PROCUREMENT OF GEOTECHNICAL INVESTIGATION SERVICES FOR JOHANNESBURG WATER (SOC) Ltd

CONTRACT JW12055

File reference – WO#06

WORKS ORDER WO#06
LENASIA HIGH LEVEL RESERVOIR
GEOTECHNICAL INVESTIGATION

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Geotechnical Report

KHH2133 / 3030013205
Rev.1

Knight Piésold CONSULTING

WORKS ORDER WO#06
LENASIA HIGH LEVEL RESERVOIR
GEOTECHNICAL INVESTIGATION

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WORKS ORDER WO#06

LENASIA HIGH LEVEL RESERVOIR
GEOTECHNICAL INVESTIGATION

1. INTRODUCTION

Knight Piésold (KP) was appointed by Johannesburg Water as part of the Procurement of Geotechnical Investigation Services Contract JW12055 WO#06, to perform a geotechnical investigation for the proposed Lenasia High Level Reservoir, south of Johannesburg.

The site is located on municipal ground owned by the Lenasia South Municipality and is situated approximately 50m north-west of an existing reservoir. The site location is shown in Figure 1 at the back of the report.

The investigation was aimed at determining the geotechnical properties of the foundation materials, bedrock conditions and excavatability. Comments on site water management aspects, particularly pertaining to shallow groundwater or seepage were also required.

This report provides foundation recommendations for the proposed reservoir and contains all supporting documentation.

2. SITE DESCRIPTION AND GEOLOGY

The site is located on the side slope of a localised hill, with a gentle slope to the south-west. Drainage takes place by means of sheetwash towards the south-west.

An existing reservoir is located to the south-east of the site. The site is situated approximately 2km to the west of Road R553 and was entirely covered with grass. The proposed reservoir has a diameter of approximately 53m and a height of approximately 9m.

According to the published 1:250 000 scale Geological Series, Sheet 2626 (West Rand) of the area, the site is underlain by ferruginous quartzite, shale and hornfels of the Timeball Hill Formation, Pretoria Group, Transvaal Supergroup. Refer to Figure 2 for the relevant portion of the geological map.

According to the geological map the transition between the Timeball Hill Formation and the chert, dolomite and chert breccia of the Malmani Subgroup, Chuniespoort Group, Transvaal Supergroup is situated approximately 1,3km to the north of the site.

The Malmani Subgroup consists of chert-bearing, alternating with chert-free dolomite formations. These rocks have a notorious reputation for the development of karst subsurface landscape, associated with a highly irregular and voided bedrock profile, as well as heterogenic soil conditions. The Eccles Formation may be closest to the site and is known to be predominantly chert-bearing. The soil cover often comprises highly erodible soils, which can readily erode by downward percolating water to create leached or voided zones, which may result in the formation of sinkholes and subsidences [1][1].

The Timeball Hill Formation is younger than the Malmani Subgroup and therefore occurs on top, which implies that dolomite and chert may be present with depth at the proposed reservoir site.

According to Weinert's climatic N-value the site falls in an area classified as N<5, indicating a relatively humid climate. The predominant weathering mode is chemical decomposition, opposed to mechanical disintegration that dominates in more arid regions [2].

3. METHOD OF INVESTIGATION

Six test pits (TP1 to TP6) were excavated by means of a New Holland Fiat Tractor Loader Backhoe (TLB) on 15 April 2014. The test pits were excavated to refusal depth outside the proposed reservoir foundation area (refer to Figure 3).

Twenty one DPSH tests (DPSH1 to DPSH21) were conducted by *Roelf Fourie Geotechnical Services* during the period of 14 to 15 April 2014. The DSPH tests were done in a grid pattern at the proposed foundation area of the reservoir.

The test pits were logged by an engineering geologist according to the recommended standard procedures [3]. The co-ordinates of the test pits were recorded with a handheld Global Positioning System (GPS) with an accuracy of approximately 5m. These coordinates are indicated

Soil samples were taken from representative soil horizons and delivered to *Geostrada* in Pretoria for laboratory tests to determine:

- Foundation indicator parameters (grading, hydrometer and Atterberg Limits)
- Modified AASHTO Compaction density and CBR
- Basson Corrosivity Index

Summaries of the test pit profiles and DPSH test results are provided in Tables 1 and 2, respectively, at the back of the report. The laboratory test results are summarised in Tables 3 and 4. The test pit profiles, DPSH test results and laboratory test results are contained in Appendices A, B and C respectively.

[1] References are indicated thus and are listed at the back of the report.

4. SOIL PROFILE

4.1 Test Pits

The site is characterised by relatively consistent shale bedrock depth conditions and with quartzite only occurring in TP6.

The typical soil profile encountered in TP1 to TP5 is summarised as follows:

- Brown hillwash, consisting of loose silty gravelly sand, with a thickness of between 0,2m and 1m. The average thickness of this surface layer is approximately 0,7m.
- Red brown mottled yellow brown soft to stiff, with depth, residual shale. This layer extends to depths of between 2,5m and 3,3m.
- TLB refusal occurred at depths of between 2,5m and 3,3m on highly weathered very soft to soft rock shale.

In TP6 the hillwash is underlain by grey brown medium dense to dense silty sandy gravel residual quartzite to 1,1m, which is underlain by red brown soft gravelly sandy silt residual shale to 1,8m, where refusal occurred on closely jointed soft rock quartzite.

No water seepage was encountered in any of the test pits, but seepage may be expected during the wet season.

4.2 DPSH Testing

DPSH tests were conducted in a grid pattern across the foundation area of the proposed reservoir.

The DPSH test results which are summarised in Table 2 and contained in Appendix B were interpreted as indicated in the table below.

Description	DPSH (blows per 300mm)
Sandy Materials (Non-cohesive Materials)	
Very loose	<5
Loose	5 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	>50
Clayey Materials (Cohesive Materials)	
Very soft	<2
Soft	2 – 4
Firm	4 – 8
Stiff	8 – 15
Very stiff	15 – 30

The presence of cobbles to depths of between 0,9m and 1,5m complicated the interpretation of the DPSH test results and also resulted in shallow (<1,5m) refusal at almost 50% of the test positions. Gravel may also cause a denser consistency to be reflected in the DPSH test and even refusal. In general the DPSH test results were interpreted as being non-cohesive to a depth of between 0,9m and 1,5m and cohesive below this depth.

The DPSH tests correlate reasonably with the test pit profile descriptions.

5. LABORATORY TEST RESULTS

5.1 Geotechnical Test Results

The residual shale soil, according to the test results, comprises sandy clayey silt with minor shale gravel. The clay content varies between 8% and 23%. The Plasticity Index (PI) value varies between 7% and 10%, while Liquid Limit (LL) is between 28% and 39%.

The compaction tests on the residual shale yielded a Modified AASHTO maximum dry density (MDD) of between 1713kg/m^3 and 1752kg/m^3 with an optimum moisture content of between 9,5% and 13,9%. The CBR test results indicate very low strengths of between 2% and 3% at 93% MDD and subsequently classifies the residual soil as poorer than G9 quality material.

The transported soil cover (hillwash) comprises sandy gravel with a low silt and clay content, both less than 9%. The PI value of this material is 7% while the LL is 24%. The residual quartzite soil contains gravelly sand with a low silt and clay content. The clay content was measured at 13%, while the PI value and LL is 6% and 22% respectively. All the materials available on site have a low potential for expansiveness.

5.2 Chemical Test Results

Chemical tests were conducted on three soil samples to determine the corrosivity towards metal and aggressiveness towards concrete. The tests were conducted on distilled water extracts from the soil samples.

A summary of the essential test results is tabulated below.

Sample No.	Depth (m) – (m)	Stability pH (pHs)	Langelier Index	Ryznar Index	Aggressive-ness Index	Corrosivity Ratio
TP1/1	0,9 – 3,1	11,4	-7,3	18,6	5593	1,5
TP2/1	1,0 – 3,0	11,7	-6,4	18,2	4914	0,9
TP4/1	0,7 – 2,5	11,7	-6,0	17,7	4621	0,7

The table below provides an interpretation for the above results.

Index	Aggressive	Neutral	Non-Aggressive
Stability pH, pHs	> pH	= pH	> pH
Langelier Index	Negative Value	Zero	Positive Value
Ryznar Index	>7,5	6 - 7	< 6
Corrosivity towards metals	>0,2	-	-

According to the above results, the following is apparent:

- The pHs value of all samples is above the pH value, i.e. all samples indicate aggressiveness towards concrete.
- The Langelier Index of all samples is below zero, i.e. all samples indicate aggressiveness towards concrete.
- The Ryznar Index of all samples is above 7,5, i.e. all samples indicate aggressiveness towards concrete.
- Leaching corrosion is the expected corrosion method.
- It is not anticipated that the soil will be corrosive towards metals.

Thus the conclusion is made that the transported and residual soils at the site are highly aggressive towards concrete and may be corrosive towards metals.

6. GEOTECHNICAL EVALUATION

6.1 General

Quartzite boulders and cobbles are present at surface in the northern and western portions of the proposed reservoir site and a gravel and cobble hillwash and residual quartzite layer occurs form the surface to between 0,7m and 1,1m. Soft rock shale was present from depths of between 2,5m and 3,3m in all the test pits, with the exception of TP6, where soft rock quartzite occurred from 1,8m depth. Definite indications of the presence of alternating shale and quartzite layers were found in TP2 and TP6.

6.2 Foundation Conditions

Although the materials occurring at the site are fairly consistent, the foundation conditions are variable. It is also apparent that the DPSH refusal depths of <1,5m are all in the west half of the reservoir site.

The required allowable bearing capacity for a reservoir perimeter wall less than 10m high normally does not exceed 150kPa, while the allowable bearing capacity below the floor does not exceed 100kPa.

Although the residual silty shale is mostly stiff to very stiff below 2,5m depth, there are frequently water spillages which migrate into the soil at a reservoir and may cause softening of such soil with resulting differential settlement.

The natural ground at the site has a cross fall over the reservoir footprint of approximately 1,5m from north-east (TP1, TP2, TP3) to south-west (TP4, TP5, TP6). The TLB refusal depths vary from between 2,8m and 3,3m (TP1 to TP3) to between 1,8m and 2,8m (TP4 to TP6).

It is thus recommended that the soils be excavated to the very soft to soft rock surface, i.e. to between 2,8m and 3,3m on the north-east side and 1,8m and 2,8m on the south-west side and to 2m wider than the reservoir footprint. The gravelly hillwash and the gravelly residual quartzite can be used for backfilling, but the silty residual shale must be spoiled.

Construct a founding platform (soil raft) to the required reservoir founding level with imported G5 type material. Backfill in 200mm thick layers, each layer compacted with a 10t or larger compactor to 98% of Modified AASHTO maximum dry density at optimum moisture content.

The reservoir may then be constructed directly on the soil raft and with an allowable bearing pressure of not more than 150kPa, the expected settlement should be less than 15mm.

The laboratory tests indicated that the residual shale soil contains relatively high clay content and subsequently classifies as worse than G9 quality material and is not suitable for backfilling or for the construction of engineered fill. The residual shale soil should be excavated and spoiled and may only be used for general fill or for rehabilitation purposes. However, the residual quartzite and transported soils covering the site has low clay contents with substantial amounts of gravel and sand and may be sufficient for backfilling or for the construction of engineered fill.

Temporary excavation slopes must be cut to slopes not steeper than 1:1 (V:H) above the groundwater table, with 1:1,5 (V:H) slopes in wet to saturated ground. These slopes are to be reviewed once the laboratory test results are available.

Slopes in rock may be steeper at approximately 1:0,5 (V:H), but where near vertical joints may be present, the slope should be cut back to such steeply dipping joint surface. A competent person should, however, inspect the foundation excavations to assess sidewall stability and to ensure that the floor conditions are suitable for placement of the foundation backfill.

For the reservoir hard excavation will be required for depths deeper than the TLB refusal depths. The excavations for the pipe trenches in the vicinity of the reservoir may also require hard excavation in places, depending upon the pipe trench depth.

The chemical test results indicate that the transported and residual soils can be expected to be aggressive towards concrete and slightly corrosive towards metals. It is recommended that the following measures be implemented:

- Either use site blend of portland cement mixture with 10% condensed silica fume or portland cement with 30% fly ash (SABS 1466) [5].
- Recommended minimum cover of 25mm over reinforcement (applicable only if reinforcing or pre-stressing steel is present).

7. CONCLUSIONS AND RECOMMENDATIONS

- According to the published 1:250 000 scale Geological Series, Sheet 2626 (West Rand) of the area, the site is underlain by ferruginous quartzite, shale and hornfels of the Timeball Hill Formation, Pretoria Group, Transvaal Supergroup.

- According to the geological map, chert, transition to dolomite and chert breccia of the Malmani Subgroup, Chuniespoort Group, Transvaal Supergroup is located approximately 1,3km to the north of the site. The Timeball Hill Formation is younger than the Malmani Subgroup and had been deposited on top of the dolomite, which may therefore be present with depth at the reservoir site.

- The site is covered with a layer of gravelly hillwash and residual quartzite to depths of between 0,7m and 1,1m, which is underlain by silty residual shale to depths of between 1,8m and 3,3m.

- TLB refusal occurred in very soft to soft rock shale at depths of between 2,5m and 3,3m and at 1,8m on soft rock quartzite in one test pit only.

- No water seepage was encountered in any of the test pits, but seepage may be expected in the wet season. If water seepage is encountered during excavation of foundations, measures will have to be taken for dewatering during construction.

- It is recommended that all the material to the refusal depths of the TLB be excavated and that a compacted soil raft be constructed with imported G5 material. The clayey silty residual shale is not suitable and must be spoiled. Backfill in 200mm thick layers compacted to 98% of Modified AASHTO maximum dry density at optimum moisture content and construct the reservoir on the soil raft.

- Where the soil cover exceeds 1m and in wet conditions, soil slopes should be cut back to 1:1,5 (V:H). Slopes in rock may be subvertical, 1:0,5 (V:H), but should be assessed by a competent person.

- The concrete and reinforcing steel requires protection from the aggressiveness and corrosiveness properties of the in situ soils.

8. REFERENCES

[1] Brink, A.B.A. (1979). *Engineering Geology of Southern Africa, Volume 1*. Building Publications, Pretoria.

[2] Weinert, H. (1965). A climatic index of weathering. *Geotechnique*, Vol. 24, No. 4, pp. 475-488.

[3] The South African Institute of Engineering Geologists (1996). *Guidelines for Soil and Rock Logging*.

[4] Franki Africa (2008). *A guideline to practical geotechnical engineering in Southern Africa.* 4th Edition.

[5] J.J. Basson. *Deterioration of concrete in aggressive waters – measuring aggressiveness and taking countermeasures*. Portland Cement Institute.

TABLE 1 : SUMMARY OF TEST PIT PROFILES

TEST PIT No.	TOTAL DEPTH (m) R: REFUSAL	THICKNESS OF LAYERS (m) – (m)				
		TRANSPORTED SOILS	RESIDUAL SOILS		BEDROCK	
		Hillwash	Shale	Quartzite	Shale	Quartzite
TP1	3,1R	0 - 0,9	0,9 - 3,1	-	3,1+	-
TP2	3,3R	0 - 1,0	1,0 - 3,3	-	3,3+	-
TP3	2,8R	0 - 0,7	0,7 - 2,8	-	2,8+	-
TP4	2,5R	0 - 0,7	0,7 - 2,5	-	2,5+	-
TP5	2,8R	0 - 0,8	0,8 - 2,8	-	2,8+	-
TP6	1,8R	0 - 0,2	1,1 - 1,8	0,2 - 1,1	-	1,8+

Note: No water was encountered in any of the test pits
R: Denotes refusal of the TLB.

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TABLE 2 : SUMMARY OF DPSH RESULTS

Test	Refusal Depth (m)	Depth (m - m)	Consistency	
			Non - cohesive	Cohesive
DPSH1	0,3R	0 - 0,3	Very dense	-
DPSH2	4,5R	0 - 0,6	Medium dense	-
		0,6 - 0,9	Dense	-
		0,9 - 1,5	Very dense	-
		1,5 - 2,1	-	Firm
		2,1 - 2,4	-	Stiff
		2,4 - 4,5	-	Very stiff
DPSH3	0,9R	0 - 0,3	Medium dense	-
		0,3 - 0,9	Very dense	-
DPSH4	2,1R	0 - 0,6	Medium dense	-
		0,6 - 1,2	Loose to Medium dense	-
		1,2 - 1,8	-	Firm to Stiff
		1,8 - 2,1	-	Very stiff
DPSH5	0,6R	0 - 0,3	Loose	-
		0,3 - 0,6	Very dense	-
DPSH6	1,2R	0 - 0,6	Medium dense	-
		0,6 - 0,9	Loose	-
		0,9 - 1,2	Very dense	-
DPSH7	3,3R	0 - 0,6	Medium dense	-
		0,6 - 1,2	Loose to Medium dense	-
		1,2 - 1,5	-	Firm
		1,5 - 2,7	-	Stiff
		2,7 - 3,3	-	Very stiff
DPSH8	2,7R	0 - 0,3	Dense	-
		0,3 - 1,2	Loose to Medium dense	-
		1,2 - 1,5	-	Stiff
		1,5 - 2,1	-	Firm
		2,1 - 2,7	-	Very stiff
DPSH9	1,5R	0 - 0,9	Medium dense	-
		0,9 - 1,5	Very dense	-
DPSH10	0,6R	0 - 0,6	Very dense	-
DPSH11	3,3R	0 - 0,3	Medium dense	-
		0,3 - 0,6	Dense	-
		0,6 - 1,2	Medium dense	-
		1,2 - 1,8	-	Firm
		1,8 - 2,4	-	Stiff
		2,4 - 3,3	-	Very stiff
DPSH12	4,2R	0 - 1,5	Medium dense	-
		1,5 - 2,4	-	Soft
		2,4 - 2,7	-	Firm
		2,7 - 3,3	-	Soft
		3,3 - 3,9	-	Stiff
		3,9 - 4,2	-	Very stiff

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Test	Refusal Depth (m)	Depth (m - m)	Consistency	
			Non - cohesive	Cohesive
DPSH13	1,5R	0 - 1,2	Loose to Medium dense	-
		1,2 - 1,5	-	Very stiff
DPSH14	1,2R	0 - 0,9	Medium dense	-
		0,9 - 1,2	Very dense	-
DPSH15	2,7R	0 - 0,3	Medium dense	-
		0,3 - 0,6	Very dense	-
		0,6 - 1,2	Medium dense	-
		1,2 - 1,8	-	Firm
		1,8 - 2,1	-	Very stiff
		2,1 - 2,4	-	Stiff
		2,4 - 2,7	-	Very stiff
DPSH16	3R	0 - 0,6	Dense to Very dense	-
		0,6 - 1,2	Medium dense	-
		1,2 - 2,4	-	Firm
		2,4 - 2,7	-	Stiff
		2,7 - 3,0	-	Very stiff
DPSH17	1,8R	0 - 0,3	Dense	-
		0,3 - 0,6	Medium dense	-
		0,6 - 0,9	Loose / Firm	-
		0,9 - 1,5	-	Soft to Firm
		1,5 - 1,8	-	Very stiff
DPSH18	0,6R	0 - 0,3	Medium dense	-
		0,3 - 0,6	Very dense	-
DPSH19	3R	0 - 0,9	Medium dense	-
		0,9 - 1,2	-	Stiff
		1,2 - 1,5	-	Very stiff
		1,5 - 1,8	-	Soft
		1,8 - 3,0	-	Very stiff
DPSH20	2,1R	0 - 0,3	Medium dense	-
		0,3 - 0,6	Dense	-
		0,6 - 0,9	Very dense	-
		0,9 - 1,2	-	Stiff
		1,2 - 1,8	-	Firm
		1,8 - 2,1	-	Very stiff
DPSH21	0,3R	0 - 0,3	Very dense	-

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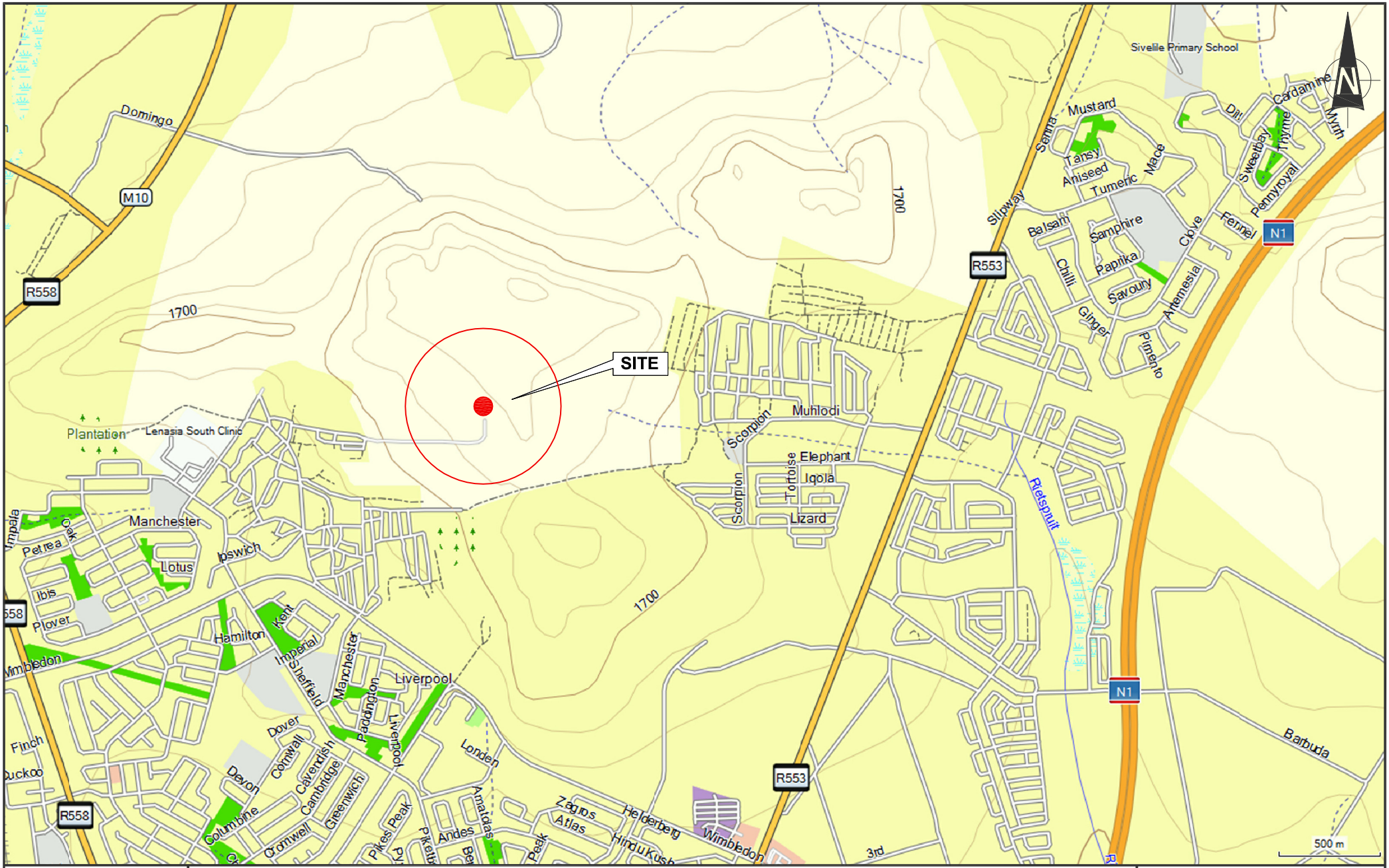
TABLE 3 : SUMMARY OF GEOTECHNICAL LABORATORY TEST RESULTS

SAMPLE		GRADING (%)				ATTERBERG LIMITS (%)			GM	PE	USC	Mod. AASHTO COMPACTION		CBR AT % COMPACTION			COLTO CLASS	MATERIAL DESCRIPTION
No.	DEPTH (m)	Gravel	Sand	Silt	Clay	LL	PI	LS				MDD (kg/m³)	OMC (%)	98	95	93		
TP1/1	0,9 – 3,1	22	34	36	8	28	7	2.0	0,86	Low	CL/ML	1713	9,7	6	5	3	<G9	Residual Shale
TP2/1	1,0 – 3,3	16	9	56	19	38	10	3,5	0,58	Low	ML	1752	13,9	3	2	2	<G9	Residual Shale
TP3/1	0,1 – 0,7	71	15	7	7	24	7	4,0	2,29	Low	GC-GM	-	-	-	-	-	-	Hillwash (transported soil)
TP4/1	0,7 – 2,5	12	22	49	17	39	8	2,5	0,54	Low	ML	1722	9,5	6	4	2	<G9	Residual Shale
TP5/1	0,1 – 0,8	53	29	9	9	24	7	2,5	1,88	Low	GC-GM	-	-	-	-	-	-	Hillwash (transported soil)
TP5/2	0,8 – 2,8	5	16	56	23	39	9	3,0	0,28	Low	ML	-	-	-	-	-	-	Residual Shale
TP6/2	1,1 – 1,8	29	46	12	13	22	6	2,5	1,39	Low	SC	-	-	-	-	-	-	Residual Quartzite

LL : Liquid Limit
PI : Plasticity Index
LS : Linear Shrinkage
GM : Grading Modulus
PE : Potential Expansiveness
USC : Unified Soil Classification

OMC : Optimum Moisture Content
MDD : Maximum Dry Density
SC : Clayey Sands, Sand-Clay Mixtures
GM : Silty Gravels
GC : Clayey Gravels
ML : Clayey Silt with minor sand



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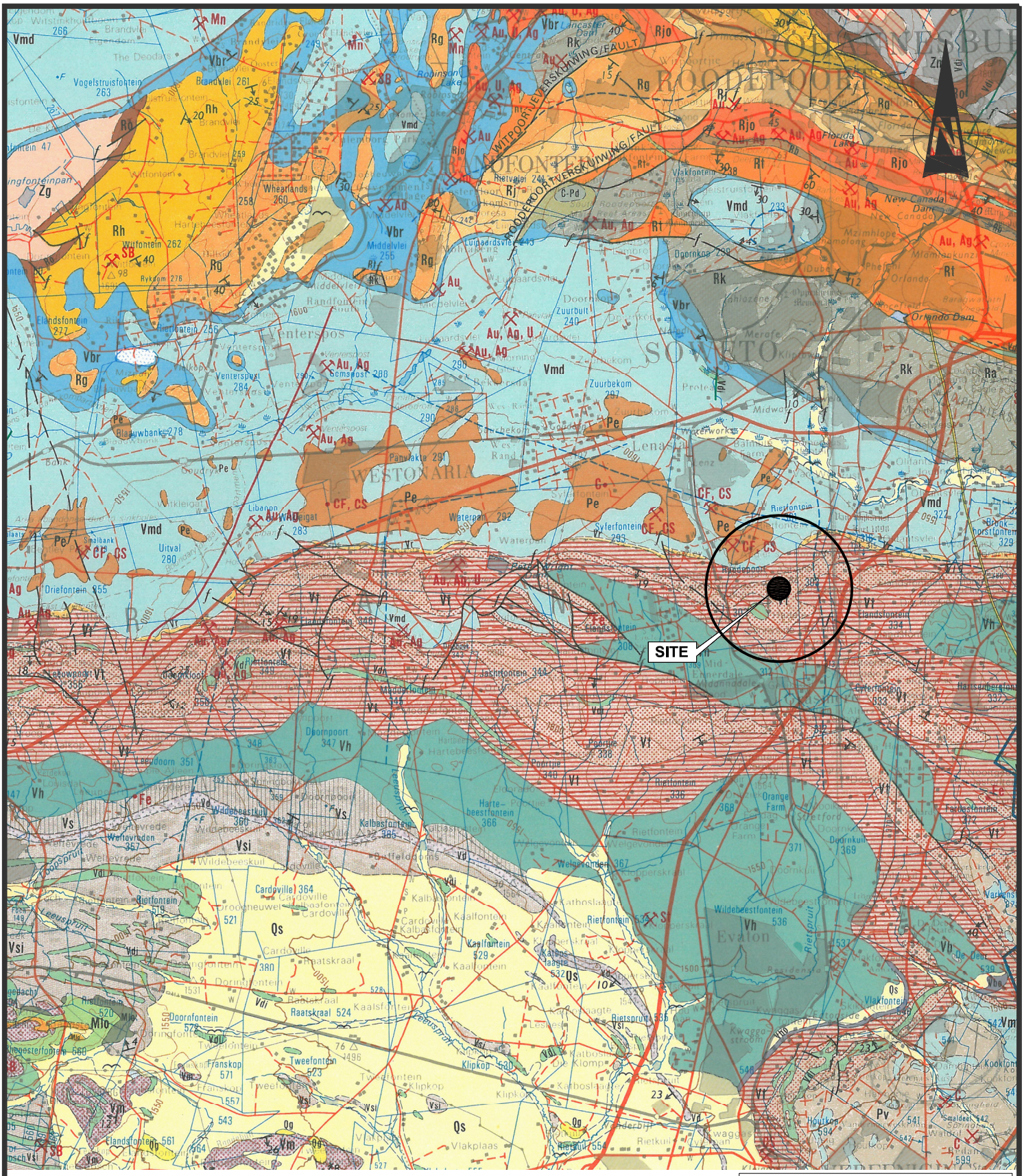
WOKP#06 - LENASIA HIGH LEVEL RESERVOIR

LOCALITY PLAN

PROJECT NO: 303001321/05

FIGURE NO 1

SCALE N.T.S.



GEOLOGICAL LEGEND:

Vh : Andesite, agglomerate and tuff of the Hekpoort Formation, Pretoria Group, Transvaal Supergroup.

Vt : Ferruginous quartzite and shale of the Timeball Hill Formation, Pretoria Group, Transvaal Supergroup.

Vmd: Dolomite, chert and remnants of chert breccia of the Malmani Subgroup, Chuniespoort Group, Transvaal Supergroup

REFERENCE MAP
1:250 000 SCALE
GEOLOGICAL SERIES
SHEET: 2626 WEST RAND
NOT TO ORIGINAL SCALE

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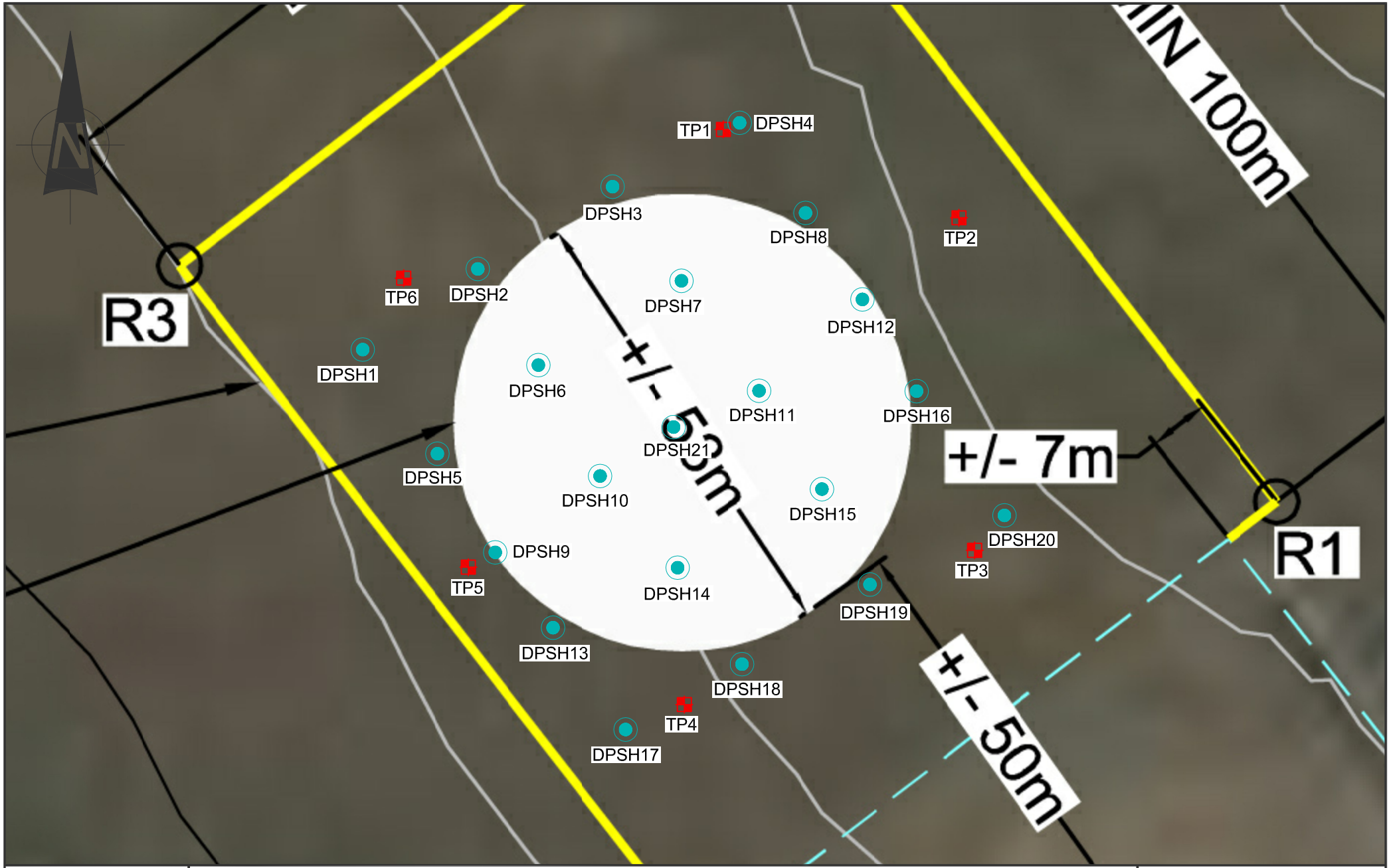
JOBURG WATER GEOTECH INVESTIGATION SERVICES
WOKP#06 - LENASIA HIGH LEVEL RESERVOIR

GEOLOGY MAP

PROJECT NO: 303001321/05
FIGURE NO 2
SCALE N.T.S.



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WOKP#06 - LENASIA HIGH LEVEL RESERVOIR

SITE PLAN SHOWING TEST PIT AND DPSH POSITIONS

PROJECT NO: 303001321/05

FIGURE NO 3

SCALE N.T.S.

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APPENDIX A

TEST PIT PROFILES

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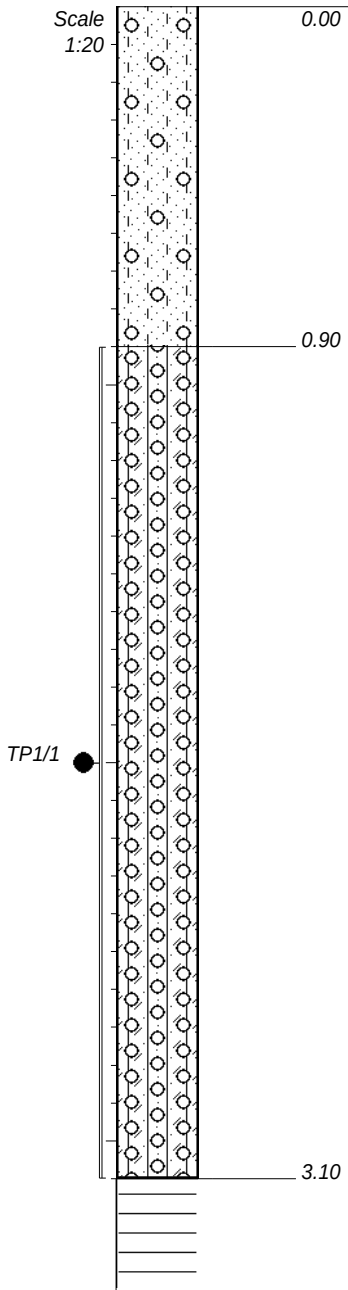
JOBURG WATER
WO 06 LENASIA HIGH LEVEL RESERVOIR
GEOTECHNICAL INVESTIGATION

HOLE No: TP1
Sheet 1 of 1

JOB: 3030013205



0.00

Slightly moist, brown, loose, intact, silty gravelly sand, with scattered, sub-angular quartzite cobbles. **HILLWASH**.

0.90

Moist, reddish brown mottled yellowish brown, soft to firm with depth, relict bedding, sandy clayey SILT, with gravel. **RESIDUAL SHALE**.

3.10

EOH: Refusal of TLB on very soft rock SHALE.

NOTES

1) No groundwater seepage encountered.

2) Bulk sample TP1/1 taken between 0,9m--3,1m.

CONTRACTOR : Kosmos Plant Hire
MACHINE : New Holland 110
DRILLED BY :
PROFILED BY : HH / KM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION : 90 degrees
DIAM :
DATE :
DATE : 15 April 2014

DATE : 03/06/2014 12:12
TEXT : C\WP51\PROFILES\MAHHH.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : 2 918 654
Y-COORD : -86 248

HOLE No: TP1

D079 E Mouton

dotPLOT 7016 PBpH7

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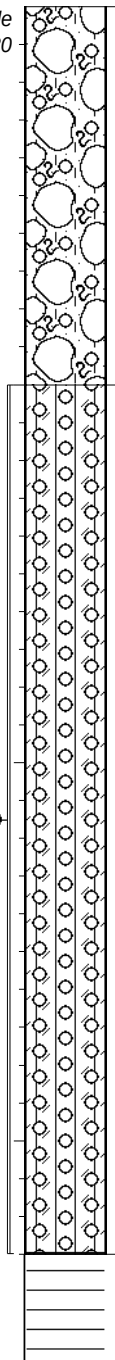
JOBURG WATER
WO 06 LENASIA HIGH LEVEL RESERVOIR
GEOTECHNICAL INVESTIGATION

HOLE No: TP2
Sheet 1 of 1

JOB: 3030013205

Scale 1:20



0.00 Slightly moist, brown, loose, intact, silty sandy GRAVEL, with scattered, sub-angular quartzite cobbles and boulders, and abundant roots. **HILLWASH**.

1.00 Moist, reddish brown mottled yellowish brown, soft to stiff with depth, relict bedded, clayey SILT, with gravel. **RESIDUAL SHALE**, with a subhorizontal quartzite band between 1,3m and 1,5m.

3.30 EOH: Refusal of TLB on very soft rock SHALE.

NOTES

1) No groundwater seepage encountered.

2) Bulk sample TP2/1 taken between 1,0m--3,3m.

CONTRACTOR : Kosmos Plant Hire
MACHINE : New Holland 110
DRILLED BY :
PROFILED BY : HH / KM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION : Vertical
DIAM :
DATE :
DATE : 15 April 2014

DATE : 03/06/2014 12:12
TEXT : C\WP51\PROFILES\MAHHH.TXT

COORDINATE SYSTEM : WGS84 (Lo 27)
X-COORD : 2 918 665
Y-COORD : -86 274

HOLE No: TP2

D079 E Mouton

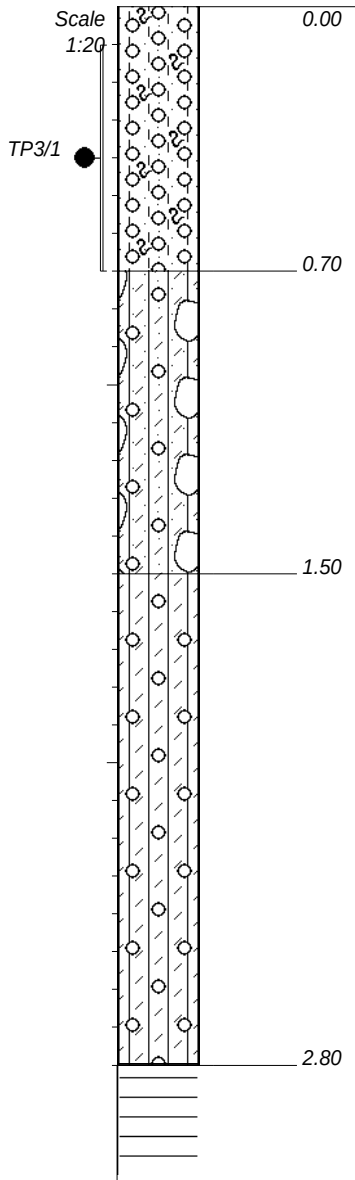
dotPLOT 7016 PBpH7

Knight Piésold CONSULTING

JOBURG WATER
WO 06 LENASIA HIGH LEVEL RESERVOIR
GEOTECHNICAL INVESTIGATION

HOLE No: TP3
Sheet 1 of 1

JOB: 3030013205



0.00

Slightly moist, brown, loose, intact, silty sandy GRAVEL, with scattered sub-angular quartzite cobbles and abundant rootlets. **HILLWASH**.

0.70

Slightly moist, reddish brown, soft to firm, intact, sandy clayey SILT, with scattered gravel and cobbles. **RESIDUAL SHALE**.

1.50

Moist, reddish brown mottled yellowish brown, firm to stiff, relict bedded, gravelly clayey SILT. **RESIDUAL SHALE**.

2.80

EOH: Refusal of TLB on very soft rock SHALE.

NOTES

1) No groundwater seepage encountered.

2) Small bag sample TP3/1 taken between 0,1m--0,7m.

CONTRACTOR : Kosmos Plant Hire
MACHINE : New Holland 110
DRILLED BY :
PROFILED BY : HH / KM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION : Vertical
DIAM :
DATE :
DATE : 15 April 2014

DATE : 03/06/2014 12:12
TEXT : C\WP51\PROFILES\MAHHH.TXT

COORDINATE SYSTEM : WGS84 (Lo 27)
X-COORD : 2 918 702
Y-COORD : -86 276

HOLE No: TP3

D079 E Mouton

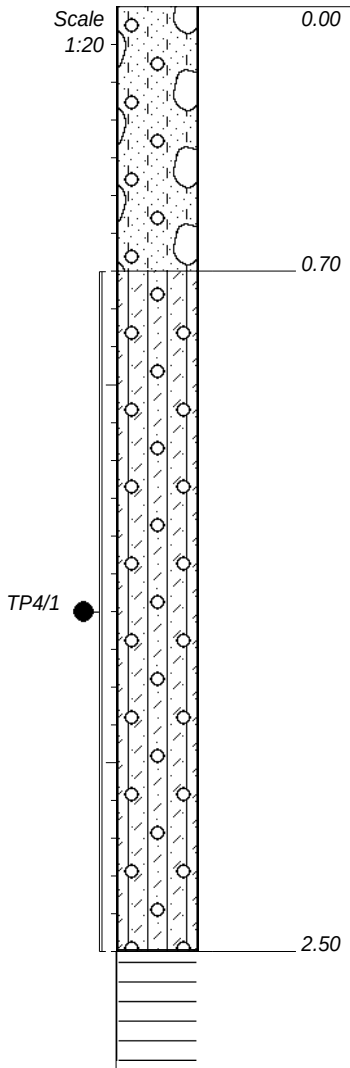
dotPLOT 7016 PBpH7

Knight Piésold CONSULTING

JOBURG WATER
WO 06 LENASIA HIGH LEVEL RESERVOIR
GEOTECHNICAL INVESTIGATION

HOLE No: TP4
Sheet 1 of 1

JOB: 3030013205



Slightly moist, brown becoming reddish brown with depth, loose, intact, silty gravelly SAND, with sub-angular quartzite cobbles. **HILLWASH**.

Moist, red brown mottled yellow brown blotched grey, soft with relict bedding and rock texture in places, gravelly sandy clayey SILT. **RESIDUAL SHALE**.

Note:
Firm from 1,4m to 2m.
Stiff from 2m to 2,5m.

EOH: Refusal on highly weathered, closely jointed, soft rock SHALE.

NOTES

1) No groundwater seepage encountered.

2) Bulk sample TP4/1 taken between 0,7m--2,5m..

CONTRACTOR : Kosmos Plant Hire
MACHINE : New Holland 110
DRILLED BY :
PROFILED BY : HH / KM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION : Vertical
DIAM :
DATE :
DATE : 15 April 2014

DATE : 03/06/2014 12:12
TEXT : C\WP51\PROFILES\MAHHH.TXT

COORDINATE SYSTEM : WGS84 (Lo 27)
X-COORD : 2 918 721
Y-COORD : -86 243

HOLE No: TP4

D079 E Mouton

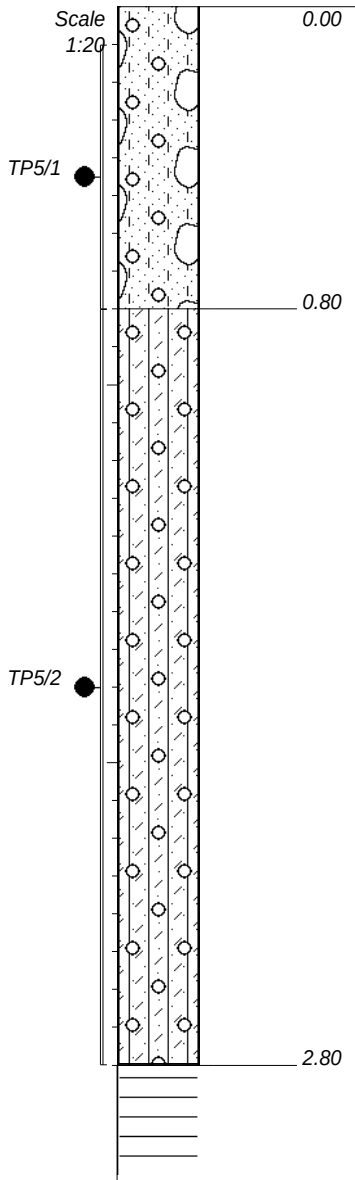
dotPLOT 7016 PBpH7

Knight Piésold CONSULTING

JOBURG WATER
WO 06 LENASIA HIGH LEVEL RESERVOIR
GEOTECHNICAL INVESTIGATION

HOLE No: TP5
Sheet 1 of 1

JOB: 3030013205



0.00

Slightly moist, brown mottled grey, loose, intact, silty gravelly SAND, with subrounded quartzite cobbles and rootlets. **HILLWASH**.

0.80

Moist, red brown mottled yellow brown, soft, relict bedded in places, sandy clayey SILT, with scattered shale gravel. **RESIDUAL SHALE**.

Note:
Firm from 1,9m to 2,5m.
Stiff from 2,5m to 2,8m.

2.80

EOH: Refusal of TLB on highly weathered, closely jointed, soft rock SHALE.

NOTES

1) No groundwater seepage encountered.

2) Small bag samples TP5/1 taken between 0,1m--0,8m and TP5/2 taken between 0,8m--2,8m.

CONTRACTOR : Kosmos Plant Hire
MACHINE : New Holland 110
DRILLED BY :
PROFILED BY : HH / KM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION : Vertical
DIAM :
DATE :
DATE : 15 April 2014

DATE : 03/06/2014 12:12
TEXT : C\WP51\PROFILES\MAHHH.TXT

COORDINATE SYSTEM : WGS84 (Lo 27)
X-COORD : 2 918 705
Y-COORD : -86 217

HOLE No: TP5

D079 E Mouton

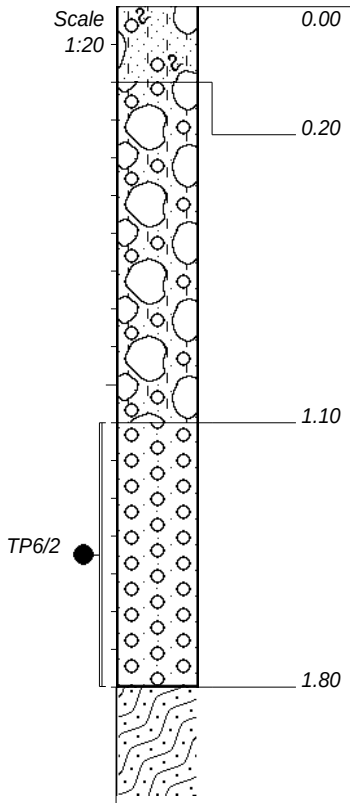
dotPLOT 7016 PBpH7

Knight Piésold CONSULTING

JOBURG WATER
WO 06 LENASIA HIGH LEVEL RESERVOIR
GEOTECHNICAL INVESTIGATION

HOLE No: TP6
Sheet 1 of 1

JOB: 3030013205



0.00

Slightly moist, brown blotched grey and yellow brown, loose, intact, silty gravelly SAND, with sub-angular cobbles and abundant rootlets. **HILLWASH**.

0.20

Slightly moist, greyish brown blotched grey, medium dense to dense in places, relict jointed, silty sandy GRAVEL, with abundant cobbles and boulders. **RESIDUAL QUARTZITE**.

1.10

Slightly moist, red brown mottled yellow brown, loose, intact, sandy GRAVEL. **RESIDUAL QUARTZITE**.

1.80

EOH: Refusal of TLB on closely jointed, soft rock QUARTZITE.

NOTES

1) No groundwater seepage encountered.

2) Small bag sample TP6/2 taken between 1,1m--1,8m.

CONTRACTOR : Kosmos Plant Hire
MACHINE : New Holland 110
DRILLED BY :
PROFILED BY : HH / KM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION : Vertical
DIAM :
DATE :
DATE : 15 April 2014

DATE : 03/06/2014 12:12
TEXT : C\WP51\PROFILES\MAHHH.TXT

COORDINATE SYSTEM : WGS84 (Lo 27)
X-COORD : 2 918 670
Y-COORD : -86 210

HOLE No: TP6

Knight Piésold
CONSULTING

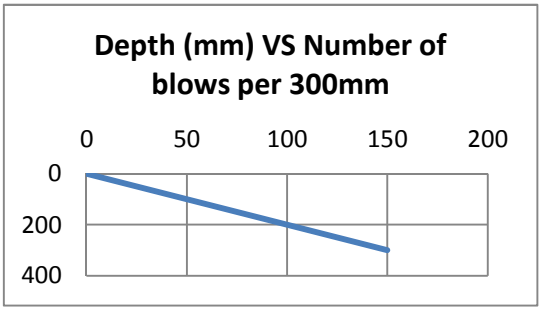
APPENDIX B

DPSH TEST RESULTS

SITE NAME: **Lenasia High Level Reservoir**
Job Number: **3030013205 WO#6**
Date of Tests: **14/04/2014 to 15/04/2014**

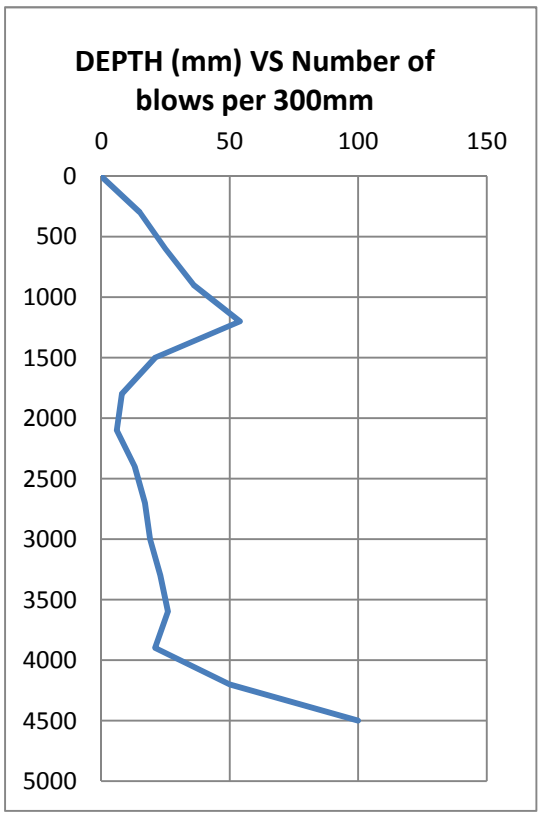
DPSH1

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
150	300	150/ REF	Very Dense



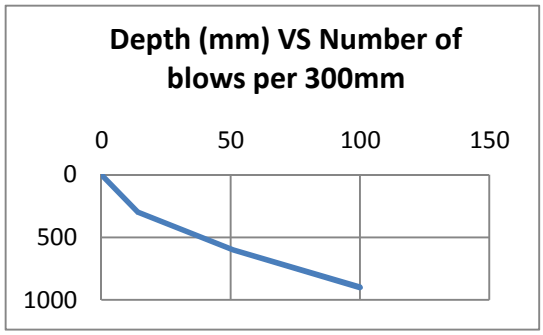
DPSH2

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
15	300	15	Medium Dense
25	600	25	Medium Dense
36	900	36	Dense
54	1200	54	Very Dense
21	1500	21	Medium Dense
8	1800	8	Firm
6	2100	6	Firm
13	2400	13	Stiff
17	2700	17	Very stiff
19	3000	19	Very stiff
23	3300	23	Very stiff
26	3600	26	Very stiff
21	3900	21	Very stiff
50	4200	50	Very stiff
100	4500	100/ REF	Very stiff



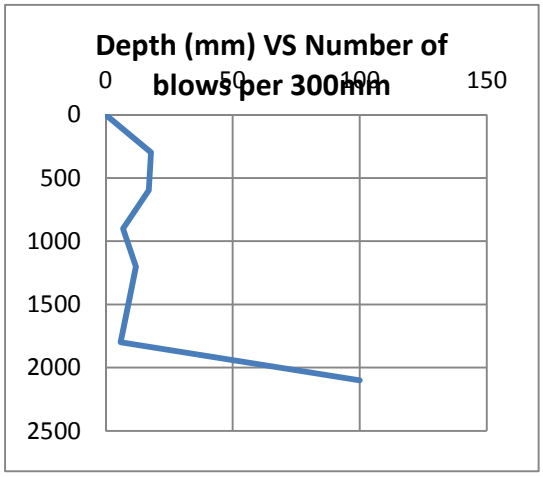
DPSH3

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
14	300	14	Medium Dense
51	600	51	Very Dense
100	900	100/ REF	Very Dense



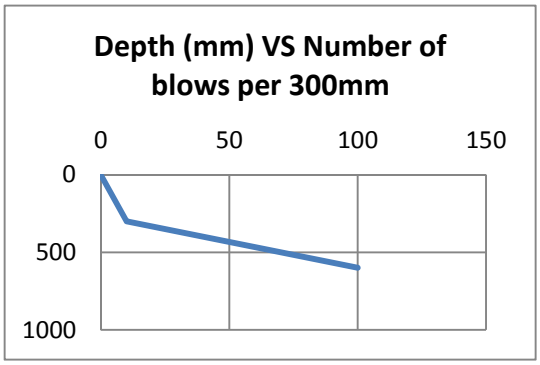
DPSH4

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
18	300	18	Medium Dense
17	600	17	Medium Dense
7	900	7	Loose
12	1200	12	Medium Dense
9	1500	9	Firm
6	1800	6	Firm
100	2100	100/ REF	Very stiff



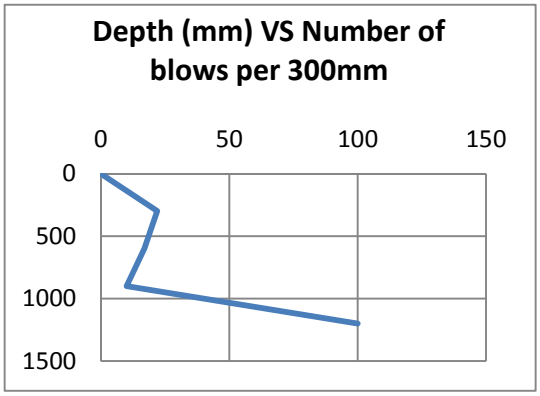
DPSH5

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
10	300	10	Loose
100	600	100/ REF	Very Dense



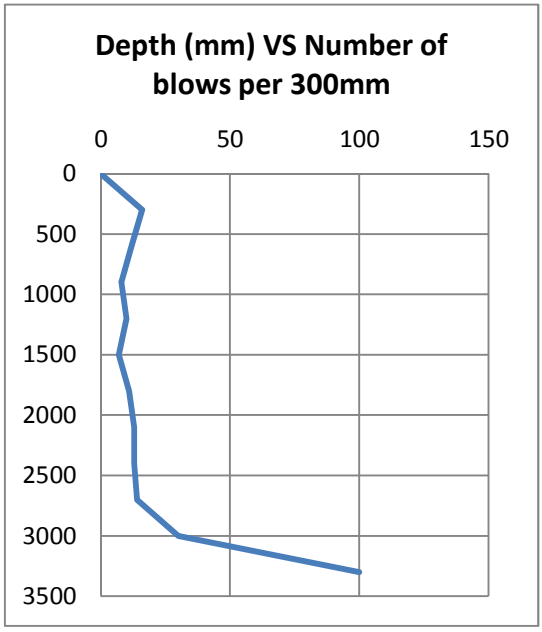
DPSH6

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
22	300	22	Medium Dense
17	600	17	Medium Dense
10	900	10	Loose
100	1200	100/ REF	Very Dense



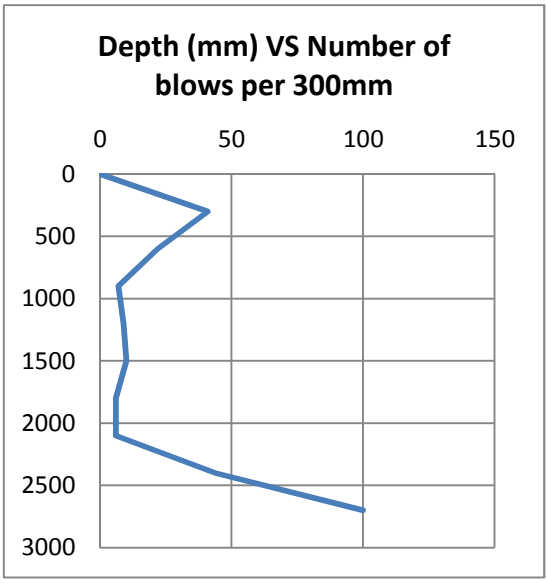
DPSH7

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
16	300	16	Medium Dense
12	600	12	Medium Dense
8	900	8	Loose
10	1200	10	Loose / Medium Dense
7	1500	7	Firm
11	1800	11	Stiff
13	2100	13	Stiff
13	2400	13	Stiff
14	2700	14	Stiff
30	3000	30	Very stiff
100	3300	100/ REF	Very stiff



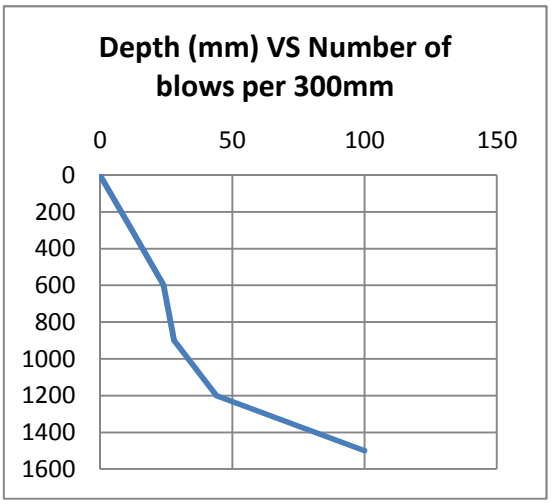
DPSH8

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
41	300	41	Dense
22	600	22	Medium Dense
7	900	7	Loose
9	1200	9	Loose / Medium Dense
10	1500	10	Stiff
6	1800	6	Firm
6	2100	6	Firm
44	2400	44	Very stiff
100	2700	100/ REF	Very stiff



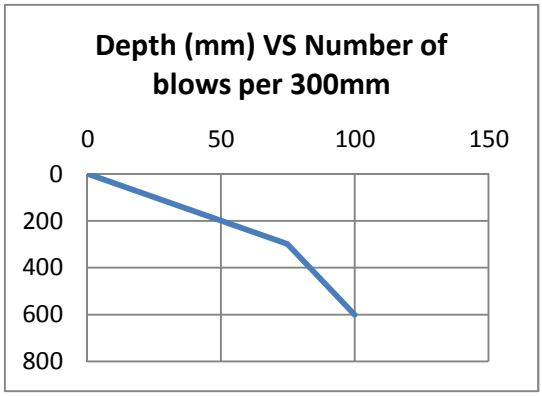
DPSH9

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
12	300	12	Medium Dense
24	600	24	Medium Dense
28	900	28	Medium Dense
44	1200	44	Very Dense
100	1500	100/ REF	Very Dense



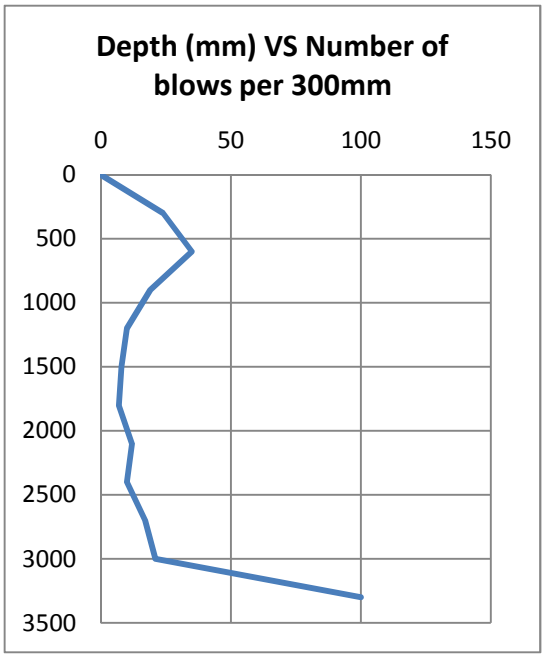
DPSH10

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
75	300	75	Very Dense
100	600	100/ REF	Very Dense



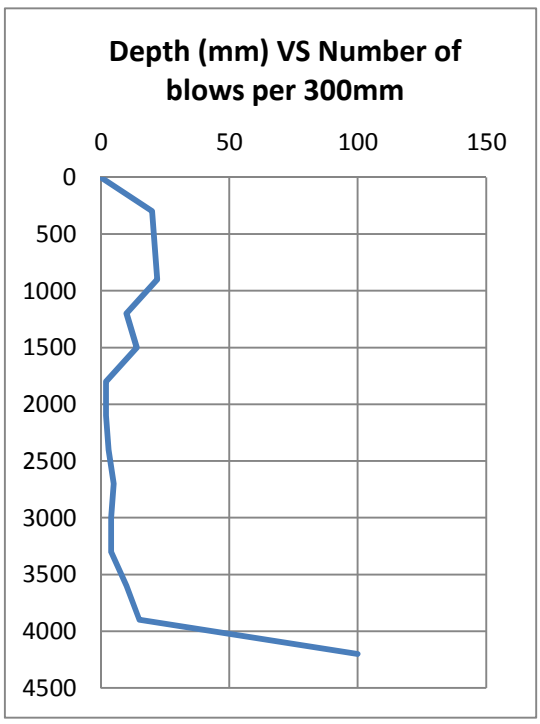
DPSH11

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
24	300	24	Medium Dense
35	600	35	Dense
19	900	19	Medium Dense
10	1200	10	Medium Dense
8	1500	8	Firm
7	1800	7	Firm
12	2100	12	Stiff
10	2400	10	Stiff
17	2700	17	Very stiff
21	3000	21	Very stiff
100	3300	100/ REF	Very stiff



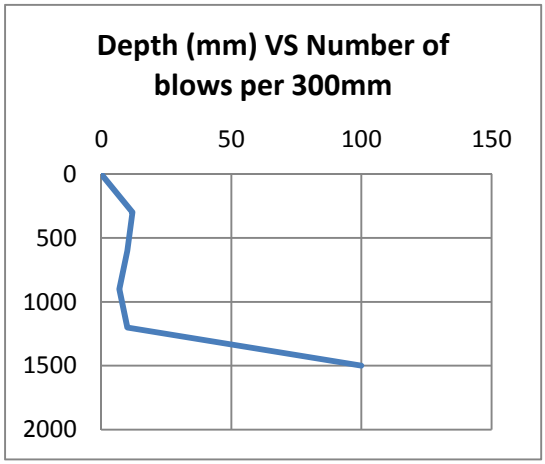
DPSH12

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
20	300	20	Medium Dense
21	600	21	Medium Dense
22	900	22	Medium Dense
10	1200	10	Medium Dense
14	1500	14	Medium Dense
2	1800	2	Soft
2	2100	2	Soft
3	2400	3	Soft
5	2700	5	Firm
4	3000	4	Soft
4	3300	4	Soft
10	3600	10	Stiff
15	3900	15	Stiff
100	4200	100/ REF	Very stiff



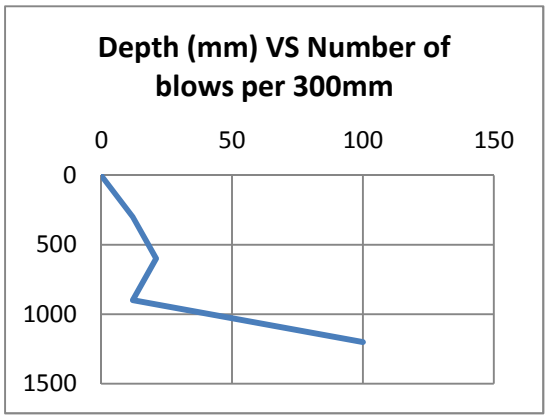
DPSH13

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
12	300	12	Medium Dense
10	600	10	Loose / Medium Dense
7	900	7	Loose
10	1200	10	Loose / Medium Dense
100	1500	100/ REF	Very Dense



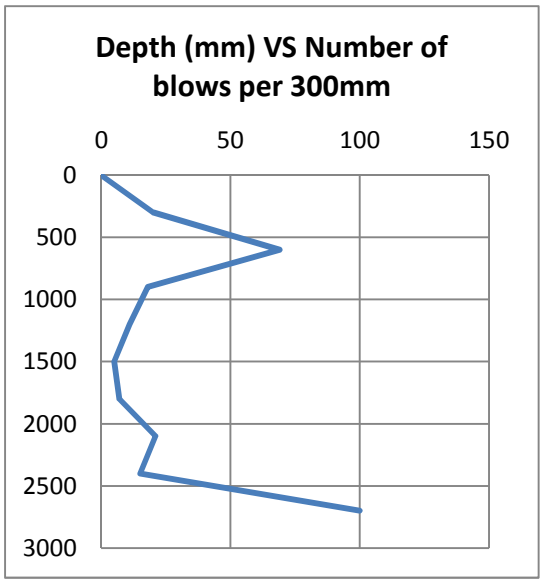
DPSH14

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
12	300	12	Medium Dense
21	600	21	Medium Dense
12	900	12	Medium Dense
100	1200	100/ REF	Very Dense



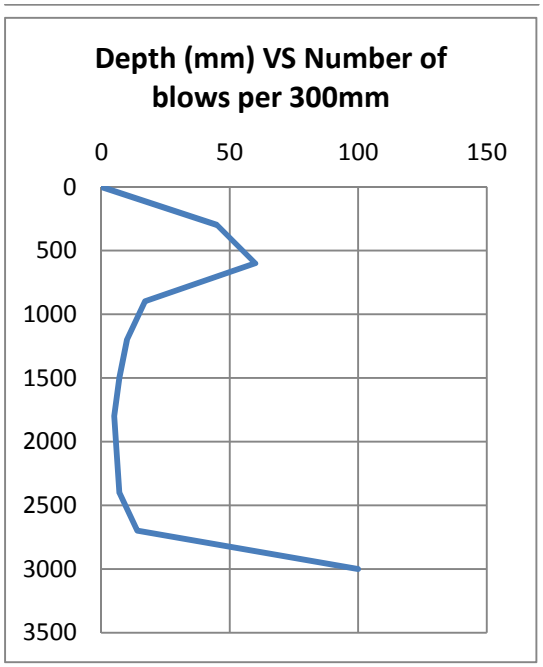
DPSH15

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
20	300	20	Medium Dense
69	600	69	Very Dense
18	900	18	Medium Dense
11	1200	11	Medium Dense
5	1500	5	Firm
7	1800	7	Firm
21	2100	21	Very stiff
15	2400	15	Stiff / Very Stiff
100	2700	100/ REF	Very stiff



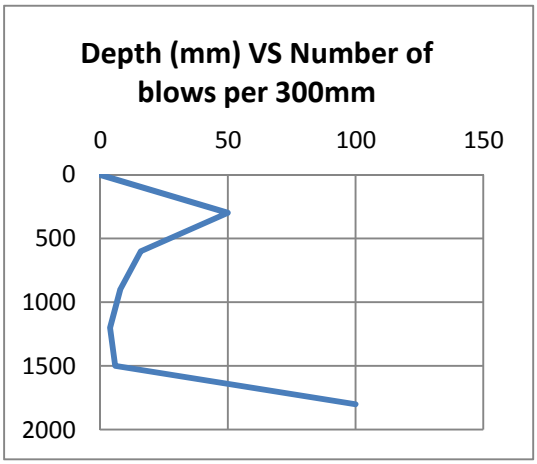
DPSH16

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
45	300	45	Dense
60	600	60	Very Dense
17	900	17	Medium Dense
10	1200	10	Loose / Medium Dense
7	1500	7	Firm
5	1800	5	Firm
6	2100	6	Firm
7	2400	7	Firm
14	2700	14	Stiff
100	3000	100/REF	Very stiff



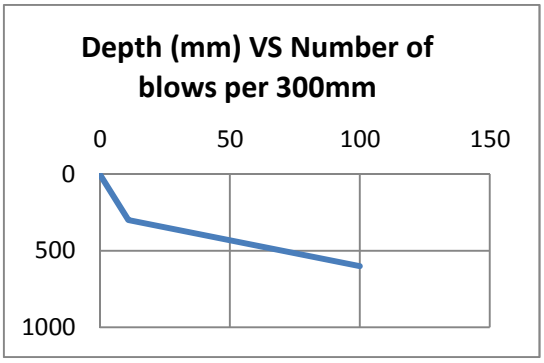
DPSH17

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
50	300	50	Dense
16	600	16	Medium Dense
8	900	8	Loose / Firm
4	1200	4	Soft
6	1500	6	Firm
100	1800	100/ REF	Very stiff



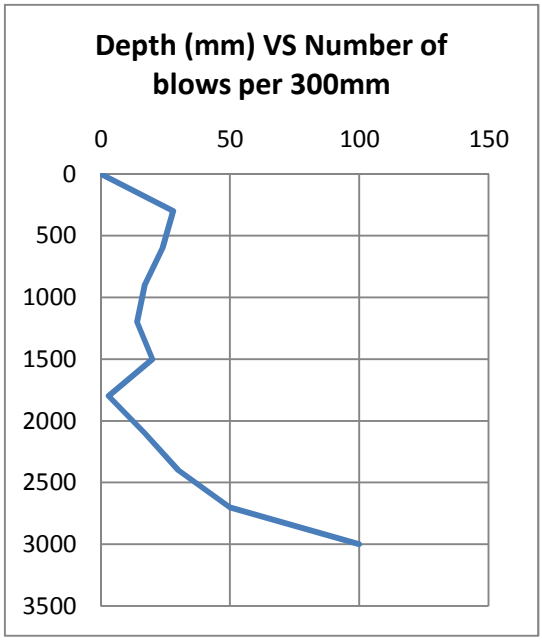
DPSH18

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
11	300	11	Medium Dense
100	600	100/ REF	Very Dense



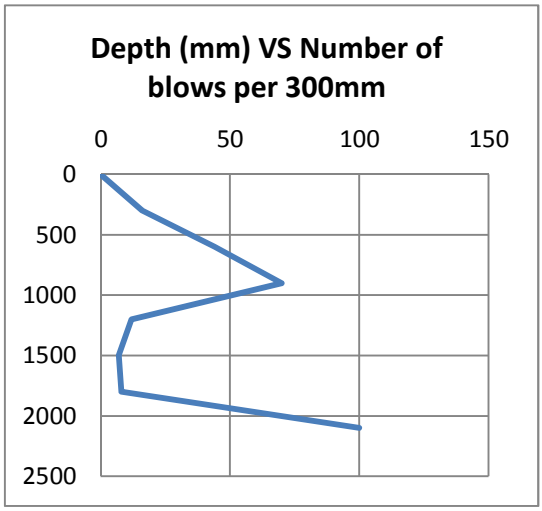
DPSH19

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
28	300	28	Medium Dense
24	600	24	Medium Dense
17	900	17	Medium Dense
14	1200	14	Stiff
20	1500	20	Very stiff
3	1800	3	Soft
17	2100	17	Very stiff
30	2400	30	Very stiff
50	2700	50	Very stiff
100	3000	100/ REF	Very stiff



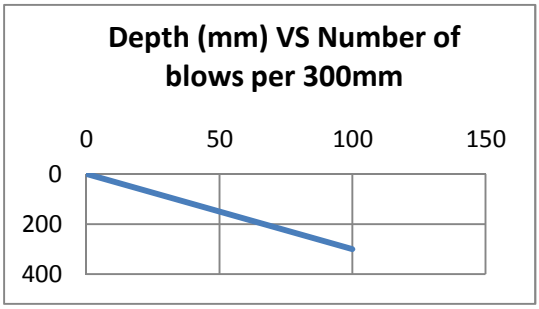
DPSH20

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
16	300	16	Medium Dense
44	600	44	Dense
70	900	70	Very Dense
12	1200	12	Stiff
7	1500	7	Firm
8	1800	8	Firm
100	2100	100/ REF	Very stiff



DPSH21

Number of Blows	Depth (mm)	No. of blows/ 300mm	Consistency
0	0	0	-
100	300	100/ REF	Very Dense



Knight Piésold
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APPENDIX C

LABORATORY TEST RESULTS

T0023

GEOSTRADA
engineering materials laboratory

SUMMARY OF TEST RESULTS ON SOILS - REP COM 2

Client: Knight Piesold **Project:** Lenasia High Level Resevoir **Project Number:** **Job No:** 2014-C-574 **Date:** 28/05/2014

Sample No	Hole No / TP No	Depth (m)	Description	Percentage Passing Sieve (mm) - TMH1 A1, A5, MT1																		% Gravel > 2.00 mm	% Sand 2.00 - 0.060 mm	% Silt 0.060-0.002 mm	% Clay < 0.002mm	Atterberg Limits (TMH1 A2-A4) < 0.425 mm			MDD (kg/m³) & OMC (%) (TMH1 A7)		CBR (Modified AASHTO) TMH1 A8						
				Sieve Analysis																						LL	PI	LS			% Swell	90%	93%	95%	97%	98%	100%
				53.0	37.5	26.5	19.0	13.2	9.5	4.75	2.00	0.425	0.250	0.150	0.075	0.060	0.050	0.020	0.005	0.002	GM															
4/4153	TP 1/1	0.9 - 3.1					100	97	93	85	78	73	71	68	63	44	40	28	13	8	0.86	22	34	36	8	28	7	2.0	1713	9.7	0.24	2.0	3.3	4.5	5.4	5.9	7.1
4/4154	TP 2/1	1.0 - 3.3			100	97	95	93	91	88	84	80	80	79	78	75	71	56	35	19	0.58	16	9	56	19	38	10	3.5	1752	13.9	0.50	1.1	1.7	2.3	2.9	3.2	3.9
4/4155	TP 3/1	0.1 - 0.7		100	97	91	81	66	53	38	29	26	24	20	16	14	13	9	8	7	2.29	71	15	7	7	24	7	4.0								
4/4156	TP 4/1	0.7 - 2.5					100	99	98	94	88	81	81	80	77	66	63	54	30	17	0.54	12	22	49	17	39	8	2.5	1722	9.5	0.19	0.9	2.0	3.5	5.7	6.3	7.6
4/4157	TP 5/1	0.1 - 0.8		100	91	89	84	76	70	57	47	40	39	33	25	18	17	15	10	9	1.88	53	29	9	9	24	7	2.5								
4/4158	TP 5/2	0.8 - 2.8							100	99	95	91	91	89	86	79	76	67	41	23	0.28	5	16	56	23	39	9	3.0								
4/4159	TP 6/2	1.1 - 1.8			100	94	85	83	81	77	71	61	58	43	29	25	23	19	14	13	1.39	29	46	12	13	22	6	2.5								

Remarks:

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FOUNDATION INDICATOR TEST RESULTS - REP COM 7

Client:	**Knight Piesold Consulting**	**Source/Location:**		**Job No:**	**2014-C-470**
Project Name:	**Lenasia High Level Reservoir**	**Layer:**		**Sample No:**	**4/4153**
Project No:				**Date:**	**28/05/2014**
Hole/TP No:	**TP 1/1**	**Stabilizing Agent:**		**Test Method:**	**TMH1 A1, A5 & MT1**
Depth (m):	**0.9 - 3.1**	**Section:**		**Client Ref No:**	
Description:		**Chainage:**		**GPS X:**	
Additional Info:		**Offset:**		**GPS Y:**	

SIEVE ANALYSIS

Sieve (mm)	% Passing	Sieve (mm)	% Passing
75.0	**100**	0.425	**73**
63.0	**100**	0.250	**71**
53.0	**100**	0.150	**68**
37.5	**100**	0.075	**63**
26.5	**100**	0.060	**44**
19.0	**100**	0.050	**40**
13.2	**97**	0.020	**28**
9.5	**93**	0.005	**13**
4.75	**85**	0.002	**8**
2.00	**78**		

ATTERBERG LIMITS

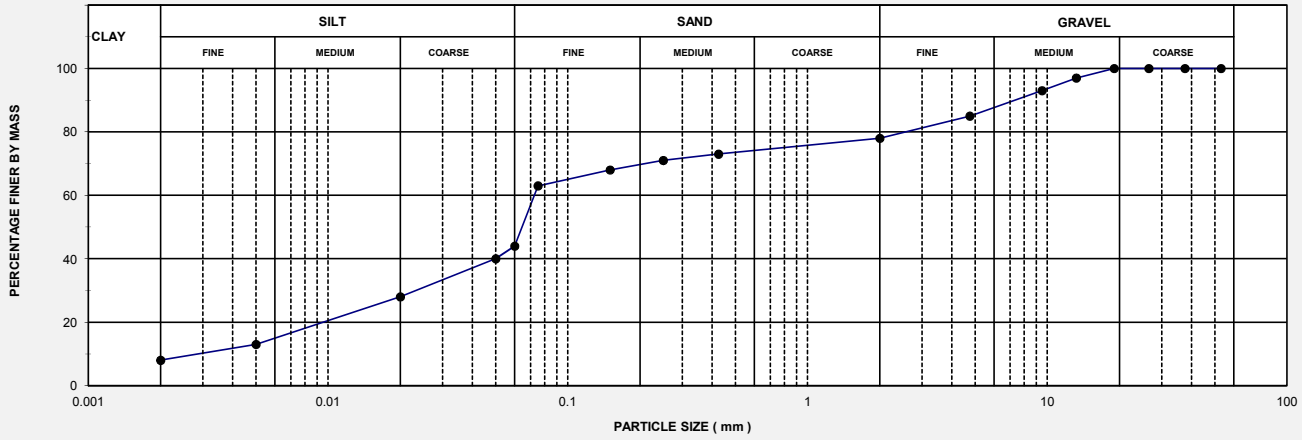
Liquid Limit	(%)	**28**
Plastic Limit	(%)	**21**
Plasticity Index	(%)	**7**
Weighted PI	(%)	**5**
Linear Shrinkage	(%)	**2.0**
Grading Modulus		**0.86**
Uniformity coefficient		**23**
Coefficient of curvature		**3.1**

Remarks:

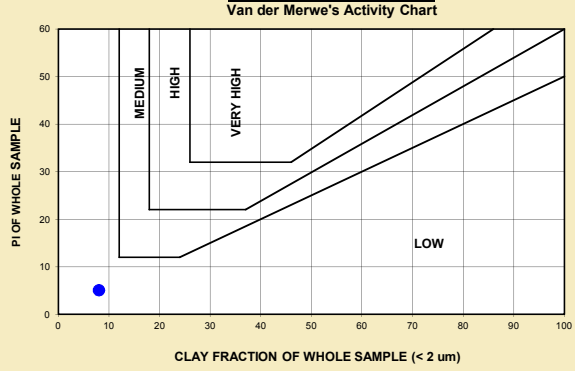
SOIL CLASSIFICATION

% Gravel	**22**
% Sand	**34**
% Silt	**36**
% Clay	**8**
Activity	**0.9**
Unified Classification	**CL-ML**
TRB Classification	**A - 4**

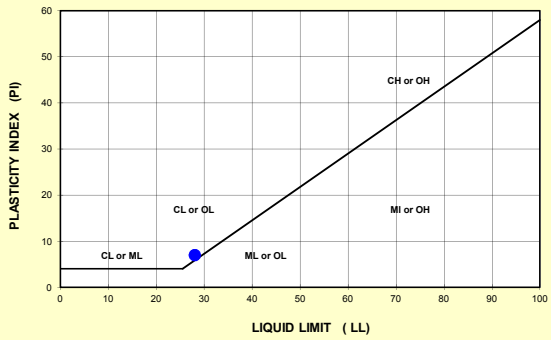
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



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FOUNDATION INDICATOR TEST RESULTS - REP COM 7

Client:	**Knight Piesold Consulting**	**Source/Location:**		**Job No:**	**2014-C-470**
Project Name:	**Lenasia High Level Reservoir**	**Layer:**		**Sample No:**	**4/4154**
Project No:				**Date:**	**28/05/2014**
Hole/TP No:	**TP 2/1**	**Stabilizing Agent:**		**Test Method:**	**TMH1 A1, A5 & MT1**
Depth (m):	**1.0 - 3.3**	**Section:**		**Client Ref No:**	
Description:		**Chainage:**		**GPS X:**	
Additional Info:		**Offset:**		**GPS Y:**	

SIEVE ANALYSIS

Sieve (mm)	% Passing	Sieve (mm)	% Passing
75.0	**100**	0.425	**80**
63.0	**100**	0.250	**80**
53.0	**100**	0.150	**79**
37.5	**100**	0.075	**78**
26.5	**97**	0.060	**75**
19.0	**95**	0.050	**71**
13.2	**93**	0.020	**56**
9.5	**91**	0.005	**35**
4.75	**88**	0.002	**19**
2.00	**84**		

ATTERBERG LIMITS

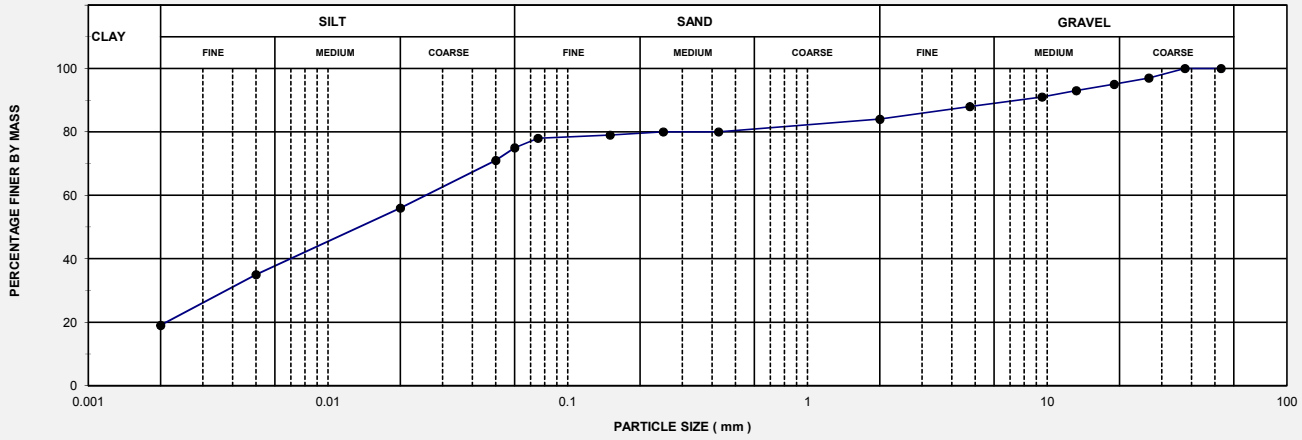
Liquid Limit	(%)	**38**
Plastic Limit	(%)	**28**
Plasticity Index	(%)	**10**
Weighted PI	(%)	**8**
Linear Shrinkage	(%)	**3.5**
Grading Modulus		**0.58**
Uniformity coefficient		**14**
Coefficient of curvature		**0.3**

Remarks:

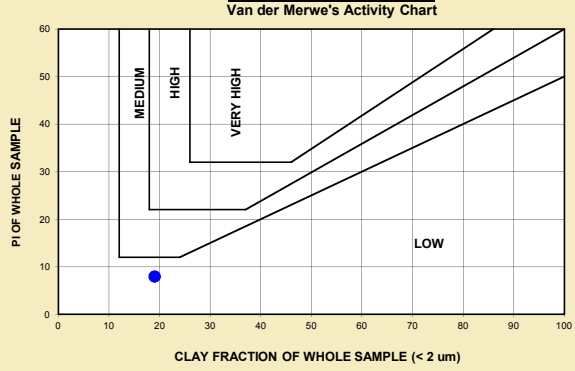
SOIL CLASSIFICATION

% Gravel	**16**
% Sand	**9**
% Silt	**56**
% Clay	**19**
Activity	**0.5**
Unified Classification	**ML**
TRB Classification	**A - 4**

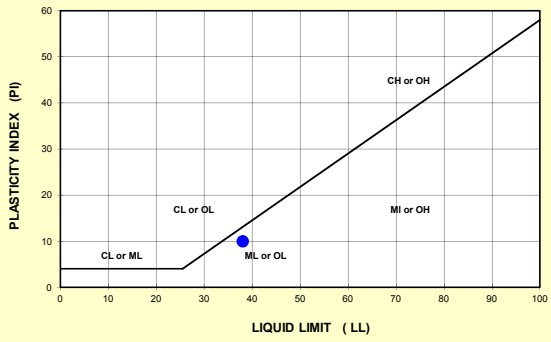
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



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FOUNDATION INDICATOR TEST RESULTS - REP COM 7

Client:	**Knight Piesold Consulting**	**Source/Location:**		**Job No:**	**2014-C-470**
Project Name:	**Lenasia High Level Reservoir**	**Layer:**		**Sample No:**	**4/4155**
Project No:				**Date:**	**28/05/2014**
Hole/TP No:	**TP 3/1**	**Stabilizing Agent:**		**Test Method:**	**TMH1 A1, A5 & MT1**
Depth (m):	**0.1 - 0.7**	**Section:**		**Client Ref No:**	
Description:		**Chainage:**		**GPS X:**	
Additional Info:		**Offset:**		**GPS Y:**	

SIEVE ANALYSIS

Sieve (mm)	% Passing	Sieve (mm)	% Passing
75.0	**100**	0.425	**26**
63.0	**100**	0.250	**24**
53.0	**100**	0.150	**20**
37.5	**97**	0.075	**16**
26.5	**91**	0.060	**14**
19.0	**81**	0.050	**13**
13.2	**66**	0.020	**9**
9.5	**53**	0.005	**8**
4.75	**38**	0.002	**7**
2.00	**29**		

ATTERBERG LIMITS

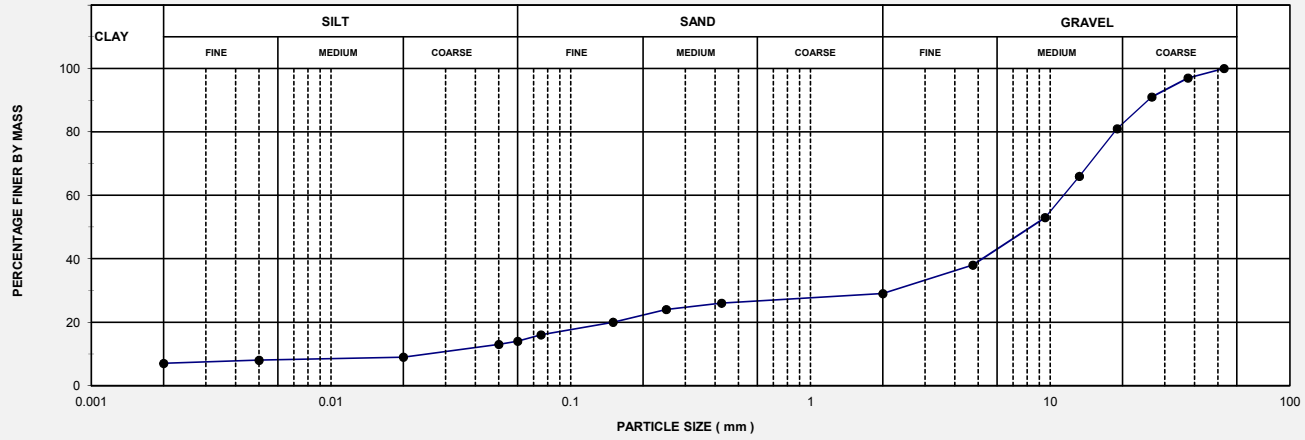
Liquid Limit	(%)	**24**
Plastic Limit	(%)	**17**
Plasticity Index	(%)	**7**
Weighted PI	(%)	**2**
Linear Shrinkage	(%)	**4.0**
Grading Modulus		**2.29**
Uniformity coefficient		**390**
Coefficient of curvature		**15.7**

Remarks:

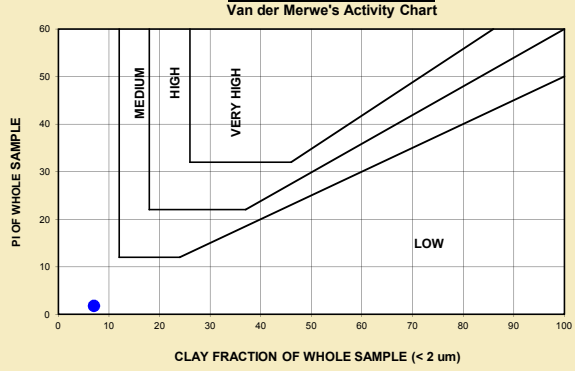
SOIL CLASSIFICATION

% Gravel	**71**
% Sand	**15**
% Silt	**7**
% Clay	**7**
Activity	**1.0**
Unified Classification	**GC-GM**
TRB Classification	**A - 2 - 4**

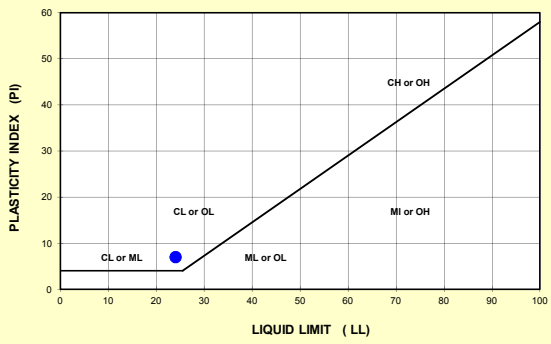
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



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FOUNDATION INDICATOR TEST RESULTS - REP COM 7

Client:	**Knight Piesold Consulting**	**Source/Location:**		**Job No:**	**2014-C-470**
Project Name:	**Lenasia High Level Reservoir**	**Layer:**		**Sample No:**	**4/4156**
Project No:				**Date:**	**28/05/2014**
Hole/TP No:	**TP 4/1**	**Stabilizing Agent:**		**Test Method:**	**TMH1 A1, A5 & MT1**
Depth (m):	**0.7 - 2.5**	**Section:**		**Client Ref No:**	
Description:		**Chainage:**		**GPS X:**	
Additional Info:		**Offset:**		**GPS Y:**	

SIEVE ANALYSIS

Sieve (mm)	% Passing	Sieve (mm)	% Passing
75.0	**100**	0.425	**81**
63.0	**100**	0.250	**81**
53.0	**100**	0.150	**80**
37.5	**100**	0.075	**77**
26.5	**100**	0.060	**66**
19.0	**100**	0.050	**63**
13.2	**99**	0.020	**54**
9.5	**98**	0.005	**30**
4.75	**94**	0.002	**17**
2.00	**88**		

ATTERBERG LIMITS

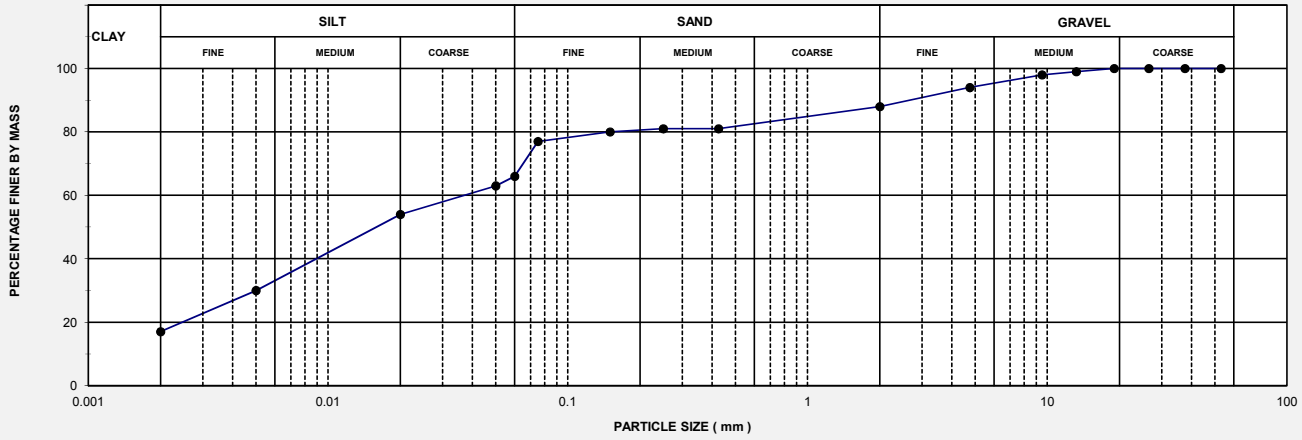
Liquid Limit	(%)	**39**
Plastic Limit	(%)	**31**
Plasticity Index	(%)	**8**
Weighted PI	(%)	**6**
Linear Shrinkage	(%)	**2.5**
Grading Modulus		**0.54**
Uniformity coefficient		**20**
Coefficient of curvature		**0.6**

Remarks:

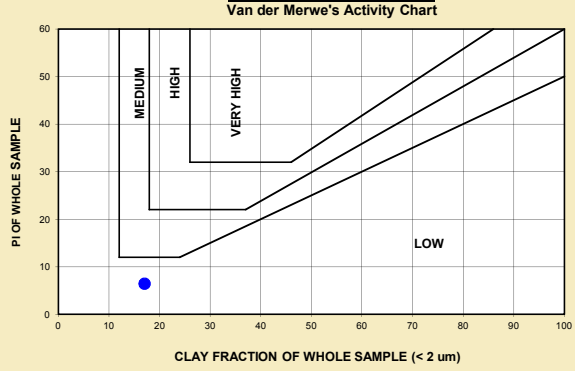
SOIL CLASSIFICATION

% Gravel	**12**
% Sand	**22**
% Silt	**49**
% Clay	**17**
Activity	**0.5**
Unified Classification	**ML**
TRB Classification	**A - 4**

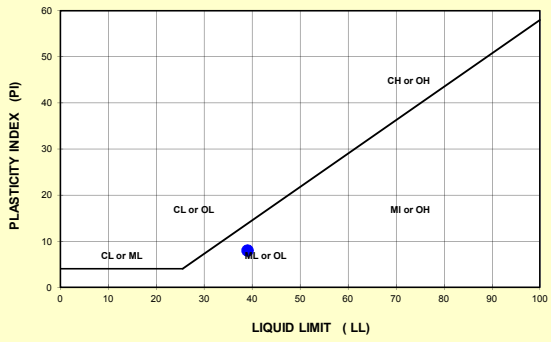
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



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FOUNDATION INDICATOR TEST RESULTS - REP COM 7

Client:	**Knight Piesold Consulting**	**Source/Location:**		**Job No:**	**2014-C-470**
Project Name:	**Lenasia High Level Reservoir**	**Layer:**		**Sample No:**	**4/4157**
Project No:				**Date:**	**28/05/2014**
Hole/TP No:	**TP 5/1**	**Stabilizing Agent:**		**Test Method:**	**TMH1 A1, A5 & MT1**
Depth (m):	**0.1 - 0.8**	**Section:**		**Client Ref No:**	
Description:		**Chainage:**		**GPS X:**	
Additional Info:		**Offset:**		**GPS Y:**	

SIEVE ANALYSIS

Sieve (mm)	% Passing	Sieve (mm)	% Passing
75.0	**100**	0.425	**40**
63.0	**100**	0.250	**39**
53.0	**100**	0.150	**33**
37.5	**91**	0.075	**25**
26.5	**89**	0.060	**18**
19.0	**84**	0.050	**17**
13.2	**76**	0.020	**15**
9.5	**70**	0.005	**10**
4.75	**57**	0.002	**9**
2.00	**47**		

ATTERBERG LIMITS

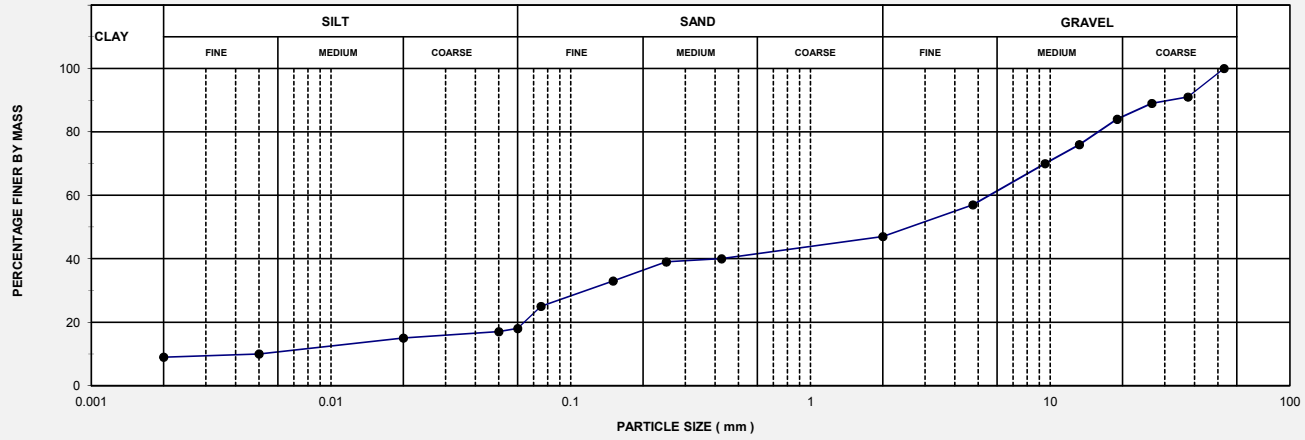
Liquid Limit	(%)	**24**
Plastic Limit	(%)	**17**
Plasticity Index	(%)	**7**
Weighted PI	(%)	**3**
Linear Shrinkage	(%)	**2.5**
Grading Modulus		**1.88**
Uniformity coefficient		**835**
Coefficient of curvature		**0.4**

Remarks:

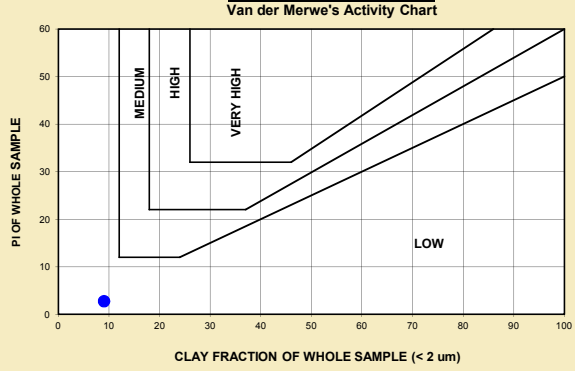
SOIL CLASSIFICATION

% Gravel	**53**
% Sand	**29**
% Silt	**9**
% Clay	**9**
Activity	**0.8**
Unified Classification	**GC-GM**
TRB Classification	**A - 2 - 4**

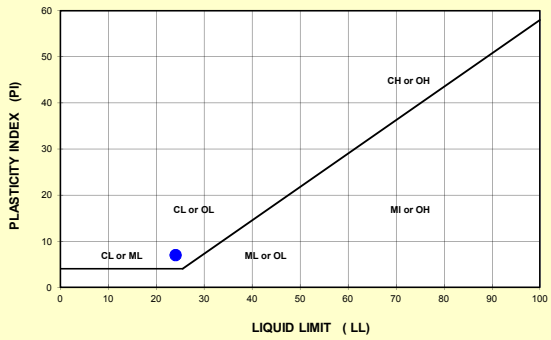
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



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FOUNDATION INDICATOR TEST RESULTS - REP COM 7

Client:	**Knight Piesold Consulting**	**Source/Location:**		**Job No:**	**2014-C-470**
Project Name:	**Lenasia High Level Reservoir**	**Layer:**		**Sample No:**	**4/4158**
Project No:				**Date:**	**28/05/2014**
Hole/TP No:	**TP 5/2**	**Stabilizing Agent:**		**Test Method:**	**TMH1 A1, A5 & MT1**
Depth (m):	**0.8 - 2.8**	**Section:**		**Client Ref No:**	
Description:		**Chainage:**		**GPS X:**	
Additional Info:		**Offset:**		**GPS Y:**	

SIEVE ANALYSIS

Sieve (mm)	% Passing	Sieve (mm)	% Passing
75.0	**100**	0.425	**91**
63.0	**100**	0.250	**91**
53.0	**100**	0.150	**89**
37.5	**100**	0.075	**86**
26.5	**100**	0.060	**79**
19.0	**100**	0.050	**76**
13.2	**100**	0.020	**67**
9.5	**100**	0.005	**41**
4.75	**99**	0.002	**23**
2.00	**95**		

ATTERBERG LIMITS

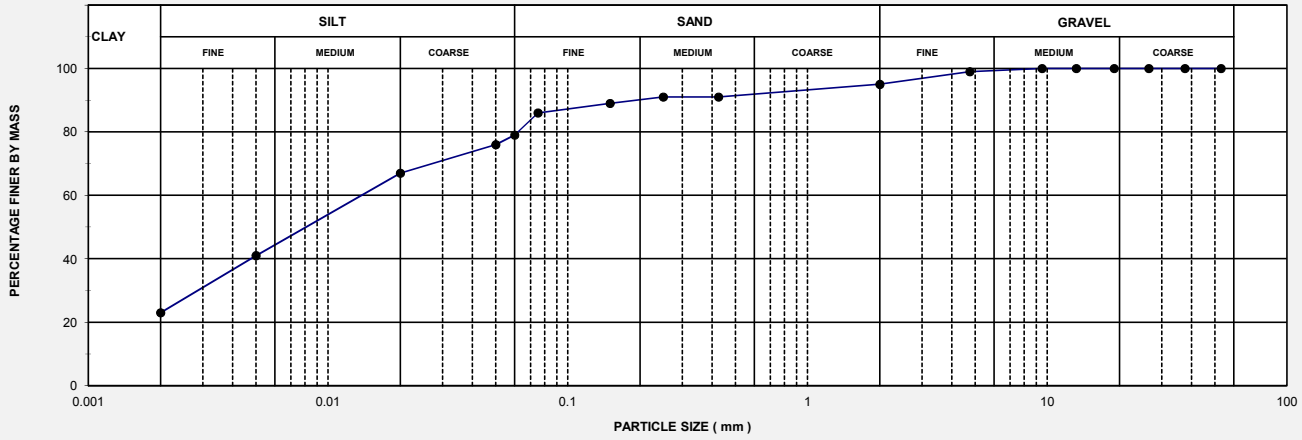
Liquid Limit	(%)	**39**
Plastic Limit	(%)	**30**
Plasticity Index	(%)	**9**
Weighted PI	(%)	**8**
Linear Shrinkage	(%)	**3.0**
Grading Modulus		**0.28**
Uniformity coefficient		**8**
Coefficient of curvature		**0.3**

Remarks:

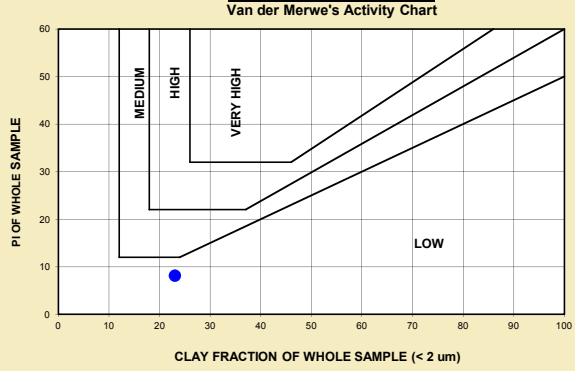
SOIL CLASSIFICATION

% Gravel	**5**
% Sand	**16**
% Silt	**56**
% Clay	**23**
Activity	**0.4**
Unified Classification	**ML**
TRB Classification	**A - 4**

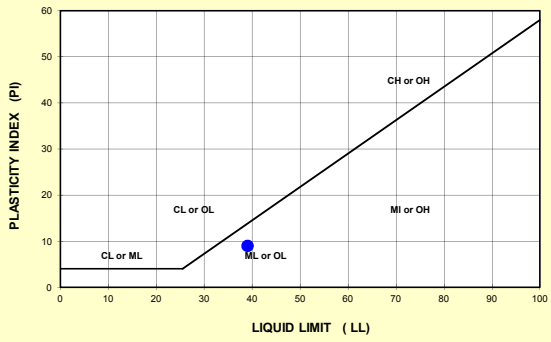
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



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FOUNDATION INDICATOR TEST RESULTS - REP COM 7

Client:	**Knight Piesold Consulting**	**Source/Location:**		**Job No:**	**2014-C-470**
Project Name:	**Lenasia High Level Reservoir**	**Layer:**		**Sample No:**	**4/4159**
Project No:				**Date:**	**28/05/2014**
Hole/TP No:	**TP 6/2**	**Stabilizing Agent:**		**Test Method:**	**TMH1 A1, A5 & MT1**
Depth (m):	**1.1 - 1.8**	**Section:**		**Client Ref No:**	
Description:		**Chainage:**		**GPS X:**	
Additional Info:		**Offset:**		**GPS Y:**	

SIEVE ANALYSIS

Sieve (mm)	% Passing	Sieve (mm)	% Passing
75.0	**100**	0.425	**61**
63.0	**100**	0.250	**58**
53.0	**100**	0.150	**43**
37.5	**100**	0.075	**29**
26.5	**94**	0.060	**25**
19.0	**85**	0.050	**23**
13.2	**83**	0.020	**19**
9.5	**81**	0.005	**14**
4.75	**77**	0.002	**13**
2.00	**71**		

ATTERBERG LIMITS

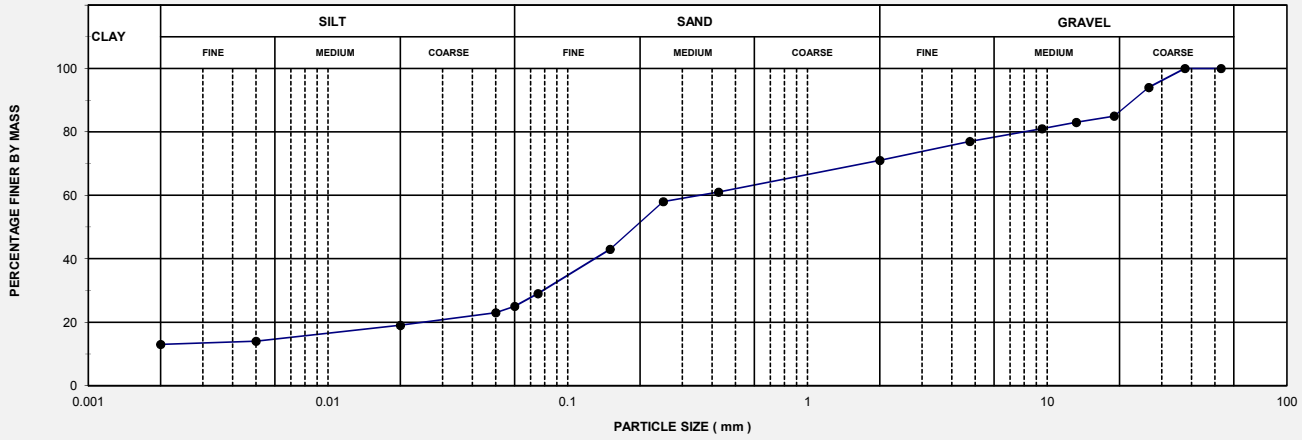
Liquid Limit	(%)	**22**
Plastic Limit	(%)	**16**
Plasticity Index	(%)	**6**
Weighted PI	(%)	**4**
Linear Shrinkage	(%)	**2.5**
Grading Modulus		**1.39**
Uniformity coefficient		**183**
Coefficient of curvature		**9.2**

Remarks:

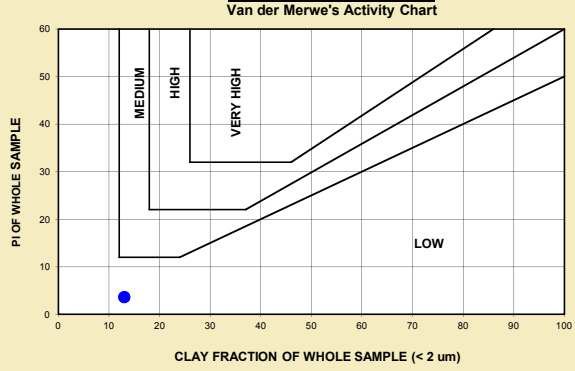
SOIL CLASSIFICATION

% Gravel	**29**
% Sand	**46**
% Silt	**12**
% Clay	**13**
Activity	**0.5**
Unified Classification	**SC**
TRB Classification	**A - 2 - 4**

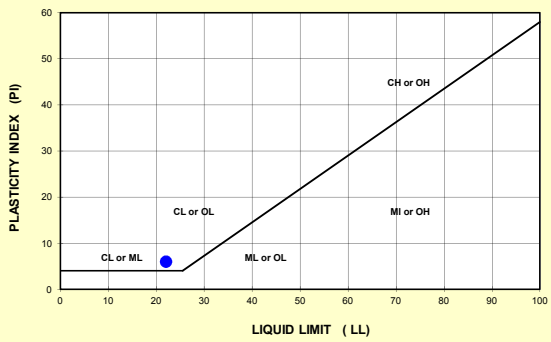
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



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CERTIFICATE OF ANALYSES
BASSON INDEX

Date received: 2014-04-25
Project number: 255
Report number: 45671
Date completed: 2014-05-19
Order number: 10437

Client name: Geostrada
Address: P.O.Box 11126, Hatfield, 0028
Telephone: 012 432 0531

Contact person: Gerrie Jv Rensburg
Email: gerriej@geostrada.co.za
Cell: 082 309 4448

Analyses in mg/ℓ (Unless specified otherwise)	Sample Identification: Lenasia High level Reservior		
	TP 1/2 - 0.9-3.1 (4/4153)	TP 2/1 – 0.3-2.2 (4/4154)	TP 4/1 – 0.7-2.5 (4/4156)
Sample Number	**4644**	**4645**	**4646**
pH Value at 25°C	4.1	5.3	5.7
pHs Value at 20°C (calc)	11.4	11.7	11.7
Electrical Conductivity in mS/m at 25°C	1.1	0.9	1.3
Total Dissolved Solids* (calc)	<10	<10	<10
Total Alkalinity as $CaCO_3$	<5	<5	<5
Total Hardness as $CaCO_3$ (calc)	<5	<5	<5
Calcium Hardness as $CaCO_3$ (calc)	<5	<5	<5
Calcium as Ca	<2	<2	<2
Magnesium as Mg	<2	<2	<2
Free & Saline Ammonia	<0.2	<0.2	0.2
Ammonium as NH_4 (calc)	<0.3	<0.3	0.3
Sulphate as SO_4	<5	<5	<5
Chloride as Cl	<5	<5	<5
Langelier Index at 25°C (calc)	-7.3	-6.4	-6.0
Ryznar Index at 25°C (calc)	18.6	18.2	17.7
Corrosivity Ratio (calc)	1.5	0.9	0.7
Leaching Index [LCSI] (calc)	**5593**	**4913**	**4620**
Spalling Index [SCSI] (calc)	**0**	**1**	**1**
Aggressiveness Index [N_c] (calc)	**5593**	**4914**	**4621**

***TDS Calculated EC X 6.7**
2:1 Distilled Water : Soil Extract

Important notes (see table for corrections on p. 3):

1. The above aggressiveness index is only applicable for conditions of laminar flow at a mean annual temperature of 20°C.
2. For stagnant/turbulent conditions the aggressiveness index must be corrected.
3. For wet/dry cycling conditions (for example in tidal zones) the aggressiveness index must be corrected.
4. For mean annual temperatures lower/higher than 20°C the aggressiveness index must be corrected.

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Guidelines for assessing overall aggressiveness (N_c):

N_c	Aggressiveness
Not greater than 300	None to mild
400-700	Mild to moderate
800-1000	High
= or > 1 100	Very high

Aggressiveness Towards *Concrete and Fibre Cement Pipes*			
Index	**Aggressive**	**Neutral**	**Non- Aggressive**
a) Stability pH (pHs)	>pH	= pH	<pH
b) Langelier Index	Neg. Value	Zero	Pos. Value
c) Ryznar Index	>7.5	6-7	<6

Corrosiveness Towards metals	
Corrosivity	>0.2

Sample Name	Sample Number	Corrosivity Indices	Basson Index
TP 1/2 - 0.9-3.1 (4/4153)	4644	Corrosive	Aggressive
TP 2/1 – 0.3-2.2 (4/4154)	4645	Corrosive	Aggressive
TP 4/1 – 0.7-2.5 (4/4156)	4646	Corrosive	Aggressive

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To correct for:	Multiply	By: (see Notes 2 to 5 below)
Turbulence	LCSI	1.75
Stagnance	LCSI	0.5
Temperature	LCSI, SCSI, N7 Where N7=0.2 x Cl in mg/l	(1+ [0.05 x (T-20)])
Wet-dry cycles	SCSI	0.23×10^{-6} x TDS x DTF x CPA Where: DTF = Dry Time Fraction CPA = wet-dry cycles per annum

Note 1: Only if the concrete contains embedded steel.
Note 2: To preserve the correct logical relationships when dealing with the negative sub-indices (ie LCSI or SCSI having minus values) they should be multiplied by the reciprocal of the relevant factor indicated in this column
Note 3: If more than one correction is required, multiply by the product of the individual correction factors
Note 4: Use subscript c to indicate that the index has been corrected, eg for turbulent conditions $LCSI_c$ = LCSI x 1.75
Note 5: Round off corrected indices to the nearest 100.

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