Geotechnical Investigation Report

14 February 2022

Geotechnical Investigation For

The Installation of a 400mm Diameter Sewer Line in R K Khan Within Ward 73 In Chatsworth.

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EXECUTIVE SUMMARY

Umgudulu Projects (Pty) Ltd was appointed by eThekwini Municipality to conduct a geotechnical investigation for a proposed pipeline upgrade in Chatsworth RK Khan within ward 73, in Durban.

The investigation consisted of excavation of five (5) test pits along the pipeline, five (5) Dynamic Probing Light (DPL) tests, and laboratory testing. The test pits revealed that the soil profile comprises combinations of the transported horizon, residual, and bedrocks.

The transported material present at the site is classified as G10. The material that is G10 according to the TRH 14 guidelines (CSIR: 1987), should therefore be suitable for use in the construction of subgrade layer material and low stiffness engineered fill.

The transported material underlying the site consists of non-cohesive soils. It is expected that the materials will be compressible and collapsible when the moisture conditions change from dry to moist due to rainwater infiltration.

In the investigated site, soft excavation conditions are present along the entire route and in the test pits. The materials on the sewer line route can therefore be readily be excavated with a TLB.

Sidewall collapse or instability is expected during the construction on this site as some of the test pits were stable during the investigation. As far as the excavation of service trenches is concerned, trenches less than 1.0 m in depth may be excavated with vertical sidewalls, while deeper temporary excavations and excavations experiencing seepage will require trimming the slope and ensuring that any loose materials in transported soil layers are removed before workers are allowed into the excavations. Slope angles in excavations should not exceed 30 degrees. Shoring is required for excavations extending depths of 2.0 m below surface level.

1 Introduction

Umgudulu Projects received an appointment on the 29th of November 2021 from eThekwini Municipality to conduct a geotechnical investigation for the proposed 400mm diameter sewer pipeline upgrade located in Chatsworth RK Khan within ward 73.

To meet the requirements for the investigation, the investigation was conducted in accordance with the South African Institute of Civil Engineering Code of Practice (SAICE, 2010).

The fieldwork was conducted on the 15th of December 2021 with the following objectives:

- To describe the investigation procedure.
- To provide an overview of the geology of the site.
- Discuss the soil profiles encountered.
- Comment on the groundwater conditions.
- Characterizes the soil properties based on the results of laboratory testing.
- Comment on the excavatability of the subsoil.
- Identify and discuss potential problematic geotechnical considerations
- Provide geotechnical recommendations regarding the founding of pipeline; and
- Presents generic geotechnical related construction recommendations.

This report presents the findings and the analysis of the data as obtained from the field investigation i.e., soil profiles, in-situ, and laboratory testing.

2 Available information

At the time of the investigation the following information was available:

- A 1:250 000 scale geological map of Durban, sheet 2930 (Council for Geoscience, 1986).
- A 1:250 000 scale soil map of Durban, sheet 2626 (Soil and Research Institute, 1998).
- Aerial photographs, sourced from Google Earth.
- Locality plans indicate the extent of the investigated section.

In addition, the client's personnel showed us the extent of the pipeline.

3 Site description

3.1 Site Locality

The sewer pipeline to be upgraded is located at about 150m north of RK Khan Hospital and 100m east of RK Khan Cir Road in Chatsworth. The existing pipeline is running parallel to the stream as shown in Figure 1 below.

Figure 1: Showing the investigated sewer pipeline route.

3.2 Topography and vegetation

The investigated area is gently sloping towards the stream with a sandstone outcrop inside the river. At the time of the investigation, the site was covered by grass, shrubs, and trees.

3.3 Climate

Chatsworth has a Mediterranean climate with hot and dry summers and mild winters. It receives a significant amount of rainfall during the year. The average temperature in the area is 22°C during a year. It normally receives about 382 mm of rain per year. (Climate-Data.Org: 2012).

The Weinert Climatic N-value for the area is <5 indicating that the climate is semi-humid and chemical weathering processes are dominant (Weinert, 1980).

4 Geology

According to the published 1:250 000 geological map of Durban Sheet 2930 (Council for Geoscience, 1986), the site is underlain by the Natal Group (**O-Sn**) sedimentary rocks, with the lithology consisting of red-brown coarse-grained arkosic to subarkosic sandstone; micaceous sandstone; subordinate siltstone and mudstone. Figure 2 below shows the geological map of the investigated area.

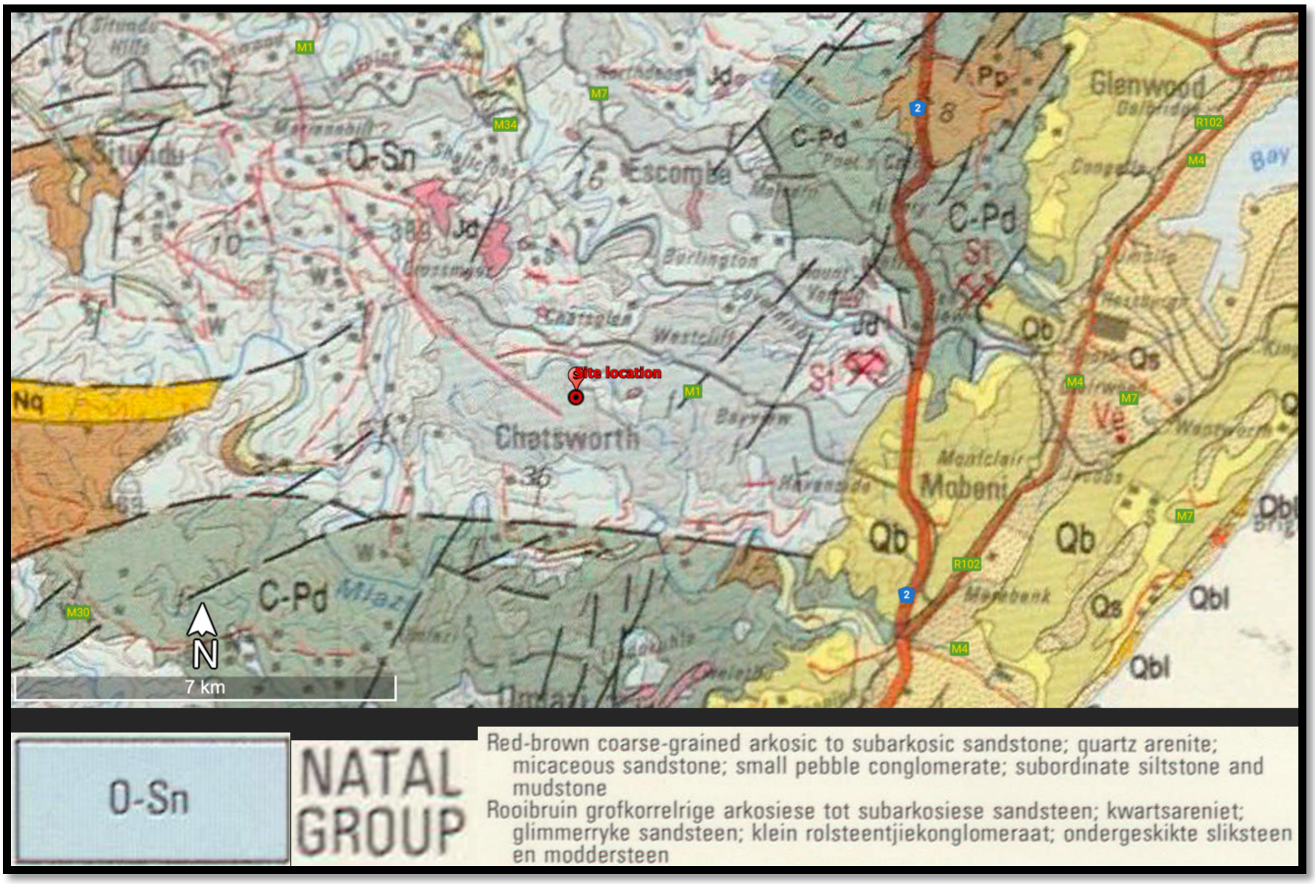

Figure 2: Showing the geological map of the study area; (Geological Survey, printed by the Government Printer, Pretoria, 1986).

5 Investigation Methodology

The geotechnical study was carried out in three phases. The first phase was a desktop study, which was followed by the second phase of fieldwork, analysis and reporting was the third phase. The desktop study commenced before the fieldwork. During the fieldwork, representative samples were taken and submitted to a SANAS accredited laboratory for soil testing.

5.1 Desktop study

The desk study of available geological information involved perusing aerial images, available published geological maps, and relevant literature. The purpose of the study was to give technical guidance on the expected geological and geotechnical conditions on the site.

5.2 Fieldwork

The fieldwork comprised of the following:

- Excavation and profiling of test pits.
- Collection of representative soil samples for laboratory testing; and
- In-situ testing.

5.2.1 Test Pitting

Five (5 No) test pits were excavated and profiled along the pipeline route. Test pits were hand excavated to a depth of 2m below the existing ground levels or to refusal on a hard material or until sidewall stability of a test pit was unsafe. Test pit positions were marked using a hand-held GPS, on the UTM grid and WGS84 datum.

A two-person team carried out the test pitting to comply with accepted safety requirements as reflected in the Site Investigation Code of Practice (SAICE, 2010). The test pits were set out and profiled by a team of engineering geologists/ geotechnical engineers by South African standards (SANS 633:2012). The details of the test pits are summarised in Table 1 below and the detailed test pit soil profiles are attached in Appendix A.

Table 1: Test pit summary

Test Pit No.	Coordinates (WGS84)		Depth (m)	Remarks
	Longitude	Latitude		
TP1	29°54'42.89"S	30°53'13.55"E	2.00	No Refusal
TP2	29°54'43.23"S	30°53'14.24"E	1.60	Refusal on Sandstone
TP3	29°54'43.48"S	30°53'14.89"E	1.00	Refusal on Sandstone
TP4	29°54'43.78"S	30°53'15.47"E	0.90	Refusal on Sandstone
TP5	29°54'44.08"S	30°53'16.14"E	1.90	Refusal on Sandstone

5.2.2 Sampling

Representative disturbed soil samples from the different soil layers encountered on the sites were taken to a SANAS-accredited laboratory to conduct the material property testing and characterization of the samples' engineering properties.

5.2.3 In-situ testing

The in-situ field testing was conducted using Dynamic Probe Light (DPL) tests. The DPLs were conducted adjacent to each test pit along the pipeline to determine the consistency of the in-situ material.

5.3 Laboratory testing

The collected samples were taken to a SANAS accredited laboratory for soil testing. The following tests were conducted.

- Foundation Indicator test (comprising sieve and hydrometer grading analyses and Atterberg Limits).
- MOD CBR test for the determination of compaction characteristics. It comprises of Mods, i.e., maximum dry densities (MDD) and optimum moisture contents (OMC), as well as CBR's).
- pH test for the determination of pH and conductivity.

6 Field Investigation Results

The detailed descriptions of the soil profiles encountered in the test pits are presented in Appendix B; while the soil profiles encountered from the excavated test pits on-site are summarised below. The layers encountered are as follows:

- Transported layer.
- Residual layer.
- Sandstone bedrock.

6.1 Transported layer

The transported layer was encountered in all the test pits excavated along the pipeline route. This layer was described as moist, dark brown, slightly clayey sand with roots. The layer has a loose overall consistency. The thickness of this layer ranges from 1.0 to 2.0m.

6.2 Residual Layer

The transported layer was underlain by the residual layer at the site. It was described as moist to wet, light orange-brown, slightly clayey silty sand with a medium dense average consistency.

6.3 Sandstone bedrock.

Sandstone was encountered at the base of all test pits at the site. It was described as light brown, slightly weathered, widely jointed, coarse-grained, medium-hard rock. The DPL refusal was encountered in this layer.

7 In situ testing Results

The results from the DCP tests conducted adjacent to the test pit reveal that the transported and residual layer is loose. to medium dense. The early refusal was encountered on sandstone bedrock at a depth ranging from 1.00 - 2.60m. The detailed DCP results are attached in Appendix B of this report.

8 Groundwater conditions

The pipeline runs adjacent to the flawing stream therefore, groundwater problems are anticipated at the site.

9 Laboratory Test Results

9.1 Foundation Indicators

Representative samples of selected horizons were collected for laboratory testing and submitted for foundation indicator tests. The test results are attached in Appendix C and summarized in Table 2 and Table 3 below.

Table 2: Summary of section foundation indicator tests results

Hole no.	Depth (m)	Soil composition			GM	Atterberg limits			Activity	Unified soil classification
		Clay & Silt (%)	Sand (%)	Gravel (%)		LL (%)	WPI (%)	LS (%)		
Transported layer										
TP01	0.25 – 1.0	26	73	1.00	1.00	SP	SP	1.5	LOW	SM
TP01	1.0 – 2.0	23	77	0	1.02	SP	SP	0.5	LOW	SM
TP02	0 – 1.0	21	78	1.00	1.03	SP	SP	1.0	LOW	SM

<u>Where:</u>

GM	=	Grading modulus.
LL	=	Liquid Limit.
WPI	=	Weighted Plasticity Index (PI x % passing the 0.425 mm sieve).
LS	=	Linear Shrinkage.
Activity	=	Expansiveness of the soil according to Van der Merwe's method.
SM	=	Silty sand, sand-silty mixture.

Table 2 above indicates that:

The **transported layer** at the site generally consists of Silty sand mixture (SM). The layer has a high (1.00-1.30) grading moduli. The fine fractions of this material also exhibit a material that is non-plastic. The weighted plasticity index (WPI) of the soil is very low. The material has a low potential for expansiveness, according to the method proposed by Van der Merwe (1973)

9.2 Compaction Tests

Samples of materials identified as potential sources of construction materials were sampled for laboratory testing. The samples were subjected to compaction tests in which the moisture-density relationship was established, with Californian Bearing Ratio (CBR) tests carried out to determine the suitability of the soils for use in constructing layer works below paved areas. The test results are attached in Appendix C and are summarised in Table 3 below:

Table 3: Summary of section compaction test results

Hole no.	Depth (m)	OMC (%)	MDD (kg/m³)	Swell (%)	CBR at various densities				TRH 14 Class
					90 %	93 %	95 %	98 %	
	Transported								
TP01	0.25–1.00	9.2	1982	0.1	6.5	11	16	26	G10

Where:

OMC	=	Optimum moisture content
MDD	=	Maximum dry density (Mod AASHTO)
Swell	=	Soaked at 100% Mod AASHTO compaction

The compactibility factor for the transported material at the site is 0.39. The transported material underlying the site has a high (1982kg/m^3) maximum dry density and moderate (9.2%) optimum moisture content value. The swell is very low (0.1), and the tests yielded low to moderate CBR values at densities typically specified in the field (93% to 95%). The material is classified as (**G10**) according to the TRH 14 (CSIR: 1987) guidelines.

The material that is **G10** according to the TRH 14 guidelines (CSIR: 1987), should therefore be suitable for use in the construction of subgrade layer material and low stiffness engineered fill.

9.3 Chemical Tests

Disturbed samples of the various horizons were taken and subjected to chemical tests by DIN 50929 requirements. The chemical test results are attached in Appendix C and are summarised in Table 4 and Table 5 below. Several environmental factors influence buried metals. These factors are:

- Electrical conductivity of the soil
- Chemical properties of the soil
- The ability of the soil to support sulfide-reducing bacteria.
- Heterogeneity of the soil (long-line currents)
- Differential aeration
- Stray currents in the soil, and
- Bacteria attack

The conductivity of the soil has a profound influence on the rate of corrosion of buried metallic objects. Based on the significance of soil resistivity on corrosivity, Duligal (1996) provides the following table for evaluation of the conductivity of soil:

Table 4: Guideline values for interpretation of soil conductivity (Duligal, 1996)

Soil conductivity		
Soil conductivity (mS/m)	**Soil resistivity (Ohm.cm)**	**Corrosively classification**
More than 50	0 – 2000	Extremely corrosive
25 - 50	2000 – 4000	Very corrosive
20 - 25	4000 – 5000	Corrosive
10 - 20	5000 – 10 000	Mildly corrosive
Less than 10	>10 000	Not generally corrosive

Disturbed samples of the transported and residual material were taken and subjected to chemical (pH and conductivity) tests. The test results are summarised as follows.

Based on Evans guideline (1977), a soil pH less great than 6 indicates less corrosion potential.

Table 5: Chemical test results summary for the pipeline

Hole no.	Depth (m)	pH	Conductivity (mS/m)
Transported material			
TP1	1.0 – 2.0	4.427	43.83
TP2	0–1.0	4.748	44.80

According to the soil conductivity guideline values (Table 4) (Duligal, 1996) and the results in Table 5, the transported material on this site is very corrosive due to its low pH being <6, and conductivity values show a very high corrosiveness of the material. Corrosion of buried metallic elements is therefore likely on these materials.

10 Geotechnical Considerations and Recommendations

10.1 Shallow seepage/groundwater level

The pipeline is adjacent to the flowing stream therefore groundwater seepage is anticipated. The pipeline falls within an area where the subsoil profile is dominated by a material containing a high proportion of fines, the formation of a perched water table may occur during periods of heavy rainfall and measures should be taken to manage stormwater during construction. Provision must be made for dewatering measures and sidewall stabilization when needed.

10.2 Collapsible / Compressible soil profile

The transported material underlying the site consists of non-cohesive soils. These materials have a loose to medium consistency. It is expected that the materials will be compressible and collapsible when the moisture conditions change from dry to moist due to rainwater infiltration.

Problems related to compressibility and collapsibility are expected at the site due to the nature of the silty sand content encountered in the transported materials. It is expected that these materials will be compressible and collapsible when the moisture conditions change.

10.3 Erodibility of the soil profile

The soil layers encountered along the sewer line route are non-cohesive and therefore expected to be highly erodible. Also, some portions of the proposed site are characterized by relatively flat topography and gradually gains gain elevation over a gently sloping topography.

Protective measures against flooding and erosion must be implemented adjacent to all watercourses and drainage lines.

10.4 Excavatability

The ease at which the soil can be excavated is an important criterion in the selection of a site. The excavation characteristics of the strata have been estimated from the performance of the TLB used for the investigation as per the terms of SANS 1200D "Classification of material for machine excavation".

The excavation conditions along the pipeline should be categorized as '**soft mechanical excavation**' to depths ranging between 1.0m and 2.60m below groundt level of the proposed replacement pipeline.

10.5 Trench stability

In general, it is anticipated that the vertical sidewall of trench excavations will be unstable. The sidewalls of the test pit excavated during the fieldwork were not stable while the investigation was in progress. It is considered that in general trenches not exceeding 1.5m depth can remain open for periods of up to a day without significant collapse provided no significant rainfall and the associated rise in groundwater seepage occurs during this period. Trenches deeper than 1.0m should be battered to a safe angle of 1V:2H or supported laterally. In this respect, it is recommended that no trenches be left open for prolonged periods to prevent sidewall failure.

An experienced geotechnical engineer or an engineering geologist must regularly inspect pipe trenching and sidewall stability.

10.6 Reuse of materials

The material that will be utilized in this project is selected fill and imported bedding material/ padding material. Comments on the existing material's suitability for potential applications are, provided below.

10.6.1 Construction Materials

Due to its silty sand content and indications from the foundation indicator results, the transported material on this site is classified as a G10 according to the TRH 14 guidelines. The transported material that is G10 according to the TRH 14 guidelines (CSIR: 1987), should therefore be suitable for use in the construction of subgrade layer material and low stiffness engineered fill.

10.6.2 Bedding Material

In terms of the SANS1200LB (1983) concerning bedding requirements, buried pipelines require two types of selected material. Those selected materials are termed "Selected Granular Material" and "Selected Fill Material".

From visual inspection of the materials encountered in the inspection pits, the following comments and recommendations regarding the suitability and use of in-situ materials can be made:

- Materials encountered on site are fine-grained silty sand.
- Selected Granular Material is described as "granular, non-cohesive and singularly graded between 0.60 and 0.90mm. The material must be free draining and have a compatibility factor not exceeding 0.40".

- Selected Back Fill Material is defined as “a material with a Plasticity Index (PI) not exceeding 6, free from lumps, vegetation, and stones of a diameter exceeding 30mm”.

According to SABS1200LB, the compactibility test results of the transported (0.39) materials on this site meet the requirements for bedding material. The quantities of the in-situ transported material might not be sufficient and therefore a need may arise to imported/ acquire more bedding material from commercial sources. This imported material will also need to be evaluated against the site specification for bedding material.

In general, the “Selected Granular Material” is used as bedding material to support the pipe, while the “Selected Back Fill Material” is used as blanket material over the crown of the pipe. Backfill material is generally placed above the blanket materials, up to ground level.

10.6.3 Selected Fill material

Selected fill material shall be material that has a PI not exceeding 6 and that is free from vegetation and lumps and stones of diameter exceeding 30 mm.

Based on the results from lab testing, most of the transported and uncemented pedogenic material found on site meet the requirements for Selected Fill Material.

11 Conclusion

Based on the results from lab testing, the transported material found on-site meets the requirements for Selected Fill Material. Should the sources of Selected Fill Material be not sufficient in terms of volume for the sewer line installation; Selected Fill Material may be acquired from commercial sources.

12 References

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Appendix A

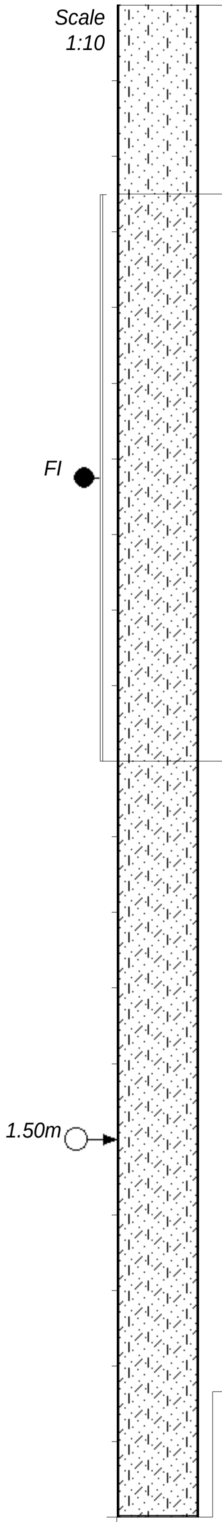
Soil Profile Descriptions

HOLE No: TP1
Sheet 1 of 1

Sewer Line in R K Khan Chatsworth.

JOB NUMBER: 000

Scale 1:10



0.00

Moist, dark brown, loose to medium dense, intact silty SAND with roots. **Transported**.

0.25

Moist, dark greyish brown, medium dense, intact slightly clayey silty SAND with roots. **Transported**.

1.00

Moist to wet, light brown, medium dense, intact, slightly clayey silty sand. **Residual**.

2.00

NOTES

1) Groundwater seepage encountered @ 1.50m.

2) Test pit sidewalls unstable.

3) FI, MOD/CBR, Ph/Conductivity sample @ 0.25--1.00m.

4) No refusal.

CONTRACTOR :
MACHINE : by Hand
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PROFILED BY : Mabaso

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DIAM :
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DATE : 15/12/2021

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X-COORD :
Y-COORD :

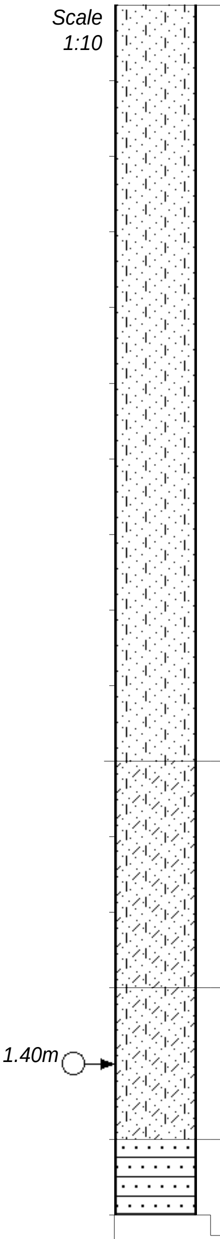
HOLE No: TP1

Sewer Line in R K Khan Chatsworth.

HOLE No: TP2
Sheet 1 of 1

JOB NUMBER: 000

Scale 1:10



0.00	Moist, dark greyish brown, loose to medium dense, intact silty SAND with roots. **Transported**.
1.00	Moist, dark greyish brown, medium dense, intact slightly clayey silty SAND with roots. **Transported**.
1.30	Moist to wet, light brown, medium dense, intact, slightly clayey silty sand. **Residual**.
1.50	Light brown, slightly weathered, highly fractured, medium-hard rock Sandstone.
1.60	

NOTES

1) Groundwater seepage encountered @ 1.40m.
2) Test pit sidewalls unstable.
3) FI sample @ 0--1.00m..
4) Refusal on the sandstone rock.

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PROFILED BY : Mabaso

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SETUP FILE : STANDARD.SET

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X-COORD :
Y-COORD :

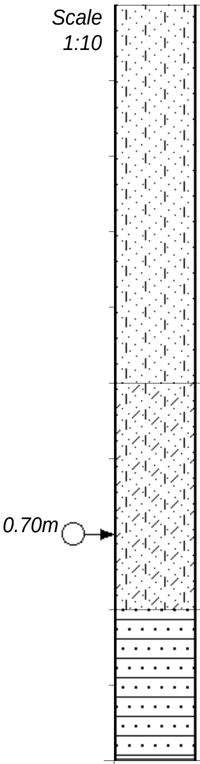
HOLE No: TP2

HOLE No: TP3
Sheet 1 of 1

Sewer Line in R K Khan Chatsworth.

JOB NUMBER: 000

Scale
1:10



0.00	Moist, dark greyish brown, loose to medium dense, intact silty SAND with roots. **Transported**.
0.50	Moist to wet, light brown, medium dense, intact, slightly clayey silty sand. **Residual**.
0.80	Light brown, slightly weathered, highly fractured, medium-hard rock Sandstone.
1.00	

NOTES

1) Groundwater seepage encountered @ 0.70m.

2) Test pit sidewalls unstable.

3) No sample was taken.

4) Refusal on the sandstone rock.

CONTRACTOR :
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SETUP FILE : STANDARD.SET

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ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP3

Sewer Line in R K Khan Chatsworth.

HOLE No: TP4
Sheet 1 of 1

JOB NUMBER: 000

Scale
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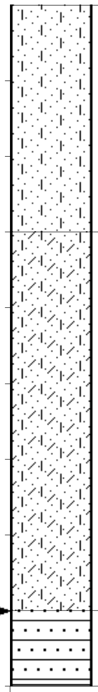

0.80m

0.00	Moist, dark greyish brown, loose to medium dense, intact silty SAND with roots. **Transported**.
0.30	Moist to wet, light brown, medium dense, intact, slightly clayey silty sand. **Residual**.
0.80	Light brown, slightly weathered, highly fractured, medium-hard rock Sandstone.
0.90	

NOTES

1) Groundwater seepage encountered @ 0.80m.

2) Test pit sidewalls unstable.

3) No sample was taken.

4) Refusal on the sandstone rock.

CONTRACTOR :
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PROFILED BY : Mabaso

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ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP4

Sewer Line in R K Khan Chatsworth.

HOLE No: TP5
Sheet 1 of 1

JOB NUMBER: 000

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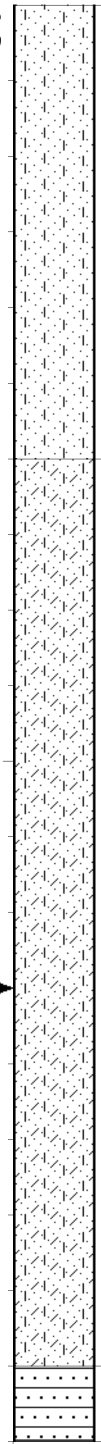

1.30m

0.00

Moist, dark greyish brown, loose to medium dense, intact silty SAND with roots. **Transported**.

0.60

Moist to wet, light brown, medium dense, intact, slightly clayey silty sand. **Residual**.

1.80

Light brown, slightly weathered, highly fractured, medium-hard rock Sandstone.

1.90

NOTES

1) Groundwater seepage encountered @ 1.30m.

2) Test pit sidewalls unstable.

3) No sample was taken.

4) Refusal on the sandstone rock.

CONTRACTOR :
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DRILLED BY :
PROFILED BY : Mabaso

TYPE SET BY :
SETUP FILE : *STANDARD.SET*

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DATE : 15/12/2021

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TEXT : *..neinRKKhanChatsworth.txt*

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP5

Sewer Line in R K Khan Chatsworth.

LEGEND
Sheet 1 of 1

JOB NUMBER: 000

	SAND	{SA04}
	SILTY	{SA07}
	CLAYEY	{SA09}
	SANDSTONE	{SA11}
Name	DISTURBED SAMPLE	{SA38}
5.5	WATER SEEPAGE/water strike	{CH50}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :

INCLINATION :
DIAM :
DATE :
DATE :

ELEVATION :
X-COORD :
Y-COORD :

TYPE SET BY :
SETUP FILE : STANDARD.SET

DATE : 21/02/2022 11:08
TEXT : ..neinRKKhanChatsworth.txt

LEGEND
SUMMARY OF SYMBOLS

Appendix B

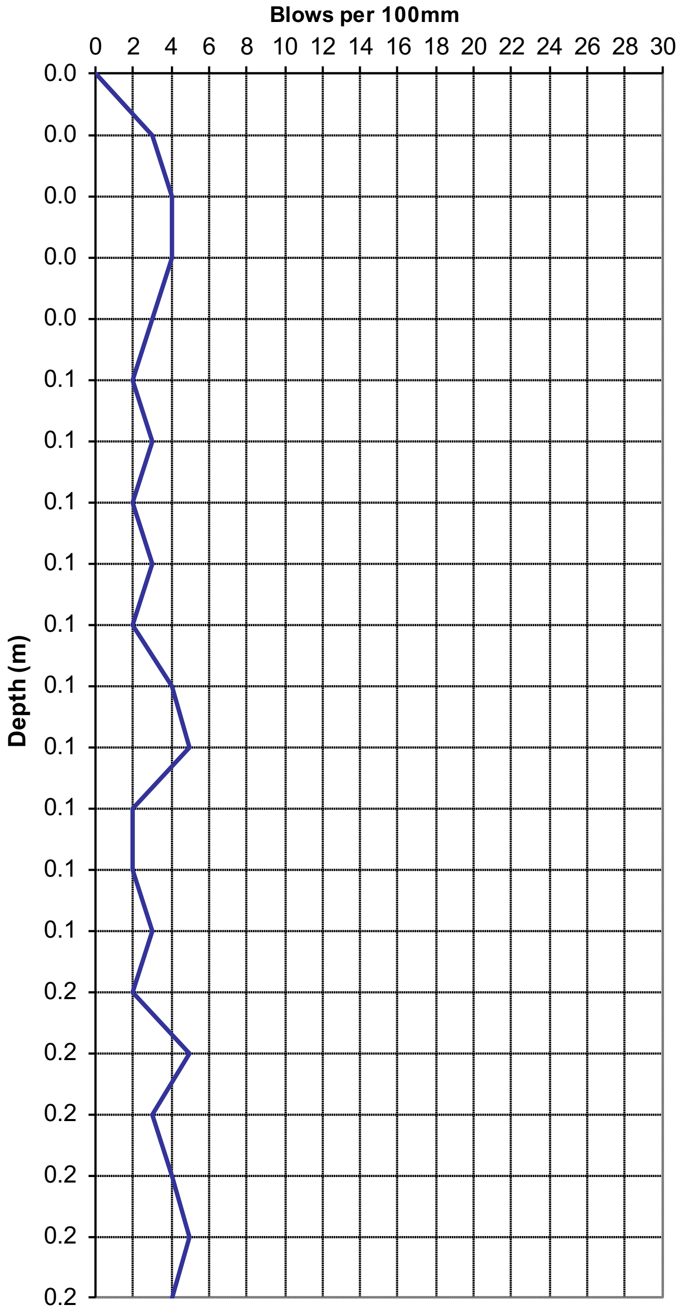
DCP test results

Client:	eThekwini Municipality	Ref. No.:	10012
Project:	RK Khan Pipeline Sewer	Date:	15-Dec-21
Section:		Operator:	Mabaso

CBR DYNAMIC CONE PENETROMETER PROBE — *TEST No* *DCP1*

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE AND SHOULD BE VERIFIED BY TEST OR OBSERVATION.

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0,0	0			
0,1	3	Loose	<30 deg	5
0,2	4	Med.Dense	30 deg	7
0,3	4	Med.Dense	30 deg	7
0,4	3	Loose	<30 deg	5
0,5	2	Loose	<30 deg	3
0,6	3	Loose	<30 deg	5
0,7	2	Loose	<30 deg	3
0,8	3	Loose	<30 deg	5
0,9	2	Loose	<30 deg	3
1,0	4	Med.Dense	30 deg	7
1,1	5	Med.Dense	32 deg	8
1,2	2	Loose	<30 deg	3
1,3	2	Loose	<30 deg	3
1,4	3	Loose	<30 deg	5
1,5	2	Loose	<30 deg	3
1,6	5	Med.Dense	32 deg	8
1,7	3	Loose	<30 deg	5
1,8	4	Med.Dense	30 deg	7
1,9	5	Med.Dense	32 deg	8
2,0	4	Med.Dense	30 deg	7
2,1	5	Med.Dense	32 deg	8
2,2	5	Med.Dense	32 deg	8
2,3	4	Med.Dense	30 deg	7
2,4	8	Med.Dense	35 deg	14
2,5	5	Med.Dense	32 deg	8
2,6	9	Med.Dense	35 deg	15
2,7	R	V.V.Dense	>40 deg	>55
2,8				
2,9				
3,0				
3,1				
3,2				
3,3				
3,4				
3,5				
3,6				
3,7				
3,8				
3,9				
4,0				

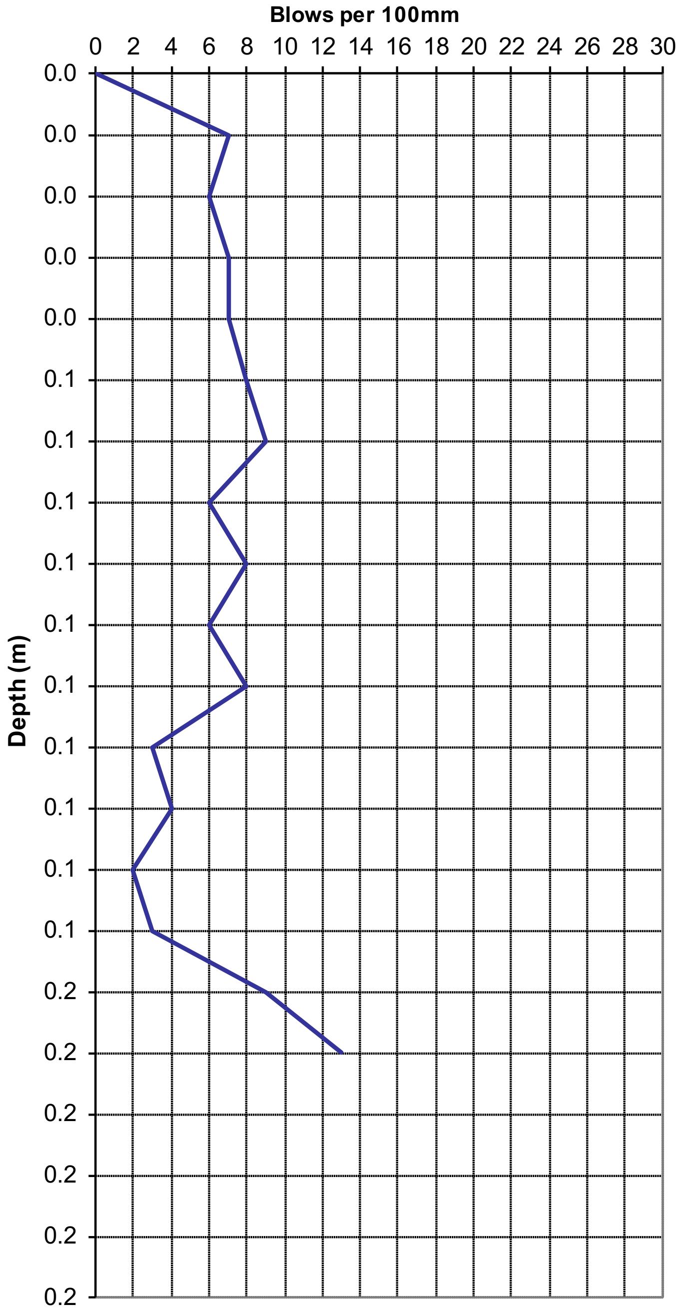


Client:	eThekwini Municipality	Ref. No.:	10012
Project:	RK Khan Pipeline Sewer	Date:	15-Dec-21
Section:		Operator:	Mabaso

CBR DYNAMIC CONE PENETROMETER PROBE ***TEST No*** ***DCP2***

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE AND SHOULD BE VERIFIED BY TEST OR OBSERVATION.

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0,0	0			
0,1	7	Med.Dense	34 deg	12
0,2	6	Med.Dense	33 deg	10
0,3	7	Med.Dense	34 deg	12
0,4	7	Med.Dense	34 deg	12
0,5	8	Med.Dense	35 deg	14
0,6	9	Med.Dense	35 deg	15
0,7	6	Med.Dense	33 deg	10
0,8	8	Med.Dense	35 deg	14
0,9	6	Med.Dense	33 deg	10
1,0	8	Med.Dense	35 deg	14
1,1	3	Loose	<30 deg	5
1,2	4	Med.Dense	30 deg	7
1,3	2	Loose	<30 deg	3
1,4	3	Loose	<30 deg	5
1,5	9	Med.Dense	35 deg	15
1,6	13	Dense	37 deg	23
1,7	R	V.V.Dense	>40 deg	>55
1,8				
1,9				
2,0				
2,1				
2,2				
2,3				
2,4				
2,5				
2,6				
2,7				
2,8				
2,9				
3,0				
3,1				
3,2				
3,3				
3,4				
3,5				
3,6				
3,7				
3,8				
3,9				
4,0				

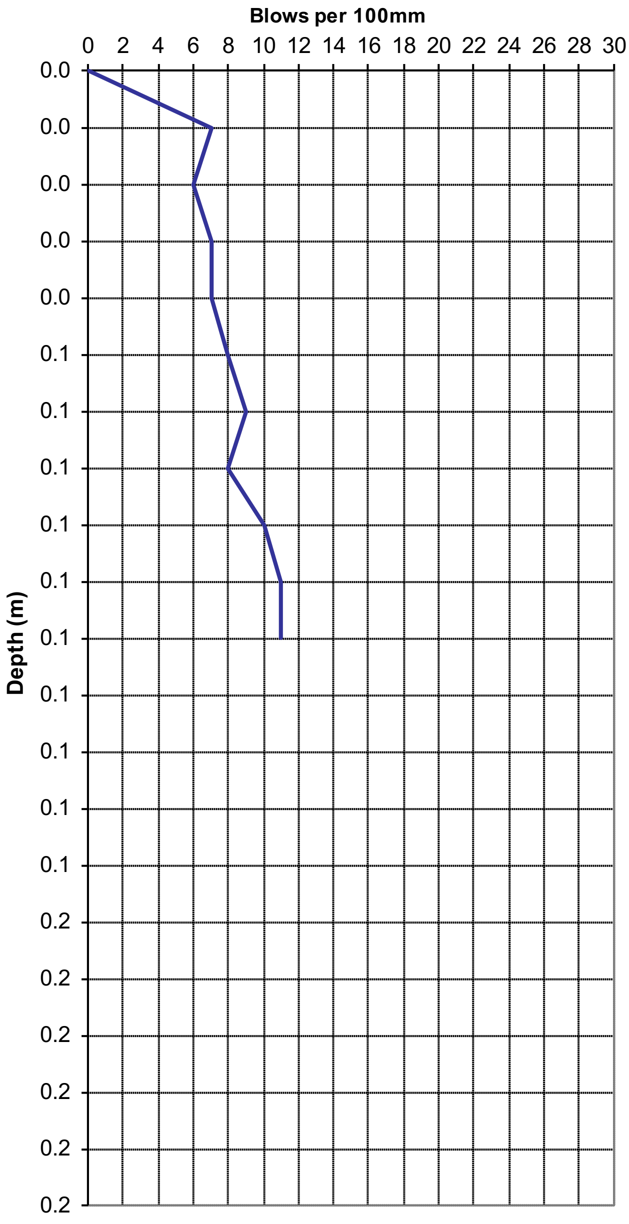


Client:	eThekwini Municipality	**Ref. No.:**	10012
Project:	RK Khan Pipeline Sewer	**Date:**	15-Dec-21
Section:		**Operator:**	Mabaso

CBR DYNAMIC CONE PENETROMETER PROBE ***TEST No DCP3***

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE AND SHOULD BE VERIFIED BY TEST OR OBSERVATION.

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0,0	0			
0,1	7	Med.Dense	34 deg	12
0,2	6	Med.Dense	33 deg	10
0,3	7	Med.Dense	34 deg	12
0,4	7	Med.Dense	34 deg	12
0,5	8	Med.Dense	35 deg	14
0,6	9	Med.Dense	35 deg	15
0,7	8	Med.Dense	35 deg	14
0,8	10	Med.Dense	36 deg	17
0,9	11	Dense	36 deg	19
1,0	11	Dense	36 deg	19
1,1	R	V.V.Dense	>40 deg	>55
1,2				
1,3				
1,4				
1,5				
1,6				
1,7				
1,8				
1,9				
2,0				
2,1				
2,2				
2,3				
2,4				
2,5				
2,6				
2,7				
2,8				
2,9				
3,0				
3,1				
3,2				
3,3				
3,4				
3,5				
3,6				
3,7				
3,8				
3,9				
4,0				

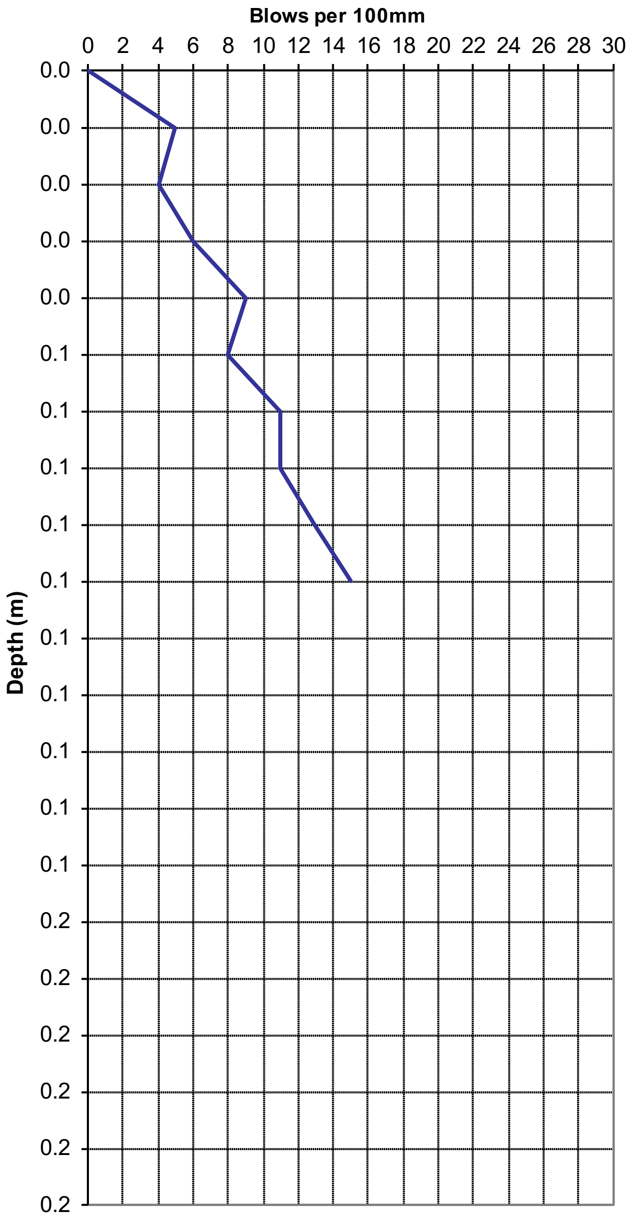


Client:	eThekwini Municipality	Ref. No.:	10012
Project:	RK Khan Pipeline Sewer	Date:	15-Dec-21
Section:		Operator:	Mabaso

CBR DYNAMIC CONE PENETROMETER PROBE — ***TEST No DCP4***

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE AND SHOULD BE VERIFIED BY TEST OR OBSERVATION.

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0,0	0			
0,1	5	Med.Dense	32 deg	8
0,2	4	Med.Dense	30 deg	7
0,3	6	Med.Dense	33 deg	10
0,4	9	Med.Dense	35 deg	15
0,5	8	Med.Dense	35 deg	14
0,6	11	Dense	36 deg	19
0,7	11	Dense	36 deg	19
0,8	13	Dense	37 deg	23
0,9	15	Dense	37 deg	27
1,0	R	V.V.Dense	>40 deg	>55
1,1				
1,2				
1,3				
1,4				
1,5				
1,6				
1,7				
1,8				
1,9				
2,0				
2,1				
2,2				
2,3				
2,4				
2,5				
2,6				
2,7				
2,8				
2,9				
3,0				
3,1				
3,2				
3,3				
3,4				
3,5				
3,6				
3,7				
3,8				
3,9				
4,0				



Client:	eThekwini Municipality	Ref. No.:	10012
Project:	RK Khan Pipeline Sewer	Date:	15-Dec-21
Section:		Operator:	Mabaso

CBR DYNAMIC CONE PENETROMETER PROBE ***TEST No*** ***DCP5***

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE AND SHOULD BE VERIFIED BY TEST OR OBSERVATION.

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0,0	0			
0,1	2	Loose	<30 deg	3
0,2	3	Loose	<30 deg	5
0,3	2	Loose	<30 deg	3
0,4	2	Loose	<30 deg	3
0,5	3	Loose	<30 deg	5
0,6	6	Med.Dense	33 deg	10
0,7	7	Med.Dense	34 deg	12
0,8	8	Med.Dense	35 deg	14
0,9	10	Med.Dense	36 deg	17
1,0	12	Dense	36 deg	21
1,1	10	Med.Dense	36 deg	17
1,2	8	Med.Dense	35 deg	14
1,3	8	Med.Dense	35 deg	14
1,4	7	Med.Dense	34 deg	12
1,5	7	Med.Dense	34 deg	12
1,6	6	Med.Dense	33 deg	10
1,7	4	Med.Dense	30 deg	7
1,8	4	Med.Dense	30 deg	7
1,9	7	Med.Dense	34 deg	12
2,0	15	Dense	37 deg	27
2,1	R	V.V.Dense	>40 deg	>55
2,2				
2,3				
2,4				
2,5				
2,6				
2,7				
2,8				
2,9				
3,0				
3,1				
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3,4				
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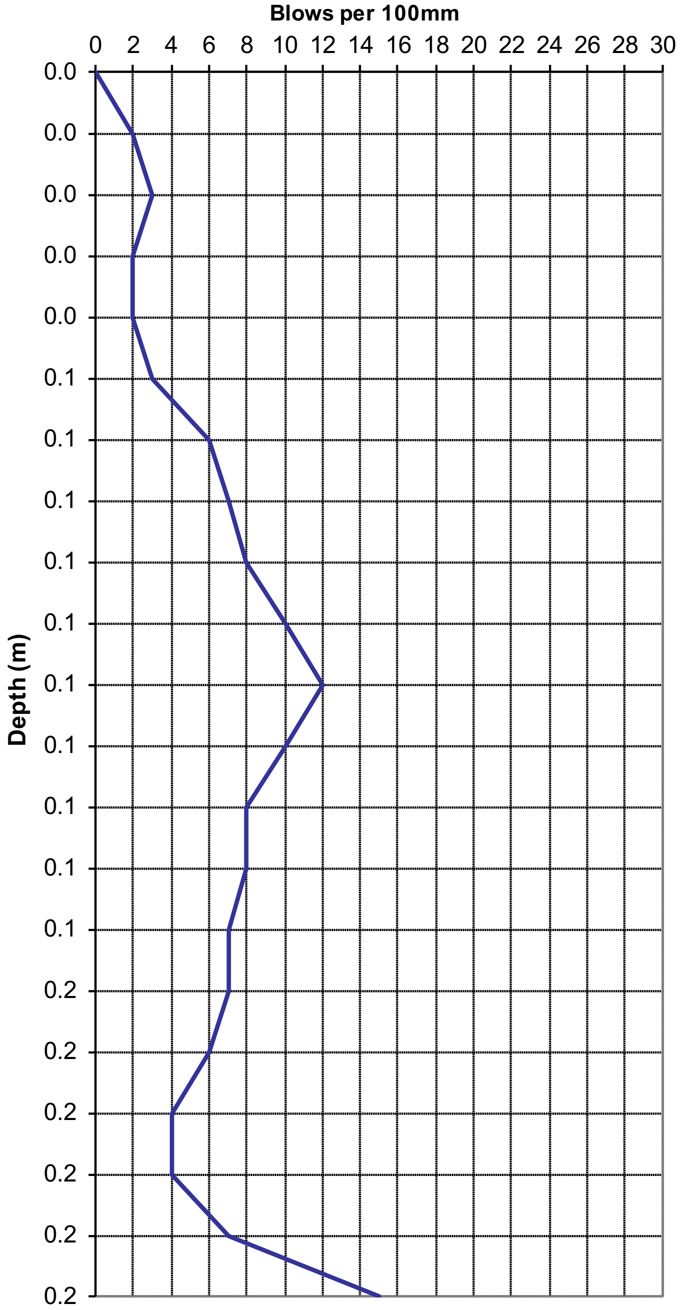
3,9				
4,0				



Appendix C

Laboratory Test results