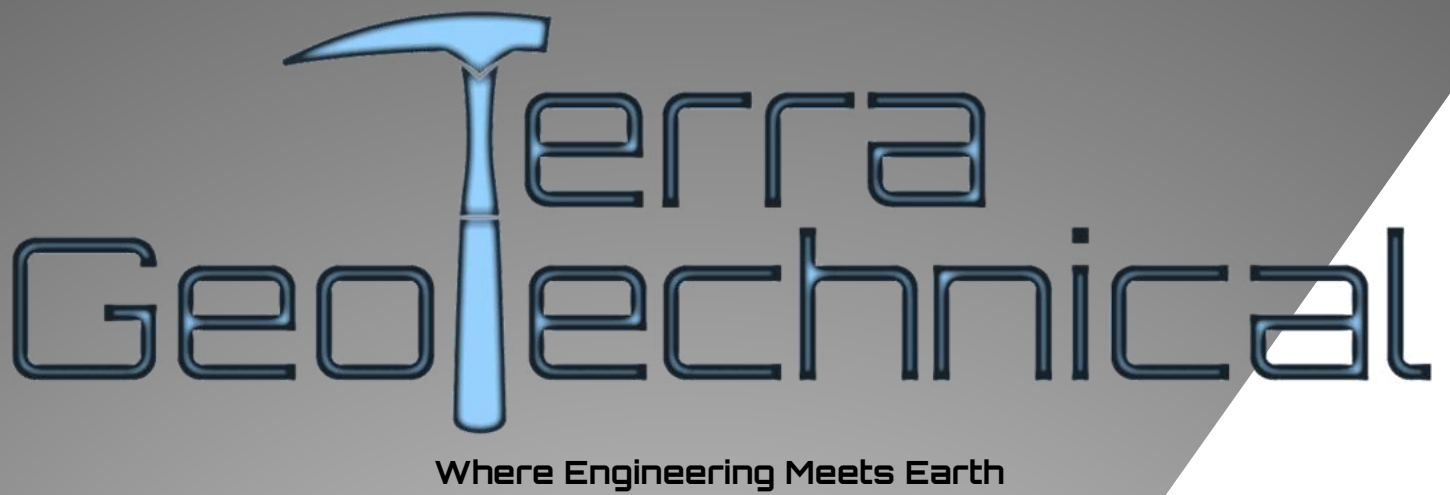




Engineering Geological Report

In support of the proposed

Robertson Fire Station

Robertson

Western Cape

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The information presented in this document is based on the information supplied by the Client prior to the commencement of the investigation. All care and diligence have been taken in rendering services and preparing these documents.

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1. Introduction

A geotechnical investigation was conducted for the proposed new Robertson Fire Station. The development incorporates various low load bearing structures as well as internal roadways.

This investigation was undertaken in order to assess the engineering geological character of the area, focusing on the geotechnical properties which will affect the overall development potential of the site.

1.1. Terms of Reference

Terra Geotechnical was appointed in September 2021, by Ms Nadia Malan (representing Tusk CSS (Pty) Ltd), to conduct this geotechnical investigation. The area of investigation was defined and approved before the commencement of the investigation. The distribution of testing locations and the associated sampling were done where physically possible and to best model the geotechnical character of the site for this specific development.

Standard soils laboratory testing was conducted by Roadlab Mossel Bay. The quantity and nature of samples were governed by the nature of the proposed development and the in-situ characteristics of the material excavated across the site.

1.2. Sources of Information

The following sources of information were utilized:

Geological Map:

- 3319 Worcester; scale 1:250 000 (digital format)

Remote Sensing Information:

- Google Earth Pro TM
- Elevation Heat Map; Online Resource
- Planet GIS

Layout Map provided by the client

1.3. Objectives

The investigation had the following aims:

- identify potential **geotechnical hazards**
- to determine and evaluate the **mechanical properties of the soil** material occurring within the boundaries of the study area regarding the construction of a warehouse and associated infrastructure.
- **define the ground conditions** and classify the conditions through detailed soil profile descriptions and groundwater occurrences **within the zone of influence of foundations**
- To assess **the in-situ mechanical properties** and the **re-usability of the natural material** underlying the development in question.
- To evaluate the **excavation characteristics** across the development in question.
- To **recommend** measures to be implemented during the design and development of the area in question.

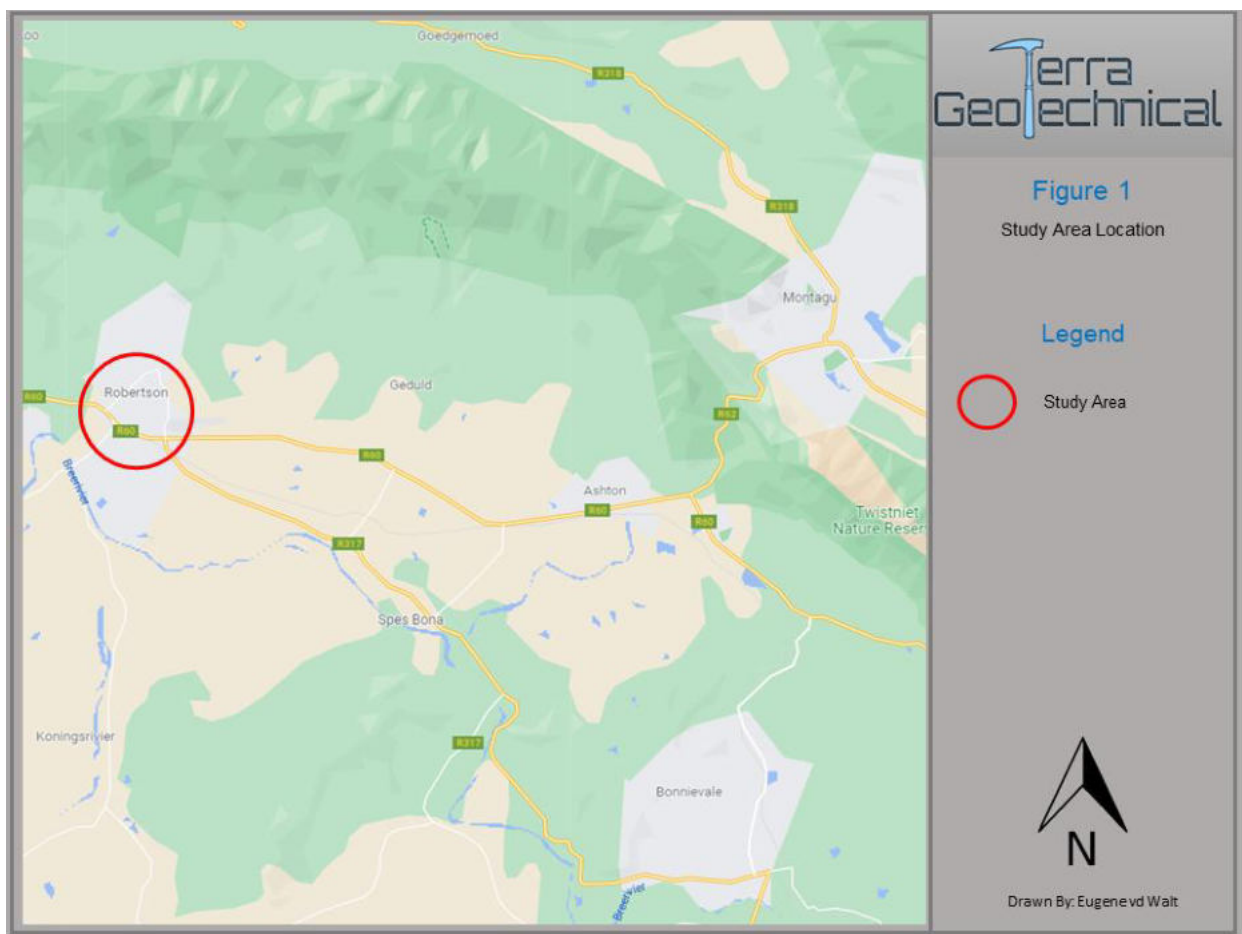
It must be noted that this investigation was conducted to assist with the design and construction phase of the development.

2. General Location and Description of Site

2.1. Location

The study area for this investigation at the southern valley floor of the Langeberg Mountains, approximately midway between Swellendam and Worcester along the Regional road 60 (R60), in the Western Cape Province. On a more localized scale site falls within the Langeberg Local Municipality and is located within the town of Robertson. The site is easily accessible through a network of sealed roads and is located just north of Kerk street.

Figure 1 below, graphically depicts the location of the study area.



The site is defined as an irregular shaped parcel of land on the western side of the Callie de Wet Sport Grounds. The site is known as erf 8250 and is approximately 0.5 ha in size. On the surface, the site hosts a single concrete and masonry infrastructural unit, whilst subsurface services (water, sewer, electricity) traverse the site.

The site is located roughly at the following coordinates:

Latitude: 33.812402° S

Longitude: 19.892245° E

Figure 2 below, graphically depicts the site location

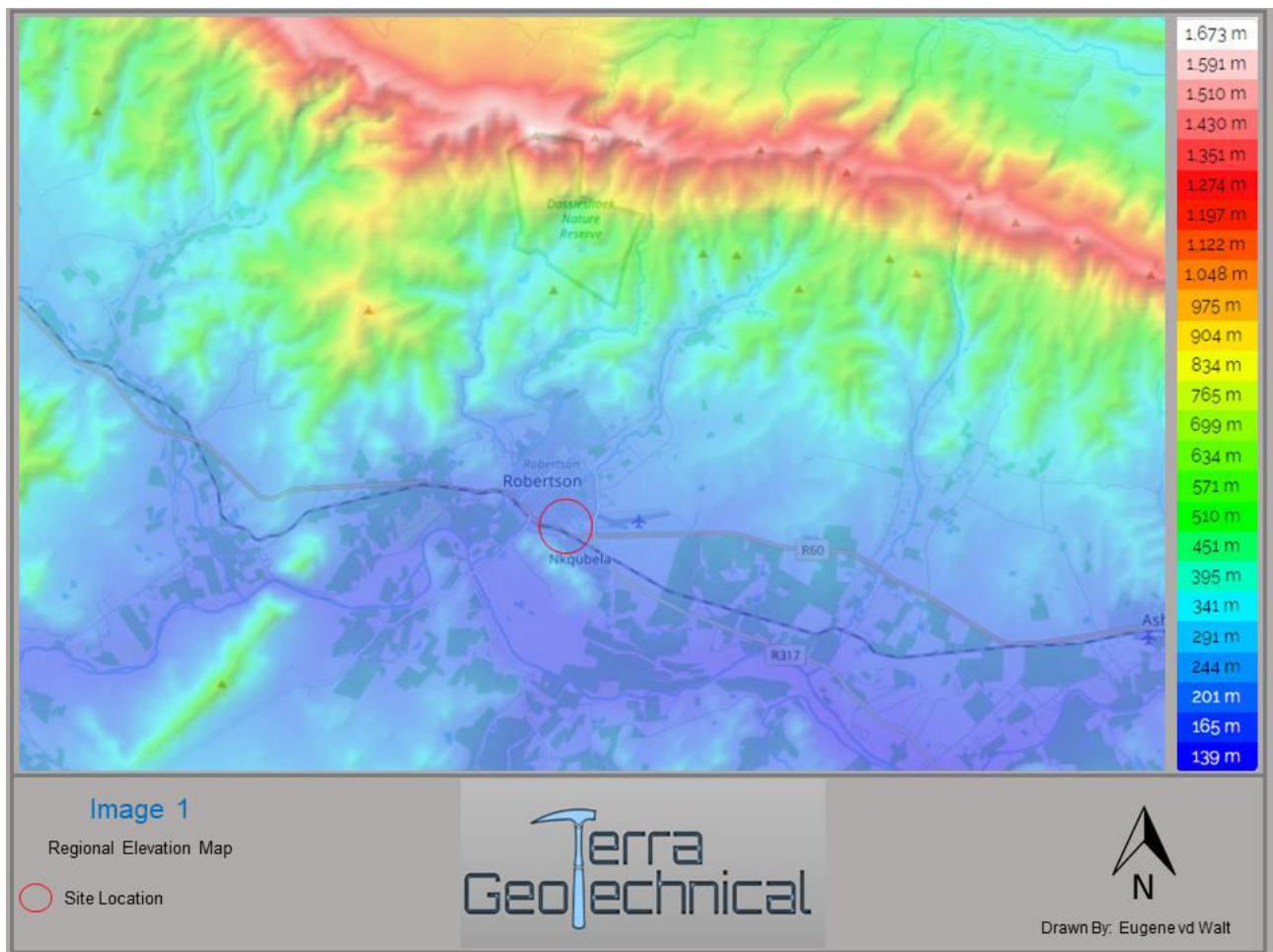


2.2. Topography

2.2.1. Regional Topography

Regionally, the study area located on the southern valley floor of the Langeberg Mountain range. The study area is generally flat with minor ridges and hills located within the valley floor and only the Langeberg Mountains providing a major change in relief to the north of the study area.

Image 1 graphically depicts the elevation and topography of the study area.



The colour coded image above clearly depicts the flat lying nature of the study area, with the **higher lying Langeberg mountains depicted by the red and yellow** and the **lower lying valley depicted by the blue colours**

The site itself, is generally flat lying with the topography having been altered slightly due to the developments within the area.

2.3. Climate

The climate in Robertson region is referred to as steppe climate. Generally little rainfall throughout the year receiving approximately 405 mm of rain per year, with most rainfall occurring during November. The average midday temperatures range from 11°C in July to 22°C in February.

Climate determines the mode and rate of weathering. The effect of climate on the weathering process (i.e. soil formation) is determined by the climatic N value defined by Weinert, 1980. The climatic N-value of the area is deemed to be less than **5**; which implies a surplus of water. The implication of the N-value in general (for an $N < 5$ area) is that the soil profile is likely to be deep, and comprise chemically decomposed residual soils, rather than drier climates which will comprise of physically disintegrated residual soils. This mode of weathering favours deep soil formation with scattered rocky fragments occurring within the soil matrix.

3. Geological Setting

3.1. Regional Geological Setting

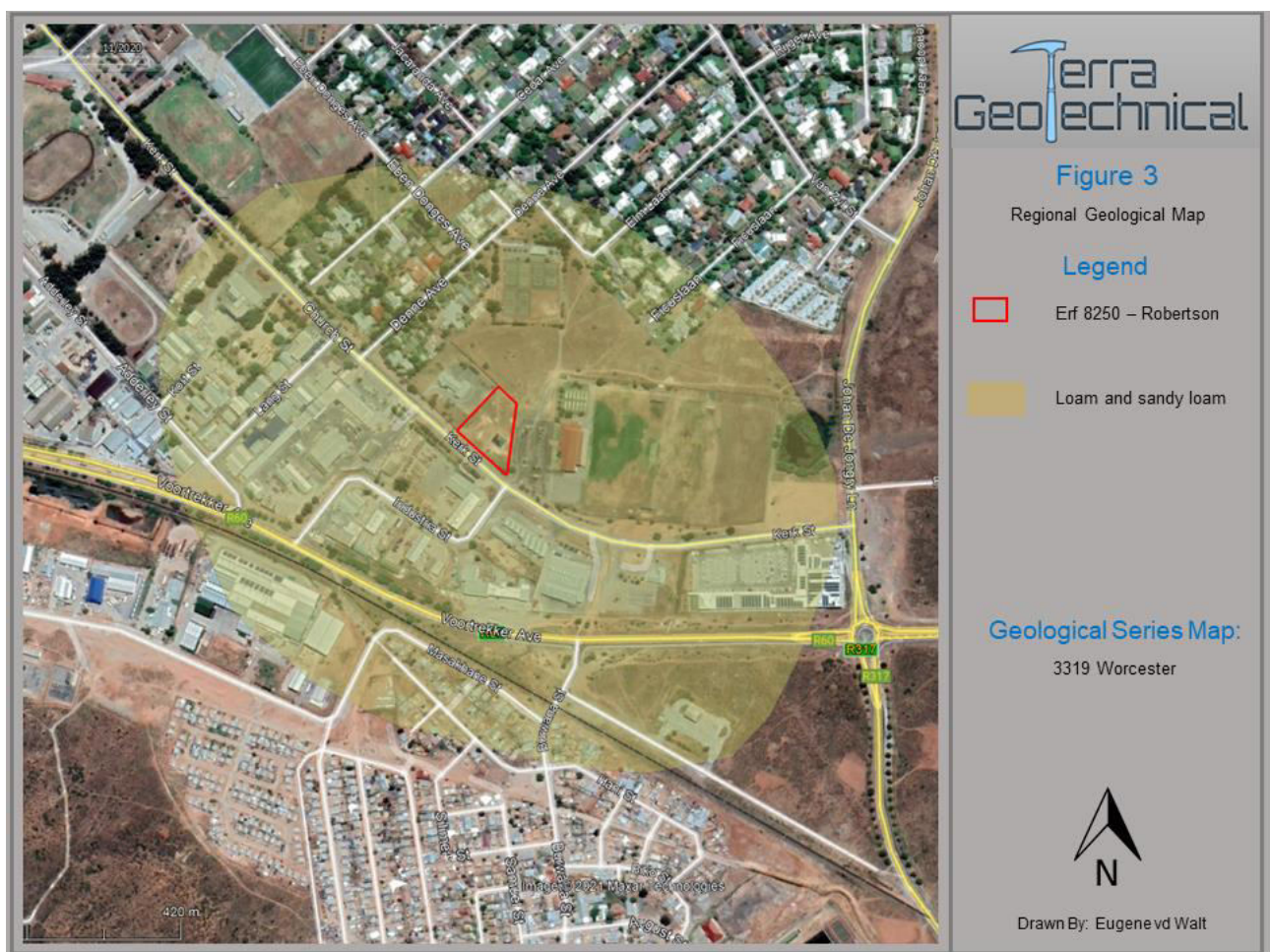
According to the available geological information (geological series map: 3319 Worcester); the study area is underlain by relatively recent transported loam and sandy loam deposits of Quaternary & Tertiary Age.

The study area does not reflect any risk for the formation of sinkholes or subsidence's caused by the presence of water-soluble rocks (dolomite or limestone), and as such is not deemed “**dolomitic land**”.

The **regional geological setting** of the study area (minus the surficial soil cover) is illustrated by **Figure 3** below.

3.2. Prominent Geological Structures

The available geological information does not indicate the presence of any geologically important structures traversing the site.



4. Geotechnical Field Investigation and Laboratory Testing

4.1. Reconnaissance Study

The investigation commenced with the conducting of the following actions:

- The collation and evaluation of available geological and geotechnical information.
- The compilation of a base map showing the regional geological setting

4.2. Site Investigation

The field work phase was conducted by Terra Geotechnical during September 2021. Test pits were placed throughout the study area where deemed safe and in such a way as to accurately describe the general soil conditions occurring within the boundaries of the study area. On the clients' request, test pits only had to be excavated to a depth of 1.5m below ground level.

The succession of soil and rock layers exposed within the test pits were logged according to the industry-standard method proposed by Jennings et al (1973), and a series of detailed photographs were taken of the different soil layers, and samples were taken of the soil- and rock material deemed to be important to the proposed development.

1.5 meter DCP tests were attempted adjacent to each of the test pits. These tests were utilized to determine in-situ geotechnical material characteristics of the loadbearing substrata.

4.3. Laboratory Testing

The following tests were conducted on soil samples taken during the field work phase:

- Standard foundation indicator tests were conducted on disturbed soil samples in order to determine its composition (i.e.: the relative percentages of gravel, sand, silt and clay present within each sample), to evaluate the heave and compressibility potential of these soils, and to calculate the maximum heave and/or differential settlement that can be expected. The following tests were conducted:
 - ❖ Atterberg Limits (Liquid Limit and Plasticity Index) and Linear Shrinkage
 - ❖ Particle-size distribution
- Standard road indicator tests were conducted by on bulk soil samples in order to determine its composition, and to evaluate the suitability of the materials for use in the construction of access roads and parking areas. The following additional tests were conducted:
 - ❖ Maximum Dry Density versus Optimum Moisture Content
 - ❖ Californian Bearing Ratio versus Compaction Effort (MOD AASHTO method)

4.4. Reporting

The investigation concluded with the compilation of a technical report detailing all methodology utilised during the study and all results obtained. This report includes a detailed potential evaluation of the site in terms of the proposed development, based on the results of the geotechnical investigation, with recommendations regarding foundation design and layer works as well as construction and excavatability.

5. Geotechnical Setting

5.1. Trenching

Trenching and associated sampling were done as to best model the geotechnical and material characteristics of the site with regards to the proposed development.

5.1.1. Excavation of test pits

A total of 4 test pits, numbered TP1 to TP4 (Figure 4), were excavated, by means of a Komatsu PC70 mechanical excavator during September 2020, at which time the exposed soil layers were profiled.

The placement of test pits were influenced by the subsurface infrastructure as well as the proposed development layout.

5.1.2. Generalised engineering geological parameters

The following general engineering geological characteristics were noted:

- **Site Excavatability**

Generally, no problems are foreseen during the excavation of shallow foundation trenches or deep service trenches to a depth of 1.5 m below natural ground level, through the use of a mechanical excavator of similar size and strength to what was used during the investigation, however, localized difficulty in excavation was encountered within TP3 from a depth of 1.4 m.

Excavation type to a depth of 1.5 m below the natural ground level is deemed to be Soft Excavation, with localized Intermediate Excavation (less than 5% across the site).

- **Rock- and/or pedocrete outcrops**

Bedrock or pedocrete outcrops were not encountered within the investigated area.

- **Sidewall stability**

All the test pits excavated during the investigation proved to host stable sidewalls for a period of at least 1 hour.

- **Groundwater seepage**

No groundwater seepage was encountered in any of the test pits. The presence of localized ferruginized material as well as leached horizons are further evident of perched groundwater conditions. In general, the soil profile encountered was profiled as being moist.

5.1.3. Generalised soil profile

The results of the trenching phase indicate that the whole site is covered by a relatively homogeneous succession of soil layers. Typically, the site was covered by a boulder alluvial horizon, underlain by another alluvial horizon. This alluvial horizon is underlain by a reworked residual material horizon, which is further underlain by residual material.

- **Boulder Alluvium**

The upper boulder horizon covered the whole site. This horizon was generally present as frequent cobbles and boulders up to 600 mm diameter contained in a slightly moist light brown, medium dense silty sandy matrix. The boulders were generally moderately densely packed.

This horizon was encountered from surface to depths of between 0.6 and 1.1 m.

Due to the abundant organic material within the upper portion of this horizon, it will be necessary to remove it before any construction work begins.

The lab tests on these materials indicate they have a moderate plasticity with a potential “low” activity.

- **Lower Alluvium**

The upper boulder horizon was underlain by another alluvial horizon. This horizon was generally showed signs of reworking through water movement and exhibited a cohesive nature. This horizon was generally present as moist, orange brown mottled red and grey clayey/silty sand, exhibiting a firm to stiff consistency. Scattered gravels and cobbles was present.

The horizon had a thickness of between 0.1 and 0.9 m and was encountered throughout the site, although it was absent in TP3.

The lab tests on these materials indicate they have a moderate plasticity with a potential “medium” activity.

Due to the medium potential activity of these soils, and the possibility that they could soften up if they become saturated, they are not considered as a suitable medium for any of the structures

- **Ferruginized Residual**

A ferruginized horizon consisting of clayey/silty sand with frequent gravels and scattered cobbles was encountered below the lower alluvium. It has undergone various degrees of ferruginization and are weakly to strongly cemented. It was difficult to discern between ferruginized transported or ferruginized residual material, although the ferruginized material was described as residual.

This horizon was encountered from depths of between 0.7 and 1.5 m

The lab tests on these materials indicate they have a moderate plasticity, but due to low clay content it classifies as a potential “low” activity.

Detailed test pit profiles are included in Appendix A.

5.2. DCP testing

A total of 5 DCP tests were carried out across the site to assess the consistency of the in-situ sub-soils and provide an indication of the founding conditions beneath the site.

4 DCP tests were attempted from surface, adjacent to each of the test pits. Due to the presence of cobbles and boulders within the soil horizons at shallow depth, the DCP tests were generally hampered with no useable results obtained.

An additional DCP test was conducted at TP1 in the soil horizon directly underlying the boulder alluvium. This test commenced from a depth of 0.6 m below ground level and was advanced a further 1.0 m before the DCP encountered penetration difficulty due to very dense soil.

The results of this DCP test (DCP1), is included in Appendix C. The test indicates that soil horizons increase in consistency with an increase in depth.

The results of the DCP test indicate that the residual material underlying the site exhibits moderate to high CBR values. The lab tests on this material however, yielded much poorer CBR results. The major contributing factor to this difference is that the DCP test is done at in-situ moisture conditions, whereas the laboratory tests are conducted at saturated moisture conditions.

6. Geotechnical Evaluation

6.1. Engineering- and material characteristics

6.1.1. Sampling

The following samples were taken:

Disturbed samples	:	1 x Boulder Alluvium
	:	1 x Lower Alluvium
	:	1 x Ferruginized Residual
Bulk Samples	:	1 x Boulder Alluvium
	:	1 x Ferruginized Residual

Detailed soil test results are included as in Appendix B.

It should be noted that when saturated and loaded, the soils will undergo loss of strength with the soil grains being forced into a denser state of packing and a reduction in void ratio (decrease in volume). Due to the fine grained nature of the lower alluvial material, the material is also deemed to be sensitive to moisture changes and will undergo heave and shrinkage with changes in moisture. The result of which is varying degrees of consolidation and heave. For this reason, the assessment and quantification of both the degree and nature of consolidation and heave, under planned foundation loads, will form the basis of the mechanical assessment of the sites' subsoils to follow.

Table 1 on the following page summarizes the material properties sampled across the site

Soil Profile Make-up and Associated Sampling		Material Characteristics- Laboratory Assessment																
		Bulk and Disturbed samples tested by Roadlab																
Test Pit nr & Material Description	Sample Depth (mm below ground level)	Soil Composition					Fines Analysis (measured from material passing the 0.075 mm sieve)		Moisture Content	Unified Soil Classification System	Activity		Material Compaction Characteristics					
		Sieve Analysis (cumulative percentage passing)				Grading Modulus (GM)	Plasticity Index (PI)		Linear Shrinkage (LS)		In-Situ Moisture Content	USCS Symbol	Potential Expansiveness (according to van der Merwe)	Swell Percentage	COLTO Classification	Measured CBR Values (percentage compaction of MOD AASTHO; CBR of 13.344 kN)		
		2,0 mm	0,425 mm	0,075 mm	0.002 mm		Minimum	Maximum	Minimum	Maximum	%					90%	93%	95%
Natural Material (Untreated)																		
TP1 Ferruginized Residual	1000-1900	62	47	33	2,6	1,58	20	6,9	-	SC	Low	0,00%	>G9	1	2	2		
TP3 Boulder Alluvium	0-700	60	50	29	5,8	1,61	8	3	-	SC	Low	0,00%	G8	8	13	17		
TP4 Lower Alluvium	1100-1500	77	62	48	12,9	1,13	25	8,8	28,4	SC	Medium	2,00%	Inferred >G9	-	-	-		

6.1.1. Soil Test Results: Boulder Alluvium

In the light of the soil test results and visual observations, the **Boulder Alluvium** sampled can be summarised as follows:

- The abundant boulders encountered within this horizon did not form part of the sampling process as these large particles typically get discarded during the testing process
- The material has a fines fraction (passing the 0.075mm sieve) of 29%, with the clay fraction constituting 5.8% of the sample.
- This **plasticity** of the **fines fraction** of the material is tested to **8**, with the weighted PI calculated at 4.
- According to the Unified Soil Classification the material classifies as a clayey sand (**SC**) with a **Grading Modulus** of **1.61**
- According to the *van der Merwe* method of determining **Potential expansiveness**, this material classifies as a **low risk** for potential expansiveness.
- This material is deemed to be **Potentially Compressible**.

The results of road indicator tests conducted on the bulk samples of this material can be summarized as follows

- This material typically tests as a **G8-type material** according to the COLTO classification system.
- When compacted to 93% MOD AASHTO, this material provides a **bearing capacity of approximately 100 kPa**.
- Should this material be utilized for layer works during construction, the oversized cobbles and boulders need to either be crushed or removed in its entirety.

6.1.2. Soil Test Results: Lower Alluvium

In the light of the soil test results and visual observations, the **Lower Alluvium** sampled can be summarised as follows:

- The material has a fines fraction (passing the 0.075mm sieve) of 48%, with the clay fraction constituting 12.9% of the sample.
- This **plasticity** of the **fines fraction** of the material is tested to **25**, with the weighted PI calculated at 15.6.

- According to the Unified Soil Classification the material classifies as a clayey sand (**SC**) with a **Grading Modulus** of **1.13**
- According the to the *van der Merwe* method of determining **Potential expansiveness**, this material classifies as a **medium risk** for potential expansiveness due to moderate PI values and clay content.
- The **swell potential** of this material yielded a swell percentage of **2.0%**.
- This material is deemed to be **Potentially Compressible**.

The inferred road indicator results of this material can be summarized as follows

- Due to the moderately high PI values, this material will classify as a **worse than G9-type material** according to the COLTO classification system.
- It is not recommended that this material be used in the construction of any load bearing layer works.

6.1.3. Soil Test Results: Ferruginized Residual

In the light of the soil test results and visual observations, the **Ferruginized Residual** material sampled can be summarised as follows:

- The material has a fines fraction (passing the 0.075mm sieve) of 33%, with the clay fraction constituting 2.6% of the sample.
- This **plasticity** of the **fines fraction** of the material is tested to **20**, with the weighted PI calculated at 9.3.
- According to the Unified Soil Classification the material classifies as a clayey sand (**SC**) with a **Grading Modulus** of **1.58**
- According the to the *van der Merwe* method of determining **Potential expansiveness**, this material classifies as a **low risk** for potential expansiveness.
- This material is deemed to be **Potentially Compressible**.

The results of road indicator tests conducted on the bulk samples of this material can be summarized as follows

- This material typically tests as a worse than **G9-type material** according to the COLTO classification system.
- This material reacts very poorly to compaction and when compacted to 93% MOD AASHTO, this material provides a **bearing capacity of less than 30 kPa**.

- It is not recommended that this material be utilized in any load bearing layer works during construction.

The DCP test that was advanced into this horizon yielded CBR results in excess of 15, indicating a competent horizon, whereas the lab results of the compacted material only reached a CBR of 3 at a compaction effort of 100%. The major contributing factor for this large difference in strength, is that the lab sample was tested under saturated conditions and the on-site tests were conducted at natural moisture conditions. This is clear evidence that the material strength characteristics will change greatly when inundated with water.

6.1.4. Heave Characteristics of In-Situ Soils:

Soil heave is the process of the change in volume correlating to a change in moisture content. This phenomenon is prominent in soils containing a high content of active clays.

According to van der Merwe, the lower alluvial material encountered on site also classifies as a **medium potential for heave**. This correlates to a **swell percentage of at least 2%**.

This thickness of this layer varies across the site. The heave will be calculated according to the most prominent horizon encountered (0.4 m thick).

When calculating the amount of heave expected with the **generalized heave equation**, this material is deemed to undergo a minor amount of heave. The value is calculated to approximately **5 mm**.

Due to this layer being so thin, the effect of the material on the structural development is deemed to be low.

Please note, the degree of soil heave displays an inversely proportional relationship to the bearing loads, and therefore the degree of heave reduces with an increased bearing load. This is of greater concern for light structures, such as walkways, pavements, surface beds, etc.

6.1.5. Standard Consolidation of In-Situ Soils:

There are three components to settlement namely immediate settlement (also referred to as elastic settlement), primary consolidation settlement and secondary consolidation (also referred to as creep).

Immediate settlement takes place as a load is exerted on the soil mainly due to distortion of the soil. As pore water begins to flow out of the soil a time dependant decrease in volume occurs which is termed consolidation settlement. This settlement will continue until a condition of constant effective stress is reached. This primary consolidation settlement takes place generally in fine grained materials (high percentage of clay or silt).

Secondary consolidation settlement is not considered a concern as this type of settlement usually occurs in soft organic clays where plastic flow within the soil mass results in displacement of the soil particles.

Based on the visual observations and detailed profiling, the material is deemed to be potentially compressible with an inferred settlement of between 10 and 20 mm.

6.2. Suitability of On-Site Soils

The upper boulder alluvium reacted moderately to compaction and tested as a G8-type material (COLTO). For the material to be utilized in layer works the oversized cobbles and boulders have to be removed from the material, or alternatively crushed to be within allowable sizing limits. If the boulders and cobbles are not removed, this material is not deemed suitable for backfilling purposes against foundation walls, however it could be re-used for general landscaping.

The lower alluvial horizon is not deemed suitable for re-use during construction, due to its high PI and fines values.

The ferruginized residual material reacted poorly to compaction and tested as a worse than G9-type material (COLTO). For this reason, this material should not be used in any load bearing layers during the construction process.

6.3. Roads

For access roads and parking areas, it is recommended that an allowance is made for importation of selected subgrade layer works of two layers of G7 quality below the subbase. The recommended layers are as follows or an alternative engineered design can be followed;

Layer	Material	Thickness	Required Compaction
Pavers	Cement interlocking paving on 25 mm sand bedding	80 mm	
Subbase	Imported G4/G5 crushed rock	150 mm	95% MDD
SGG	Imported G7 gravel	300 mm	93% MDD

If the existing boulder alluvial material covering the site is not removed and replaced with competent material, differential settlements are anticipated due to its variable load transfer through the strata. This could result in maintenance to be required over short and long term periods depending on the loading.

The performance of the pavement structure is highly dependent on the subsurface groundwater conditions and maintaining the subgrade and pavement structure in a dry condition. The surface of the pavement should be properly graded to direct runoff water towards suitable drainage features. It is recommended that the lateral extent of the subbase layers not be terminated vertically immediately behind the curb/edge of pavement line but be extended beyond the curb

7. Geotechnical Considerations

7.1. General

The results of this study reveal that the site exhibits geotechnical characteristics that may require the implementation of specific design and precautionary measures to reduce the risk of structural damage due to adverse geotechnical conditions.

The upper (on average 0.9 m) horizon covering the site consists of unconsolidated boulder alluvium. These soils possess variable densities and a disturbed appearance in some areas due to previous construction activities. Based on these considerations, this horizon is deemed unsuitable in its natural state, for the support of the proposed structures or paved road/parking without any engineered reworking.

The boulder alluvium is underlain by firm moisture sensitive cohesive alluvial soils which displayed an expansive nature. This layer is at most 0.4 m thick and as such does not pose any risk for the construction in terms of heave and shrinkage. The moderately high PI and clay values makes this material unsuitable for re-use during construction

The ferruginized residual layer is deemed to exhibit a stiff to very stiff consistency and in its natural state is deemed suitable for use as load bearing founding horizon (100 kPa), provided that appropriate design precautions are implemented.

The following constraints needs to be considered;

- The results of this investigation reveal that the boulder alluvium encountered may undergo a **degree of consolidation** (i.e. loss of volume) under loading or when saturated; requiring that structures be adequately strengthened to prevent structural damage. This will be exacerbated due to **differential settlement** beneath foundations.
- The presence of ferruginized and leached material indicates the presence of a historic water table or the **movement of soil moisture** through the load bearing strata. Please note that should water move through the load bearing strata, a reduction in bearing capacity could be expected by up to 50%.
- **Very gentle slopes** that could lead to **surface water ponding**.
- **Localized difficulty in excavation** to 1.5 m (less than 5% expected)

Foundations should not be placed on the variable topsoil occurring within the upper 0.6-1.1 m of the profile.

Deep trenches excavated within this boulder zone, will be subjected to over break, as such the excavated trenches will require shuttering or the wider trenches will require more concrete.

At least 500 mm of boulders should be removed, the exposed surface compacted to densify the remaining boulders into a dense packing. Backfill with suitable G6 quality material and

compact to at least 93% MOD AASHTO (designed and approved by the design engineer). Reinforcement of the foundations are essential.

Water should not be allowed to infiltrate any of the layer works.

7.2. Site Classification

In the light of the results of this study, the site can be grouped into a SINGLE geotechnical entity/development potential zone.

NHBRC Site Classification	Partridge, Wood and Brink (1993) Classification	Excavation Class	Slope Stability
S1/H	2B- Fluctuating moisture conditions less than 1.5 m below ground 1C- Flow soil-heave predicted 2D- Moderate soil Compressibility 1F- Localized Difficulty in excavation to 1,5m	Soft Excavation with localized Intermediate excavation	Stable and gentle slopes

7.3. Soil Excavatability

Generally, no problems are foreseen during the excavation of shallow foundation trenches or deep service trenches to a depth of 1.5 m below natural ground level, through the use of a mechanical excavator of similar size and strength to what was used during the investigation, however, localized difficulty in excavation was encountered within TP3 from a depth of 1.4 m.

Excavation type to a depth of 1.5 m below the natural ground level is deemed to be Soft Excavation, with localized Intermediate Excavation (less than 5% across the site).

The following additional comments on excavation of service trenches apply:

- Trenches may have to be dewatered, especially after heavy precipitation events.
- The side walls of deep excavations should be shored to prevent injury or death due to side wall failure

7.4. Slope Stability

In the light of the **gentle to very gentle slopes** across the site, specialised methods for the stabilisation of cuts into the slopes **are not** deemed necessary.

7.5. Foundation recommendations and solutions

Modified normal foundations

Trim and spoil the upper 200 mm of material or at least all material with vegetation below the construction footprint.

Place foundations at depths below the boulder alluvium and lower clayey alluvium (depths of between 0.7 and 1.5m across the site). The preliminary layout of the structures and the corresponding test pits, indicate the foundations will be placed at roughly 1.0 m depth.

Safe bearing pressures of 100 kPa are applicable.

Modified normal construction methods are required to withstand predicted heave and settlements. Suitable measures include reinforcing of the strip footings, reinforcement in brickwork of plinth walls, reinforcement of surface beds, articulation joints at all external doors and effective site drainage.

Below surface beds, natural boulder material will need to be over-excavated and backfilled and compacted by suitable material.

8. Good Construction Practices

An important factor in the promotion of a stable site is the control and removal of both surface and ground water from the site. It is important that the design of the storm water management system allow for the drainage of accumulated surface water.

8.1. Surface Drainage

It is recommended that an efficient surface drainage system be installed around all structures and along all roads throughout the study area in order to:

- prevent the ponding of water next to structures directly after heavy precipitation events, this may lead to differential settlement as the saturated material undergoes densification.
- prevent large-scale changes in soil moisture beneath the structures on a seasonal basis
- prevent the possible lateral movement of liquids within the upper soil horizons

The precautionary measures should ideally include:

- the sealing of open ground surfaces by means of either of the following:
- the cultivation of a natural soil cover (e.g.: grass)
- compaction of the soil surface
- bitumen or concrete paving
- the removal of surface water to a distance of at least 1 m beyond structures by means of watertight paving.
- the removal of surface run-off by means of an efficient surface drainage system.
- roads should preferably be constructed parallel to the natural surface elevation contours rather than perpendicular to it, in order to reduce run-off velocities
-
- Roads should be constructed with adequate drainage to minimize the possible effects of seasonal shallow perched ground water and surface water run-off to prevent deterioration

8.2. Earthworks

All vegetation should be cleared from the areas over which structures are to be built.

It is recommended that all earthworks be carried out in accordance with SABS 1200. The fill should be placed in layers not exceeding 200 mm loose thickness and compacted to a minimum of 93% Modified AASHTO maximum dry density. Cobbles and boulders larger than $\frac{2}{3}$ of the layer thickness and clayey or organic material must not be included in the fill material.

All fill operations should be observed by a competent professional and tested periodically to confirm compaction is achieved.

9. Limitations

The extent of the investigations undertaken is deemed adequate, within the time and budget constraints, to present an overview of the geotechnical conditions across the investigation site.

It must be borne in mind that the overall interpretation of geotechnical conditions is based upon point information derived from the respective test positions and that conditions intermediate to these have been inferred by interpolation, extrapolation and professional judgement

It is recommended the author be appointed to inspect the earthworks and foundation excavations during the development of the site to confirm founding depths and validate the recommendations provided in this report.

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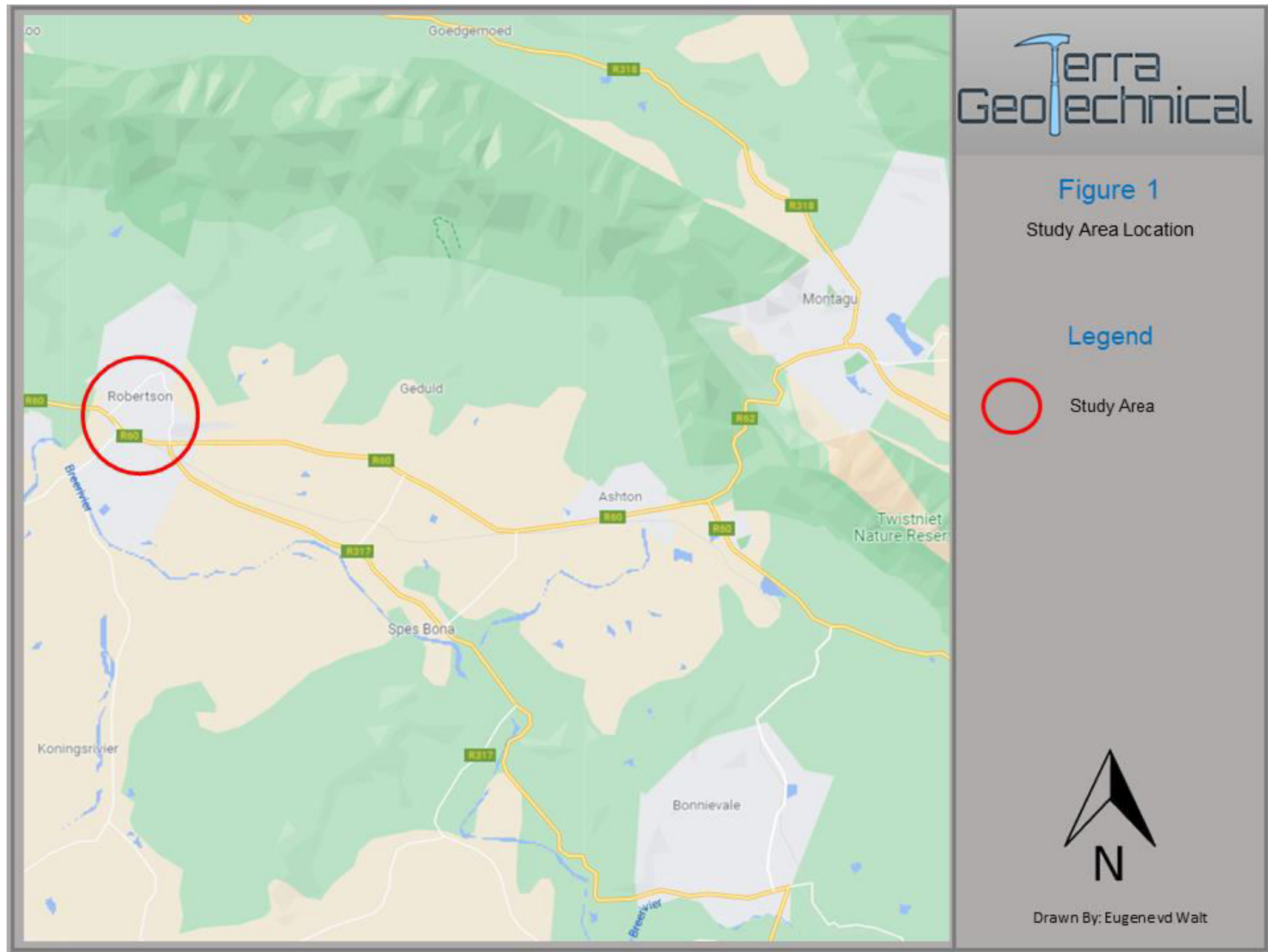
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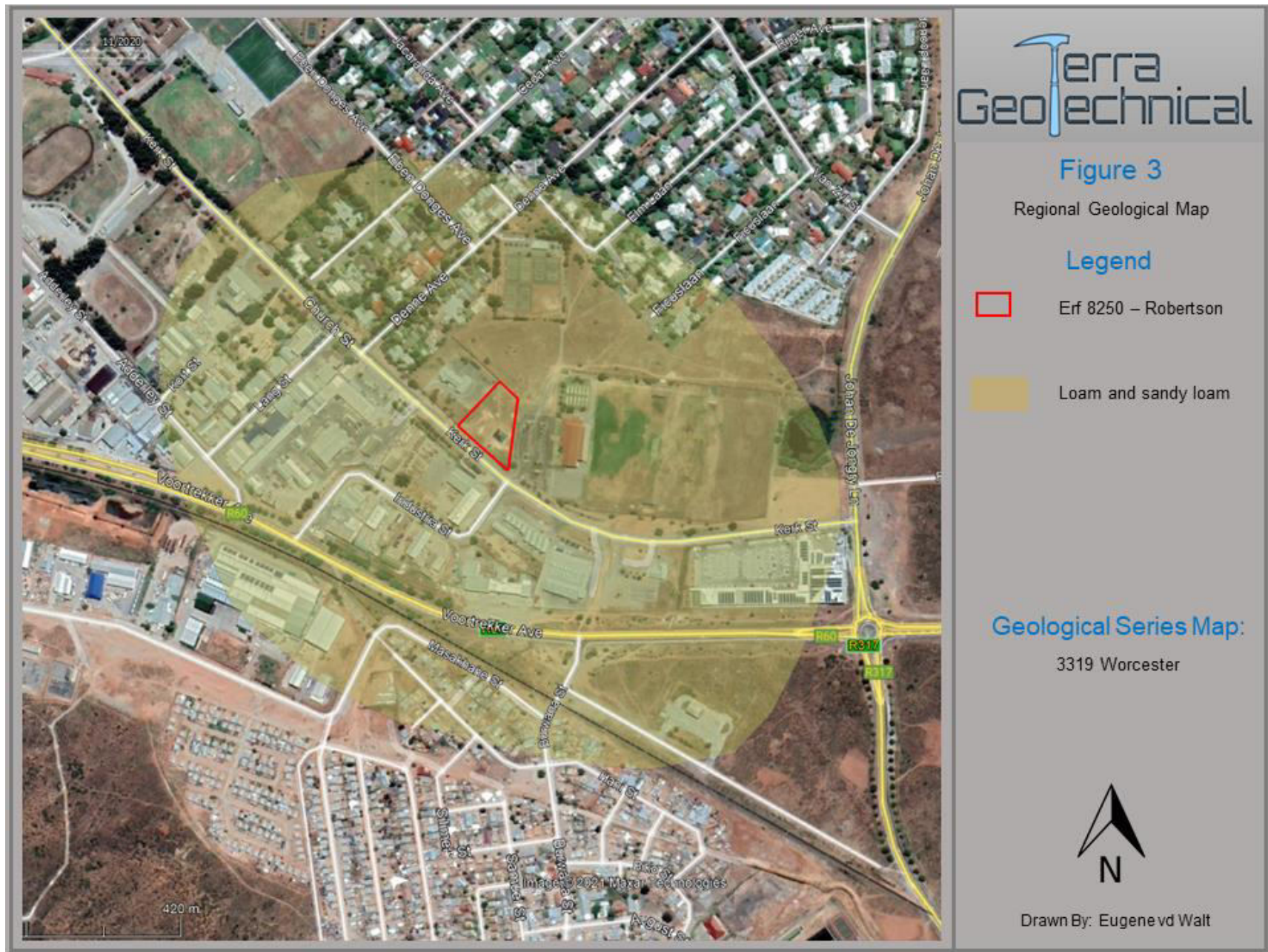
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MAPS



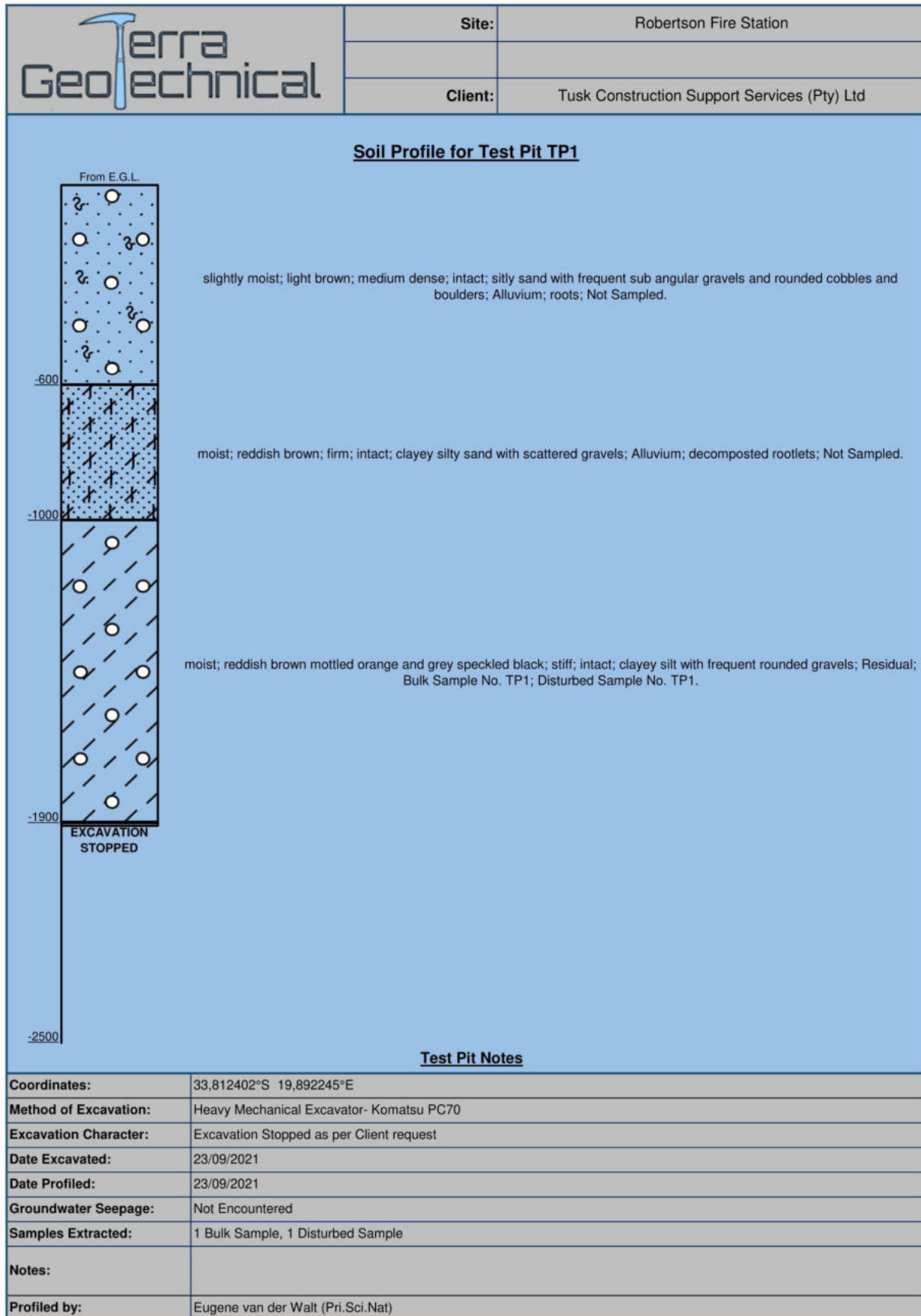






APPENDIX A

A.1 Test Pit Profiles



Soil Profile Photo of Test Pit TP1



Material Present in Test Pit TP1

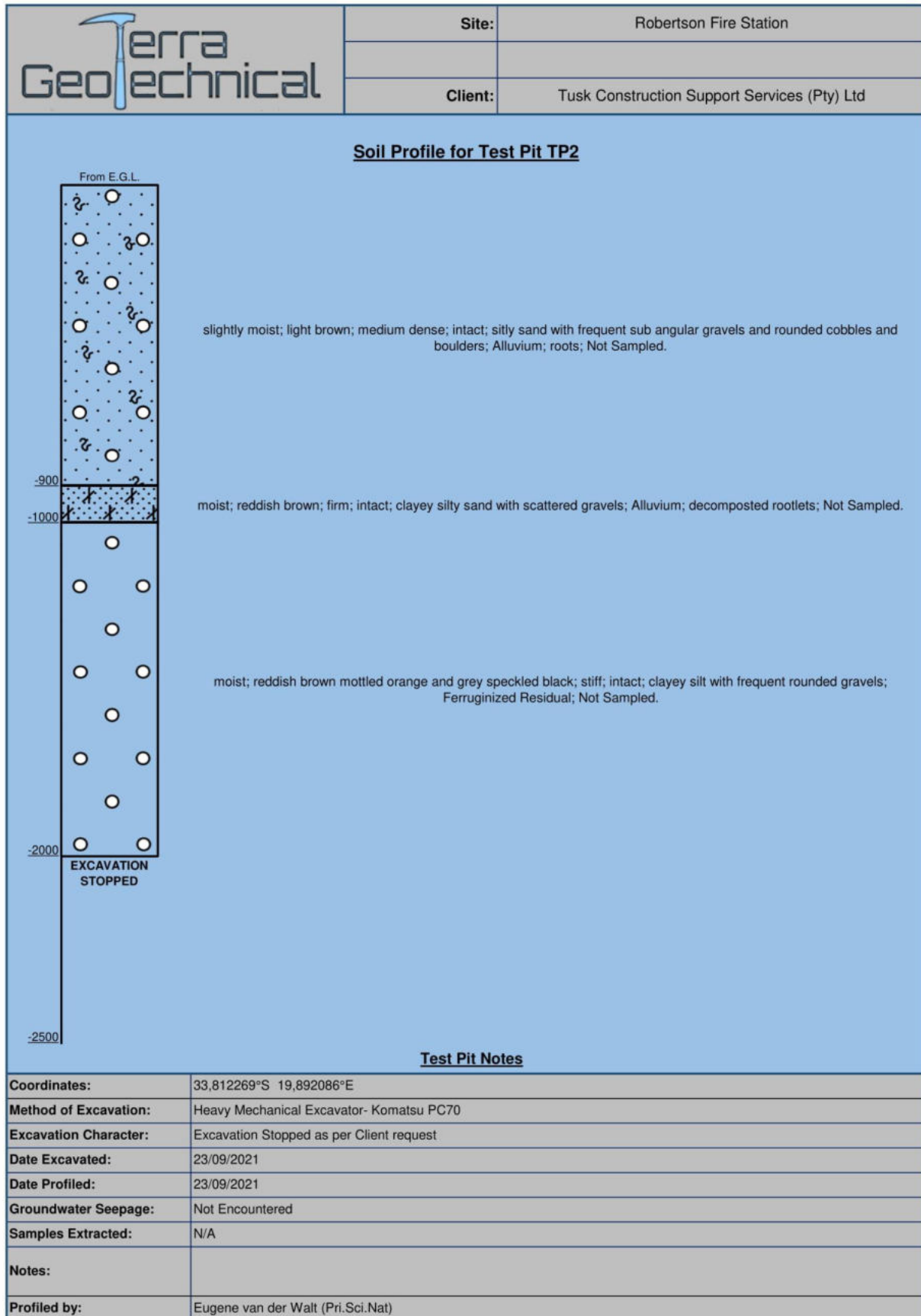


Terra Geotechnical

Robertson Fire Station

Excavated Material Test Pit TP1





Soil Profile Photo of Test Pit TP2



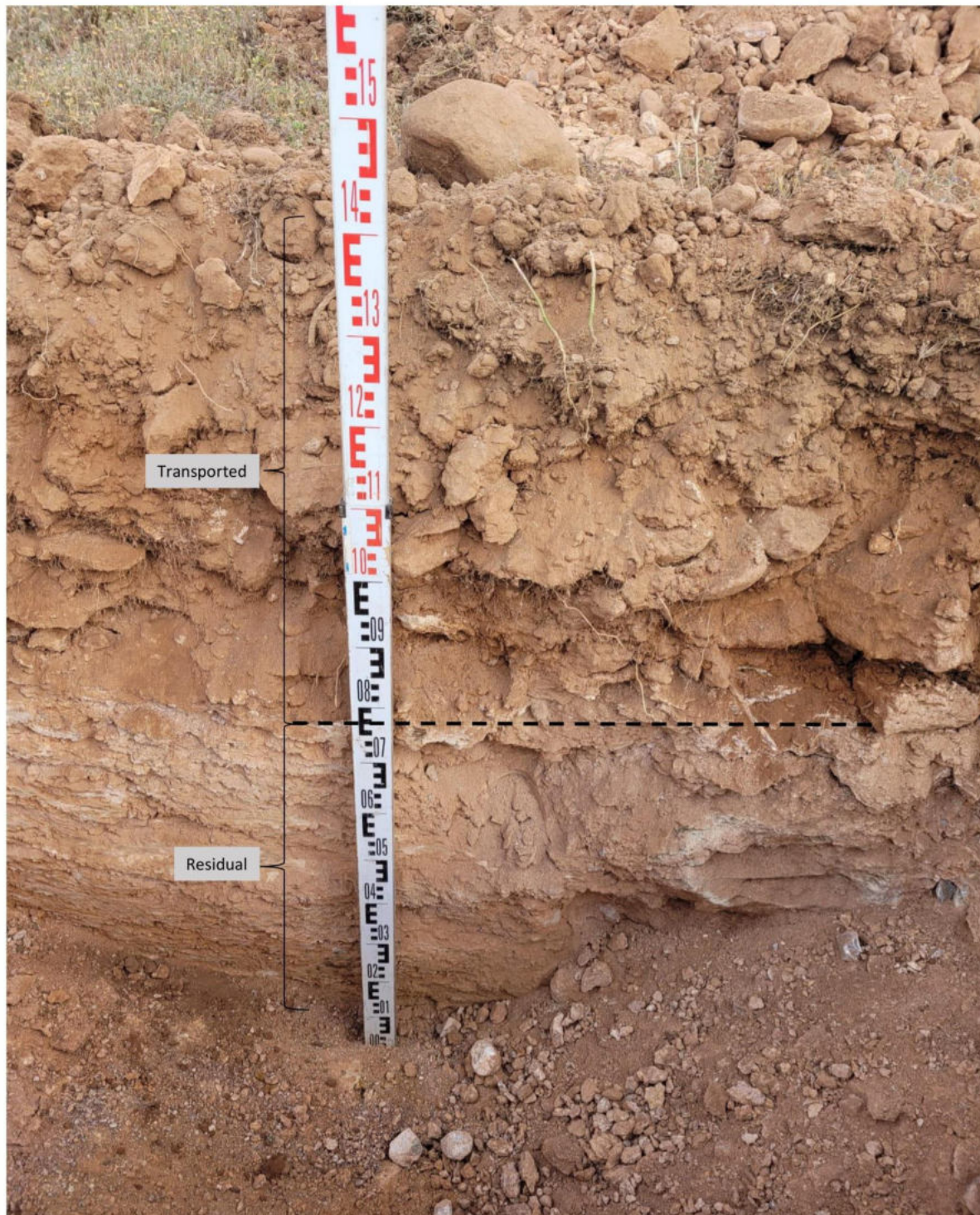
Material Present in Test Pit TP2



Excavated Material Test Pit TP2



Soil Profile Photo of Test Pit TP3



Material Present in Test Pit TP3

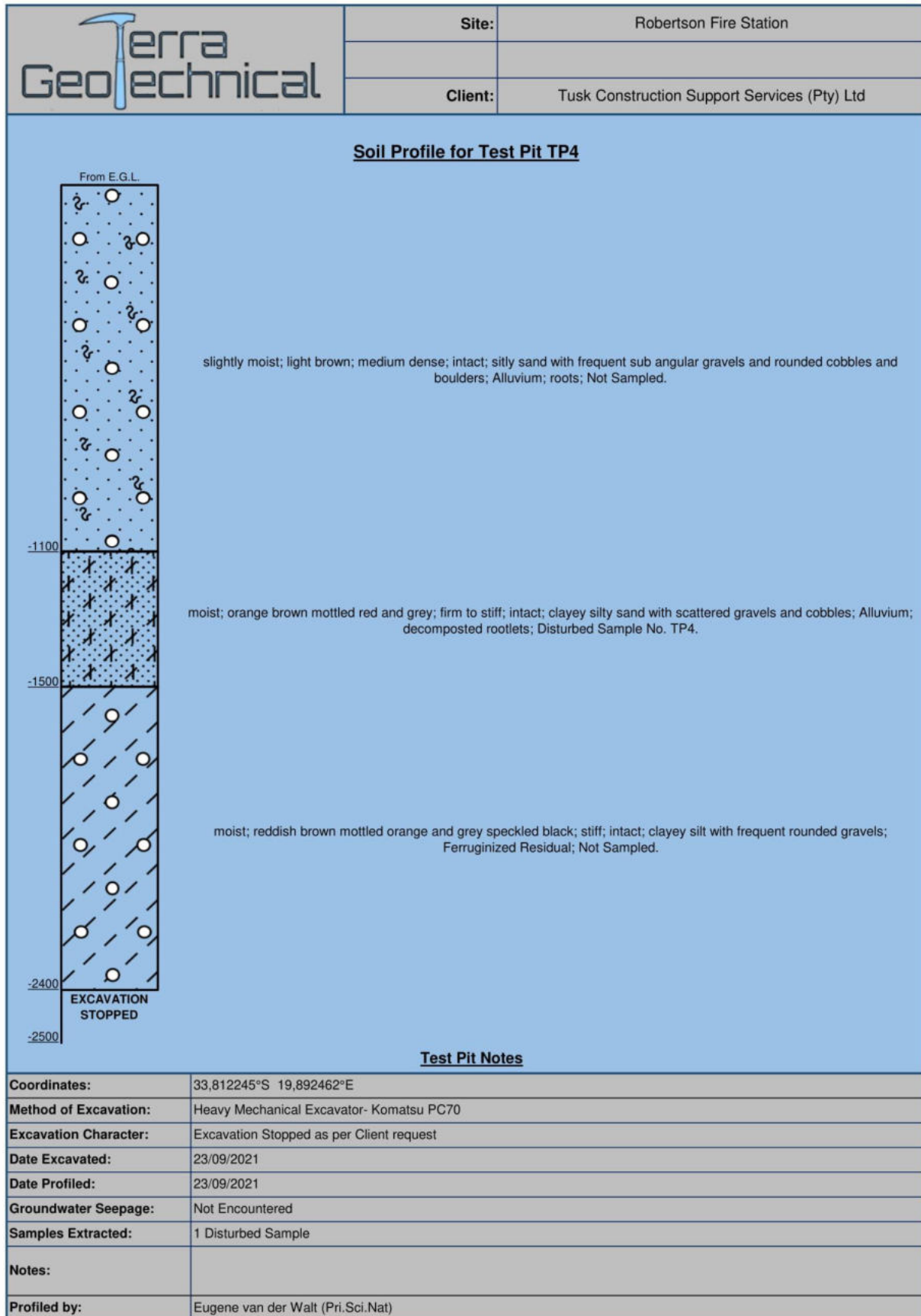


Terra Geotechnical

Robertson Fire Station

Excavated Material Test Pit TP3





Terra Geotechnical

Robertson Fire Station

Soil Profile Photo of Test Pit TP4



Material Present in Test Pit TP4



Terra Geotechnical

Robertson Fire Station

Excavated Material Test Pit TP4



APPENDIX B

B.1

Laboratory Test Results



Roadlab Mossel Bay

7 Bally Crescent, Voorbaai

P.O. Box 35, Hartenbos

Tel: 067 418 4529

Email: Rohann@roadlab.co.za

Web: www.roadlab.co.za

OUR REF : M14608

CLIENT : Terra Geotechnical

PROJECT : Robertson Fire Station

DATE RECEIVED : 2021.09.29

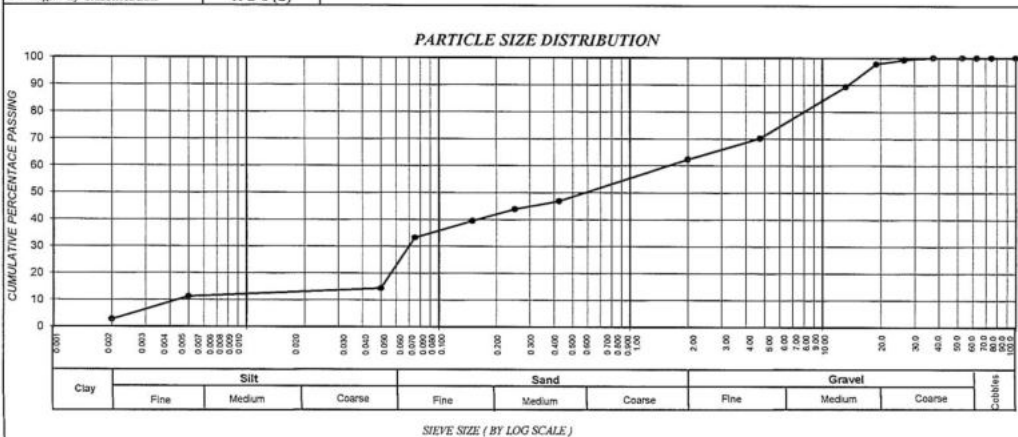
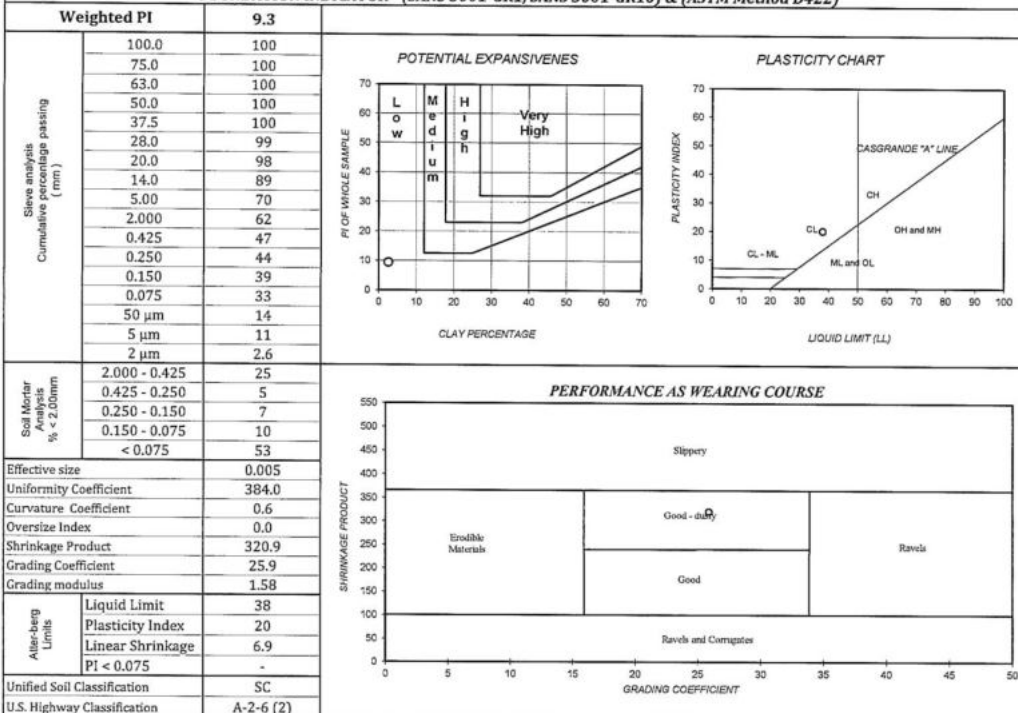
POSITION : TP1 (1000-1900mm)

LAYER : -

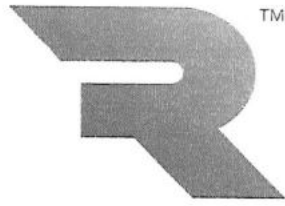
SAMPLE No. : 8620

SAMPLE DESCRIPTION : Dark Reddish Clayey Sandstone Gravel
Silty Gravelly Sand

FOUNDATION INDICATOR - (SANS 3001-GR1, SANS 3001-GR10) & (ASTM Method D422)



CLAY (%) (0.001-0.002)	SILT (%) (0.002-0.060)	SAND (%) (0.060-2.00)	GRAVEL (%) (2.00-60.0)
2.6	17.4	42.3	37.7

**ROADLAB****Roadlab Mossel Bay**

7 Bally Crescent, Voorbaai

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Tel: 067 418 4529

Email: Rohann@roadlab.co.za

Web: www.roadlab.co.za

OUR REF : M14608

CLIENT : Terra Geotechnical

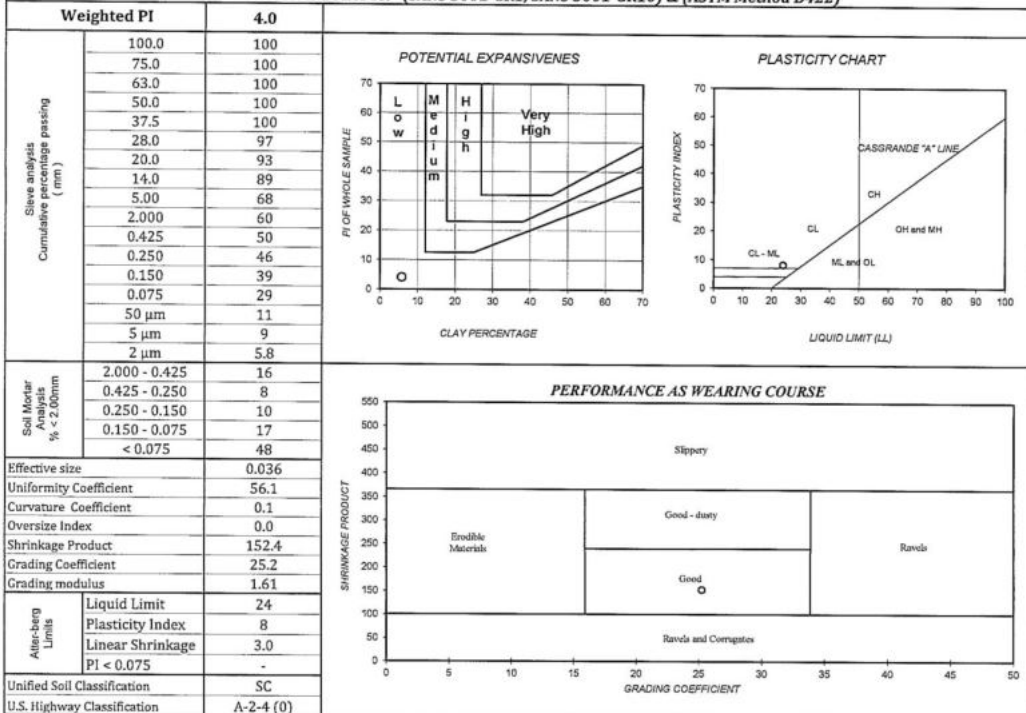
PROJECT : Robertson Fire Station

DATE RECEIVED : 2021.09.29

POSITION : TP3 (0-700mm)

LAYER : -

SAMPLE No. : 8619

SAMPLE DESCRIPTION : Light Brown Q/S/S + Calcrete Gravel
Silty Gravelly Sand**FOUNDATION INDICATOR - (SANS 3001-GR1, SANS 3001-GR10) & (ASTM Method D422)**



ROADLAB

Roadlab Mossel Bay

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Web: www.roadlab.co.za

OUR REF : M14608

CLIENT : Terra Geotechnical

PROJECT : Robertson Fire Station

DATE RECEIVED : 2021.09.29

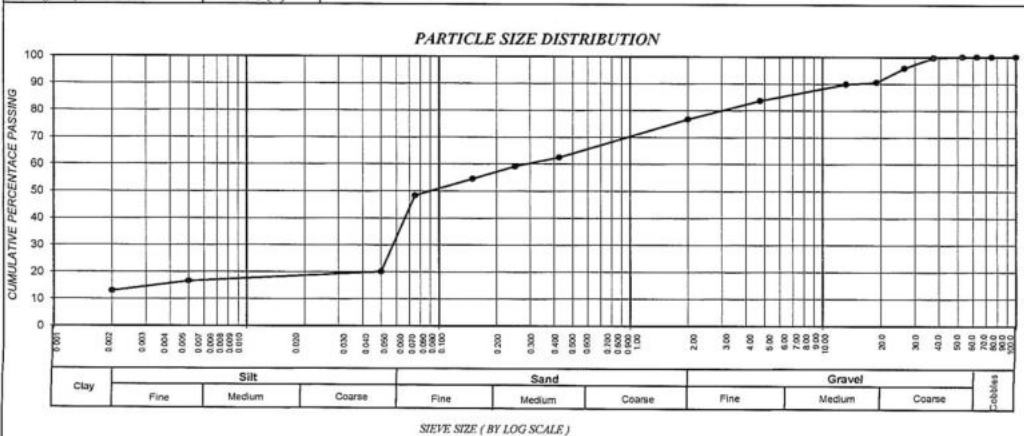
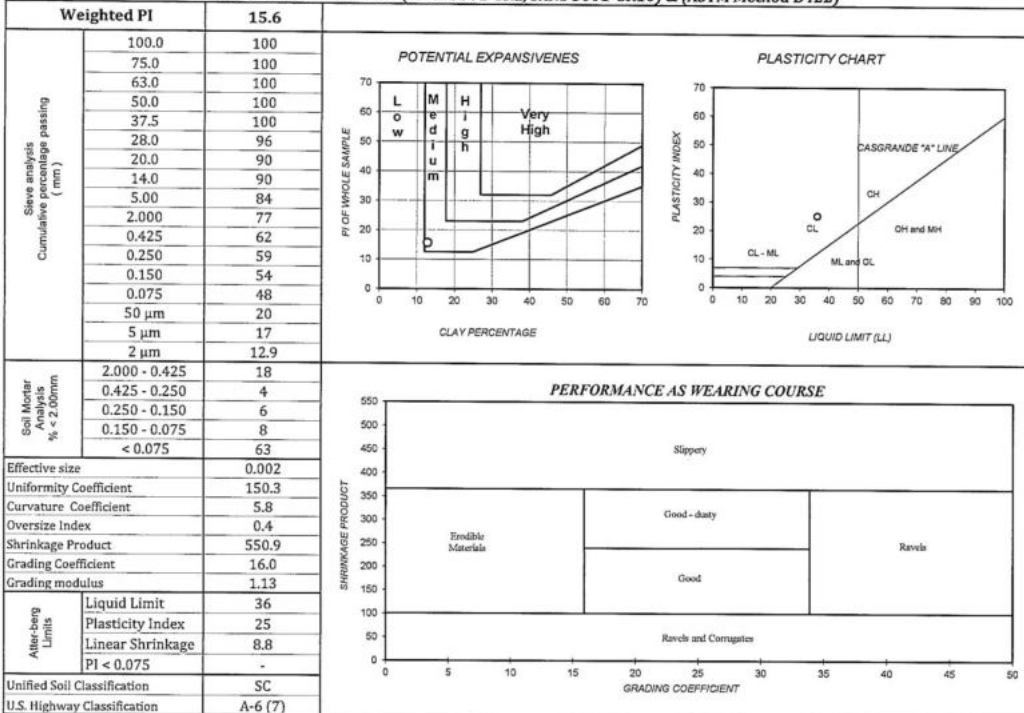
POSITION : TP4 (1100-1500mm)

LAYER : -

SAMPLE No. : 8621

SAMPLE DESCRIPTION : Dark Reddish Brown Silty Clayey + Q/S/S Pebbles
Clayey Silty Gravelly Sand

FOUNDATION INDICATOR - (SANS 3001-GR1, SANS 3001-GR10) & (ASTM Method D422)



CLAY (%) (0.001-0.002)	SILT (%) (0.002-0.060)	SAND (%) (0.060-2.00)	GRAVEL (%) (2.00-60.0)
12.9	15.7	47.9	23.5



Roadlab Mosslab
 7 Bally Crescent, Voorbaai
 P.O. Box 35, Hartenbos
 Tel: 084 799 0398
 Email: rohann@roadlab.co.za
 Web: www.roadlab.co.za

MOISTURE CONTENT RECORD FORM

Robertson Fire Station

Layer:

Date	Postion	Tin number	Tin weight	Wet + Tin	Dry + Tin	M% Oven
29/09/2021	TP4 (1100-1500mm)	CX26	34.1	1348.4	1057.7	28.4
					Average	28.4

Rohann Theart
 Technical Signatory



Job Request No.: M14608

Terra Geotechnical

Andre Nel Building

C/O Fynbos & Perdekui Avenue, Stilbaai
6674

Attention : Eugene Van Der Walt

Project : Robertson Fire Station

Full Classification SANS 3001

Roadlab Mossel Bay

7 Bally Crescent, Voorbaai

P.O. Box 35, Hartenbos

Tel: 084 799 0398 Fax:

Email: elizabeth@roadlab.co.za

Web: www.roadlab.co.za

Date Reported : 2021/10/11

SAMPLE INFORMATION AND PROPERTIES				
SAMPLE NO.	8619	8620		
HOLE NO. / Km / CHAINAGE				
ROAD NO. / NAME Line 1	N/P	N/P		
ROAD NO. / NAME Line 2				
LAYER TESTED/SAMPLED	TP3	TP 1		
SAMPLE DEPTH	0-700mm	1000-1900mm		
DATE SAMPLED	29/09/2021	29/09/2021		
COLOUR OF SAMPLE	Light Brown	Dark Reddish		
TYPE OF SAMPLE	Q/S/S+Calcrete Gravl	Clayey Sandstone		
SIEVE ANALYSIS - % PASSING SIEVES *(SANS 3001-GR1:2010, SANS 3001-GR2:2010)				
SIEVE ANALYSIS (GR 1) % PASSING	100.0 mm			
	75.0 mm			
	63.0 mm			
	50.0 mm			
	37.5 mm	100	100	
	28.0 mm	97	99	
	20.0 mm	93	98	
	14.0 mm	89	89	
	5.0 mm	68	70	
	2.0 mm	60	62	
0.425 mm	50	47		
0.075 mm	29	33		
GM %	1.6	1.6		
SOIL MORTAR ANALYSIS (SANS 3001-PR5:2011)				
COARSE SAND	2.000 - 0.425	16	25	
COARSE FINE SAND	0.425 - 0.250	8	5	
MEDIUM FINE SAND	0.250 - 0.150	10	7	
FINE FINE SAND	0.150 - 0.075	17	10	
SILT CLAY	0.075	48	53	
ATTERBERG LIMITS ANALYSIS - *(SANS 3001-GR10:2010)				
ATTERBERG LIMITS (%)	LIQUID LIMIT	24	38	
	PLASTICITY INDEX	8	20	
SANS GR10,GR11	LINEAR SHRINKAGE	3.0	6.5	
	H.R.B.	A-2-4(0)	A-2-6(2)	
CLASSIFICATION	COLTO	G8	-	
	TRH 14	G9	-	
CALIFORNIA BEARING RATIO - *(SANS 3001-GR30:2010, SANS 3001-GR40:2010)				
SANS GR30	OMC %	15.5	13.5	
MAX. DRY DENSITY	MDD (kg/m³)	1723	1868	
	COMP MC %	15.5	13.6	
SWELL % @	MOD NRB PRO	0.15 0.24 0.31	3.42 4.45 4.76	
	100 %	34	3	
	98 %	26	3	
C.B.R.	97 %	23	2	
SANS GR40	95 %	17	2	
	93 %	13	2	
	90 %	8	1	
STABILISER IN LAB				
TEST TYPE	CBR	CBR		
SAMPLING METHOD	TMH 5	TMH5		
WEATHER WHEN SAMPLED	Warm	Warm		
Deviation from Test Method : Samples & Delivered by Client.				
Remarks and Notes : Samples & Delivered by Client.				
Opinions and interpretations are not included in our schedule of accreditation. (T0947) The samples were subjected to analysis according to (SANS)(TMH5)(DOT)(ASTM) The test results reported relate to the samples tested. Further use of the above information the responsibility or liability of Roadlab. Document may only be reproduced of published in their full context. Report compiled by : Jessica Myburgh				
 Accreditation No. T0947 Prog.ver 10.7 (2019/11/07)		 Elizabeth Roux Mahager		

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APPENDIX C

C.1

DCP Test Results

