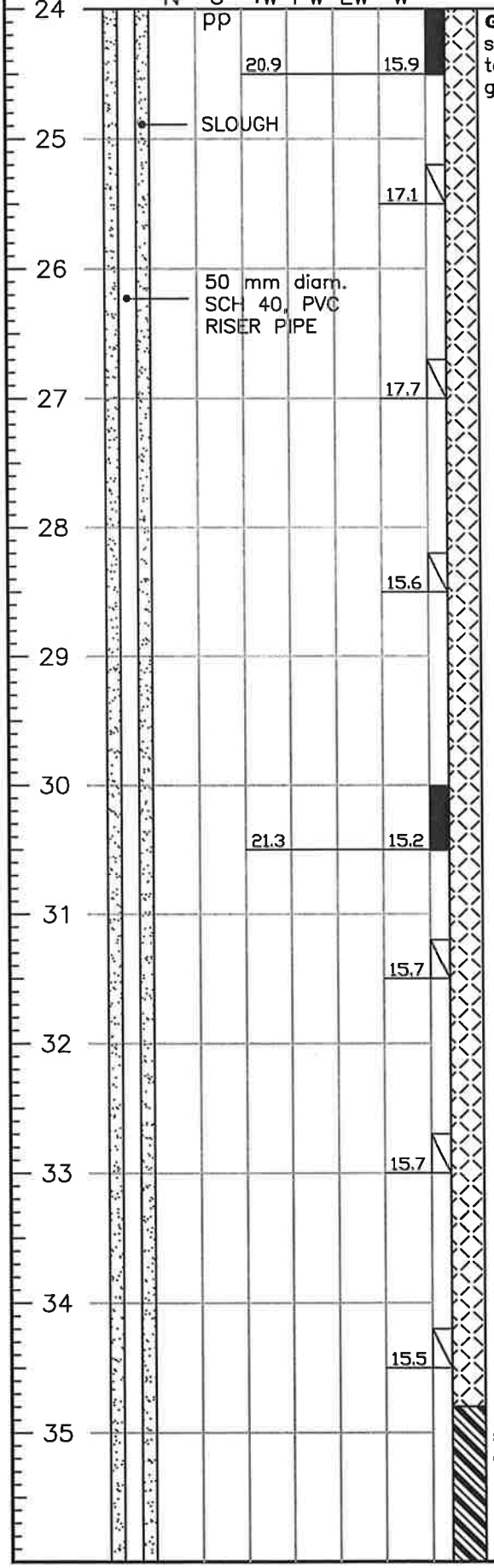
LOCATION:

EAST BANK
SOUTH SASKATCHEWAN RIVER
OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
AUG 13/08	S08-6559-2A

TEST HOLE 08-1

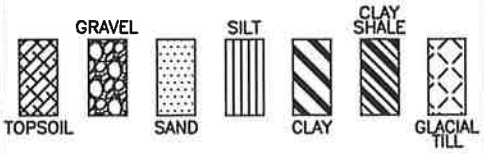


GLACIAL TILL, clay, some silt, some sand, trace gravel, very stiff to hard, medium plastic, moist, grey.

CLAY SHALE, silty, some sand, very stiff to hard, highly plastic, moist, grey.

CONTINUED ON NEXT PAGE

LEGEND:



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:

SLOPE STABILITY STUDY

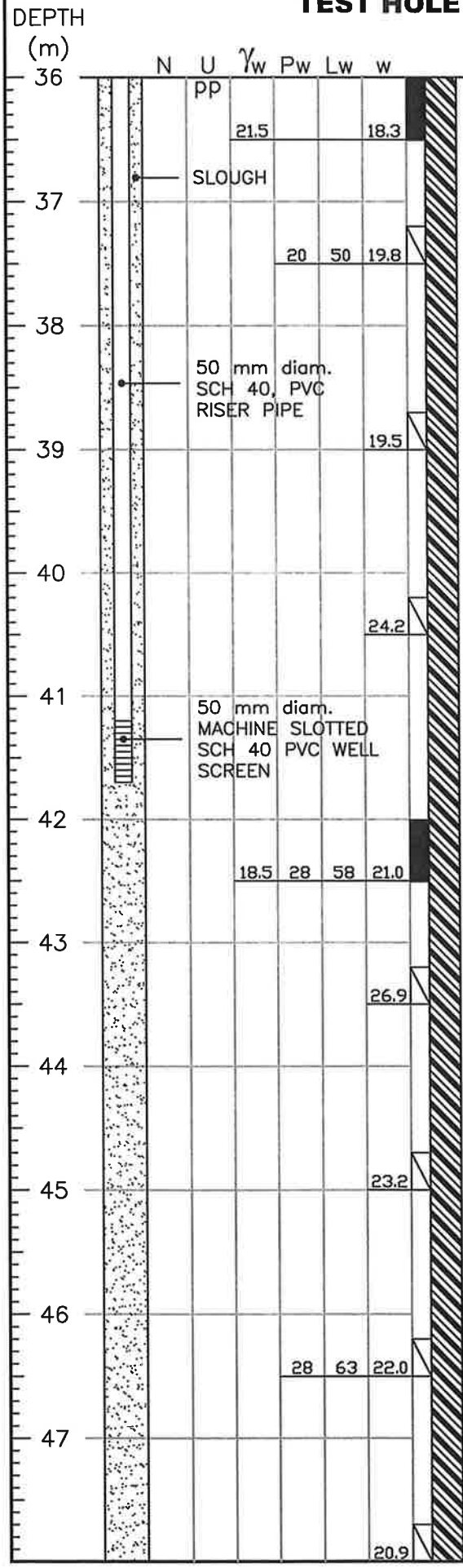
LOCATION:

EAST BANK
SOUTH SASKATCHEWAN RIVER
OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
AUG 13/08	S08-6559-2B

TEST HOLE 08-1



CLAY SHALE, silty, some sand, very stiff to hard, highly plastic, moist, grey, shale stones.

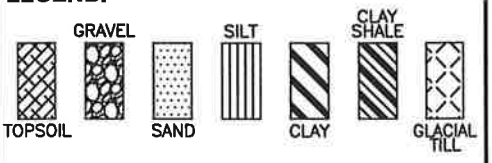
–oxide stained below 38.0 m.

–sandy, firm to stiff, seepage below 40.9 m.

–very stiff below 46.0 m.

CONTINUED ON NEXT PAGE

LEGEND:



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:

SLOPE STABILITY STUDY

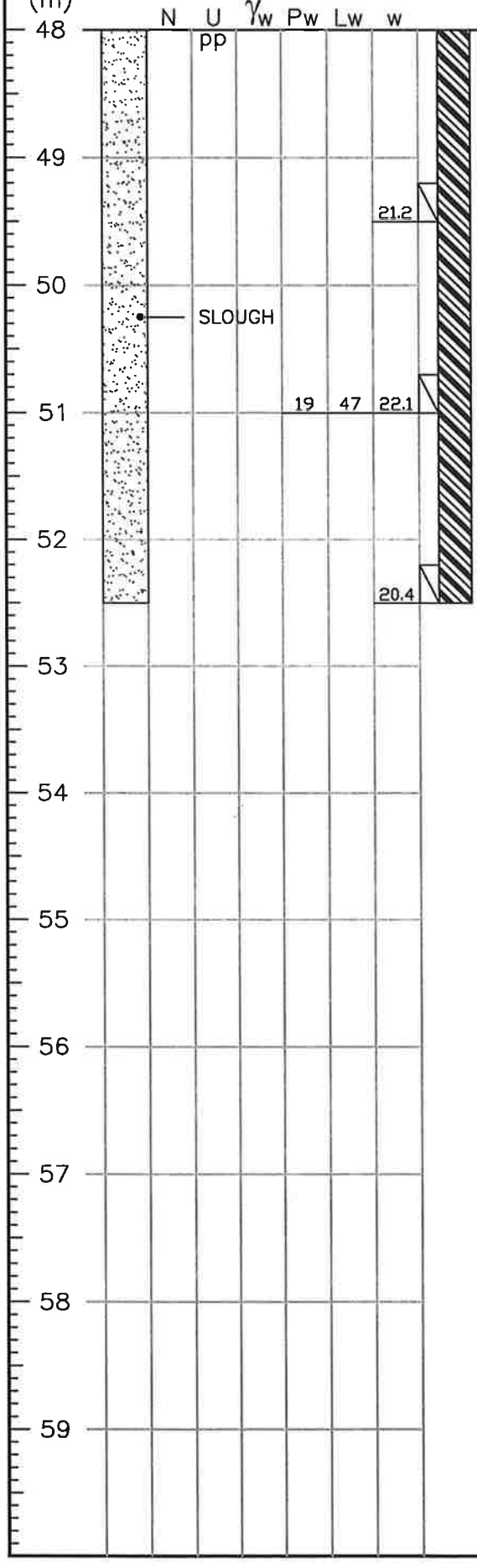
LOCATION:

EAST BANK
SOUTH SASKATCHEWAN RIVER
OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
AUG 13/08	S08-6559-2C

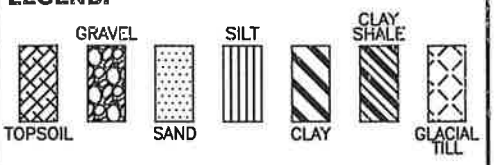
TEST HOLE 08-1



CLAY SHALE, silty, sandy, very stiff, highly plastic, moist, grey, shale stones, oxide stained, seepage.

NOTE:
1. Test Hole sloughed to 24.0 m I.A.D.

LEGEND:



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)

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:

EAST BANK
SOUTH SASKATCHEWAN RIVER
OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	**DRAWING NUMBER:**
AUG 13/08	S08-6559-2D

PIEZO. ELEV.= 511.1 m

TEST HOLE 08-2

DEPTH (m)

N U γ_w Pw Lw w ELEV: 510.0 m

pp

BENTONITE SEAL

50 mm diam. SCH 40, PVC RISER PIPE

500.7 m NOV 17/08

SAND PACKED ANNULUS

TOPSOIL, organic, roots, rootlets.
SILT, some clay, some sand, stiff, medium plastic, damp, brown.

6.6

6.0

GLACIAL TILL, clay, some silt, some sand, trace gravel, stiff to very stiff, medium plastic, moist, brown, oxide stained.

15.5

15.9

15.2

14.8

—gypsum crystals below 9.0 m.

16.6

—grey below 10.8 m.

20.7

CONTINUED ON NEXT PAGE

LEGEND:

GRAVEL, SILT, CLAY SHALE, TOPSOIL, SAND, 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:

SLOPE STABILITY STUDY

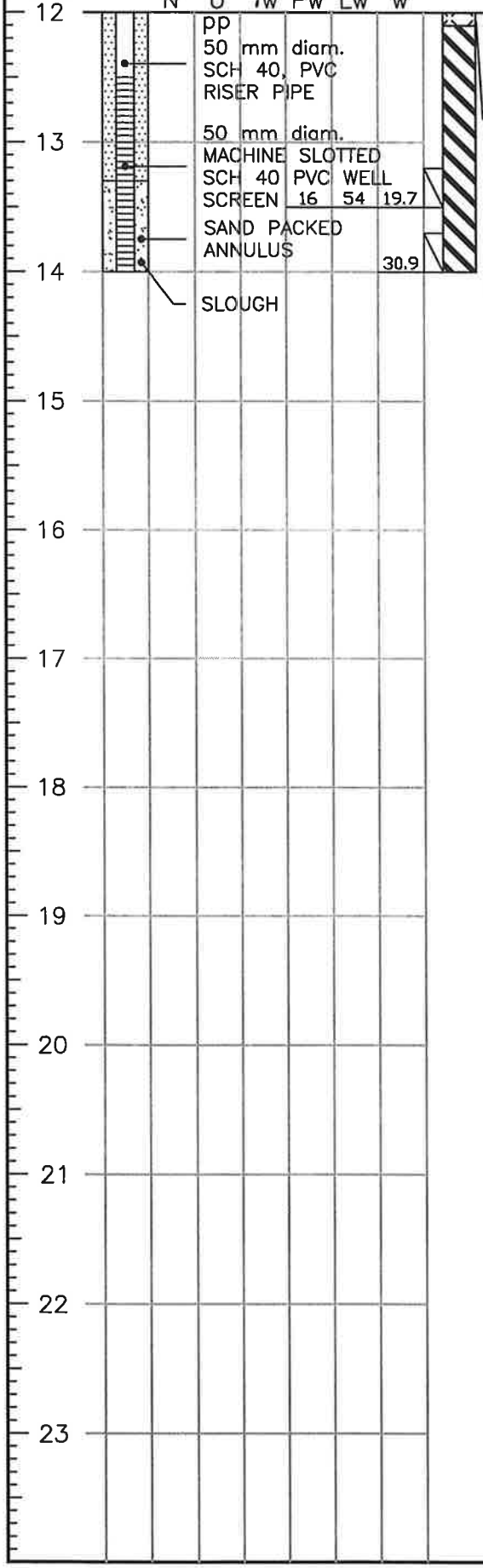
LOCATION:

EAST BANK
SOUTH SASKATCHEWAN RIVER
OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
SEP 24/08	S08-6559-3

TEST HOLE 08-2



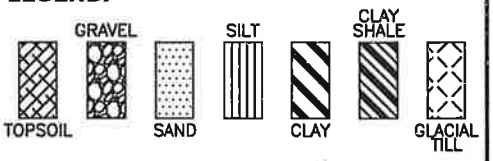
GLACIAL TILL, clay, some silt, some sand, trace gravel, stiff to very stiff, medium plastic, moist, grey, oxide stained, gypsum crystals.

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

–sandy, low plastic, seepage below 13.5 m.

NOTE:
1. Test Hole sloughed to 13.3 m I.A.D.

LEGEND:



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:

SLOPE STABILITY STUDY

LOCATION:

EAST BANK
SOUTH SASKATCHEWAN RIVER
OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	**DRAWING NUMBER:**
SEP 24/08	S08-6559-3A

PIEZO. ELEV.= 526.6 m

TEST HOLE 08-3

ELEV: 525.4 m

DEPTH (m)	N	U	γ_w	Pw	Lw	w	
0		pp					**TOPSOIL,** dark brown, roots, rootlets. **SILT,** some clay, some sand, stiff, medium plastic, damp, light brown.
1						7.9	
2							**GLACIAL TILL,** clay, some silt, some sand, trace gravel, stiff to very stiff, medium plastic, moist, brown, oxide stained, gypsum crystals.
3						10.6	
4						9.0	
5							
6						12.6	
7						13.7	
8							
9						15.5	
10						16.6	
11							–very stiff to hard, grey below 10.8 m.

BENTONITE SEAL

CUTTINGS

50 mm diam. SCH 40, PVC RISER PIPE

CONTINUED ON NEXT PAGE

LEGEND:

TOPSOIL, GRAVEL, SAND, SILT, CLAY, CLAY SHALE, 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

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P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:

SLOPE STABILITY STUDY

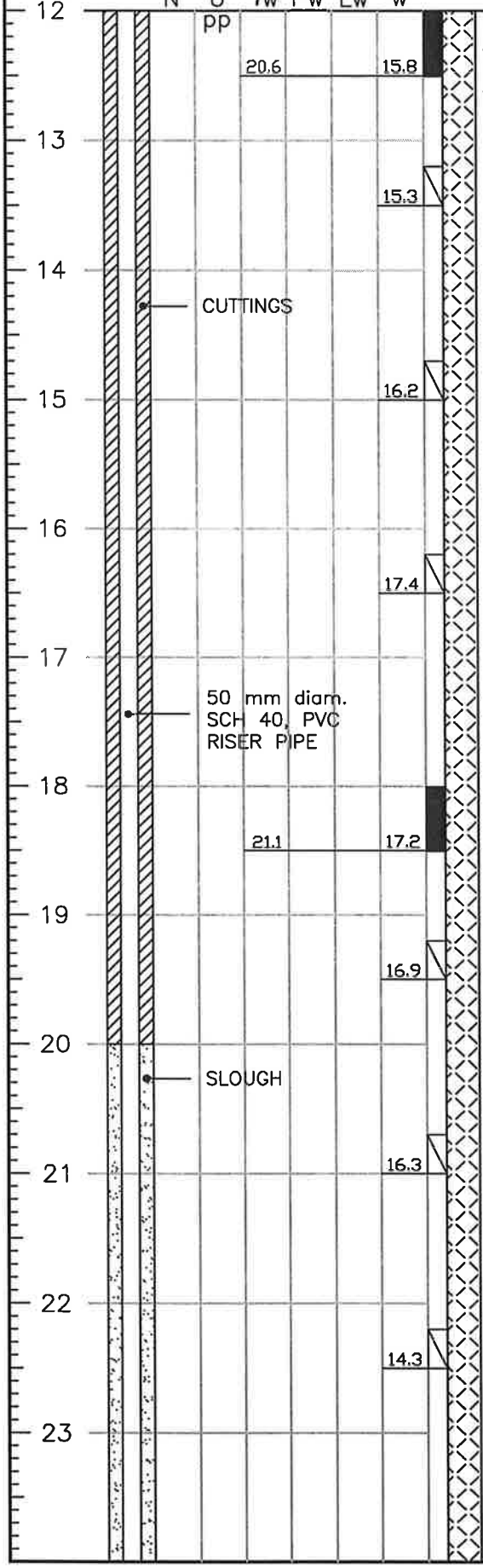
LOCATION:

EAST BANK
SOUTH SASKATCHEWAN RIVER
OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
AUG 14/08	S08-6559-4

TEST HOLE 08-3



GLACIAL TILL, clay, some silt, some sand, trace gravel, very stiff to hard, medium plastic, moist, grey, oxide stained, gypsum crystals.

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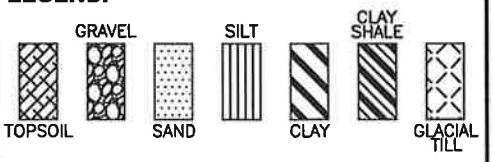
LEGEND:



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

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P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:

SLOPE STABILITY STUDY

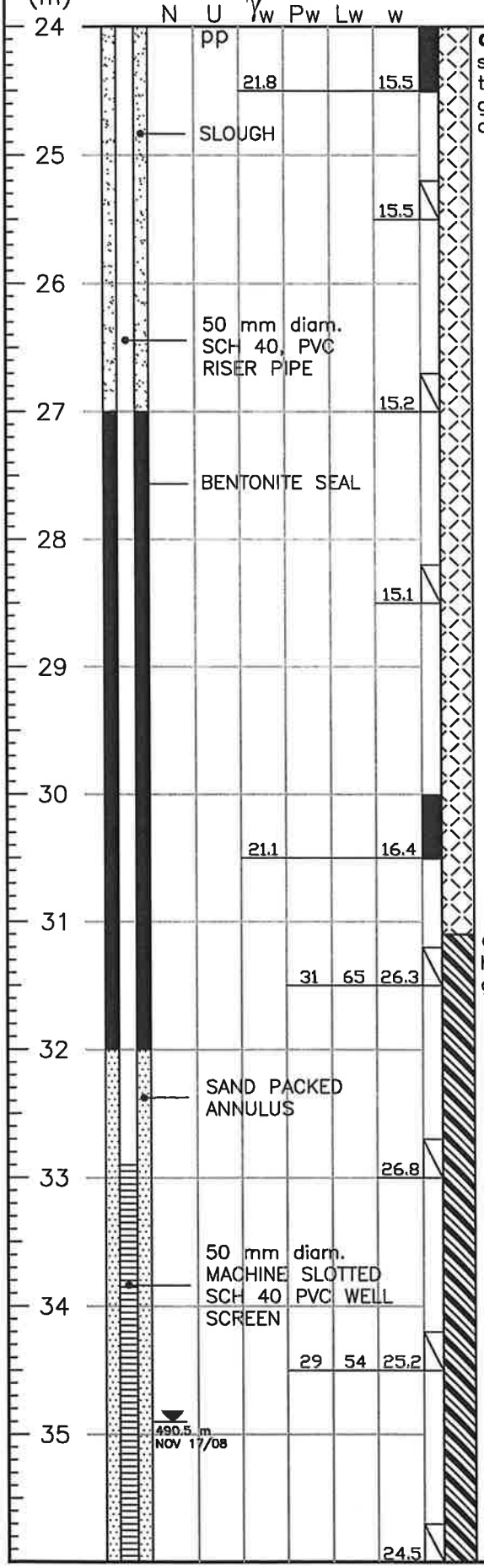
LOCATION:

EAST BANK
SOUTH SASKATCHEWAN RIVER
OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
AUG 14/08	S08-6559-4A

TEST HOLE 08-3



GLACIAL TILL, clay, some silt, some sand, trace gravel, very stiff to hard, medium plastic, moist, grey, oxide stained, gypsum crystals.

CLAY SHALE, some silt, very stiff, highly plastic, moist, light grey to grey, seepage.

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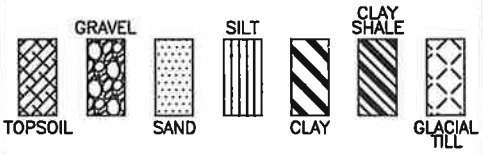
LEGEND:



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

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m^3)

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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

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P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:

SLOPE STABILITY STUDY

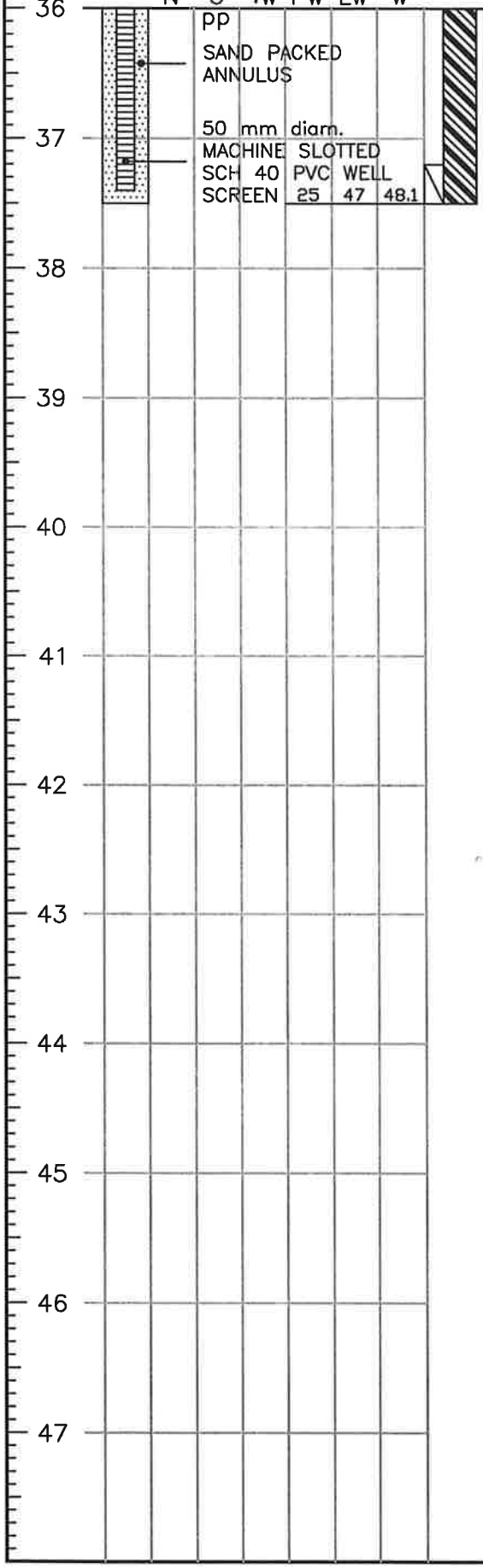
LOCATION:

EAST BANK
SOUTH SASKATCHEWAN RIVER
OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
AUG 14/08	S08-6559-4B

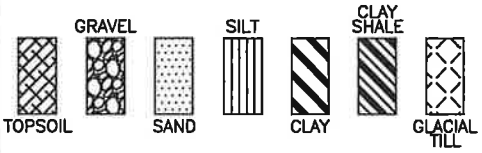
TEST HOLE 08-3



CLAY SHALE, some silt, very stiff, highly plastic, moist, light grey to grey, seepage.

NOTE:
1. Test Hole open to 37.5 m and dry I.A.D.

LEGEND:



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

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P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:

SLOPE STABILITY STUDY

LOCATION:

EAST BANK
SOUTH SASKATCHEWAN RIVER
OUTLOOK, SK

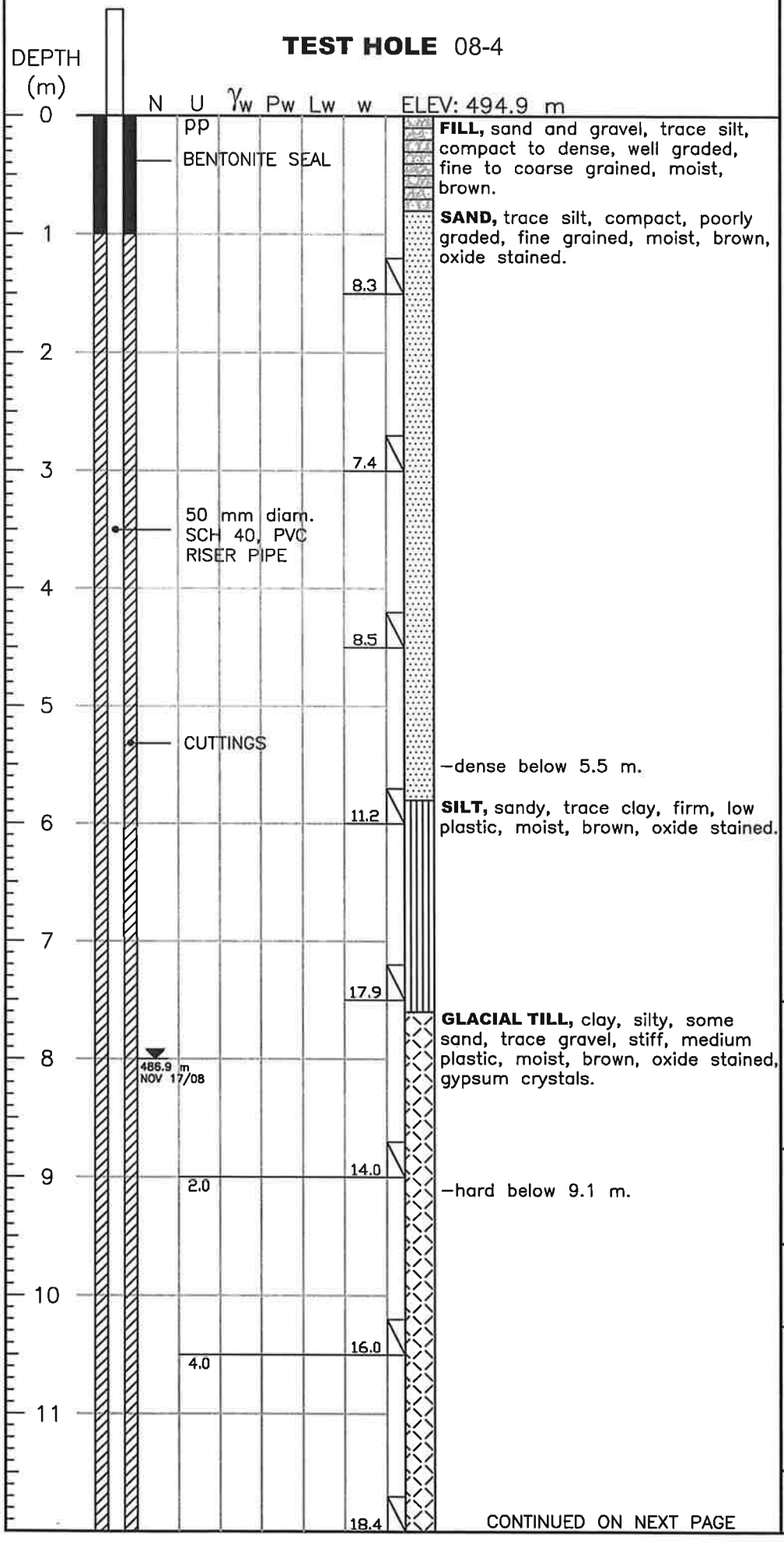
NORTHING: **EASTING:**

DATE DRILLED:	**DRAWING NUMBER:**
AUG 14/08	S08-6559-4C

PIEZO. ELEV.= 495.7 m

TEST HOLE 08-4

ELEV: 494.9 m



FILL, sand and gravel, trace silt, compact to dense, well graded, fine to coarse grained, moist, brown.

SAND, trace silt, compact, poorly graded, fine grained, moist, brown, oxide stained.

–dense below 5.5 m.

SILT, sandy, trace clay, firm, low plastic, moist, brown, oxide stained.

GLACIAL TILL, clay, silty, some sand, trace gravel, stiff, medium plastic, moist, brown, oxide stained, gypsum crystals.

–hard below 9.1 m.

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LEGEND:

FILL, GRAVEL, SAND, SILT, CLAY, CLAY SHALE, 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

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P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:

SLOPE STABILITY STUDY

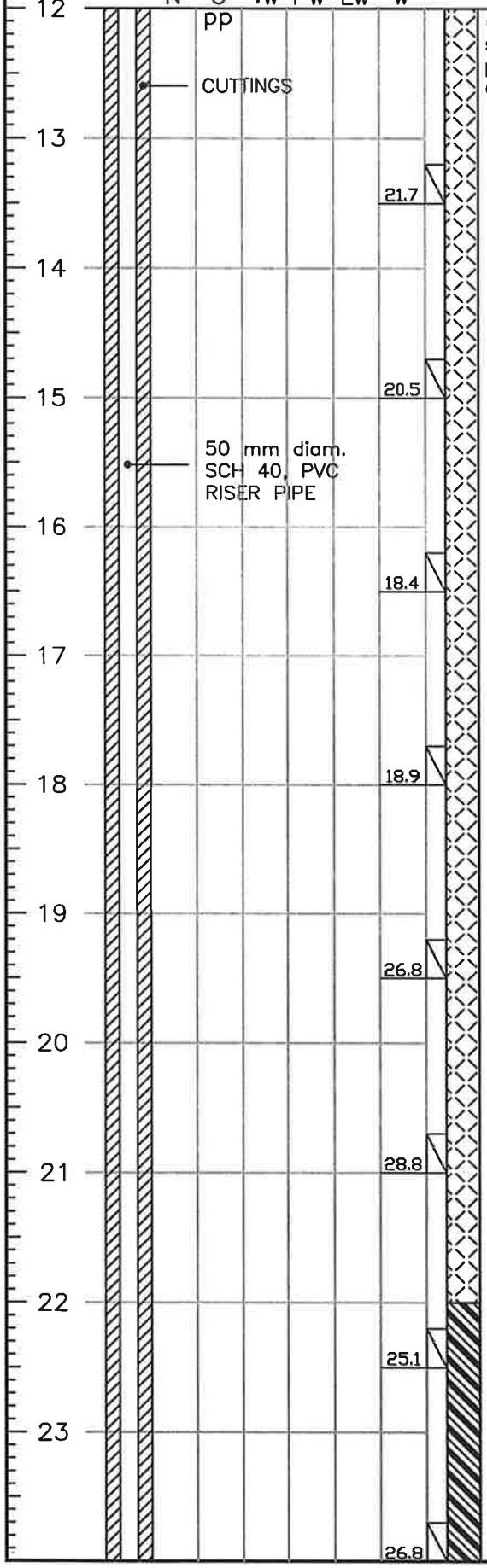
LOCATION:

EAST BANK
SOUTH SASKATCHEWAN RIVER
OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
AUG 27/08	S08-6559-5

TEST HOLE 08-4



GLACIAL TILL, clay, silty, some sand, trace gravel, hard, medium plastic, moist, brown, oxide stained, gypsum crystals.

CLAY SHALE, silty, trace sand, very stiff, highly plastic, moist, grey.

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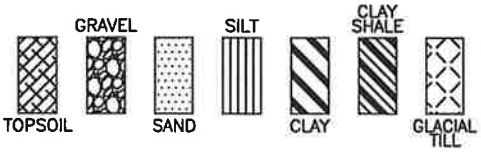
LEGEND:



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)

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P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:

SLOPE STABILITY STUDY

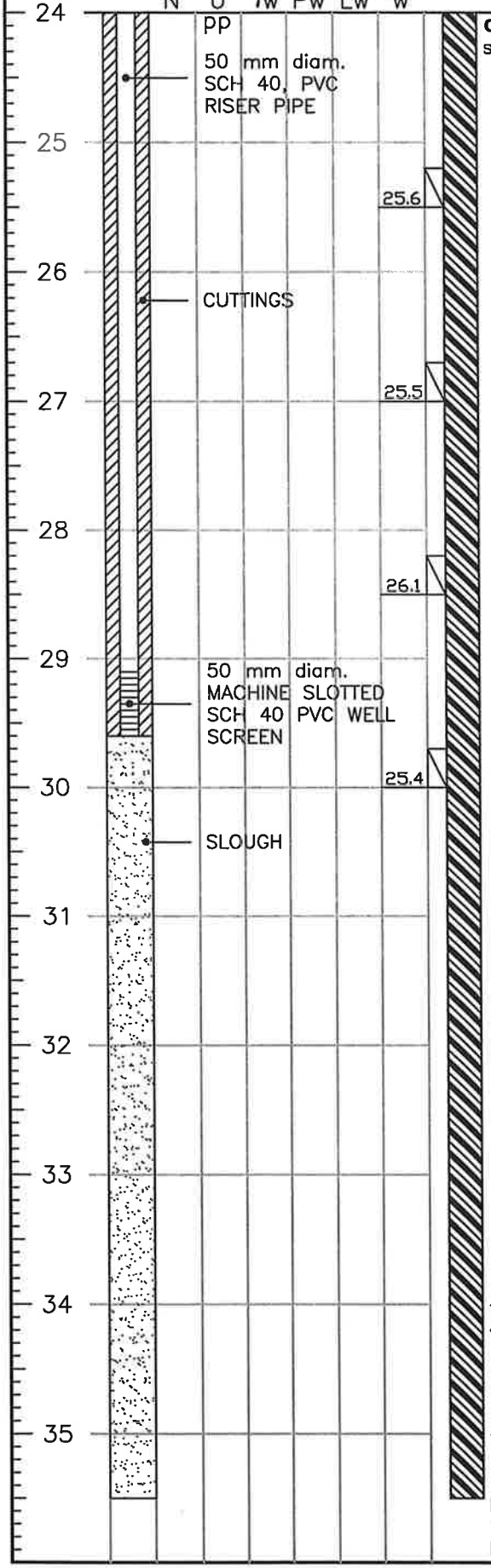
LOCATION:

EAST BANK
SOUTH SASKATCHEWAN RIVER
OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	DRAWING NUMBER:
AUG 27/08	S08-6559-5A

TEST HOLE 08-4



CLAY SHALE, silty, trace sand, very stiff, highly plastic, moist, grey.

—wet, seepage, sloughing below 34.0 m.

—sandy below 35.0 m.

NOTE:
1. Test Hole sloughed to 29.6 m I.A.D.

LEGEND:

GRAVEL, SILT, CLAY SHALE, TOPSOIL, SAND, 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

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P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:

SLOPE STABILITY STUDY

LOCATION:

EAST BANK
SOUTH SASKATCHEWAN RIVER
OUTLOOK, SK

NORTHING: **EASTING:**

DATE DRILLED:	**DRAWING NUMBER:**
AUG 27/08	S08-6559-5B