Report on the Geotechnical Investigation for

HYPERAMA PIPELINE
REIGER PARK

Gauteng Province, South Africa

Report no.: GWS18217/G00085-F0

OCTOBER 2018

GaGE CONSULTING

Specialist Tunneling, Engineering Geological and Geotechnical Engineering Consultancy

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Report to:	WSP Group Africa (Pty) Ltd Building C, Knightsbridge 33 Sloane Street Bryanston, 2191
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Report by	Reviewed by:
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1. Introduction

1.1. Terms of Reference

GaGE Consulting (Pty) Ltd was appointed by WSP Group Africa (Pty) Ltd to conduct a design-level geotechnical investigation for the development of a new pipeline in the Reiger Park area. The investigation is aimed at assessing the ground conditions and identifying geotechnical constraints that may limit the development or result in increased risk or costs for the development. This report sets out the methodology and findings of the investigation and provides recommendations for geotechnical and earthworks for the proposed development. The report is prepared in line with the requirements of relevant Codes of Practice as noted below.

1.2. Aims and Methodology

The objectives of the study were to:

i. To analyse the geotechnical conditions prevalent on the site, with specific reference to the proposed area of the new pipeline;
ii. To provide foundation and earthwork recommendations for the proposed new infrastructure and to comment on the geotechnical factors that would have an impact on the development of the site, so as to enable economic design and construction of proposed development; and
iii. To identify relevant ground-related features and determine the variability of ground conditions and effects thereof on the new structures.

The following methodology was adopted in order to realise the aims of this study:

i. A general site walk-over along with a review of available geological and geotechnical records;
ii. Geotechnical investigation including the excavation of several trial pits; and
iii. Laboratory testing of soils and rock to establish geotechnical and materials design parameters.

1.3. Scope and Limitations of the Assessment

This report presents the findings of the ground conditions at the location of the new proposed pipeline in the Reiger Park area from several discrete data points within close proximity of the proposed alignment. In particular, it sought to provide insight into the geotechnical properties of the founding strata and utilisation potential of the in-situ soils.

The nature of geotechnical engineering is such that variations in what is reported here may occur over the site. It is thus imperative that a Competent Person inspects all excavations to ensure that conditions at variance with those predicted do not occur and to undertake an interpretation of the facts supplied in this report. This report has been prepared for the exclusive use of the client, with specific application to the proposed project.

1.4. Codes of Practice

The services performed by GaGE Consulting (Pty) Ltd were conducted in a manner consistent with the level of care and skill ordinarily exercised by members of the geotechnical profession practising under similar conditions in the locality of the project. The investigation was carried out according to standard practice codes and guidelines, including:

i. Inspecting the trial pits and recording the soil profiles using the standard procedures as recommended in the guidelines by, AEG/SAICE/SAIEG (2001) “Guidelines for Soil and Rock Logging in South Africa; and
ii. The SAICE (2010) Geotechnical Division “Code of Practice for Site Investigations”.
iii. The SABS 1200 LB (1983) “South African Bureau of Standards Standardized Specification for Civil Engineering Construction, LB: bedding (pipes)”.

1.5. Information Sources

The following principal sources were consulted and/or made available:

- Topocadastral map of *Johannesburg (sheet 2628AA)* at a scale of 1:50 000, published in 2002;
- Topocadastral map of *East Rand (sheet 2628)* at a scale of 1:250 000, published in 2004;
- Geological map of *East Rand (sheet 2628)* at a scale of 1:250 000, published in 1986; and
- *Google Earth* satellite imagery.

2. Site Characterisation and Description

2.1. Site Location and Description

The site, the Hyperama Pipeline, is located approximately 2.5km north of the N17 and Rondebult Road (R21) interchange and to the immediate east of the Reiger Park township in Boksburg, in the Gauteng Province. Access to the site by car was gained via an unnamed road taken from the corner of Rondebult Road and Espri Laan that passes south of the Hyperama. The site location is shown on the satellite image in Figure 2.1.

The site is currently undeveloped with excavations and an active construction site on the eastern portion while the western limit of the site is covered by dump material. A stream, a tributary of the Elsburgspruit, runs north-south through the middle of the site with a bridge crossing that is only suitable for pedestrians. Overhead power lines are present with an unground water pipe, which utilises a bridge to cross the stream, just to the north of the proposed pipeline.

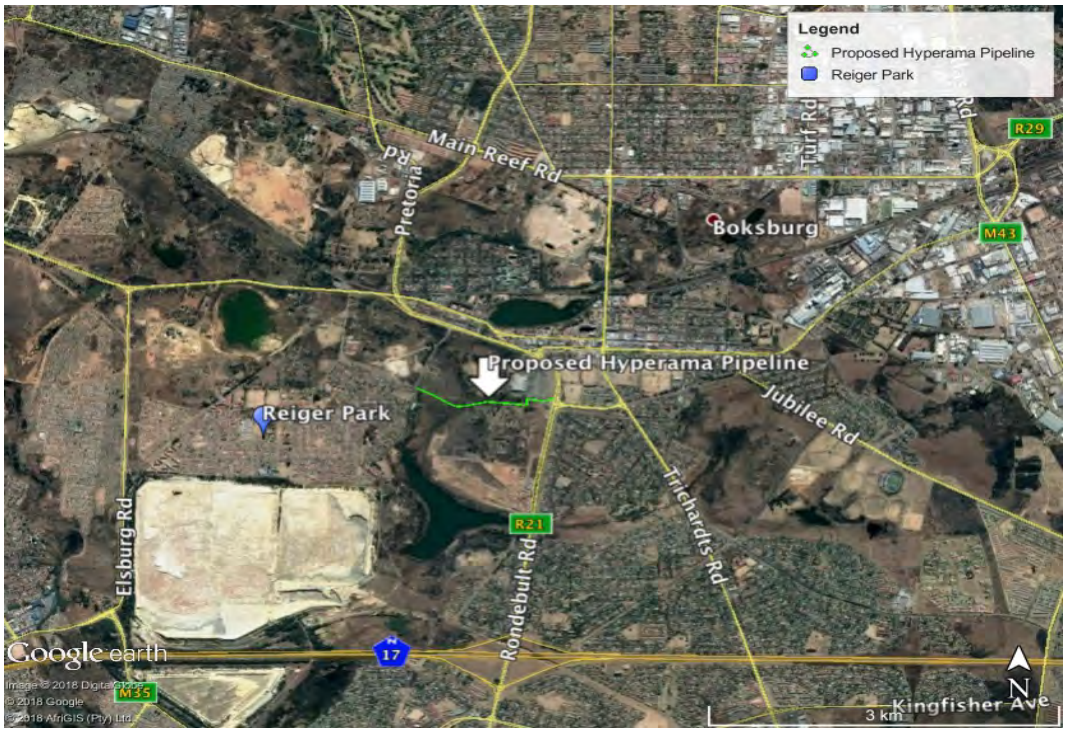


Figure 2.1 Extract from Google Earth of the greater area of Reiger Park, showing the locality of the investigated site.

2.2. Topography and Drainage

Regionally, the area is of gently undulating terrain and the site itself crosses through a depression with a perennial stream running through the middle of the site. This stream flows from Boksburgmeer dam, situated roughly 800m to

the north of the site, towards Cinderella Dam located some 1.2km south of the site. The slope on the eastern side of the river has an average gradient of 5% with a max of 11% whereas the western side has an average gradient of 2.8%.

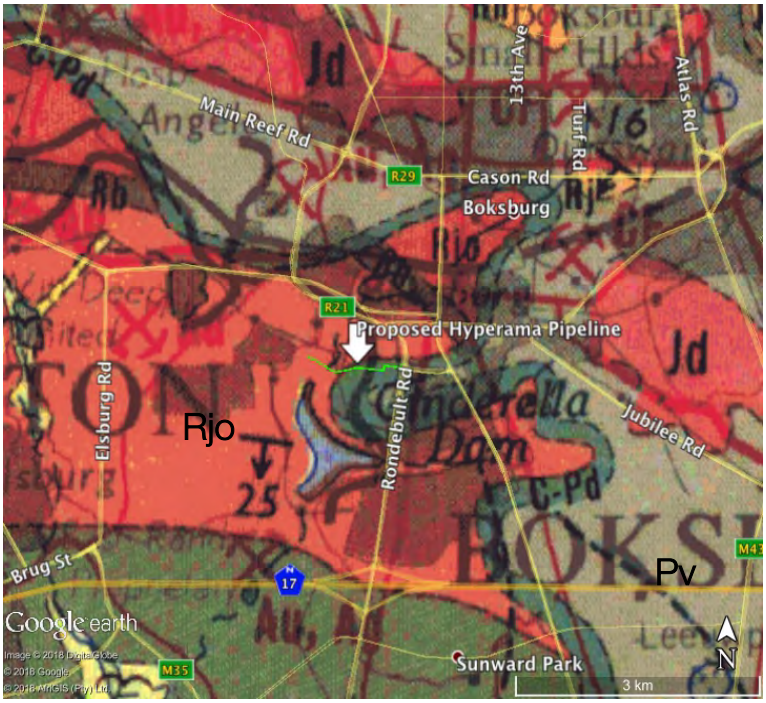
2.3. Climate

The site under investigation lies within the Highvelds' semi-arid warm climatic zone with mean annual temperate of about 16.0°C. The average annual rainfall is approximately 400mm, most of which occurs in heavy isolated falls between October and March.

Climate determines the mode of weathering as well as the rate of weathering, with the effect of climate on the weathering process (i.e. soil formation) determined by the climatic N-value defined by Weinert (1964). The site, has an N-value of 3 to 4, which implies it has a slight water surplus and suggests that chemical decomposition will prevail; resulting in deep residual soil profiles.

2.4. Geology

Referring to Figure 2-2, according to sheet 2628 East Rand of the 1:250 000 geological map series, the regional geology of the site (denoted by white arrow and the green line) comprises of sedimentary rocks of the Vryheid Formation of the Ecca Group, of the Karoo Supergroup, and the Johannesburg Subgroup of the Central Rand Group of the Witwatersrand Supergroup. The Johannesburg Subgroup (denoted by Rjo) consists predominately of quartzite and bands of lesser conglomerates. The Vryheid Formation sandstones (denoted by Pv) weather to a sandy soil with the potential of developing a collapse fabric. The presence of the Dwyka Group is inferred on the geological chart (denoted by C-Pd) and consists primarily of diamictite and lesser mudrock.



Symbol	Age	Supergroup	Group	Formation/Subgroup	Rock Type
Pv	Permian	Karoo	Ecca	Vryheid Formation	Sandstones with subordinate siltstone
C-Pd	Permian		Dwyka	-	Diamictite and lesser mudrock
Rjo	Randian	Witwatersrand	Central Rand	Johannesburg Subgroup	Quartzite with bands of lesser conglomerates

Figure 2-2 Extract from 1:250 000 geological sheet 2628 East Rand (Geological Survey 1986), showing the local geology.

2.5. Seismicity

According to the Seismic Hazard Map of South Africa contained in SANS 10160 the peak ground acceleration (g) with a 10% probability of being exceeded in a 50-year period in East Rand area is in the order of 0.2g, which would be considered a moderate hazard. This activity is attributed to deep mining.

2.6. Site History and Proposed Development

According to historical satellite imagery, the site has remained vacant with no additional development of permanent structures since ca-2002. The proposed new pipeline development will comprise of an underground UPVC pipe on either a concrete bedding cradle or a cradle of compacted selected granular material.

3. Geotechnical Investigation

3.1. Overview

The investigated site is approximately 1.2km linear in length and was investigated on 07 September 2018, comprising a site walkover, the machine-excavation of several trial pits using a Tractor Loader Backhoe (TLB) (Model: Volvo BL61 - 64kW). The trial pits were profiled according to the relevant soil profiling standards (AEG/SAICE/SAIEG, 2001) photographed, and representative soil samples retrieved from selected horizons within designated excavations for laboratory testing.

The location of the excavated trial pits is summarised in Table 3.1, and in conjunction with Figure 3.1, which shows the locality of the trial pits across the site. Soil samples were submitted to Specialised Testing Laboratory (Pty) Ltd for laboratory tests that included foundation indicator testing, which incorporated full grading (to 0.002 mm) and Atterberg limits.

All trial pits were excavated in accessible areas as to not damage existing infrastructure and these profiles are considered representative of the site conditions. The detailed trial pit profiles and accompanying photographs are provided in Appendix A, with the associated logging parameters in Appendix B, and the detailed laboratory results in Appendix C of this report.

Table 3.1 Summary of excavated trial pits and termination conditions

ID	Co-ordinates		Final Depth (m BGL)	Termination conditions	Groundwater seepage (m BGL)
	Latitude	Longitude			
HRTP1	26.229390	28.248040	1.98	AR	None
HRTP2	26.228980	28.245460	1.20	R	None
HRTP3	26.228790	28.242450	1.40	R	(wet conditions)
HRTP4	26.229160	28.240950	2.30	Water strike	2.25 (slow)
HRTP5	26.228910	28.240570	1.50	R	(wet conditions)
HRTP6	26.228510	28.239480	0.95	R	None
HRTP7	26.228090	28.237590	1.05	R	None

AR – Approaching refusal; R – Refusal

Figure 3.1 Satellite image of site showing the locality of the excavated trial pits.

3.2. Trial Pits and Ground Conditions

The seven (7) trial pits were excavated until terminated due to water seepage or refusal at a shallow depth using a TLB. The generalised profiles observed in the trial pits excavated at the site are summarised in Table 3.2. No sidewall instability was encountered in any of the trial pits with slow water seepage to wet conditions experienced in three (3) holes in close proximity to the stream. Furthermore, presence of mottling and ferricrete in the soil profiles is indicative of seasonal moisture changes.

As shown in Figure 3.2(a) and Table 3.2, the ground profiles to the east (HRPT 1, 2 and 3) and to the west (HRPT 5, 6 and 7) of the stream typically comprised of:

- A surficial colluvial or uncontrolled fill layer of medium dense to loose, slightly clayey silty fine to coarse sand with traces of angular gravel and anthropogenic material to an average depth of 0.80 m below ground level (BGL); to a alluvial loose (soft), clayey sand with traces of sub-rounded gravel to an average depth of 1.00 m BGL; which was in turn underlain by
- An occasional pebble marker, found away from the stream, described as loose to medium dense, silty sand with abundant angular gravel and cobbles to an average depth of 1.10 m BGL; underlain by
- Completely weathered sandstone (to the east of the stream) and completely weathered quartzite (to the west of the stream) being described as dense, jointed, silty sand, with to abundant angular, highly to completely weathered, coarse gravel and cobbles to an average depth of 1.50 m BGL; and further graded into
- A jointed, highly to medium weathered, soft rock (sandstone and quartzite) with depth.

HRPT7 was the only excavation to refuse in hardpan ferricrete at a depth of 1.05m (BGL).

As shown in Figure 3.2(b) and Table 3.2, the ground profile (HRTP4) to the immediate east of the stream comprised of:

- A surficial colluvial, loose, slightly clayey silty sand to a depth of 0.40 m below ground level (BGL); which was in turn underlain by
- Alluvial layer being described as slightly moist to wet with depth, soft (loose), silty clayey sand, increasing clay with depth and traces of soft to hard gravel sized concretions to a depth of 2.30m (BGL).

Table 3.2 Typical horizons observed during the geotechnical investigation

Average depth (m BGL)	Ground Unit		Description
	Symbol	Type	
0.00 - 1.00 (max 2.30*)	FILL	Uncontrolled fill	Dry, grey brown, loose, clayey silty sand
	COL	Collvium	Slightly moist, light yellow brown, medium dense to loose, clayey silty sand
	ALL*	Alluvium	Moist to wet, light grey brown, loose (soft) to medium dense, slightly clayey silty sand to silty clayey sand
1.00 - 1.10	PM	Pebble marker	Slightly moist, light brown, loose to medium dense, silty sand with abundant coarse gravel and cobbles.
1.10 - 1.50	CWR	Completely weathered rock	Slightly moist, light yellow/orange brown, dense to very dense, sand matrix with abundant angular cobbles

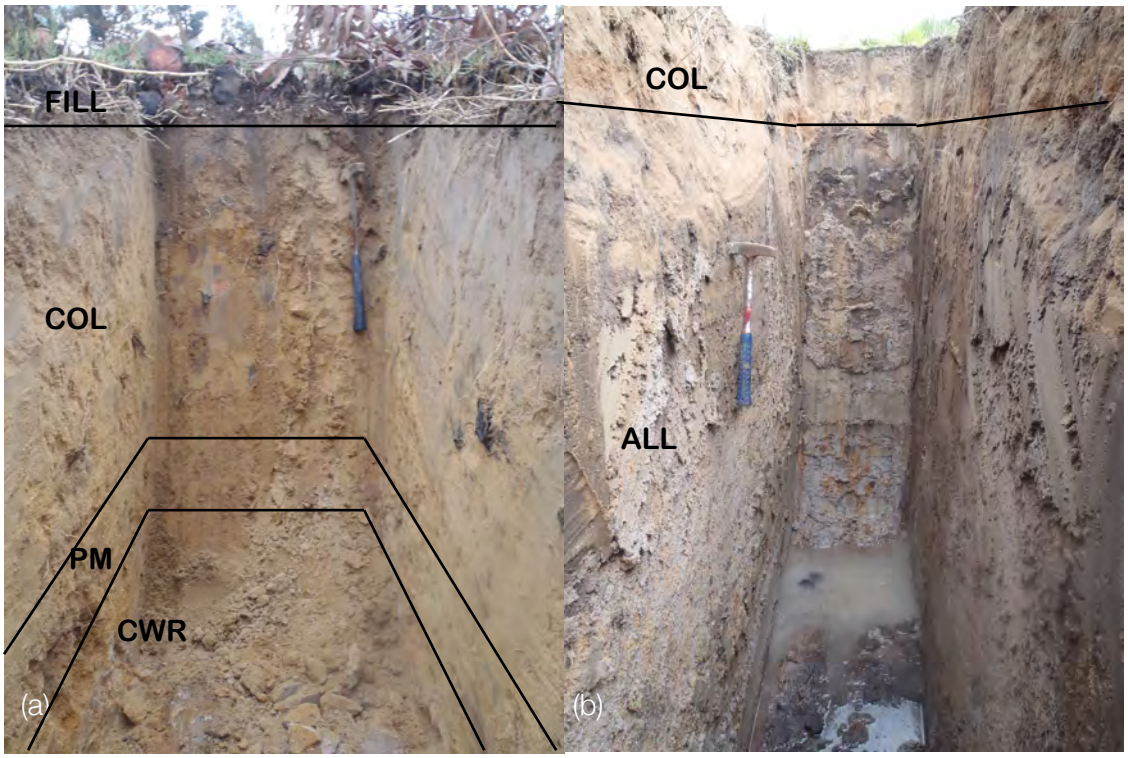


Figure 3.2 (a) Photograph of typical profile at test pit HRTP2 and (b) photograph of profile HRTP4

3.3. Laboratory and In-Situ Testing

The representative soil samples where submitted to Specialised testing Laboratory (Pty) Ltd for testing, and the following laboratory tests where scheduled:

i. 5 No. foundation indicator tests, with grading to 0.002 mm, Atterberg limits, and moisture contents;

ii. 5 No. pH and Electrical Conductivity tests; and

iii. 1 No. CBR test.

3.3.1. Foundation Indicator Testing and Electrical Conductivity

The foundation indicator results received from the laboratory are summarised in Table 3.2. According to these, the upper colluvium (COL) and upper alluvium (ALL) tested as a clayey silty SAND with low plasticity. The lower alluvium (ALL) unit, in close proximity to the stream, graded as a silty clayey SAND with moderate plasticity, and subsequently test results as having a medium expansive potential (according to the van der Merwe method).

Table 3.3 Summary of foundation indicator test results

Pit ID	Depth (m)	Ground Unit	Particle Size (%)				Atterberg Limits			MC (%)	PE	GM	Classification	
			Clay	Silt	Sand	Gravel	LL (%)	PI (%)	LS (%)				USCS	ASSHTO
HRPT1	0.87 – 1.1	COL	15	17	65	3	23	11	5.0	7.7	Low	0.96	SC	A-2-6
HRPT2	0.6 – 1	COL	16	15	65	4	19	7	3.0	5.9	Low	0.96	SC-SM	A-4
HRPT3	0 – 0.72	ALL	7	10	82	1	0	SP	0.5	17.4	Low	1.09	SM	A-2-4
HRPT4	1.7 -2.3	ALL	21	13	64	2	35	22	9.5	14.9	Medium	0.99	SC	A-6
HRPT5	0.6 - 1.05	ALL	8	15	72	5	20	7	3.0	12.8	Low	1.10	SC-SM	A-2-4

LL – Liquid Limit; PI – Plasticity Index; LS – Linear Shrinkage; MC - Moisture Content; PE - Potential Expansiveness; GM - Grading Modulus

3.3.2 *pH and Electrical Conductivity*

Soils encountered on the site have slightly acidic pH and have relatively high conductivities (for a soil) and are corrosive to highly corrosive to buried steel.

Table 3.4 Summary of pH and Electrical Conductivity

Pit ID	Depth (m BGL)	Ground Unit	pH	Electrcal Conductivity (S/m)
HRPT1	0.87 – 1.1	COL	4.7	0.048
HRPT2	0.6 – 1	COL	4.0	0.032
HRPT3	0 – 0.72	ALL	4.6	0.038
HRPT4	1.7 -2.3	ALL	5.3	0.034
HRPT5	0.6 - 1.05	ALL	5.4	0.033

3.3.3 CBR Testing

CBR tests to obtain material compaction characteristics were undertaken on a sample of the surficial colluvium clayey silty sand and gravelly sand pebble marker. The result is summarised in Table 3.4.:

Table 3.5 CBR Test Results

Pit ID	Depth (m)	Ground Unit	PI	GM	MOD AASHTO		CBR			Material classification
					Optimum moisture content (%)	Maximum dry density (kg/m^3)	93%	95%	Swell (%)	COLTO
HRTP1	0.87-1.2	COL + PM	11	0.96	6.4	2150	14	16	0.0	G8

4. Geotechnical Evaluation

4.1. Overview

A geotechnical evaluation was conducted based on the site walk-over, desk-study, profiles observed in the excavated trial pits, and the subsequent laboratory tests from the representative samples that were collected. The geology and ground conditions are relativity consistent with a thin superficial uncontrolled fill layer above a clayey silty sand colluvial layer, with a basal pebble maker, on a shallow completely weathered sandstone or quartzite bedrock; with exception to ground conditions adjacent to the stream that comprises of superficial colluvial layer above a thick clayey sand alluvial horizon.

4.2. Geotechnical Constraints and Overall Site Assessment

Based on the observations during the investigation, the site can be classified as two zones with Zone I being adjacent to the stream being characterised by deep alluvial clayey soils and shallow (perched) water table and Zone II being characterised by generally shallow bedrock profile. The extent of these Zones is shown in Figure 4.1. The principal geotechnical constraints are summarised in the table below.

Table 4.1 Summary of geotechnical zoning

ZONE	Geotechnical constraint
I	Area subjected to flooding Seasonal perched watertable Moderate soil heave potential Materials unsuitable for reuse
II	Difficult excavation (shallow bedrock) Seasonal perched watertable Moderate slopes

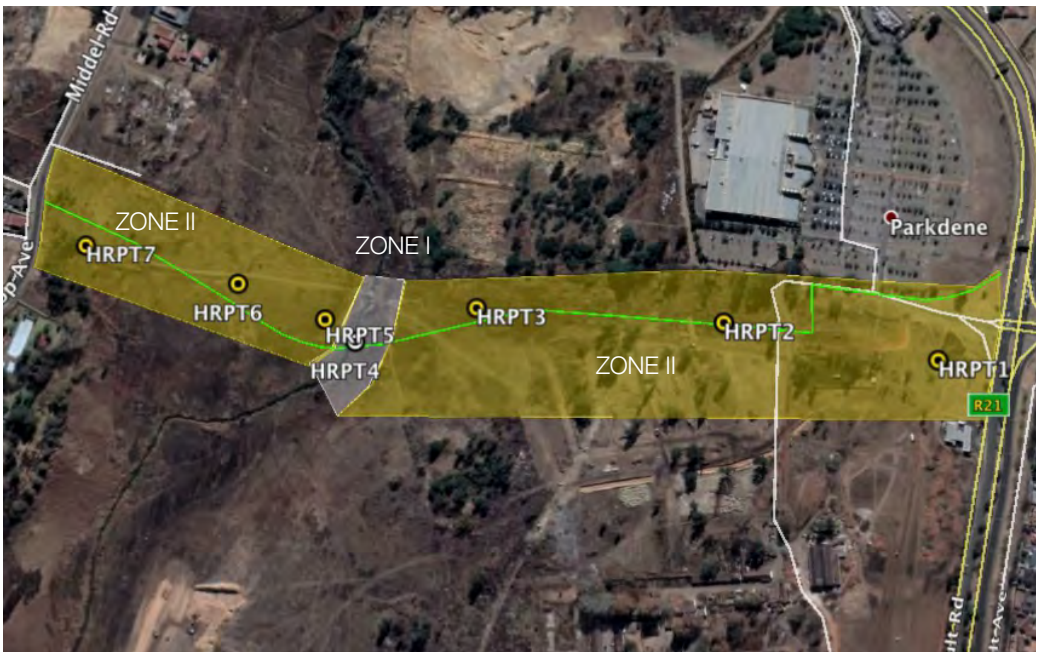


Figure 4.1 Geotechnical zoning map for proposed pipeline

4.3. Stream Crossing (Pipe Jacking)

The pipe crossing is proposed as a horizontal directional drill of approximately 50m in length and 2m below the stream level. Investigations indicate a generally shallow bedrock profile along the entire project area, although locally some variation is encountered with deep alluvial deposits on the banks of the stream. Test pit HRTP4 terminated at 2.3m due to strong water seepage (corresponding to river level) but bedrock is expected at a shallow depth below this. Consequently it reasonable to assume the most of the pipe jacking/drilling will occur through the bedrock. Bedrock comprises quartzite on which refusal of the TLB occurred and logged as hard rock (UCS > 30MPa). The quartzite will grade rapidly with depth and in the absence of deeper investigative methods (eg. core drilling), it must be assumed that fresh competent bedrock may be intercepted. Quartzite is a competent metamorphosed rock and UCS exceeding 250MPa are typical (Brink ABA, 1976), furthermore the rock is highly abrasive. A relatively high cost for the jacking is thus anticipated given the challenging conditions. This cost should be evaluated against a conventional pipe bridge crossing utilising conventional shallow pad foundations.

4.4. Groundwater Conditions

Groundwater seepage was encountered in close proximity to the stream with wet soil conditions being prevalent a substantial distance from the stream. The water table was reached at a depth of roughly 2.25 m BGL in an excavation adjacent to the stream and subsequently terminated at a depth of 2.30 m. The presence of ferricrete is indicative of seasonal moisture changes.

4.5. Excavatability

Refusal on shallow bedrock and hardpan ferricrete was reached at a depth less than 1.50 m in five (5) of the excavations. Difficult excavation conditions are expected throughout most of the site, with expectation to the area adjacent to the stream where an excavation was terminated at a depth greater than 1.5 m BGL.

4.6. Stability of Trenches

No sidewall instabilities were observed during the geotechnical site investigation and this gives an indication that no problems should be encountered with regards to the stability of long trench excavations, however any excavation deeper than 1.5m must be shored as prescribed in the relevant act.

4.7. Material Utilisation

The usability of the on-site materials for construction purposes can be assessed according to the AASHTO, Unified Soil Classifications and the CBR test results.

The low grading modulus for the alluvium near the river stream is indicative of the significant amount of fines in these soils and is not suitable for engineered cradle bedding for pipes.

However, most soils encountered (over the bedrock) on site classify as SC to SM, according to the ASSHTO classification, and therefore are expected to have fair to good workability as a construction material and have fair to good compaction characteristics. The upper transported material in the site soil profile can be utilized as G8 fill material to be placed above the bedding cradle in accordance with SANS 1200 LB.

The materials encountered on the site are not suitable for pipe bedding and this would need be sourced commercially.

4.8. Construction Quality Assurance and Validation

Based on the above evaluation, ground conditions are favourable and consistent. No further investigations are recommended.

Notwithstanding, the nature of geotechnical engineering is such that variations in what is reported here may become evident during construction, once the site has been excavated and opened-up. It is thus imperative that a competent person inspect excavations and/or foundation platforms to sure the conditions at variance with those predicted, do not occur and to undertake an interpretation of the facts applied in this report so as to validate the design and recommendations made.

References

AEG/SAICE/SAIEG Association of Engineering Geologists – South African Section, South African Institution of Civil Engineering - Geotechnical Division, and South African Institute for Engineering and Environmental Geologists (2001) Guidelines for Soil and Rock Logging in South Africa, 2nd Impression, Brink, A.B.A. and Bruin, R.M.H. (eds.), Proceedings of the Geoterminology Workshop, 1990.

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SANS, South African National Standards (1983) SANS 1200 LB: bedding (pipes)

Appendix A. Trial Pit Logs

TRIAL PIT LOG

CLIENT: WSP Group Africa (Pty) Ltd
PROJECT: HYPERAMA PIPELINE, REIGER PARK
PROJECT NO: GWS18217
SITE:

HOLE NO: HRPT1
X COORD:
Y COORD:
ELEVATION:

Depth		Description	Dynamic Probe Light Equivalent SPT-N (10 20 30 40)
	0,00	Ground Surface	
0,0		**Medium dense, slightly clayey, silty fine SAND** Dry, medium brown, mottled red and orange, medium dense, pinholed with open root channels, slightly clayey silty fine sand with abundant mixed gravel and cobbles. Fill. Roots.	
	0,34		
		Loose, silty fine SAND Slightly moist, dark grey brown, loose, voided silty fine sand with abundant angular to sub rounded, coarse gravel and cobbles mixed fragments. Fill. Few roots.	
	0,86		
		Loose, clayey, silty SAND Slightly moist, brown orange, loose, intact, clayey silty sand with few subrounded gravel. Colluvium. Few Roots.	
1,0	1,10		
	1,20	**Loose, clayey, silty SAND** Slightly moist, brown orange, loose, intact, clayey silt sand with abundant subrounded slightly weathered coarse gravel and cobbles. Pebble marker. Few Roots.	
		Loose to medium dense, clayey, silty SAND Slightly moist, orange brown mottled red, yellow and orange and stained black loose to medium dense, jointed, slightly clayey silty sand matrix with abundant angular cobble sized completely to highly weathered sandstone. Completely to highly weathered sandstone. Vryheid Formation.	
	1,98		
2,0		**Approaching refusal of soft rock, SANDSTONE**	
		End of Log	

NOTES
1: FI sample at 0.87 - 1.10
2: CBR sample at 0.87 - 1.20
3: Stable sidewalls
4: No water seepage
5:
6:
7:
8:

MACHINE: TLB: Volvo BL61 (64kW)
DIAM: Test Pit
FILE REF:
DATE PROFILED: 07/09/2018
PROFILED BY: D Swart
CHECKED BY: F. Pequenino
Prof Reg:
Prof.Reg: 20070109

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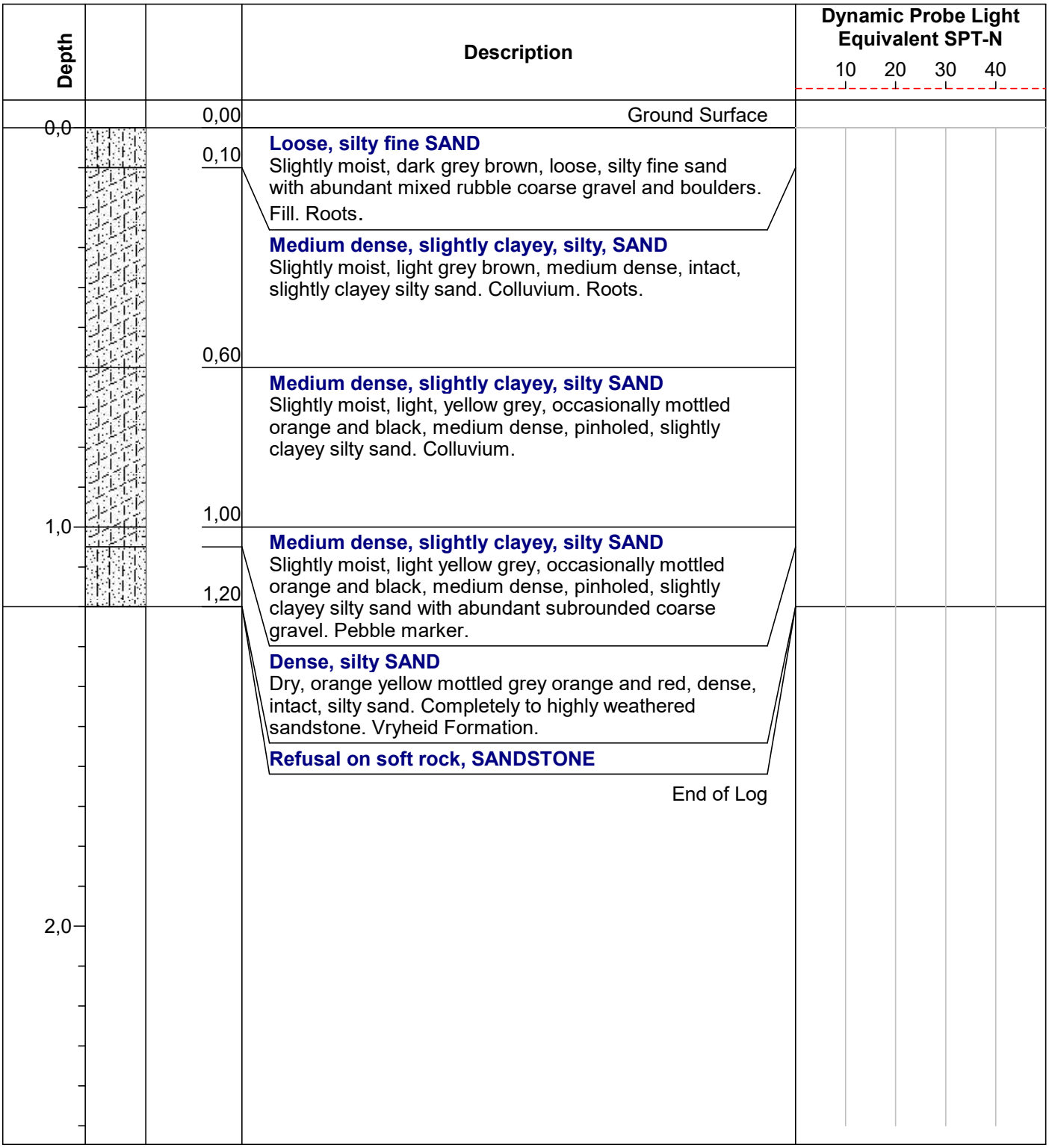
Template: GaGE TP01

TRIAL PIT LOG

CLIENT: WSP Group Africa (Pty) Ltd
PROJECT: HYPERAMA PIPELINE, REIGER PARK
PROJECT NO: GWS18217
SITE:

HOLE NO: HRPT2
X COORD:
Y COORD:
ELEVATION:



NOTES
1: FI sample at 0.60 - 1.00
2: Stable sidewalls
3: No water seepage
4:
5:
6:
7:
8:

MACHINE: TLB: Volvo BL61 (64kW)
DIAM: Test Pit
FILE REF:
DATE PROFILED: 07/09/2018
PROFILED BY: D Swart
CHECKED BY: F. Pequenino
Prof Reg:
Prof.Reg: 20070109

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Template: GaGE TP01

TRIAL PIT LOG

CLIENT: WSP Group Africa (Pty) Ltd
PROJECT: HYPERAMA PIPELINE, REIGER PARK
PROJECT NO: GWS18217
SITE:

HOLE NO: HRPT3
X COORD:
Y COORD:
ELEVATION:

Depth		Description	Dynamic Probe Light Equivalent SPT-N (10 20 30 40)
0,0	0,00	Ground Surface	
		Loose, slightly clayey, silty fine to medium SAND Moist, light brown grey, loose, intact, slightly clayey silty fine to medium sand with abundant subrounded cobbles and coarse gravel. Pebble marker. Roots.	
	0,86		
1,0	1,00	**Loose, silty SAND** Wet, grey mottled orange red and yellow, loose, intact, silty sand, matrix with abundant completely to highly weathered subangular sandstone cobbles. Reworked residual sandstone. Vryheid Formation.	
		Medium dense to dense, silty, SAND Wet, yellow red, mottled orange grey and black, medium dense to dense, jointed, silty sand, matrix with abundant slightly to highly weathered subangular to angular sandstone cobbles. Completely weathered sandstone. Vryheid Formation.	
	1,40	**Refusal on soft rock, sandstone**	
		End of Log	
2,0			

NOTES
1: FI sample at 0.00 - 0.73
2: Stable sidewalls
3: No water seepage
4:
5:
6:
7:
8:

MACHINE: TLB: Volvo BL61 (64kW)
DIAM: Test Pit
FILE REF:
DATE PROFILED: 07/09/2018
PROFILED BY: D Swart
CHECKED BY: F. Pequenino
Prof Reg:
Prof.Reg: 20070109

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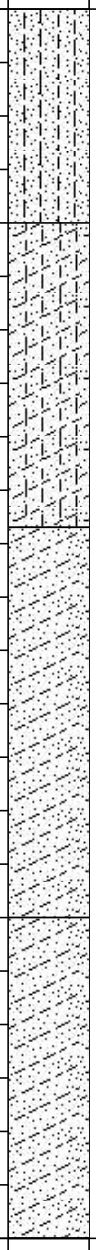
Template: GaGE TP01

TRIAL PIT LOG

CLIENT: WSP Group Africa (Pty) Ltd
PROJECT: HYPERAMA PIPELINE, REIGER PARK
PROJECT NO: GWS18217
SITE:

HOLE NO: HRPT4
X COORD:
Y COORD:
ELEVATION:



Depth		Description	Dynamic Probe Light Equivalent SPT-N (10 20 30 40)
0,0	0,00	Ground Surface	
		Loose, slightly clayey, silty SAND Slightly moist, light grey brown, loose, pinholed with open root channels, slightly clayey, silty sand. Colluvium. Roots.	
	0,40		
		Loose to medium dense, clayey, silty, SAND Slightly moist, dark purple, grey mottled orange, loose to medium dense, intact, clayey, silty sand. Alluvium.	
	0,97		
1,0		**Soft (loose), silty, clayey SAND** Wet, grey mottled orange, soft (loose), intact, silty, clayey sand. Alluvium.	
	1,70		
		Soft (loose), silty, clayey SAND Wet, grey mottled orange, soft (loose), intact, silty, clayey sand with orange hard to soft gravel-sized concretions. Alluvium.	
2,0	2,30		
		Hole stopped due to seepage	
		End of Log	

NOTES
1: FI sample at 1.70 - 2.30
2: Stable sidewalls
3: Water seepage at 2.25m
4:
5:
6:
7:
8:

MACHINE: TLB: Volvo BL61 (64kW)
DIAM: Test Pit
FILE REF:
DATE PROFILED: 07/09/2018
PROFILED BY: D Swart
CHECKED BY: F. Pequenino
Prof Reg:
Prof.Reg: 20070109

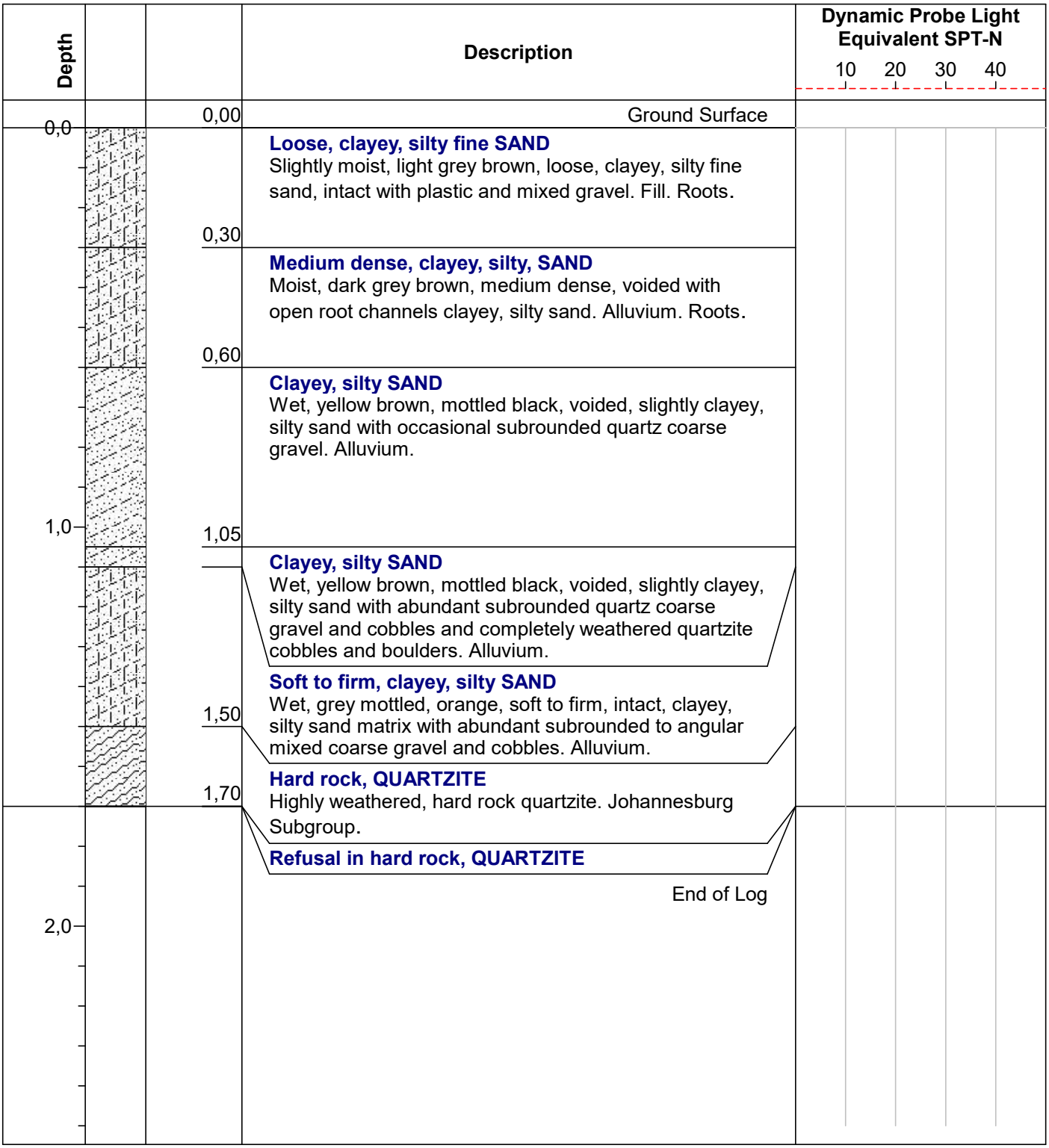
GaGE CONSULTING
www.gageconsulting.co.za

Template: GaGE TP01

TRIAL PIT LOG

CLIENT: WSP Group Africa (Pty) Ltd
PROJECT: HYPERAMA PIPELINE, REIGER PARK
PROJECT NO: GWS18217
SITE:

HOLE NO: HRPT5
X COORD:
Y COORD:
ELEVATION:



NOTES
1: FI Sample at 0.60 - 1.05
2: Stable sidewalls
3: No water seepage
4:
5:
6:
7:
8:

MACHINE: TLB: Volvo BL61 (64kW)
DIAM: Test Pit
FILE REF:

DATE PROFILED: 07/09/2018
PROFILED BY: D Swart
CHECKED BY: F. Pequenino

Prof Reg:
Prof.Reg: 20070109

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Template: GaGE TP01

TRIAL PIT LOG

CLIENT: WSP Group Africa (Pty) Ltd
PROJECT: HYPERAMA PIPELINE, REIGER PARK
PROJECT NO: GWS18217
SITE:

HOLE NO: HRPT6
X COORD:
Y COORD:
ELEVATION:

Depth		Description	Dynamic Probe Light Equivalent SPT-N (10 20 30 40)
0,0	0,00	Ground Surface	
		Loose, slightly clayey silty fine SAND Slightly moist, light grey brown, loose, intact, slightly clayey silty fine sand. Colluvium. Roots.	
	0,50	**Loose to medium dense, slightly clayey silty fine SAND** Moist, yellow brown, loose to medium dense, occasional open root channels slightly clayey silty sand with occasional translucent rounded quartz coarse gravel and rounded Fe & Mn nodules. Colluvium.	
	0,85		
	0,95	**Very dense, silty SAND** Slightly moist, yellow brown, mottled red orange and purple, very dense, jointed, silty sand with abundant highly to completely weathered angular quartzite cobbles. Completely weathered quartzite. Johannesburg Subgroup.	
1,0		**Refusal in hard rock, QUARTZITE**	
		End of Log	
2,0			

NOTES
1: No sample
2: Stable sidewalls
3: No water seepage
4:
5:
6:
7:
8:

MACHINE: TLB: Volvo BL61 (64kW)
DIAM: Test Pit
FILE REF:
DATE PROFILED: 07/09/2018
PROFILED BY: D Swart
CHECKED BY: F. Pequenino
Prof Reg:
Prof.Reg: 20070109

GaGE CONSULTING
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Template: GaGE TP01

TRIAL PIT LOG

CLIENT: WSP Group Africa (Pty) Ltd
PROJECT: HYPERAMA PIPELINE, REIGER PARK
PROJECT NO: GWS18217
SITE:

HOLE NO: HRPT7
X COORD:
Y COORD:
ELEVATION:

Depth		Description	Dynamic Probe Light Equivalent SPT-N (10 20 30 40)
	0,00	Ground Surface	
0,0		**Medium dense to dense, slightly clayey silty fine SAND** Slightly moist, brown grey, medium dense to dense, intact, clayey, silty sand. Alluvium/colluvium. Roots.	
	0,43		
	0,60	**Medium dense to dense, slightly clayey silty fine SAND** Slightly moist, yellow brown, mottled orange, medium dense to dense, intact, clayey, silty sand. Colluvium.	
	0,90	**Very dense, silty SAND** Slightly moist, yellow brown, mottled orange, very dense, intact, clayey, silty sand matrix with abundant translucent rounded to angular slightly weathered quartz coarse gravel and Fe&Mn nodules. Honeycomb ferricrete. Cemented.	
1,0	1,05	**Hardpan FERRCRETE** Slightly moist, orange red, mottled orange, yellow and black, very dense. Hardpan ferricrete. Strongly cemented.	
		Refusal on hardpan, FERRICRETE	
		End of Log	
2,0			

NOTES
1: No sample
2: Stable sidewalls
3: No water seepage
4:
5:
6:
7:
8:

MACHINE: TLB: Volvo BL61 (64kW)
DIAM: Test Pit
FILE REF:
DATE PROFILED: 07/09/2018
PROFILED BY: D Swart
CHECKED BY: F. Pequenino
Prof Reg:
Prof.Reg: 20070109

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Template: GaGE TP01

Appendix B. Profiling and Logging Parameters

SOIL DESCRIPTIVE TERMS

Reference: Brink, ABA and Bruin, RMH (2002) Guidelines for Soil and Rock Logging in South Africa, AEG/SAICE/SAIEG

DESCRIPTIVE ORDER: 1. Moisture condition; 2. Colour; 3. Consistency; 4. Soil structure; 5. Soil type; and 6. Origin

1a Consistency: Granular Soils			
SPT "N"	GRAVELS & SANDS Generally free draining soils		Dry density (kg/m3)
< 4	VERY LOOSE	Crumbles very easily when scraped with geological pick	< 1450
4-10	LOOSE	Small resistance to penetration by sharp pick point	1450-1600
10-30	MEDIUM DENSE	Considerable resistanche to penetration by sharp pick point	1600-1750
30-50	DENSE	Very high resistance to penetration by sharp pick point. Requires many blows of pick for excavation	1750-1925
> 50	VERY DENSE	High resistance to repeated blows of geological pick. Requires power tools for excavation	> 1925

1b Consistency: Cohesive Soils			
SPT "N"	SILTS & CLAYS and combination with SANDS Generally slow draining soils		UCS (kPa)
< 2	VERY SOFT	Pick point easily pushed in 100mm. Easily moulded by fingers	< 50
2-4	SOFT	Pick point easily pushed in 30-40mm. Moulded by fingers with some pressure. Easily penetrated by thumb.	50-125
4-8	FIRM	Pick point penetrates up to 10mm. Very difficult to mould with fingers. Indented by thumb with effort. Spade just penetrates.	125-500
8-15	STIFF	Slight indentation by pushing in pick point. Cannot be moulded by fingers. Penetrated by thumbnail. Pick necessary to excavate.	250-500
15-30	VERY STIFF	Slight indentation by blow of pick point. Requires power tools for excavation.	500-1000

2 Soil Type	
SOIL TYPE"	PARTICLE SIZE (mm)
CLAY	< 0,002
SILT	0,002 – 0,06
SAND	0,06 – 2
GRAVEL	2 – 60*
COBBLES	60 – 200*
* Specify average and maximum sizes, hardness, shape as well as proportion	

3 Moisture Condition	
DRY	No water detectable
SLIGHTLY MOIST	Water just discernable
MOIST	Water easily discernable
VERY MOIST	Water can be squeezed out
WET	Generally below the water table

4 Colour	
Described at natural moisture content, as seen in profile (unless otherwise specified) and using bedding thickness criteria. (e.g. thickly banded, thinly streaked, etc.)	
SPECKLED	Very small patches of colour < 2 mm
MOTTLED	Irregular patches of colour 2 – 6 mm
BLOTCHED	Large irregular patches 6 – 20 mm
BANDED	Approximately parallel bands of varying colour
STREAKED	Randomly orientated streaks of colour
STAINED	Local colour variations: associated with discontinuity surfaces

5 Soil Structure	
INTACT	No structure present
FISSURED	Presence of discontinuities, possibly cemented
SLICKENSIDED	Very smooth, glossy, often striated discontinuity planes
SHATTERED	Presence of open fissures. Soil breaks into gravel size blocks
MICRO-SHATTERED	Small scale shattering, very closely spaced open fissures. Soil breaks into sand size crumbs
RESIDUAL STRUCTURES	Relict bedding, lamination, foliation, etc.

5 Origin	
TRANSPORTED	Alluvium, hillwash, talus, etc.
RESIDUAL	Weathered from parent rock e.g. residual granite
PEDOCRETES	Ferricrete, laterite, silcrete, calcrete, etc.

Pedocretes		
DEGREE OF CEMENTATION		UCS (MPa)
VERY WEAKLY CEMENTED	Some material can be crumbled between finger and thumb. Disintegrates under knife blade to a friable state.	0,1 – 0,5
WEAKLY CEMENTED	Cannot be crumbled between strong fingers. Some material can be crumbled by strong pressure between thumb and hard surface. Under light hammer blows disintegrates to friable state.	0,5 – 2
CEMENTED	Material crumbles under firm blows of sharp pick point. Grains can be dislodged with some difficulty by a knife blade.	2 – 5
STRONGLY CEMENTED	Firm blows of sharp pick point on hand-held specimen show 1-3mm indentations. Grains cannot be dislodged by knife blade.	5 – 10
VERY STRONGLY CEMENTED	Hand-held specimen can be broken by single firm blow of hammerhead. Similar appearance to concrete.	10 - 25

ROCK DESCRIPTIVE TERMS

Reference: Brink, ABA and Bruin, RMH (2002) Guidelines for Soil and Rock Logging in South Africa, AEG/SAICE/SAIEG

DESCRIPTIVE ORDER: 1. Colour; 2. Weathering; 3. Grain size; 4. Fabric spacing; 5. Discontinuity spacing; 5. Hardness; 6. Rock type; 7. Rock formation

1a Rock Hardness: <25 MPa

HARDNESS	DESCRIPTION	UCS (MPa)
VERY SOFT	Material crumbles under firm blows of pick point. Can be peeled with a knife. SPT refusal. Too hard to cut triaxial sample by hand	1 – 3
SOFT ROCK	Firm blows with pick point: 2-4mm indents. Can just be scraped with a knife	3 - 10
MEDIUM HARD ROCK	Firm blows of pick head will break hand-held specimen. Cannot be scraped or peeled with a knife.	10 - 25

1b Rock Hardness: >25 MPa

HARDNESS	DESCRIPTION	UCS (MPa)
HARD ROCK	Breaks with difficulty, rings when struck Point load or laboratory test results necessary to distinguish between categories	25 – 70
VERY HARD ROCK		70 – 200
EXTREMELY HARD ROCK		> 200

2 Rock Type

Quartzite, sandstone, granite, limestone, etc.

4 Colour

Described in the wet state unless otherwise indicated

3. Weathering

DEGREE OF WEATHERING	EXTENT OF DISCOLOURATION	FRACTURE CONDITION	SURFACE CHARACTERISTICS	ORIGINAL FABRIC	GRAIN BOUNDARY CONDITION
UNWEATHERED	None	Closed or stained	Unchanged	Preserved	Tight
SLIGHTLY WEATHERED	< 20% of fracture spacing on both sides of fracture	Discoloured, may contain thin filling	Partial discolouration. Often unweathered rock colour	Preserved	Tight
MODERATELY WEATHERED	>20% of fracture spacing on both side of fracture	Discoloured, may contain thick filling	Partial to complete discolouration. Not friable except poorly cemented rocks	Preserved	Partial opening
HIGHLY WEATHERED	Throughout	-	Friable, possibly pitted	Mainly preserved	Partial separation. Not easily indented with knife. Does not slake
COMPLETELY WEATHERED	Throughout	-	Resembles a soil	Partially preserved	Complete separation. Easily indented with knife. Slakes

5 Fabric/Discontinuity Spacing

SEPARATION (mm)	SPACING (foliation, cleavage, bedding, etc.)	SPACING (fractures, joints, etc.)
< 6	very intensely	very highly
6 – 20	intensely	
20 – 60	very thinly	highly
60 – 200	thinly	
200 – 600	medium	moderately
600 – 2000	thickly	slightly
> 2000	very thickly	very slightly

6a Discontinuity Surface Description: Joint Filling

JOINT FILL TYPE	DEFINITION (wall separation specified in mm)
CLEAN	No fracture filling
STAINED	Colouration of rock only. No recognisable filling material
FILLED	Fracture filled with finite thickness filling material

6b Discontinuity Surface Description: Orientation

Discontinuity inclinations (i.e. of joints, bedding, faults)

6c Discontinuity Surface Description: Roughness of Discontinuity Planes

CLASSIFICATION	DESCRIPTION
SMOOTH	Appears smooth and is essentially smooth to the touch. May be slickensided *
SLIGHTLY ROUGH	Asperities on the fracture surface are visible and can be distinctly felt
MEDIUM ROUGH	Asperities are clearly visible and fracture surface feels abrasive
ROUGH	Large angular asperities can be seen. Some ridge and high side angle steps evident
VERY ROUGH	Near vertical steps and ridges occur on the fracture surface

*Where slickensides occur the direction of the slickensides should be recorded

7 Grain size

CLASSIFICATION	SIZE (mm)	RECOGNITION
VERY FINE GRAINED	< 0.2	Individual grains cannot be seen with a hand lens
FINE GRAINED	0.2 – 0.6	Just visible as individual grains under hand lens
MEDIUM GRAINED	0.6 – 2	Grains clearly visible under hand lens, just visible to the naked eye
COARSE GRAINED	2 – 6	Grains clearly visible to the naked eye
VERY COARSE GRAINED	> 6	Grains measurable

8 Rock Formation

Pietermaritzburg Formation, Cape Granite Suite etc.

Appendix C. Laboratory Results

Specialised Testing Laboratory (Pty) Ltd
Asphalt | Aggregate | Bitumen | Geotechnical
Quality | Excellence | On Time

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Gerrie | 082 309 4448 | gerrie@stlab.co.za
www.stlab.co.za

Client Name: GaGE Consulting
Project Name: Hyperama Pipeline
Job Number: GGC-07
Date: 01-Oct-18
Method: SANS 3001 GR1, GR3 GR10, GR12 GR20, GR30, GR31, GR40, GR50, GR53, GR54 & BS 1377 (where applicable)

SUMMARY OF TEST DATA

Grading & Hydrometer Analysis (% Passing)

Sample	HRPT 1	HRPT 2	HRPT 3	HRPT 4	HRPT 5			
Depth (m)	0.87 - 1.1	0.6 - 1.0	0 - 0.72	1.7 - 2.3	0.6 - 1.05			
Lab No	GGC-07-28	GGC-07-29	GGC-07-30	GGC-07-31	GGC-07-32			
53.0	**100**	**100**	**100**	**100**	**100**			
37.5	**100**	**100**	**100**	**100**	**100**			
26.5	**100**	**100**	**100**	**100**	**100**			
19.0	**100**	**100**	**100**	**100**	**100**			
13.2	**100**	**100**	**100**	**100**	**100**			
9.5	**100**	**99**	**100**	**100**	**99**			
6.7	**100**	**99**	**100**	**100**	**99**			
4.75	**99**	**98**	**100**	**99**	**98**			
2.00	**97**	**96**	**99**	**98**	**95**			
1.00	**91**	**91**	**96**	**91**	**88**			
0.425	**72**	**72**	**71**	**65**	**68**			
0.250	**62**	**59**	**48**	**52**	**53**			
0.150	**48**	**47**	**34**	**45**	**40**			
0.075	**35**	**36**	**21**	**38**	**27**			
0.060	**32**	**31**	**17**	**34**	**23**			
0.050	**30**	**30**	**16**	**33**	**21**			
0.035	**24**	**28**	**14**	**31**	**16**			
0.020	**21**	**25**	**11**	**28**	**14**			
0.006	**17**	**19**	**8**	**24**	**11**			
0.002	**15**	**16**	**7**	**21**	**8**			
GM	**0.96**	**0.96**	**1.09**	**0.99**	**1.10**			

Atterberg Limits

LL (%)	**23**	**19**	**0**	**35**	**20**			
PI (%)	**11**	**7**	**SP**	**22**	**7**			
LS (%)	**5.0**	**3.0**	**0.5**	**9.5**	**3.0**			

pH & Conductivity

pH	**4.7**	**4.0**	**4.6**	**5.3**	**5.4**			
EC (S/m)	**0.048**	**0.032**	**0.038**	**0.0340**	**0.033**			

MDD / OMC

MDD (kg/m^3)	**2150**							
OMC (%)	**6.4**							

CBR

100%	**26**							
98%	**21**							
97%	**19**							
95%	**16**							
93%	**14**							
90%	**11**							
Swell (%)	**0.0**							

UCS (MPa)

100%								
97%								
90%								

COLTO Classification

	G8							

Remarks:

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Client Name: GaGE Consulting
Project Name: Hyperama Pipeline
Job Number: GGC-07
Date: 2018-10-01
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR

Grading & Hydrometer Analysis (Particle Size (mm) & % Passing)				Atterberg Limits & Classification			
Sample	HRPT 1	HRPT 2	HRPT 3	Sample	HRPT 1	HRPT 2	HRPT 3
Depth (m)	0.87 - 1.1	0.6 - 1.0	0 - 0.72	Depth (m)	0.87 - 1.1	0.6 - 1.0	0 - 0.72
Lab No	GGC-07-28	GGC-07-29	GGC-07-30	Lab No	GGC-07-28	GGC-07-29	GGC-07-30
53.0	**100**	**100**	**100**	Liquid Limit (%)	**23**	**19**	**0**
37.5	**100**	**100**	**100**	Plastic Limit (%)	**12**	**12**	**0**
26.5	**100**	**100**	**100**	Plasticity Index (%)	**11**	**7**	**SP**
19.0	**100**	**100**	**100**	Linear Shrinkage (%)	**5.0**	**3.0**	**0.5**
13.2	**100**	**100**	**100**	PI of whole sample	**8**	**5**	**0**
9.5	**100**	**99**	**100**				
6.7	**100**	**99**	**100**	% Gravel	**3**	**4**	**1**
4.75	**99**	**98**	**100**	% Sand	**65**	**65**	**82**
2.00	**97**	**96**	**99**	% Silt	**17**	**15**	**10**
1.00	**91**	**91**	**96**	% Clay	**15**	**16**	**7**
0.425	**72**	**72**	**71**	Activity	**0.7**	**0.4**	**0.0**
0.250	**62**	**59**	**48**				
0.150	**48**	**47**	**34**	% Soil Mortar	**97**	**96**	**99**
0.075	**35**	**36**	**21**				
0.060	**32**	**31**	**17**	Grading Modulus	**0.96**	**0.96**	**1.09**
0.050	**30**	**30**	**16**	Moisture Content (%)	**7.7**	**5.9**	**17.4**
0.035	**24**	**28**	**14**	Relative Density (SG)*	**2.65**	**2.65**	**2.65**
0.020	**21**	**25**	**11**				
0.006	**17**	**19**	**8**	Unified (ASTM D2487)	**SC**	**SC-SM**	**SM**
0.002	**15**	**16**	**7**	AASHTO (M145-91)	**A - 2 - 6**	**A - 4**	**A - 2 - 4**

Remarks: *: Assumed
N / T: Not Tested

Specialised Testing Laboratory (Pty) Ltd
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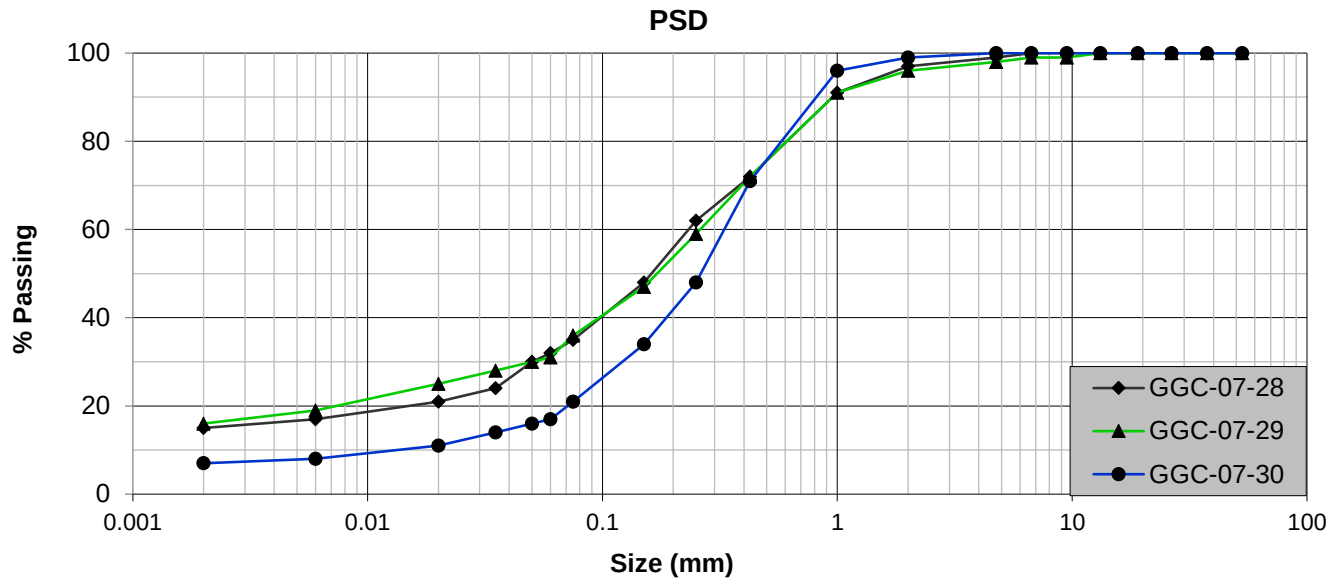
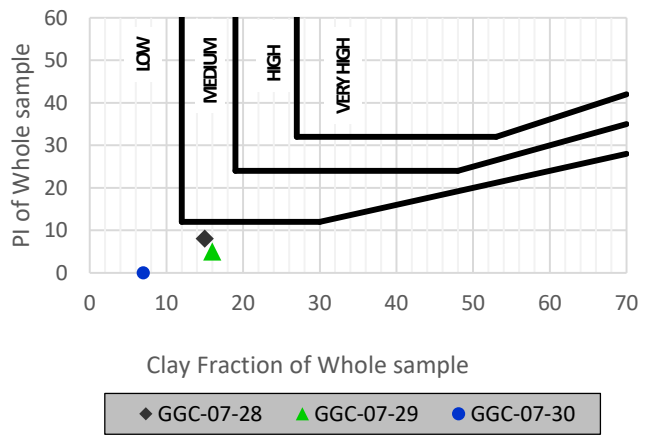
Client Name: GaGE Consulting
Project Name: Hyperama Pipeline
Job Number: GGC-07
Date: 2018-10-01
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

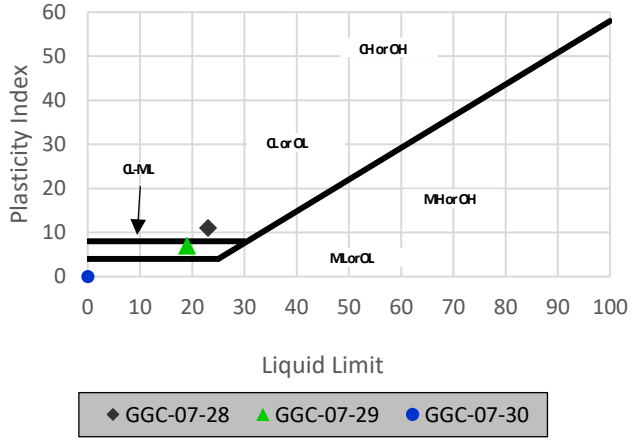
FOUNDATION INDICATOR



Potential Expansiveness



Casagrande Plasticity Chart



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Client Name: GaGE Consulting
Project Name: Hyperama Pipeline
Job Number: GGC-07
Date: 2018-10-01
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR

Grading & Hydrometer Analysis (Particle Size (mm) & % Passing)				Atterberg Limits & Classification			
Sample	HRPT 4	HRPT 5		Sample	HRPT 4	HRPT 5	
Depth (m)	1.7 - 2.3	0.6 - 1.05		Depth (m)	1.7 - 2.3	0.6 - 1.05	
Lab No	GGC-07-31	GGC-07-32		Lab No	GGC-07-31	GGC-07-32	
53.0	**100**	**100**		Liquid Limit (%)	**35**	**20**	
37.5	**100**	**100**		Plastic Limit (%)	**13**	**13**	
26.5	**100**	**100**		Plasticity Index (%)	**22**	**7**	
19.0	**100**	**100**		Linear Shrinkage (%)	**9.5**	**3.0**	
13.2	**100**	**100**		PI of whole sample	**14**	**5**	
9.5	**100**	**99**					
6.7	**100**	**99**		% Gravel	**2**	**5**	
4.75	**99**	**98**		% Sand	**64**	**72**	
2.00	**98**	**95**		% Silt	**13**	**15**	
1.00	**91**	**88**		% Clay	**21**	**8**	
0.425	**65**	**68**		Activity	**1.1**	**0.9**	
0.250	**52**	**53**					
0.150	**45**	**40**		% Soil Mortar	**98**	**95**	
0.075	**38**	**27**					
0.060	**34**	**23**		Grading Modulus	**0.99**	**1.10**	
0.050	**33**	**21**		Moisture Content (%)	**14.9**	**12.8**	
0.035	**31**	**16**		Relative Density (SG)*	**2.65**	**2.65**	
0.020	**28**	**14**					
0.006	**24**	**11**		Unified (ASTM D2487)	**SC**	**SC-SM**	
0.002	**21**	**8**		AASHTO (M145-91)	**A - 6**	**A - 2 - 4**	

Remarks: *: Assumed
N / T: Not Tested

Specialised Testing Laboratory (Pty) Ltd
Asphalt | Aggregate | Bitumen | Geotechnical
Quality | Excellence | On Time

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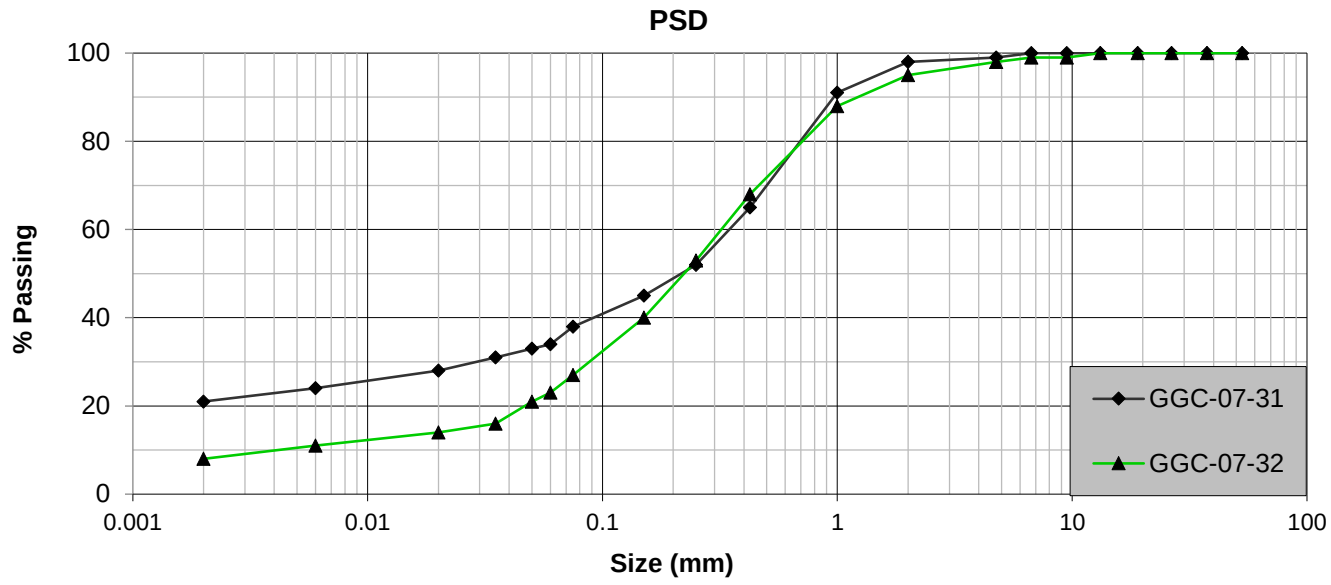
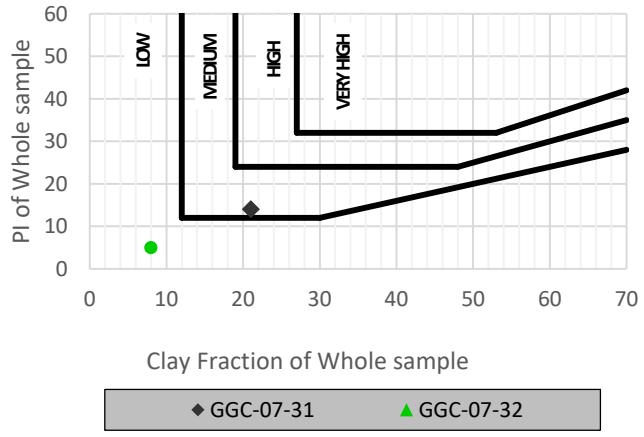
Client Name: GaGE Consulting
Project Name: Hyperama Pipeline
Job Number: GGC-07
Date: 2018-10-01
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

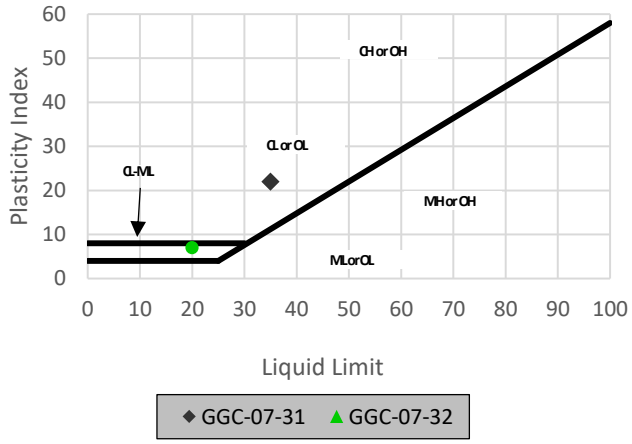
FOUNDATION INDICATOR



Potential Expansiveness



Casagrande Plasticity Chart



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Asphalt | Aggregate | Bitumen | Geotechnical
Quality | Excellence | On Time

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Roelof | 072 674 6343 | roelof@stlab.co.za
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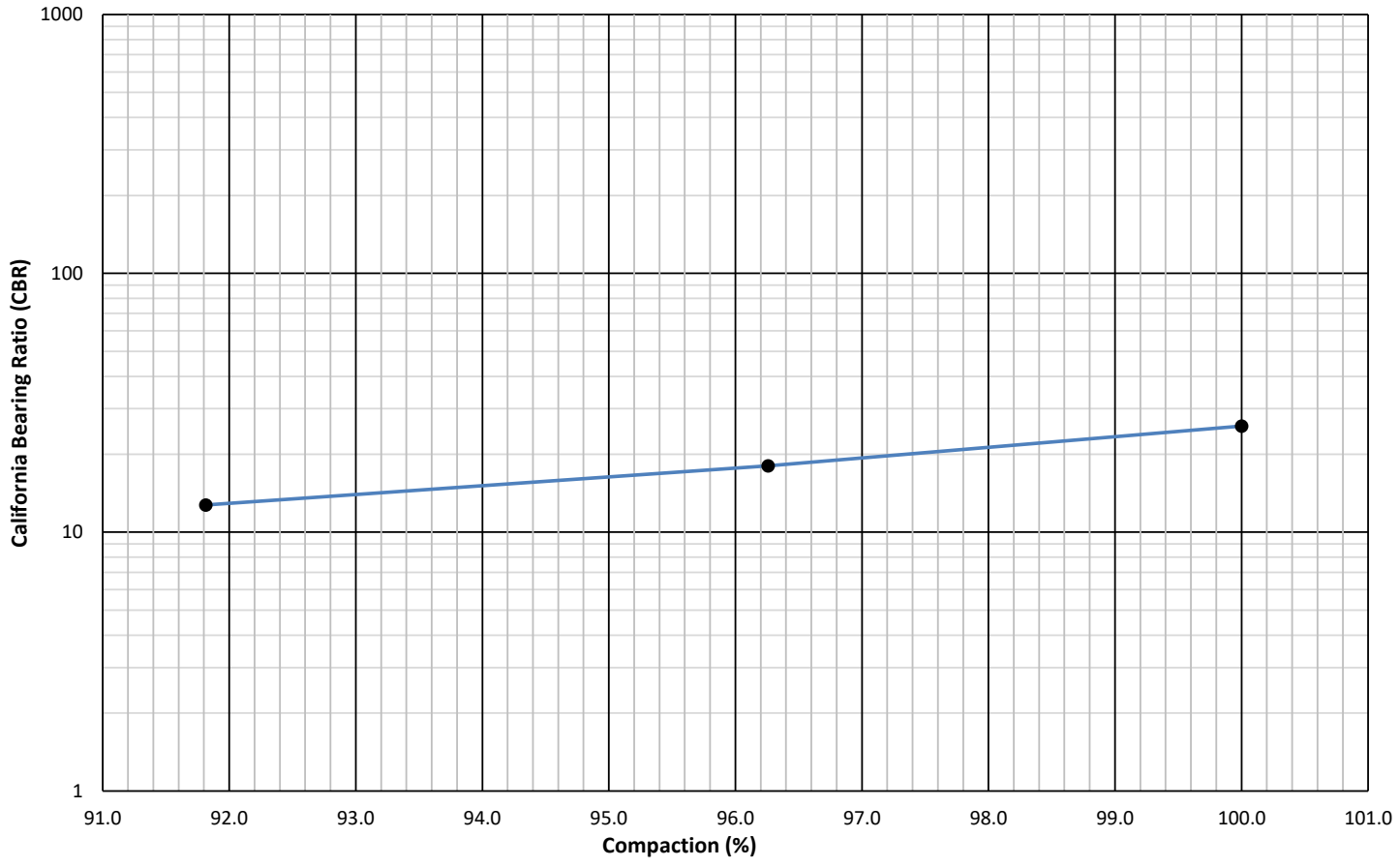
Client Name:	GaGe Consulting	**Job Number:**	GGC-07
Project Name:	Hyperama Pipeline	**Lab Number:**	GGC-07-28
Sample:	HRTP 1	**Method:**	SANS 3001 GR40
Depth: (m)	0.87 - 1.1	**Date:**	01-Oct-18

CALIFORNIA BEARING RATIO

Mod. AASHTO Values		Compaction Data: CBR			Swell	CBR at (mm)			CBR Values	
MDD	**OMC**	**Dry Dens.**	**MC**	**Comp.**						
(kg/m³)	(%)	(kg/m³)	(%)	(%)	(%)	2.5	5.0	7.5	Compaction (%)	CBR
									100	**26**
2150	6.4	2138	6.9	100.0	0.0	26	30	34	98	**21**
									97	**19**
2150	6.4	2058	6.9	96.3	0.0	18	22	25	95	**16**
									93	**14**
2150	6.4	1963	6.9	91.8	0.0	13	13	12	90	**11**



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Client Name:	GaGe Consulting	**Job Number:**	GGC-07
Project Name:	Hyperama Pipeline	**Lab Number:**	GGC-07-28
Sample:	HRPT 1	**Method:**	SANS 3001 GR30
Depth: (m)	0.87 - 1.1	**Date:**	01-Oct-18

MDD & OMC DETERMINATION (Mod. AASHTO)

Maximum Dry Density: **2150** kg/m³ Optimum Moisture Content: **6.4** %

Moisture Content (%):	4.2	5.2	6.2	7.2	8.2			
Dry Density (kg/m³)	2040	2098	2145	2130	2085