LETABA LAB (Pty) Ltd
CIVIL ENGINEERING MATERIALS LABORATORY

GEOTECHNICAL INVESTIGATION: RURAL RESIDENTIAL TOWNSHIP DEVELOPMENT MATOPORONG, REDDERSBURG

GIBB
ENGINEERING & SCIENCE

Letaba Lab

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MATOPORONG, REDDERSBURG

Conducted For:

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LIST OF ABBREVIATIONS AND DEFINTIONS

Calcrete	Calcrete is a calcium-rich hardened layer in or on a soil. It is formed from the deposition and cementation of calcareous materials as a result of climatic fluctuations in arid and semiarid regions.
CBR	**California Bearing Ratio** CBR is a penetration test for evaluation of the mechanical strength of road subgrades and base-courses. It was developed by the California Department of Transportation before World War II.
Excavation Classification	**Class A:** Hard rock excavation which may require the use of drill and blast methods to remove in-situ bedrock/boulder material to the required depth of excavation. **Class B:** Boulder or soft bedrock excavation which may require the use of heavy mechanical earth moving equipment to remove in-situ bedrock/boulder material to the required depth of excavation. **Class C:** In-situ material excavation which may require the use of light mechanical earth moving equipment or laborers through the use of a pick-and-shovel system to remove in-situ bedrock/boulder material to the required depth of excavation.
DCP	**Dynamic Cone Penetrometer** The DCP works by using a 8 kg steel mass dropping 575 mm which hits the anvil. Each stroke causes penetration of a 20mm diameter cone (60° vertex angle) which sits at the base of assembly into the soil (underlying surface). The penetration rate of the cone of the DCP is inversely proportional to the resistance level of the terrain. The DCP test is an in-situ CBR or density testing of the soil.
DPL	**Light Dynamic Penetrometer** The Light Dynamic Penetrometer (DPL) with manual driving is the one allowing dynamic penetration tests with the lightest hammer (10 kg) in the whole range of dynamic penetrometers. The apparatus, held by its handles, is maintained vertically. The constant falling heights of its hammer (50 cm) drive the rods - fitted with a standard cone - into the soil.
Ferricrete	Ferricrete is a iron-rich hardened layer in or on a soil. It is formed from the deposition and cementation of metallic materials (mainly iron and manganese) as a result of climatic fluctuations in arid and semiarid regions.
Excavatability	The excavatability of an earth (rock and regolith) material is a measure of the material to be excavated with conventional excavation equipment such as a bulldozer with rippers, light mechanical excavator or other grading equipment.
MOD AASHTO	**The Modified AASHTO** Soil Classification System which was developed by the American Association of State Highway and Transportation Officials, and is used as a guide for the classification of soils and soil-aggregate mixtures for highway construction purposes.
Residual soil	Residual soils are soils that develop from the complete weathering of their underlying parent rocks and have the same general chemistry as those rocks.
Scree	Scree is a collection of broken/loose rock fragments and debris at the base of mountain cliffs or valley shoulders that has accumulated through periodic rock falls from adjacent cliff faces and mountain sides.
TP	**Test Pit** An excavation unit used to sample or probe a site before large-scale excavation or to check surface surveys. Typically small square trenches or holes arranged in such a way as to sample a site.
Transported Soil	Soils which form from the accumulation of material which has been transported by wind, water, ice and/or gravity.

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1 Introduction

1.1 General

A detailed geotechnical investigation was conducted within the proposed location for the extension of the existing Maroporong Rural Settlement to the south west of the town of Reddersburg, in the Free State Province. 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.

1.2 Terms of Reference

Letaba Lab was appointed by GIBB Engineering and Science, as confirmed by means of a Letter of Appointment dated 2014/03/06. The client stipulated the quantity of test pits across the site in accordance with his final outcome requirements.

1.3 Scope of the investigation

The investigation had the following aims:

- to determine and describe the succession of soil and rock materials occurring beneath and across the site
- to assess the mechanical properties of the soil material covering the study area with regard to the founding of single- and double storey structures
- to evaluate site excavatability
- to recommend measures to be implemented during design and development of the area

The development potential of the study area is assessed based on the following premises:

- Single- and double storey masonry structures will be constructed.

It must be noted that this investigation was conducted for design and construction purposes.

1.4 Available information

The following sources of information were utilized:

- Geological maps:
    - 2926 Bloemfontein; scale 1 : 250 000 (digital copy)
- Topocadastral Map
    - 2926 CA (digital format)
- Site development plan
    - Compiled by: L. Pienaar
    - Date: 23/07/13
    - Scale 1:10000
    - DWG format
    - Document number- 200365/1- Draft 1
- Geotechnical site layout:
    - Google Earth and Google Maps

1.5 Development within 1 : 100 year-flood lines

It must be noted that the National Water Act (Act 36 of 1998) states the following regarding development within the 1 : 100 year-flood line of any stream or river (Thompson, 2006):

Section 21(c):

> Impeding or diverting the flow of water in watercourses (including alteration of the hydraulic characteristics of flood events) requires licensing according to the Act

Section 21(i):

> Any action that may alter the bed, banks, courses or characteristics of watercourses (including flood events) requires licensing according to the Act, including:
>
> i. widening or straightening of the bed or banks of a river to allow for the construction of a bridge, sports ground or housing development
>
> ii. altering the course of a river partially or completely (i.e.: river diversion) to be able to use or develop the area where the watercourse originally was.

2 Description of Environment

2.1 Site location and Description

The study area is defined as a roughly rhombus shaped parcel of land approximately 80 ha in size, located within close proximity of the Matoporong Rural Settlement. The study area forms as part of the proposed extension of the above mentioned rural settlement towards the south. The site is located approximately 1.5 kilometers south west of the town of Reddersburg in the central portion of the Free State Province. (Figure 1). The extension of this settlement will encompass the subdivision of the site into various land-use zones i.e. residential, recreational, business and roads (Figure 3). Each of these zones may require their own set of unique geotechnical recommendations determined by the consistency/properties of the in-situ material.

Moreover, Reddersburg is situated approximately 75 kilometers directly south of the capital of the Free State Province, Bloemfontein, along the National Road 6 (N6) South Africa. It must be noted that unplanned development consisting of both rural homes and roads has taken place within the proposed site layout area as provided by the client; geotechnical testing did however commence within these areas.

The site for this investigation is located roughly at the following coordinate:

Latitude: 29.658817° S **Longitude:** 26.160459° E

2.2 Topography

The site is located at an elevation of between approximately 1415 and 1435 meters above mean sea level (mamsl).

The study area is deemed to be notably flat, displaying slopes of **less than 2º.**

The contours of the site indicate that the slopes generally lead from the higher areas in the east and south east, towards the lower lying areas in the west and north west. The slopes in the western, northern and central portions of the site are seen to be relatively flat, with slopes eastern and south eastern portions seen to be slightly steeper. (Figure 4)

The natural surface of the site hosts small/localised excavated areas or areas which have been altered by human activity though the construction of minor road systems, small scale agricultural activity and general land degradation.

2.3 Drainage

Due to its' slope, the site will drained mainly by means of slow/low energy surface run-off (sheet-flow) with storm water eventually flowing from the east towards the west, towards the perennial river which occurs approximately 2.5 km west of the site. Minor drainage structures in the study area will direct the surface flow west and south west, towards the major perennial drainage structure, namely the Fouriespruit. This meandering river flows in a south westerly.

The gentle sloping nature of the site will lead to the formation of erosional structures such as ruts and gullies especially when natural vegetation is removed and storm-water catchment is multiplied due to infrastructure.

2.4 Climate

The Matoporong Rural Settlement falls within close proximity of the town of Reddersburg and will therefore fall under a similar climatic regime. Reddersburg normally receives about 337mm of rain per year, with most rainfall occurring during late summer. It receives the lowest rainfall (3mm) in July and the highest (58mm) in March. The average midday temperatures for Reddersburg range from 15.6°C in June to 29.3°C in January. The region is the coldest during July when the mercury drops to 0°C on average during the night.

The Climatic N-Value (Weinert, 1980) for the area is between **5 and 6**; indicating that principle mode of weathering within the regional setting will be the physical/mechanical disintegration of the parent rock rather than the chemical decomposition of the in-situ parent rock which can be expected in areas with a wetter climate. This mode of weathering will affect the evolution of the soil material deposited across the site over time.

2.5 Vegetation

The site was seen to exhibit a **grassland** type vegetation with the occasional shrubs and bushes. The natural vegetation has been denude to a degree due on-going human activities within the study area. The notable low rainfall and wide temperature ranges has led to the formation of a dry land surface fully exposed to the natural elements (i.e. wind, water and ice). The scattered grass structures indicate the presence of on-going desertification.

3 Site Geology and Groundwater Seepage

3.1 Regional stratigraphic setting

According to the available geological information (geological series map: 2926 Bloemfontein (1981)); the study area is mainly underlain by SANDSTONES, MUDSTONES, SHALES AND MINOR CONGLOMERATES belonging to the lower most portions of the Karoo Supergroup (Figure 2). This material is common through the western and southern portion of the Freestate Province and was seen to be deposited in layers within the Paleo-Karoo Basin and deep/steep synclinal structures and within faulted geological terrains. The material present within the site boundaries should be the result of various transport mechanisms and agents and will therefore display highly variable geotechnical characteristics. Due to the depositional nature of the material it can predicted that it will be horizontally continuous.

It must be noted that due to the loose deposition of the material across the sites surface, localised slope and erosion processes can lead to the formation of highly undulating site morphologies. The transport mechanism of the parent material and the evolution of the lands surface within the study area, over geological time, will lead to the formation of material with its own set of unique geotechnical properties; these properties can potentially be highly localised.

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

3.2 Prominent geological structures

The available geological information indicates no evidence for the presence of any large geological structures within close proximity to the site. The young age of the surficial material and underlying geology serves as a good indication to the absence of various periods/cycles of deformation such as alternating folding and faulting events. These structures can however be present within the basement rock (older) of the area, however, no evidence of such structures were noted on the site due to the shallow depths of excavations and the absence of bedrock out crops.

3.3 Groundwater occurrences

Significant groundwater seepage was **not** encountered in the test pits. The presence of pedogenic material (i.e. Calcrete and ferricrete) is mainly due to the evaporation of in-situ soil moisture resulting in the deposition/precipitation of these minerals and indicates the presence of seasonal perched water tables after prolonged episodes of precipitation.

4 Nature of the investigation

4.1 Desk 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
- the planning and distribution of field testing locations

4.2 Field work

The field work phase was done by Letaba Lab Bloemfontein on the following date: 2014/03/26. Test pits and DPL tests were placed throughout the study area in such a way as to accurately describe the general soil conditions occurring within the boundaries of the study area. The succession of soil and rock layers exposed within the test pits were logged 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. (Figure 5)

4.3 Laboratory testing

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

- Standard **foundation indicator tests** were conducted by Letaba Lab Bloemfontein 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:

    i. Atterberg Limits (Liquid Limit and Plasticity Index) and Linear Shrinkage

    ii. Particle-size distribution

    iii. pH and Electrical Conductivity analysis

- Standard **road indicator tests** were conducted by Letaba Lab Bloemfontein 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:

  i. Maximum Dry Density versus Optimum Moisture Content

  ii. 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 construction and excavatability.

5 Geotechnical Setting

5.1 Trenching

5.1.1 Excavation of test pits

A total of five test pits, numbered TP1 to TP5, were excavated by means of a TLB-type light mechanical excavator (TLB details: KOMATSU WB93R, 2008) , at which time the exposed soil layers were profiled and sampled. Test pits were orientated in a set structure as to accurately map the geotechnical properties of the site in all directions.

Test pit layout can be viewed in Figure 5.

5.1.2 Generalised engineering geological parameters

The following **general** engineering geological characteristics were noted:

- Excavatability

  The TLB- type light mechanical excavator generally did **not** experience any trouble excavating test pits to a depth of **1.2 m** below the natural ground level, with the exception of test pit TP3 where refusal of the TLB-type light mechanical excavator took place at a depth of **0.70** meters below natural ground level.

- Rock- and/or pedocrete outcrops

  Bedrock outcrop was **not** encountered within the study area.

- Sidewall stability

  The excavation sidewalls generally remained stable for a period of at least 1 hour with little or no over-break or collapse occurring

- Groundwater seepage

  Significant groundwater seepage was **not** encountered in the test pits.

5.1.3 Generalized soil profile

Note: this description is based on field observations, and does **not** reflect the results of any laboratory tests.

The results of the trenching phase indicate that the study area is covered by a variable thickness of topsoil, comprising of transported material followed by a soil horizon deemed to be of a residual origin.

It must be noted that the soil and rock material seen to transgress the study area is slightly variable due to the sites morphology, topography, climate and the elevated biological activity. Each soil horizon present in the study area displays its own unique gradational change in material properties, both laterally and vertically. This change is induced through the constant fluctuations in moisture within the soil horizons.

Soil profiles are included as Appendix A.

5.1.3.1 Transported Material

The area is seen to be covered by a variable topsoil layer deemed to be comprised of transported material of an aoelian and alluvial origin. This material is present as loose to medium dense, dry to slightly moist, dark brown, silty/clayey sand and silty/clayey gravel, with the inclusion of abundant dense root structures. The above mentioned transported material horizons display minor mottled and stained colour inclusions indicating the presence of vertical and lateral fluid movement within these horizons.

The topsoil is seen to occur from the surface to depths of between 0.40 and 0.60 m below the natural ground level.

5.1.3.2 Residual material

The above mentioned transported material is underlain by material deemed to be of a residual origin. This residual material has formed directly from the complete weathering of the in-situ bedrock (sandstone), as such it will have similar mineralogical properties to that of the bed rock but will have the structural properties of soil. The ongoing weathering of the in-situ bedrock has led to the formation of a dense to very dense, dry, light yellowish brown and light reddish yellow, silty/clayey sand and silty sand. This horizon is seen to host cobble sized core stones as well as occasional root structures. This residual material horizon displays stained colour inclusions, indicating the presence of vertical and lateral fluid movement within these horizons.

This residual soil horizon is seen to occur from the base of the transported horizon and seen to have a thickness of up to 1.2 m. The thickness of this horizon links directly to the limit/level of weathering of the in-situ bedrock.

It was within this horizon where refusal took place within very dense residual material.

5.1.4 Light Dynamic Penetrometer Tests

DPL test were carried out across the site to assess the consistency of the in-situ subsoils and provide an indication of the founding conditions and depth to bedrock beneath the site.

DPL tests were performed at natural moisture conditions and thus the values vary greatly from the CBR results measured under controlled conditions within the laboratory. This variation is mainly due to the lab specimens being analysed under saturated conditions. It should be noted that the strength of the in-situ soil changes greatly with change in moisture conditions.

DPL test should therefore only be used as indicative statistics for the site.

It must be noted that the results of the DPL tests completed across the site were relatively uniform with few discrepancies as compared to the excavation depths accomplished by the TLB-type light mechanical excavator.

Final depths below natural ground level range from 0.81 and 1.49 to 1.75 and 2.1 m.

The presence of abundant gravel-and cobble- and boulder sized particles within soil horizons as well as the moisture content within each horizon may have had a detrimental effect on the accuracy of the DPL results.

Full DPL results can be viewed in Appendix C

5.2 Engineering- and material characteristics

5.2.1 Sampling

The following samples were taken:

Disturbed Samples	:	4 x Transported
		1x Residual
Bulk samples	:	1 x Transported
		4 x Residual

Detailed soil test results for both the disturbed and bulk samples are included in Appendix B

5.2.2 Soil test results: Transported Material

In the light of the soil test results and visual observations, the geotechnical characteristics of the all the transported horizons can be summarised as **one** geotechnical entity as follows:

- This material is deemed to be **compressible and potentially collapsible**, with a calculated total **collapse settlement** of between **10 and 20 mm.**
- With reference to the pH and EC test conducted on the material, the material is deemed to be **slightly basic** and therefore **non-corrosive** to steel and concrete.

The results of road indicator test conducted on the disturbed and bulk samples of this material can be summarized as follows:

- This material is deemed to be moderately plastic with PI values between 7 and 18.
- This material classifies as **a G8-** type material according to the COLTO-classification system.

  The results of these tests indicate that this material reacts well to compaction, with a CBR-value of 10 at a compaction effort of 90% MOD AASHTO increasing to 29 at 100% MOD AASHTO. This translates to a calculated bearing capacity value of 105 kPa at 93% MOD AASHTO, allowing for a Factor of Safety of 1.5.

5.2.3 Soil test results: Residual Material

In the light of the soil test results and visual observations, the geotechnical characteristics of the all the residual horizons can be summarised as **one** geotechnical entity as follows:

- This material is deemed to be **compressible and potentially collapsible**, with a calculated total **collapse settlement** in **excess of 20 mm.**
- With reference to the pH and EC test conducted on the material, the material is deemed to be **slightly basic** and therefore **non-corrosive** to steel and concrete.

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

- This material is deemed to be moderately plastic with PI values between 6 and 18
- This material classifies as **a G7 and worse than G9-** type material according to the COLTO-classification system.

  The results of these tests indicate that this material reacts variably to compaction, with CBR-values of between 10 and 28 at a compaction effort of 90% MOD AASHTO increasing to between 34 and 63 at 100% MOD AASHTO. This translates to a calculated bearing capacity value of between 185 and 230 kPa at 93% MOD AASHTO, allowing for a Factor of Safety of 1.5.

5.2.4 Material usage

In light of the above mentioned soil tests which were completed on all the samples across the site the material classifies as a **G7-, G8- and worse than G9- type** material and can therefore be used as sub base and subgrade in road construction. It must be noted that this material is not of a sufficient quality (i.e. has very poor bearing capacity) to be used in soil rafts and foundations etc. If material is required for this purpose it should be imported from a local source.

5.3 Slope stability

In the light of the **gentle slopes** (less than 2°) present across the site, specialised methods for the stabilisation of cuts into the natural slopes are not deemed necessary.

5.4 Excavation classification

Significant problems **are not** foreseen during the excavation of **shallow foundation trenches** to a depth of up to 0.70 m. Significant problems **are** foreseen during the **excavation of deep service trenches** through the use of a TLB-type light mechanical excavator. The topography/slope of the site and the accessibility of the site will have a positive effect on the excavatability of the It must be noted that the conditions of the site can vary over short distances due to the transported nature of the material, so excavatability should be accessed on-site accordingly.

The following additional comments on excavation of service trenches apply:

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

5.5 Impact of geotechnical character on development

The geotechnical characteristics exhibited by the soil material covering the study area is deemed to have the following effects with regard to development:

1. Seepage / groundwater

   = Not applicable.

2. Erodability of soil

   The average slope across the area is less than 1 : 7.5 and some of the material (especially within the uppermost transported horizons) classifies as CL according to the Unified Soil Classification.

   = Not applicable.

3. Difficulty of servicing of land due to slopes

   Type 1 site: The average slopes across the site is steeper than 1 : 100 but is flatter than 1 : 20.

   = Difficulties associated with the provision of waterborne sanitation and the drainage of sites. Provision of pump stations.

4. Difficulty of excavation

   Average slope measured across the erf in any direction is flatter than 1 : 10 and in excess of 40% of the material to a depth of 1.5 m below pre-development level is classified as hard excavation.

   = Additional cost of trench excavations.

5. Precautionary measures in sites underlain by dolomite / limestone

   The study area is not deemed dolomitic land.

   = Not applicable.

6 Site Classification

6.1 General

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

These include (in order of importance):

- The occurrence of compressible and potentially collapsible material throughout the study area.
- The presence of very dense material at shallow depths.
- The presence of notably gentle slopes (less than 2°)

However, these characteristics do not disqualify the site from being used for the proposed settlement, but rather require the implementation of site-specific precautionary measures.

6.2 Site Classification

In the light of the results of this study, the study area can be divided into the following development potential zones (Figure 6):

- **Zone A**

This zone forms the central portion of the study area and is deemed the most suitable for the proposed development, provided due cognisance is given to the following characteristics during the design and construction phases of the development:

- The presence of **compressible and potentially collapsible material,** with an expected **total collapse settlement** in excess of **20 mm,** that will require specialised foundation design and construction methods.
- The presence of slopes across the study area which are **less than 2°.**

Zone A classifies as Site Class **S2/C** according to the system used by the National Home Builders Registration Council (NHBRC) and as a **2D** Moderate soil compressibility predicted**, 2I** Slopes of less than 2 degrees **-**type site according to the classification system proposed by Partridge, Wood and Brink (1993).

- **Zone B**

This zone forms the portion of the study area deemed less suitable for the proposed development, but may still be developed provided due cognisance is given to the following characteristics during the design and construction phases of the development:

- The presence of **compressible and potentially collapsible material,** with an expected **total collapse settlement** in excess of **20 mm,** that will require specialised foundation design and construction methods.
- **Difficulty of excavation** to a depth of 1.5 m below the natural ground level.
- The presence of slopes across the study area which are **less than 2°.**

Zone B classifies as Site Class **S2/C** according to the system used by the National Home Builders Registration Council (NHBRC) and as a **2D** Moderate soil compressibility predicted**, 2F** Rock or hardpan pedocretes between 10% and 40% of the total volume to a depth of 1.5 m, **2I** Slopes of less than 2 degrees **-**type site according to the classification system proposed by Partridge, Wood and Brink (1993).

- **Zone C**

This zone forms the portion of the study area deemed the least suitable for the proposed development, but may still be developed provided due cognisance is given to the following characteristics during the design and construction phases of the development:

- The presence of **compressible and potentially collapsible material,** with an expected **total settlement of** between **10 and 20 mm,** that will require specialised foundation design and construction methods.
- **Difficulty of excavation** to a depth of 1.5 m below the natural ground level.
- The presence of slopes across the study area which are **less than 2°.**

Zone C classifies as Site Class **S1/C** according to the system used by the National Home Builders Registration Council (NHBRC) and as a **3F Rock or hardpan pedocretes in excess of 40% of the total volume to a depth of 1.5 m** , **2D** Moderate soil compressibility predicted**, 2I** Slopes of less than 2 degrees **-**type site according to the classification system proposed by Partridge, Wood and Brink (1993).

6.3 Detailed Site Suitability evaluation

6.3.1 Soil excavatability

- **Zone A**

Significant problems **are not** foreseen during the excavation of **shallow foundation trenches** as well as **deep service trenches** through the use of a TLB-type light mechanical excavator to a depth of 1.5 meters below the natural ground level; thereafter excavatability is expected to decrease.

- **Zone B**

Significant problems **are not** foreseen during the excavation of **shallow foundation trenches** to a depth of 1.2 meters below the natural ground level. Thereafter, significant problems are foreseen during the excavation of **deep service trenches** through the use of a TLB-type light mechanical excavator.

- **Zone C**

Significant problems **are not** foreseen during the excavation of **shallow foundation trenches** to a depth of 0.7 meters below the natural ground level. Thereafter, significant problems are foreseen during the excavation of **deep service trenches** through the use of a TLB-type light mechanical excavator.

6.4 Slope stability

- **All Zones**

In the light of the very gentle slopes present throughout the study area, specialised methods for the stabilisation of the natural slopes are not deemed necessary.

The sidewalls of deep trenches must preferably be supported to prevent injury or loss of life through sidewall collapse.

7 Foundation Recommendations and Solutions

7.1 Zone A and B

The results of this investigation reveal that the soils covering the study area may undergo a degree of **consolidation and collapse** (i.e.: loss of volume) under loading or when saturated, requiring that structures be adequately strengthened to prevent structural damage due to **settlement** beneath foundations.

It is thus recommended that EITHER of the following foundation designs be utilised for structures to be placed within this zone:

OPTION 1

Stiffened strip footings or cellular raft

- Stiffened or cellular raft with articulation joints or lightly reinforced masonry.
- Site drainage and plumbing/service precautions
- Bearing pressures not to exceed 50 kPa
- Fabric pressure not to exceed 50 kPa

OPTION 2

Deep strip foundations

- Normal construction with drainage requirements
- Founding on a competent horizon below problem horizon
- Fabric re-enforcement in floor slabs

OPTION 3

Soil raft:

- Remove in-situ material to 1.0 m beyond the perimeter of the structure and replace with inert backfill, compacted to 93% MOD AASHTO density at -1% to +2% of optimum moisture content. (material on-site is in sufficient for use as a backfill material)
- Normal construction with lightly reinforced strip footings and light reinforcement in masonry
- Site drainage and plumbing/service precautions.

It must be noted that differential settlement is assumed to equal 50% of the total settlement. The relaxation of some of these requirements, e.g. the reduction or omission of steel or articulation joints, may result in a Category 2 level of expected damage. Furthermore these are merely recommendations. Please consult a qualified professional for additional options and final designs.

7.2 Zone C

The results of this investigation reveal that the soils covering the study area may undergo a degree of **consolidation and collapse** (i.e.: loss of volume) under loading or when saturated, requiring that structures be adequately strengthened to prevent structural damage due to **settlement** beneath foundations.

It is thus recommended that EITHER of the following foundation designs be utilised for structures to be placed within this zone:

OPTION 1

Modified Normal

- Reinforced strip footings.
- Articulation joints at some internal and external doors
- Light reinforcement in the Masonry
- Site drainage and plumbing/service precautions
- Bearing pressures not to exceed 50 kPa

OPTION 2

Deep strip foundations

- Normal construction with drainage requirements
- Founding on a competent horizon below problem horizon
- Fabric re-enforcement in floor slabs

OPTION 3

Soil raft:

- Remove in-situ material to 1.0 m beyond the perimeter of the structure and replace with inert backfill, compacted to 93% MOD AASHTO density at -1% to +2% of optimum moisture content. (material on-site is in sufficient for use as a backfill material)
- Normal construction with lightly reinforced strip footings and light reinforcement in masonry
- Site drainage and plumbing/service precautions.

It must be noted that differential settlement is assumed to equal 50% of the total settlement. The relaxation of some of these requirements, e.g. the reduction or omission of steel or articulation joints, may result in a Category 2 level of expected damage. Furthermore these are merely recommendations. Please consult a qualified professional for additional options and final designs.

8 Drainage

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 seasonal formation of perched water tables (i.e.: short-term groundwater seepage) within the soil material at shallow depth
- 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:
    a. the cultivation of a natural soil cover (e.g.: grass)
    b. compaction of the soil surface
    c. 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

8.2 Sub Surface Drainage

The seasonal occurrence of perched water tables at relatively shallow depth within the study area may lead to structural damage due to rising damp.

- However, implementation of a sub-surface drainage system is not deemed necessary if adequate damp-proofing measures are taken beneath individual structures, and the above-mentioned surface drainage system is implemented.

9 Conclusions and recommendations

1. A detailed geotechnical investigation was conducted within the proposed location for the extension of the existing Maroporong Rural Settlement to the south west of the town of Reddersburg, in the Free State Province. 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.

2. In the light of the results of this study, it can be stated that the natural soil underlying the study area exhibit some adverse geotechnical characteristics that may require the implementation of specific design and/or precautionary measures to reduce the risk of structural damage, or may hamper the development of certain areas. However, these characteristics do not disqualify the site from being used for the proposed development, but rather require the implementation of site-specific precautionary measures during the design and construction phases of the development.

   The whole study area is deemed suitable for development, but will require that due cognisance be given to the following adverse geotechnical characteristics:

   - The occurrence of **compressible and potentially collapsible** material throughout the study area.
   - The presence of very dense material at **shallow depths.**
   - The presence of notably gentle slopes **(less than 2°)**

3. The site can be further classified in development potential zones:

   - **Zone A**

   This zone forms the central portion of the study area and is deemed the most suitable for the proposed development, provided due cognisance is given to the following characteristics during the design and construction phases of the development:

   - The presence of **compressible and potentially collapsible material,** with an expected **total settlement** in excess of **20 mm,** that will require specialised foundation design and construction methods.
   - The presence of slopes across the study area which are **less than 2°.**

   Zone A classifies as Site Class **S2/C** according to the system used by the National Home Builders Registration Council (NHBRC) and as a **2D** Moderate soil compressibility predicted, **2I** Slopes of less than 2 degrees **-**type site according to the classification system proposed by Partridge, Wood and Brink (1993).

➢ **Zone B**

This zone forms the portion of the study area deemed less suitable for the proposed development, but may still be developed provided due cognisance is given to the following characteristics during the design and construction phases of the development:

- The presence of **compressible and potentially collapsible material,** with an expected **total settlement** in excess of **20 mm,** that will require specialised foundation design and construction methods.
- **Difficulty of excavation** to a depth of 1.5 m below the natural ground level.
- The presence of slopes across the study area which are **less than 2°.**

Zone B classifies as Site Class **S2/C** according to the system used by the National Home Builders Registration Council (NHBRC) and as a **2D** Moderate soil compressibility predicted, **2F** Rock or hardpan pedocretes between 10% and 40% of the total volume to a depth of 1.5 m, **2I** Slopes of less than 2 degrees **-**type site according to the classification system proposed by Partridge, Wood and Brink (1993).

➢ **Zone C**

This zone forms the portion of the study area deemed the least suitable for the proposed development, but may still be developed provided due cognisance is given to the following characteristics during the design and construction phases of the development:

- The presence of **compressible and potentially collapsible material,** with an expected **total settlement of** between **10 and 20 mm,** that will require specialised foundation design and construction methods.
- **Difficulty of excavation** to a depth of 1.5 m below the natural ground level.
- The presence of slopes across the study area which are **less than 2°.**

Zone C classifies as Site Class **S1/C** according to the system used by the National Home Builders Registration Council (NHBRC) and as a **3F Rock or hardpan pedocretes in excess of 40% of the total volume to a depth of 1.5 m** , **2D** Moderate soil compressibility predicted, **2I** Slopes of less than 2 degrees **-**type site according to the classification system proposed by Partridge, Wood and Brink (1993).

4. The soil excavatability is highly variable across the site and can be summarised as follows within each zone:

➢ **Zone A**

Significant problems **are** **<u>not</u>** foreseen during the excavation of **shallow foundation trenches** as well as **deep service trenches** through the use of a TLB-type light mechanical excavator to a depth of 1.5 meters below the natural ground level; thereafter excavatability is expected to decrease.

- **Zone B**

  Significant problems **are <u>not</u>** foreseen during the excavation of **shallow foundation trenches** to a depth of 1.2 meters below the natural ground level. Thereafter, significant problems are foreseen during the excavation of **deep service trenches** through the use of a TLB-type light mechanical excavator.

- **Zone C**

  Significant problems **are <u>not</u>** foreseen during the excavation of **shallow foundation trenches** to a depth of 0.7 meters below the natural ground level. Thereafter, significant problems are foreseen during the excavation of **deep service trenches** through the use of a TLB-type light mechanical excavator.

5. In the light of the results of this investigation, it is recommended that foundation- and service trenches be inspected by an engineering geologist or geotechnical engineer in order to identify and assess any variance in the geotechnical character exposed in these trenches.

10 Bibliography

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MAPS

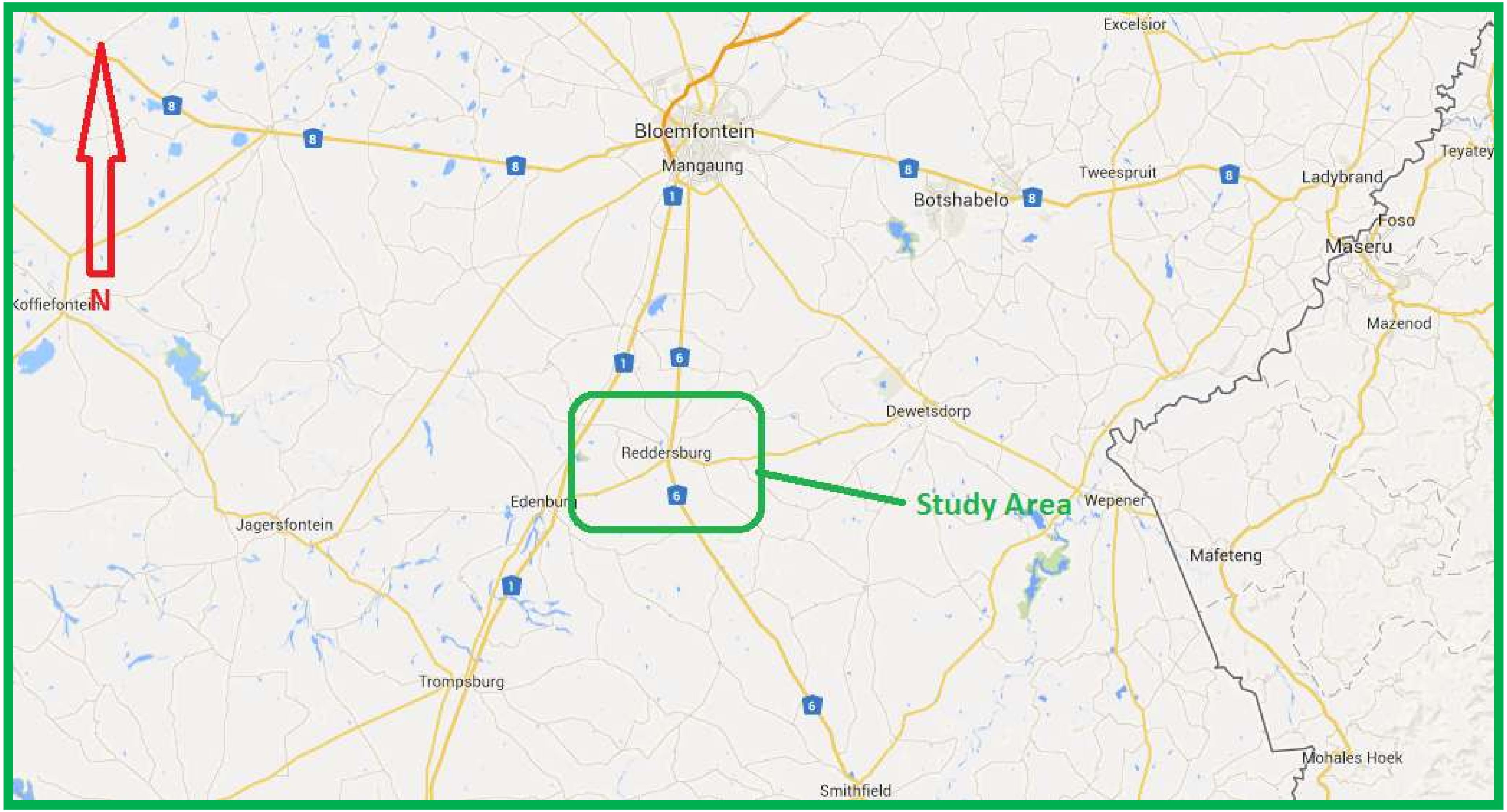


Figure 1: Study Area Location

Figure 2: Regional Geology Map- Light yellow is deemed Quaternary Sediments (as described in text)

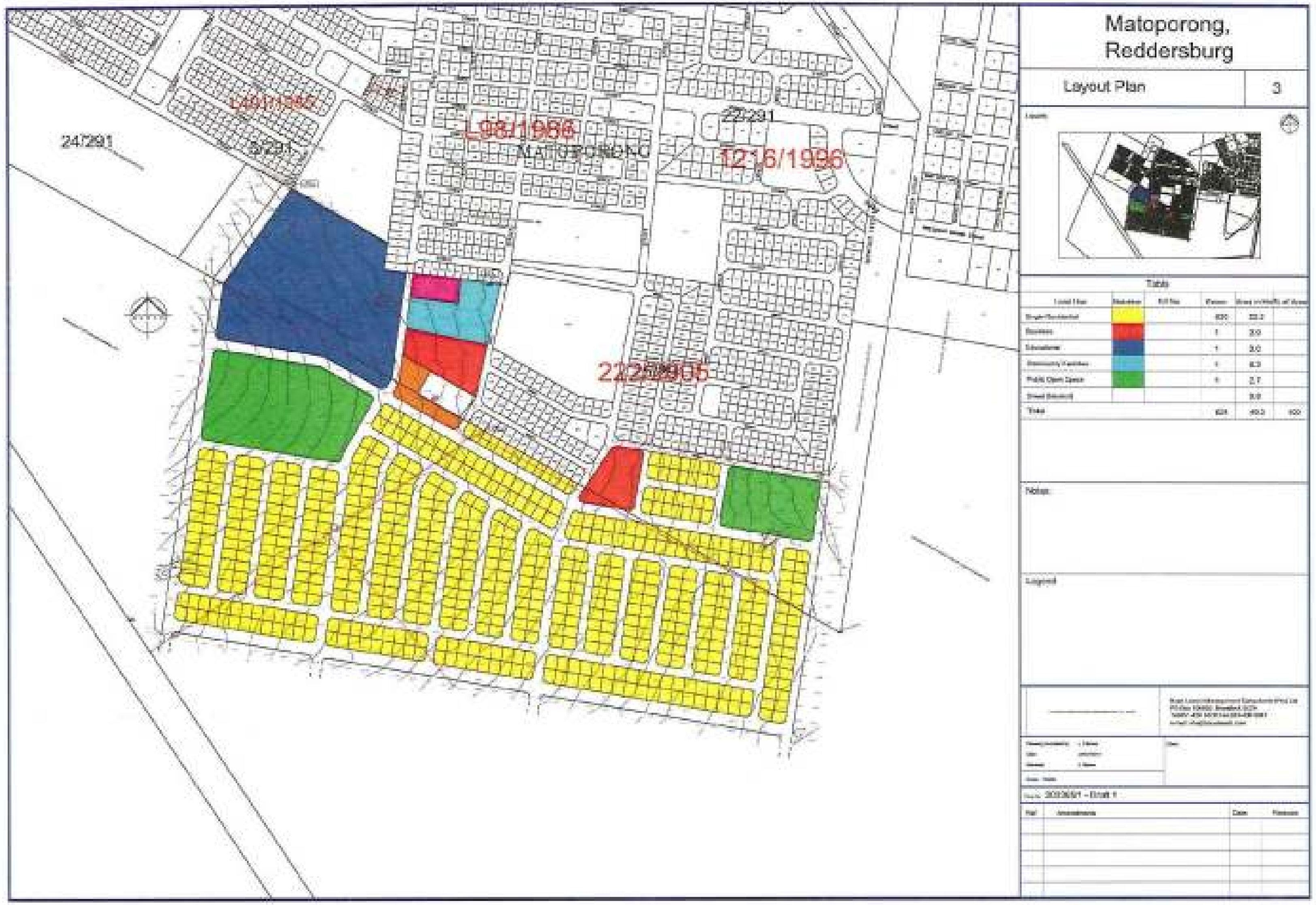


Figure 3: Site Layout Provided by the Client

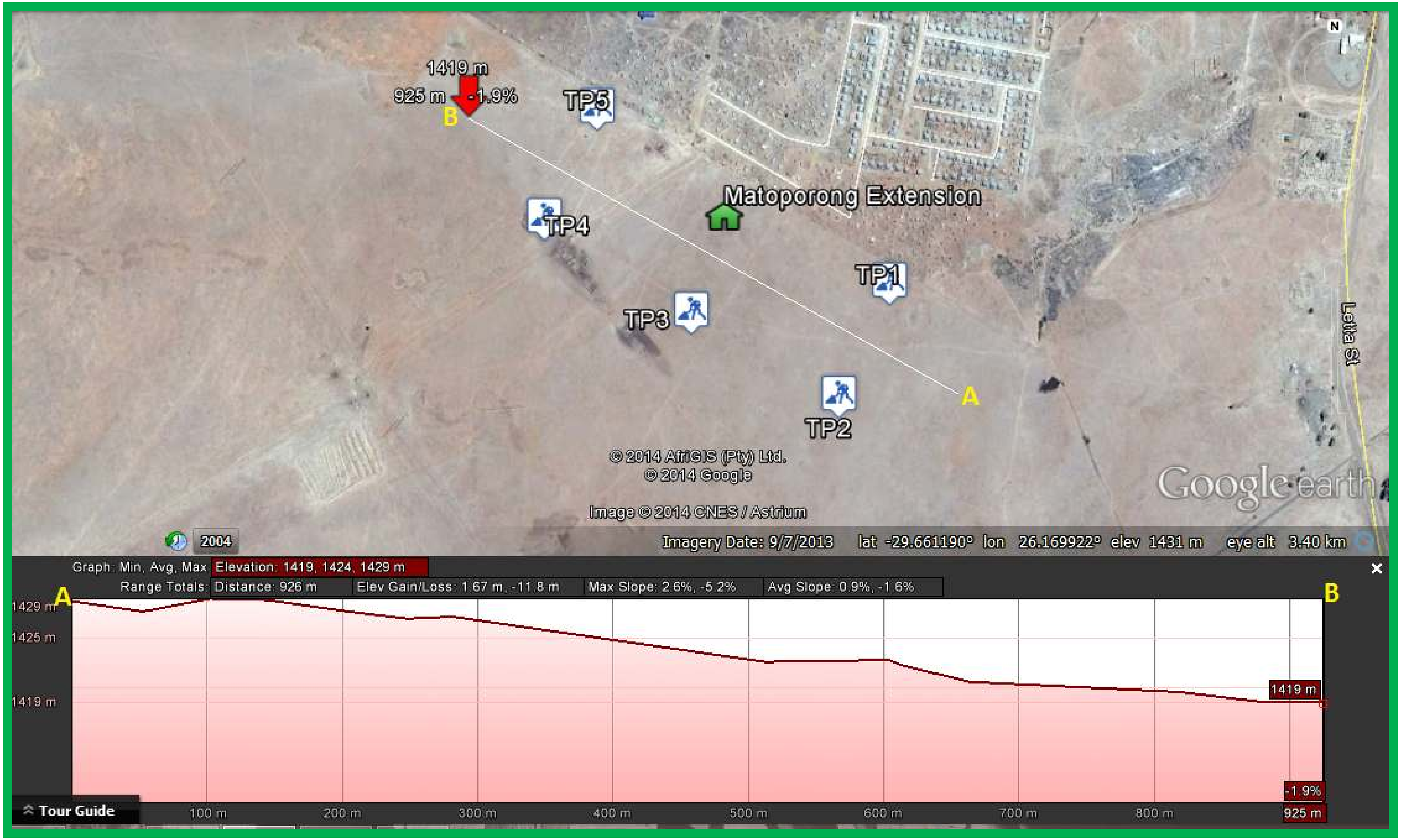


Figure 4: Study Area Location with a cross-sectional view of the site from A to B.

Figure 5: Study Area- Layout Map

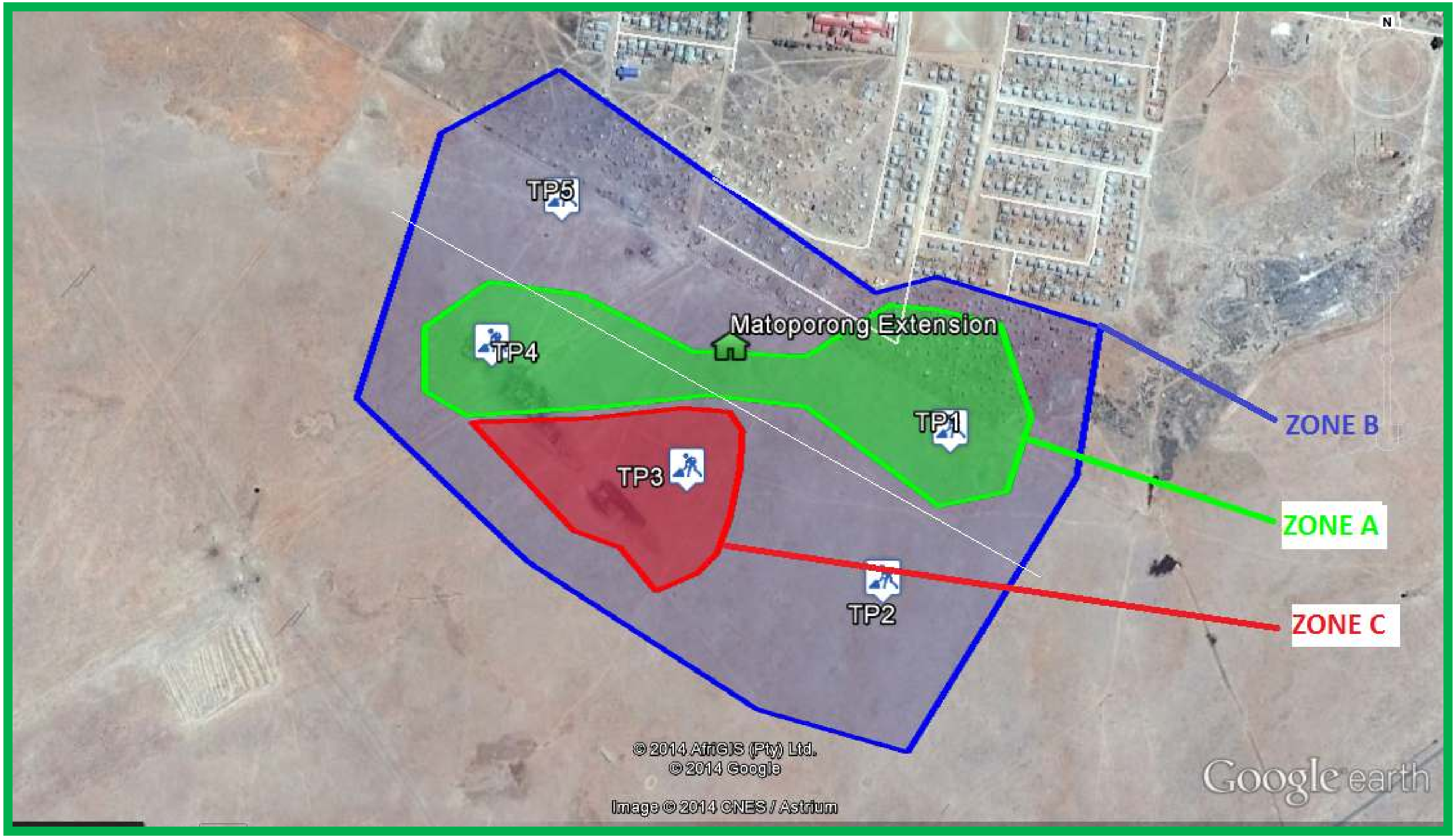


Figure 6- Study Area- Development Potential Zonation

LETABA LAB MATOPORONG-REDDERSBURG

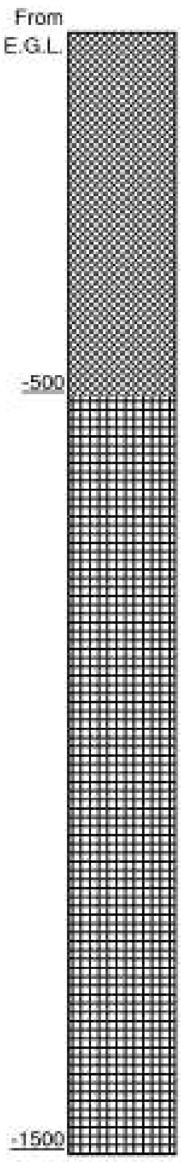
GPS CO-ORDINATES		
TP:	CO-ORDINATES	DPL No.
PROPOSED CONSTRUCTION AREA COVERED		
TP: 1	S29°39.581' E26°09.798'	DPL No. 1
TP: 2	S29°39.677' E26°09.745'	DPL No. 2
TP: 3	S29°39.602' E26°09.595'	DPL No. 3
TP: 4	S29°39.518' E26°09.442'	DPL No. 4
TP: 5	S29°39.420' E26°09.498'	DPL No. 5

Appendix A

Soil Profiles

LETABA LAB **SOIL PROFILES FOR Gibb Engineering & Science - Reddersburg**

Soil profile for TP No : 1



dry light Brown , med dense , silty/clayey sand , transported - roots :- Sample No : 1980/9

dry light Yellow , very dense , sub-angular sandstone, residual - roots and Refusal with TLB :- Sample No : 1980/10

LETABA LAB **Gibb Engineering & Science - Reddersburg**

Test Pit 1

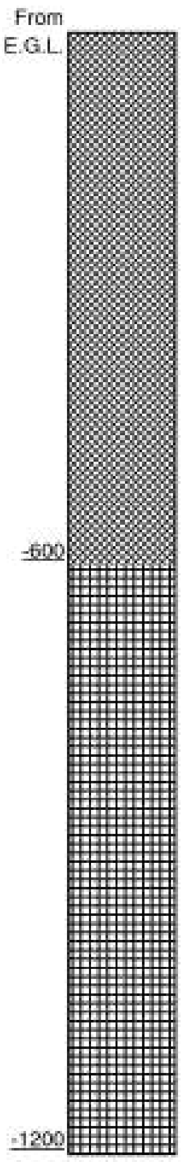
North from TP 1

South from TP 1

Profile - Test Pit 1

LETABA LAB **SOIL PROFILES FOR Gibb Engineering & Science - Reddersburg**

Soil profile for TP No : 2



slightly moist dark Brown , loose , silty/clayey sand , transported - roots :- Sample No : 1980/7

dry light Yellow , very dense , sub-angular sandstone, residual - Refusal with TLB :- Sample No : 1980/8

LETABA LAB **Gibb Engineering & Science - Reddersburg**

Test Pit 2

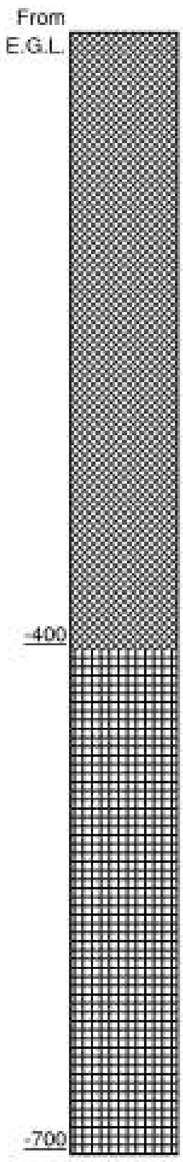
North from TP 2

South from TP 2

Profile - Test Pit 2

LETABA LAB **SOIL PROFILES FOR Gibb Engineering & Science - Reddersburg**

Soil profile for TP No : 3



slightly moist dark Brown , loose , silty/clayey sand , transported - roots :- Sample No : 1980/5

dry light Yellow , very dense , sub-angular sandstone, residual - Refusal with TLB :- Sample No : 1980/6

LETABA LAB **Gibb Engineering & Science - Reddersburg**

Test Pit 3

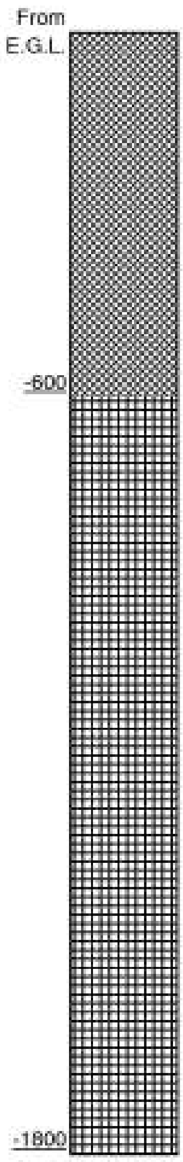
North from TP 3

South from TP 3

Profile - Test Pit 3

LETABA LAB **SOIL PROFILES FOR Gibb Engineering & Science - Reddersburg**

Soil profile for TP No : 4



slightly moist dark Reddish Brown , loose , silty/clayey sand , transported - roots :- Sample No : 1980/3

slightly moist dark Yellowish Brown stainded Reddish Orange, very dense , sub-angular sandstone, residual - roots and Refusal with TLB :- Sample No : 1980/4

LETABA LAB **Gibb Engineering & Science - Reddersburg**

Test Pit 4

North from TP 4

South from TP 4

Profile - Test Pit 4

LETABA LAB **Gibb Engineering & Science - Reddersburg**

Test Pit 5

North from TP 5

South from TP 5

Profile - Test Pit 5

Appendix B

Lab Results

Bulk Samples

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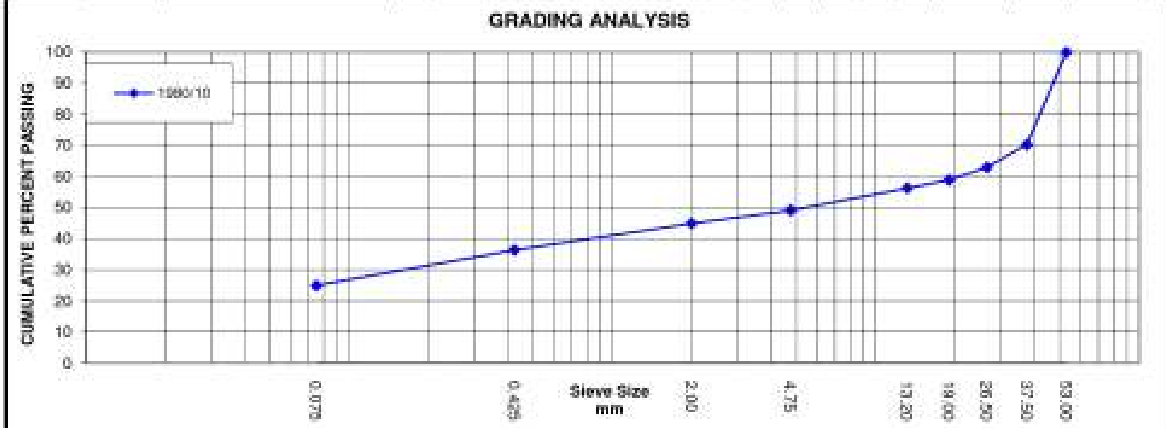
GRAVEL, SOIL AND SAND TEST REPORT

TMH 1:1986
Method A1-A5,A7 & A8

Client :	GIBB ENGINEERING & SCIENCE	Doc No:1980/10(	Date Sampled : 26-Mar-14
Address:	3 Bermakor park, 52 Reid str, Bloemfontein 9300		
Contract :	Reddersburg		Date Tested : 27-Mar-14
Description :	TP :1 sampled by lab		

Depth (m)	Sample No	Description (Unified Soil Classification)	Sieve Analysis Cumulative percentage passing 53.0	37.5	26.5	19.0	13.2	4.75	2.00	0.425	0.075	Grading Modulus	Atterberg Limits (%) Liquid Limit	Plasticity Index	Linear Shrinkage	Classification Unified Soil	COLTO : 1998	US. Highway	Group Index
0.5-1.5	1980/10	drk Brown Clayey gravel	100	70	63	59	56	49	45	36	25	1.94	30	11	5.3	GC	G7	A-2-6	0



GENERAL

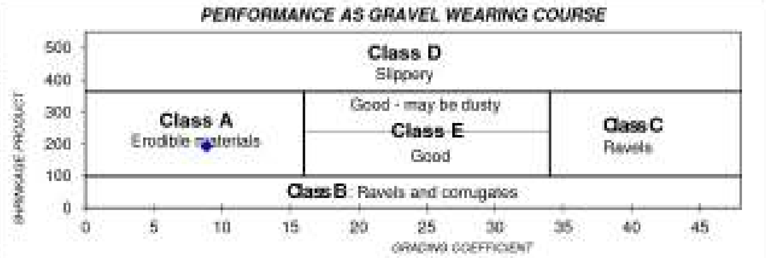
Effective size (mm):	<0.075
Uniformity co-eff. :	20828
Curvature co-eff. :	1.3
Oversize Index :	30
Shrinkage Product :	193
Grading co-eff. :	8.8

CBR RESULTS (%) :

@ 100% comp. :	55
@ 98% comp. :	49
@ 97% comp. :	46
@ 95% comp. :	41
@ 93% comp. :	35
@ 90% comp. :	28

Soil Mortar Analysis

Coarse Sand (<2.0>0.425mm) :	8.6%
Fine Sand (<0.425>0.075mm) :	11.4%
Material <0.075mm :	24.9%



REMARKS

pH: -
Electrical Conducticity: -

Please note that test results are only relevant to the sample tested, which were sampled in accordance with TMH5 : 1991, and were uncontaminated and fit for testing. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any remarks made fall outside the scope of our Quality Document.

Technical signatory (Name) : **Jayson Wingrove** *Signature:*

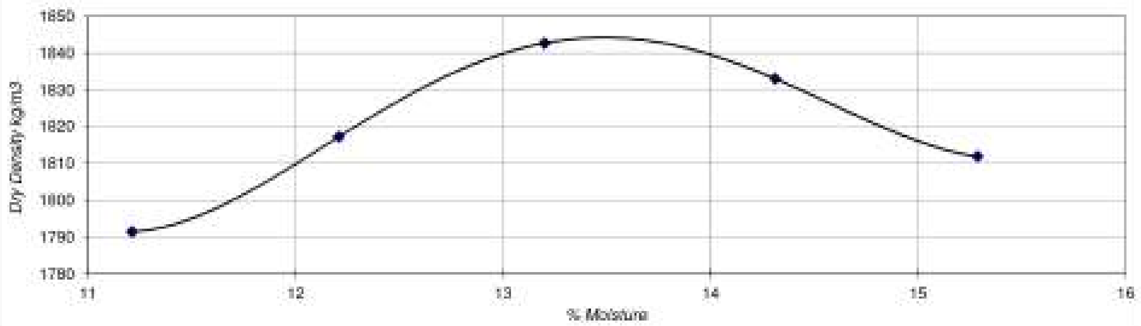
LETABA LAB

CBR and Modified A.A.S.H.T.O Density test report

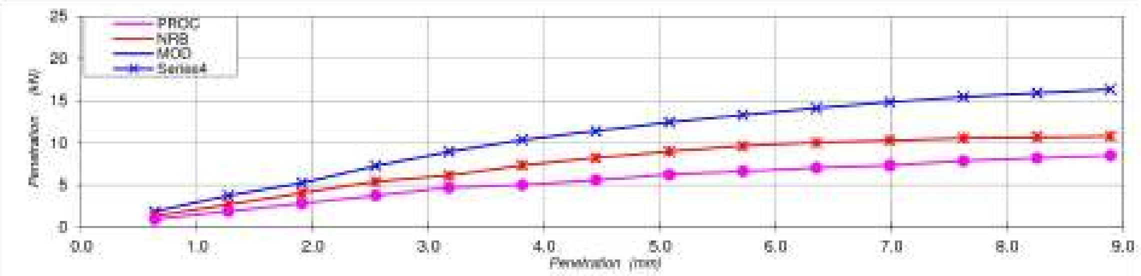
TMH 1:1986
Method A7 & A8

Client:	**GIBB ENGINEERING & SCIENCE**	Date tested:	**27-Mar-14**
Contract :	**Reddersburg**	Doc no:	**1980/10(ii)**
Description:	**TP :1 sampled by lab**	Sample no:	**1980/10**

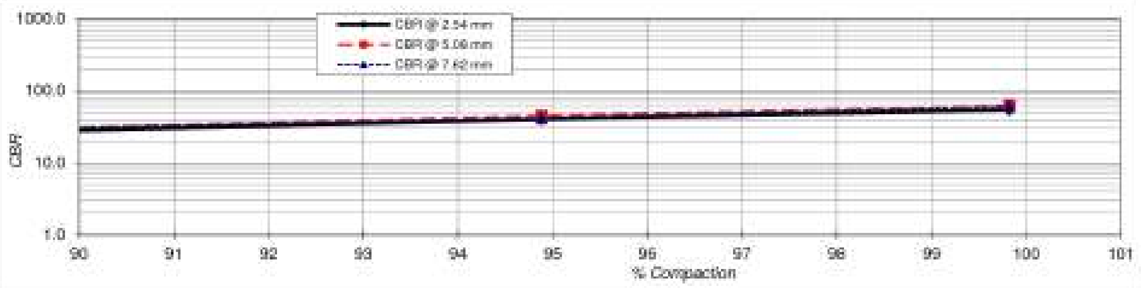
Maximum dry density =	**1844**	**kg/m³**
Optimum moisture content =	**13.5**	**%**



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	100	98	97	95	93	90
CBR of 13.344 kN	55	49	46	41	35	28

Briquette Info	*Mod*	*N.R.B.*	*Proc.*
Dry Density (kg/m³)	1841	1750	1660
Compaction Moisture (%)	13.3	13.2	13.2
Compaction (%)	99.8%	94.9%	90.0%
% Swell	0.94	1.10	1.30

Please note that test results are only relevant to the sample tested, which were sampled in accordance with TMH5 : 1981, and were uncontaminated and fit for testing. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any remarks made fall outside the scope of our Quality Document.

Technical signatory (Name) : **Jayson Wingrove** *Signature:*

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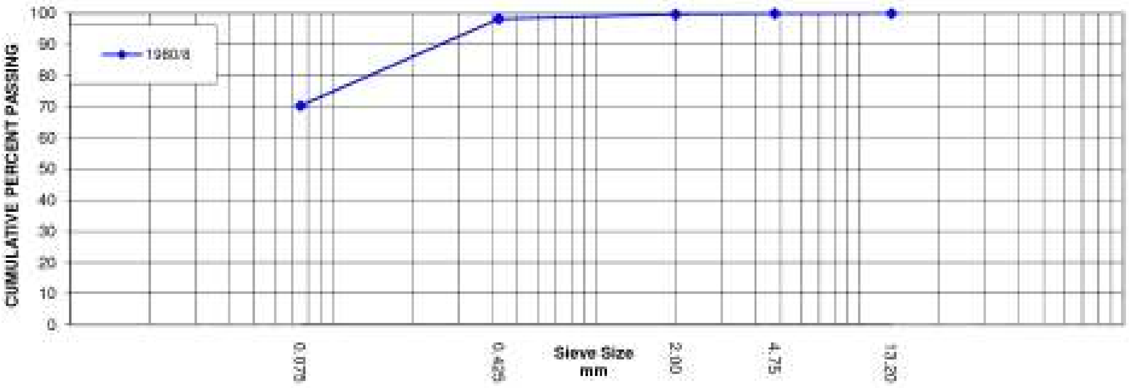
GRAVEL, SOIL AND SAND TEST REPORT

TMH 1:1986
Method A1-A5,A7 & A8

Client :	**GIBB ENGINEERING & SCIENCE**	**Doc No:1980/8(i)**	Date Sampled : **26-Mar-14**
Address:	3 Bermakor park, 52 Reid str, Bloemfontein 9300		
Contract :	**Reddersburg**		Date Tested : **27-Mar-14**
Description :	**TP :2 sampled by lab**		

Depth (m)	Sample No	Description (Unified Soil Classification)	Sieve Analysis – Cumulative percentage passing: 53.0	37.5	26.5	19.0	13.2	4.75	2.00	0.425	0.075	Grading Modulus	Atterberg Limits (%): Liquid Limit	Plasticity Index	Linear Shrinkage	Classification: Unified Soil	COLTO : 1998	US. Highway	Group Index
0.6-1.2	1980/8	lt Olive Inorganic clay					100	100	100	98	70	0.32	40	18	9.0	CL	>G9	A-6	10

GRADING ANALYSIS



GENERAL

Effective size (mm):	**<0.075**
Uniformity co-eff. :	**10**
Curvature co-eff. :	**10.0**
Oversize Index :	**0**
Shrinkage Product :	**884**
Grading co-eff. :	**0.3**

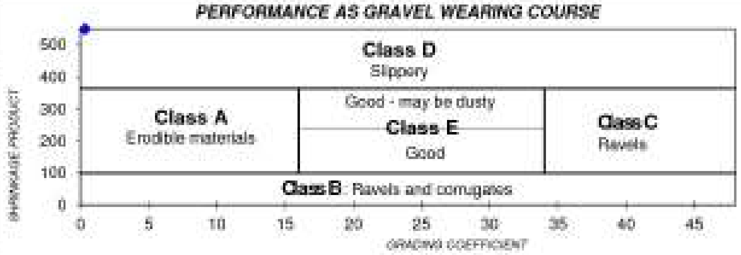
CBR RESULTS (%) :

@ 100% comp. :	**34**
@ 98% comp. :	**32**
@ 97% comp. :	**31**
@ 95% comp. :	**29**
@ 93% comp. :	**27**
@ 90% comp. :	**25**

Soil Mortar Analysis

Coarse Sand (<2.0>0.425mm) :	**1.4%**
Fine Sand (<0.425>0.075mm) :	**27.9%**
Material <0.075mm :	**70.3%**

PERFORMANCE AS GRAVEL WEARING COURSE



REMARKS

pH: -

Electrical Conducticity: -

Technical signatory (Name) : **Jayson Wingrove** *Signature:* [signature]

SF 5.4-12 Report CBR Rev 0 2011-08-08   JOB 1980-8 TP2_CBR_0.6-1.2

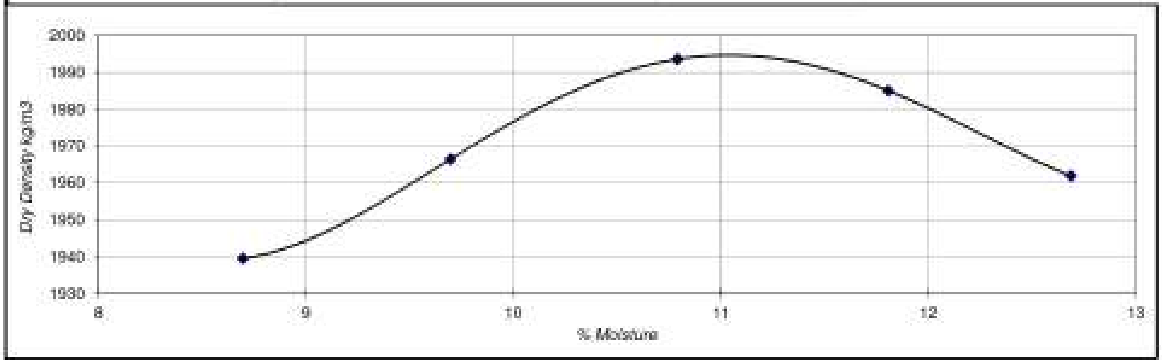
LETABA LAB

CBR and Modified A.A.S.H.T.O Density test report

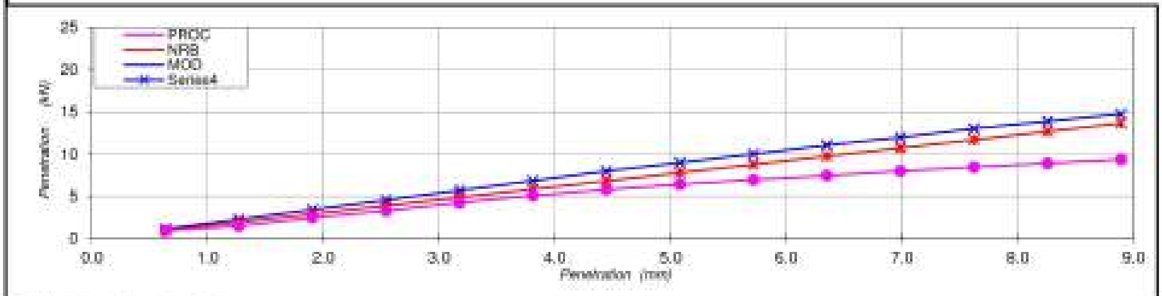
TMH 1:1986
Method A7 & A8

Client:	**GIBB ENGINEERING & SCIENCE**	Date tested:	**27-Mar-14**
Contract :	**Reddersburg**	Doc no:	**1980/8(ii)**
Description:	**TP :2 sampled by lab**	Sample no:	**1980/8**

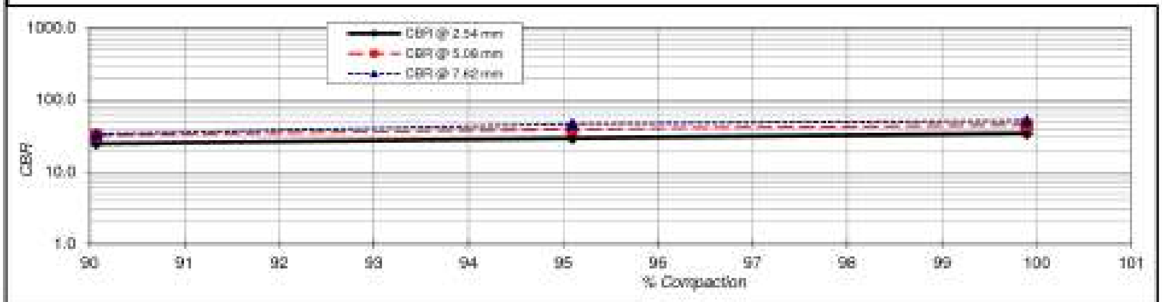
Maximum dry density =	**1994**	**kg/m³**
Optimum moisture content =	**10.8**	**%**



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	100	98	97	95	93	90
CBR of 13.344 kN	34	32	31	29	27	25

Briquette Info	Mod	N.R.B.	Proc.
Dry Density (kg/m³)	1992	1896	1796
Compaction Moisture (%)	10.9	10.8	10.8
Compaction (%)	99.9%	95.1%	90.1%
% Swell	1.73	2.06	2.36

Please note that test results are only relevant to the sample tested, which were sampled in accordance with TMH5 : 1991, and were uncontaminated and fit for testing. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any remarks made fall outside the scope of our Quality Document.

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GRAVEL, SOIL AND SAND TEST REPORT

TMH 1:1986
Method A1-A5,A7 & A8

Client :	**GIBB ENGINEERING & SCIENCE**	**Doc No:1980/5(i)**	Date Sampled : **26-Mar-14**
Address:	3 Bermakor park, 52 Reid str, Bloemfontein 9300		
Contract :	**Reddersburg**		Date Tested : **27-Mar-14**
Description :	**TP :3 sampled by lab**		

Depth (m)	Sample No	Description (Unified Soil Classification)	Sieve Analysis – Cumulative percentage passing 53.0	37.5	26.5	19.0	13.2	4.75	2.00	0.425	0.075	Grading Modulus	Atterberg Limits (%) Liquid Limit	Plasticity Index	Linear Shrinkage	Classification Unified Soil	COLTO : 1998	US. Highway	Group Index
0-0.4	1980/5	drk Brown Silty/Clayey sand			100	98	95	91	89	86	36	0.89	19	7	3.5	sm/sc	G8	A-4	0

GRADING ANALYSIS

GENERAL

Effective size (mm):	**<0.075**
Uniformity co-eff. :	**171**
Curvature co-eff. :	**0.6**
Oversize Index :	**0**
Shrinkage Product :	**301**
Grading co-eff. :	**9.9**

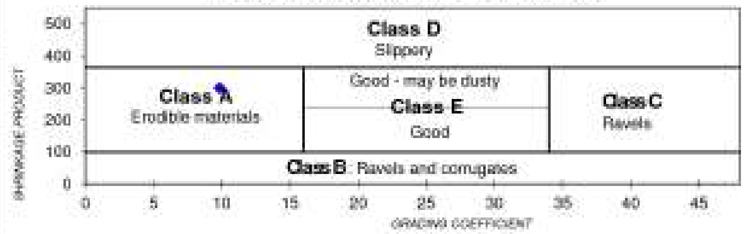
CBR RESULTS (%) :

@ 100% comp. :	**29**
@ 98% comp. :	**23**
@ 97% comp. :	**21**
@ 95% comp. :	**17**
@ 93% comp. :	**14**
@ 90% comp. :	**10**

Soil Mortar Analysis

Coarse Sand (<2.0>0.425mm) :	**3.1%**
Fine Sand (<0.425>0.075mm) :	**49.7%**
Material <0.075mm :	**36.3%**

PERFORMANCE AS GRAVEL WEARING COURSE



REMARKS

pH: 6.79
Electrical Conducticity: 154µS

Please note that test results are only relevant to the sample tested, which were sampled in accordance with TMHS : 1991, and were uncontaminated and fit for testing. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any remarks made fall outside the scope of our Quality Document.

Technical signatory (Name) : **Jayson Wingrove** *Signature:*

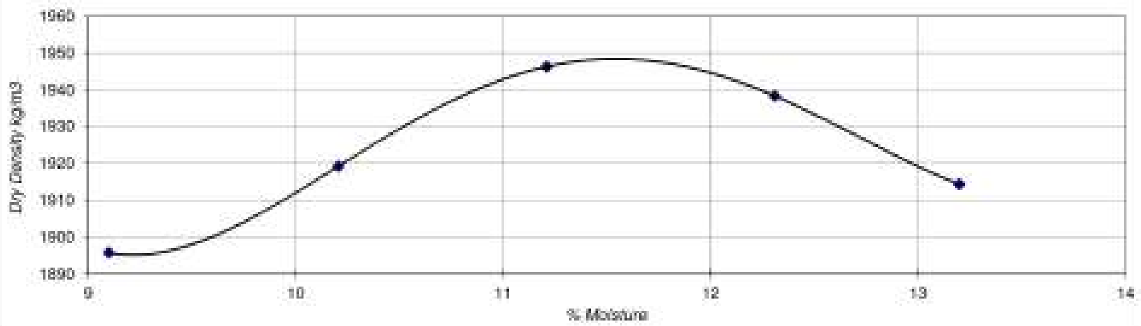
LETABA LAB

CBR and Modified A.A.S.H.T.O Density test report

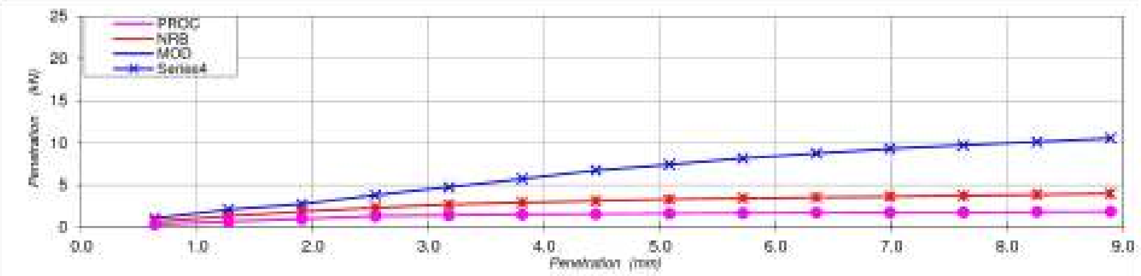
TMH 1:1986
Method A7 & A8

Client:	**GIBB ENGINEERING & SCIENCE**	Date tested:	**27-Mar-14**
Contract :	**Reddersburg**	Doc no:	**1980/5(ii)**
Description:	**TP :3 sampled by lab**	Sample no:	**1980/5**

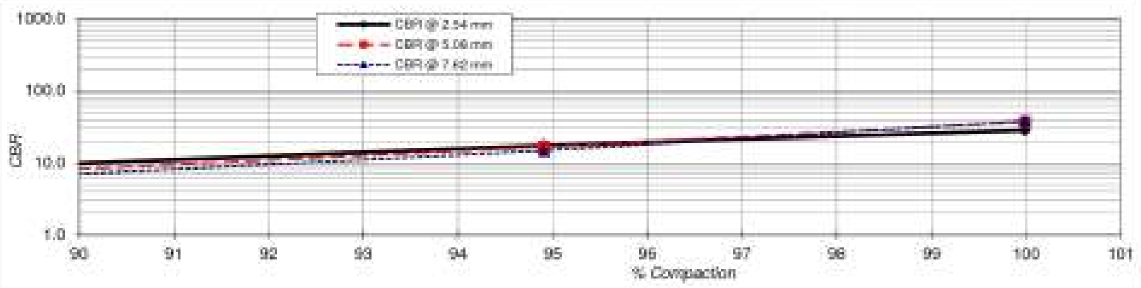
Maximum dry density =	**1948**	**kg/m³**
Optimum moisture content =	**11.4**	**%**



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	100	98	97	95	93	90
CBR of 13.344 kN	29	23	21	17	14	10

Briquette Info	Mod	N.R.B.	Proc.
Dry Density (kg/m³)	1948	1849	1752
Compaction Moisture (%)	11.0	11.1	11.1
Compaction (%)	100.0%	94.9%	89.9%
% Swell	1.54	1.75	2.20

Please note that test results are only relevant to the sample tested, which were sampled in accordance with TMH5 : 1981, and were uncontaminated and fit for testing. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any remarks made fall outside the scope of our Quality Document.

Technical signatory (Name) : **Jayson Wingrove** Signature:

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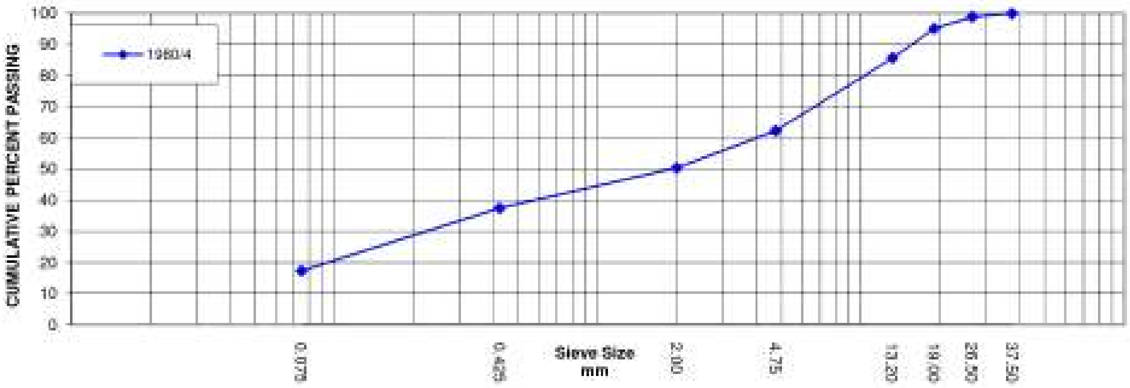
GRAVEL, SOIL AND SAND TEST REPORT

TMH 1:1986 Method A1-A5,A7 & A8

Client :	GIBB ENGINEERING & SCIENCE	Doc No:1980/4(i)	Date Sampled : 26-Mar-14
Address:	3 Bermakor park, 52 Reid str, Bloemfontein 9300		
Contract :	Reddersburg		Date Tested : 27-Mar-14
Description :	TP :4 sampled by lab		

Depth (m)	Sample No	Description (Unified Soil Classification)	Sieve Analysis, Cumulative percentage passing: 53.0	37.5	26.5	19.0	13.2	4.75	2.00	0.425	0.075	Grading Modulus	Atterberg Limits (%): Liquid Limit	Plasticity Index	Linear Shrinkage	Classification: Unified Soil	COLTO : 1998	US. Highway	Group Index
0.6-1.8	1980/4	lt Olive Clayey sand		100	99	95	86	62	50	37	17	1.95	35	15	7.4	SC	>G9	A-2-6	0

GRADING ANALYSIS



GENERAL

Effective size (mm):	<0.075
Uniformity co-eff. :	4019
Curvature co-eff. :	12.4
Oversize Index :	0
Shrinkage Product :	277
Grading co-eff. :	30.2

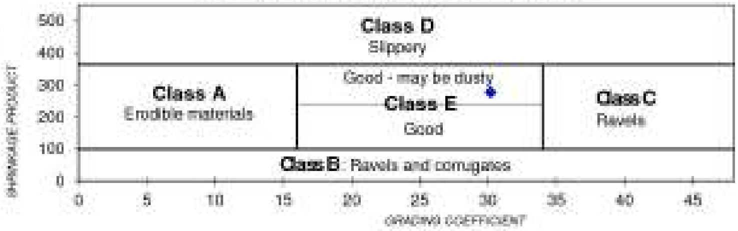
CBR RESULTS (%) :

@ 100% comp. :	40
@ 98% comp. :	38
@ 97% comp. :	36
@ 95% comp. :	34
@ 93% comp. :	30
@ 90% comp. :	25

Soil Mortar Analysis

Coarse Sand (<2.0>0.425mm) :	12.9%
Fine Sand (<0.425>0.075mm) :	20.2%
Material <0.075mm :	17.3%

PERFORMANCE AS GRAVEL WEARING COURSE



REMARKS

pH: 7.93
Electrical Conductivity: 161µS

Please note that test results are only relevant to the sample tested, which were sampled in accordance with TMH5 : 1991, and were uncontaminated and fit for testing. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any remarks made fall outside the scope of our Quality Document.

Technical signatory (Name) : **Jayson Wingrove** *Signature:*

SF 5-4-12 Report CBR Rev 0 2011-08-08 JOB 1980-4 TP4_CBR_0.6-1.8

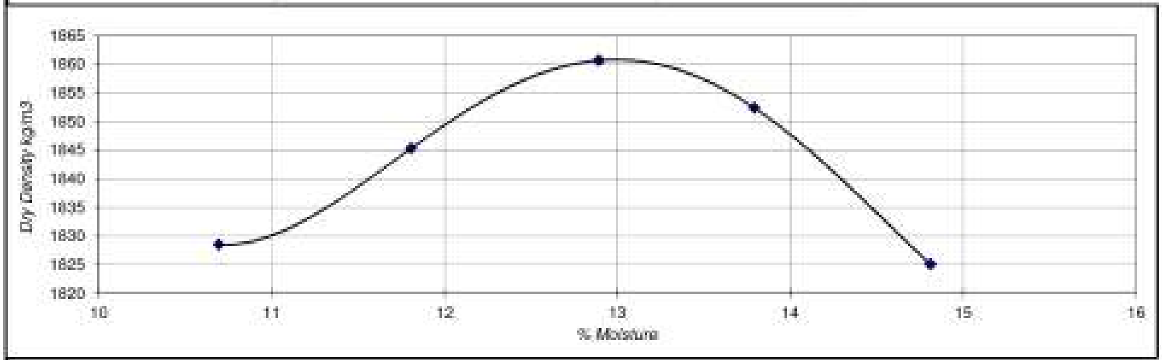
LETABA LAB

CBR and Modified A.A.S.H.T.O Density test report

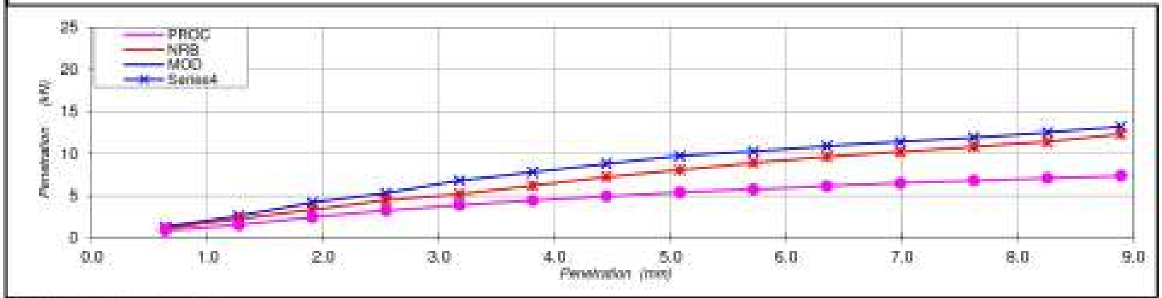
TMH 1:1986
Method A7 & A8

Client:	GIBB ENGINEERING & SCIENCE	Date tested:	27-Mar-14
Contract :	Reddersburg	Doc no:	1980/4(ii)
Description:	TP :4 sampled by lab	Sample no:	1980/4

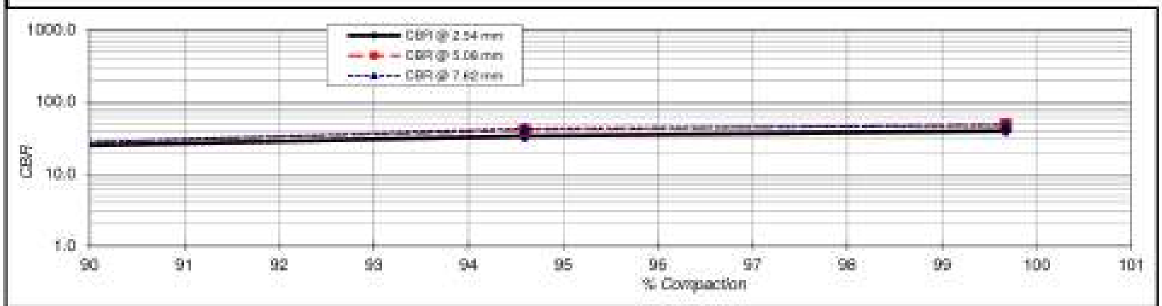
Maximum dry density =	1861	kg/m³
Optimum moisture content =	13.0	%



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	100	98	97	95	93	90
CBR of 13.344 kN	40	38	36	34	30	25

Briquette Info	Mod	N.R.B.	Proc.
Dry Density (kg/m³)	1855	1760	1668
Compaction Moisture (%)	12.9	13.0	13.0
Compaction (%)	99.7%	94.6%	89.6%
% Swell	1.65	1.89	2.13

Please note that test results are only relevant to the sample tested, which were sampled in accordance with TMH5 : 1991, and were uncontaminated and fit for testing. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any remarks made fall outside the scope of our Quality Document.

Technical signatory (Name) : **Jayson Wingrove** Signature:

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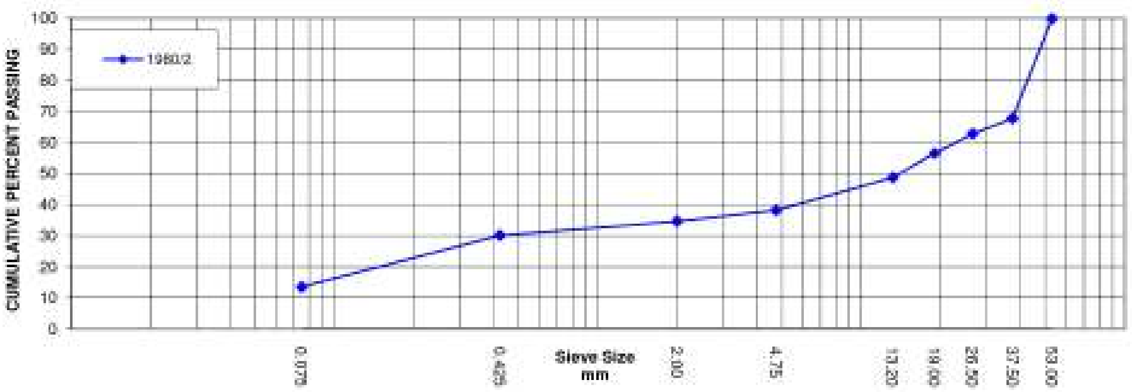
GRAVEL, SOIL AND SAND TEST REPORT

TMH 1:1986
Method A1-A5,A7 & A8

Client :	GIBB ENGINEERING & SCIENCE	Doc No:1980/2(i)	Date Sampled : 26-Mar-14
Address:	3 Bermakor park, 52 Reid str, Bloemfontein 9300		
Contract :	Reddersburg		Date Tested : 27-Mar-14
Description :	TP :5 sampled by lab		

Depth (m)	Sample No	Description (Unified Soil Classification)	Sieve Analysis Cumulative percentage passing 53.0	37.5	26.5	19.0	13.2	4.75	2.00	0.425	0.075	Grading Modulus	Atterberg Limits (%) Liquid Limit	Plasticity Index	Linear Shrinkage	Classification Unified Soil	COLTO : 1998	US. Highway	Group Index
0.6-1.3	1980/2	lt Olive Clayey gravel	100	68	63	57	49	38	35	30	14	2.22	34	15	7.6	GC	>G9	A-2-6	0

GRADING ANALYSIS



GENERAL

Effective size (mm):	<0.075
Uniformity co-eff. :	22817
Curvature co-eff. :	7.7
Oversize Index :	32
Shrinkage Product :	229
Grading co-eff. :	10.7

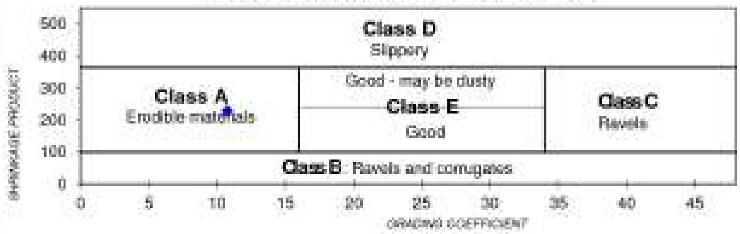
CBR RESULTS (%) :

@ 100% comp. :	63
@ 98% comp. :	52
@ 97% comp. :	48
@ 95% comp. :	40
@ 93% comp. :	34
@ 90% comp. :	26

Soil Mortar Analysis

Coarse Sand (<2.0>0.425mm) :	4.5%
Fine Sand (<0.425>0.075mm) :	16.6%
Material <0.075mm :	13.5%

PERFORMANCE AS GRAVEL WEARING COURSE



REMARKS

pH: 8.53
Electrical Conductivity: 277µS

Please note that test results are only relevant to the sample tested, which were sampled in accordance with TMH5 : 1991, and were uncontaminated and fit for testing. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any remarks made fall outside the scope of our Quality Document.

Technical signatory (Name) : **Jayson Wingrove** Signature:

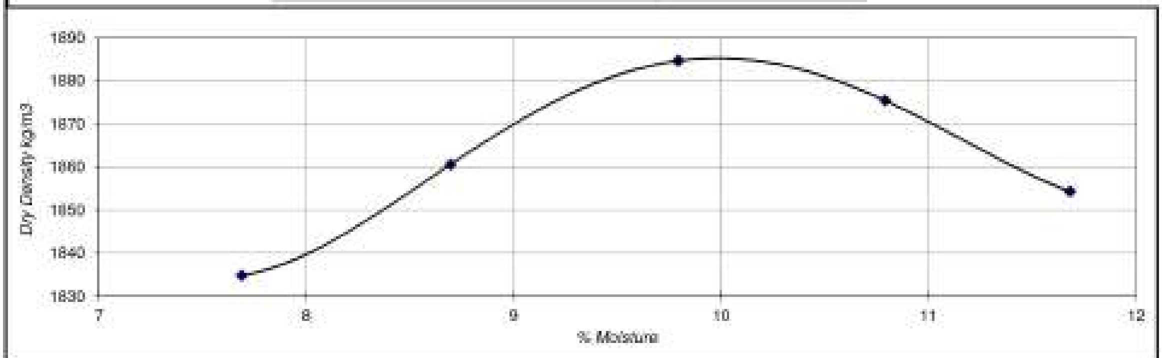
LETABA LAB

CBR and Modified A.A.S.H.T.O Density test report

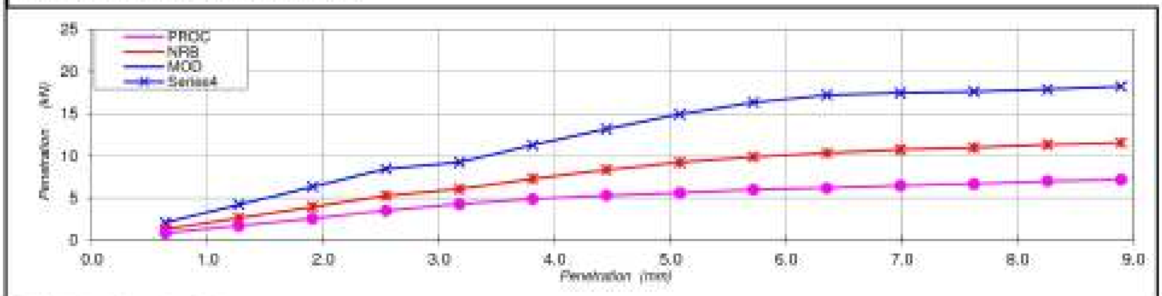
TMH 1:1986
Method A7 & A8

Client:	GIBB ENGINEERING & SCIENCE	Date tested:	27-Mar-14
Contract :	Reddersburg	Doc no:	1980/2(ii)
Description:	TP :5 sampled by lab	Sample no:	1980/2

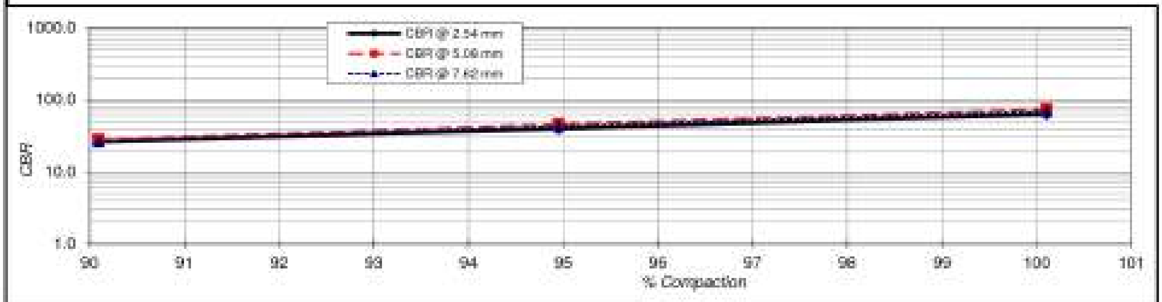
Maximum dry density =	1885	kg/m³
Optimum moisture content =	10.0	%



California Bearing Ratio (readings)



California Bearing Ratio



% Compaction	100	98	97	95	93	90
CBR of 13.344 kN	63	52	48	40	34	26

Briquette Info	Mod	N.R.B.	Proc.
Dry Density (kg/m³)	1887	1790	1698
Compaction Moisture (%)	9.7	9.9	9.7
Compaction (%)	100.1%	95.0%	90.1%
% Swell	1.65	1.81	2.20

Please note that test results are only relevant to the sample tested, which were sampled in accordance with TMH5 : 1991, and were uncontaminated and fit for testing. Any results may only be reproduced in their entirety with the written consent of Letaba Lab (Pty) Ltd, and any remarks made fall outside the scope of our Quality Document.

Technical signatory (Name) : Jayson Wingrove Signature:

QF 5.4-12 Report CBR Rd Rev 0 2011-08-08 JOB 1980-2 TP5_CBR_08-1.3

Appendix B

Lab Results

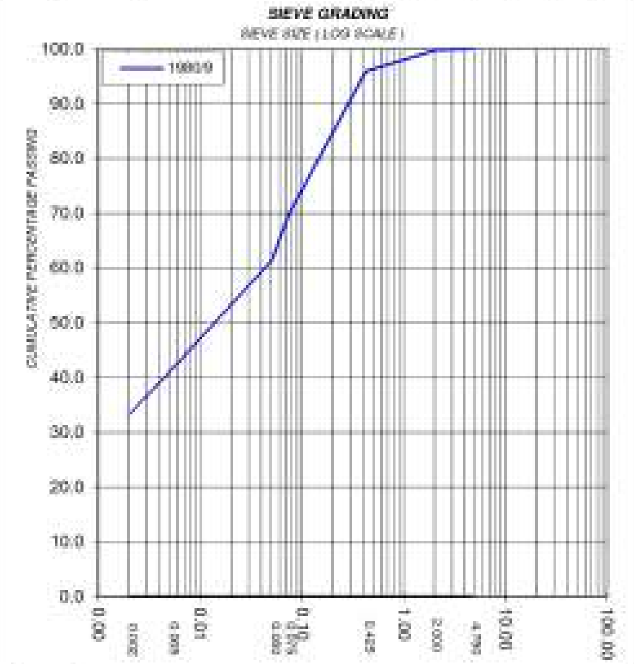
Disturbed Samples

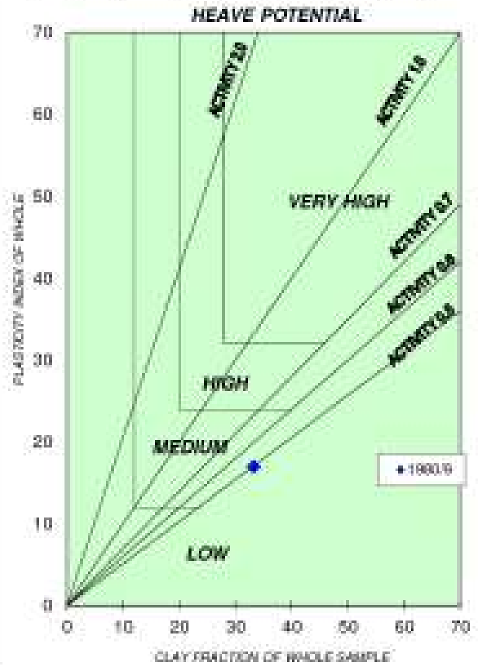
LETABA LAB

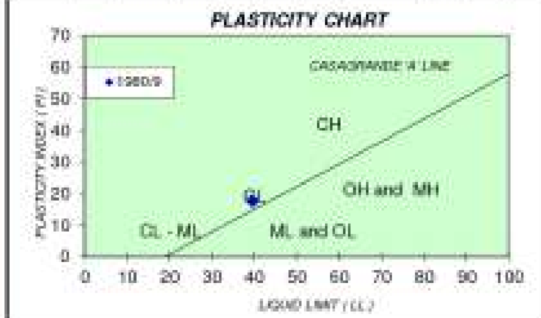
GRAVEL, SOIL AND SAND ANALYSIS

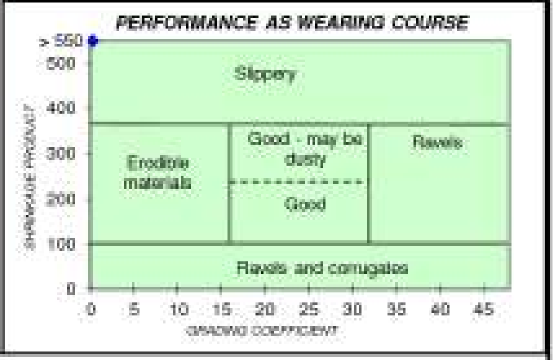
Contract : Reddersburg	Client : GIBB ENINEERING & SCIENCE	Date : 26-Mar-14	
Description : TP 1 from 0-0.5 m below NGL		Job No : 1980	

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing: 50.0 mm	37.5 mm	26.5 mm	19.0 mm	13.2 mm	4.75 mm	2.00 mm	0.425 mm	0.075 mm	0.05 mm	0.005 mm	0.002 mm	Soil Mortar Analysis % of mat. <2,00 mm: Coarse - sand <2.0 >0.425mm	Fine - sand <0.425 >0.05mm	Silt <0.05 >0.005mm	Clay <0.005 mm	Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits: Liquid Limit	Plasticity Index	Linear Shrinkage	Classifications: Unified Soil	TRH 14	US Highway	Group Index
0-0.5	1980/9	Brown Inorganic clay						100	100	96	70	61.3	40.9	33.3	3.8	34.7	20.4	41.0	<0.002	43.1	2.3	0.34	40	18	8.8	CL	-	A-6	10









Remarks:

THIS MATERIAL IS NOT SUITABLE FOR WEARING COARSE AS THE SHRINKAGE PRODUCT IS GREATER THAN 550

pH : -

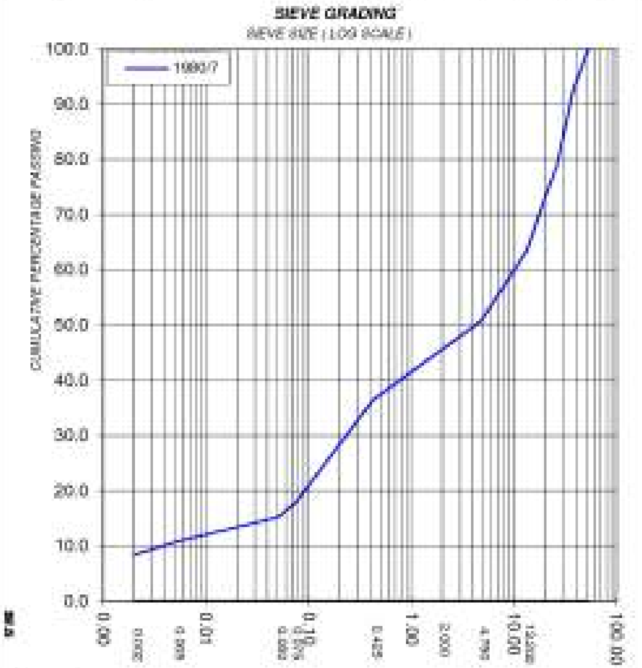
Electrical Conductivity : -

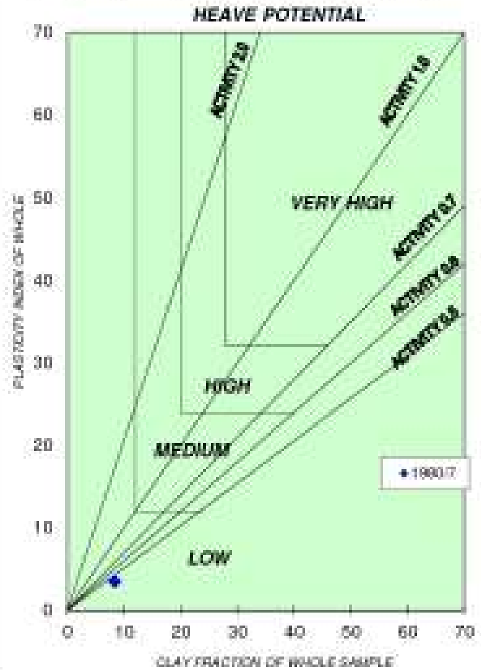
JOB 1980-9 TP1_FIND_0-0.5

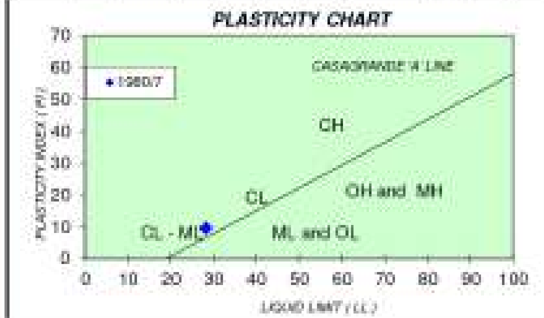
LETABA LAB — GRAVEL, SOIL AND SAND ANALYSIS

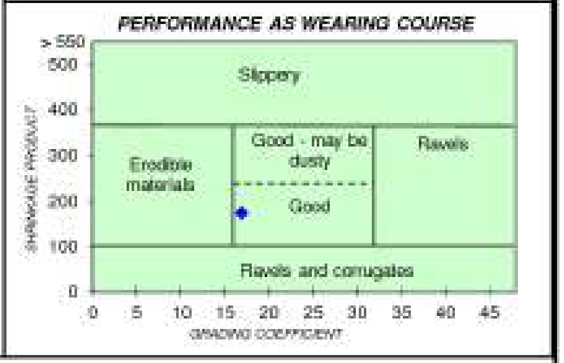
Contract :	Reddersburg	Client : GIBB ENINEERING & SCIENCE	Date : 26-Mar-14
Description :	TP 2 from 0-0.6 m below NGL		Job No : 1980

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis – Cumulative percentage passing: 53.0 mm	37.5 mm	26.5 mm	19.0 mm	13.2 mm	4.75 mm	2.00 mm	0.425 mm	0.075 mm	0.05 mm	0.005 mm	0.002 mm	Soil Mortar Analysis % of mat. <2,00 mm: Coarse - sand <2.0 >0.425mm	Fine - sand <0.425 >0.05mm	Silt <0.05 >0.005mm	Clay <0.005 mm	Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits: Liquid Limit	Plasticity Index	Linear Shrinkage	Classifications: Unified Soil	TRH 14	US Highway	Group Index
0-0.6	1980/7	drk Brown Clayey sand	100	92	79	72	63	51	46	36	18	15.2	10.8	8.4	20.3	46.4	9.8	23.6	0.004	2710.9	1.5	2.00	28	10	4.8	SC	-	A-2-4	0









Remarks:

pH : -

Electrical Conductivity : -

JOB 1980-7 TP2_F-IND_0-0.6

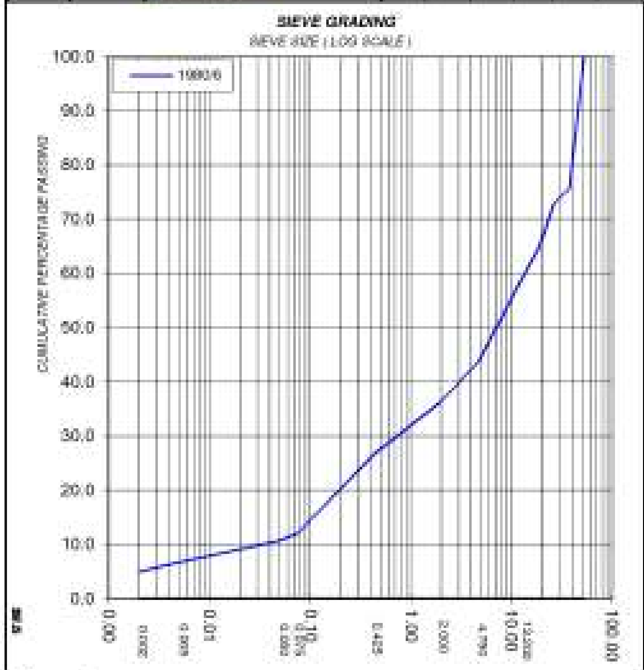
LETABA LAB

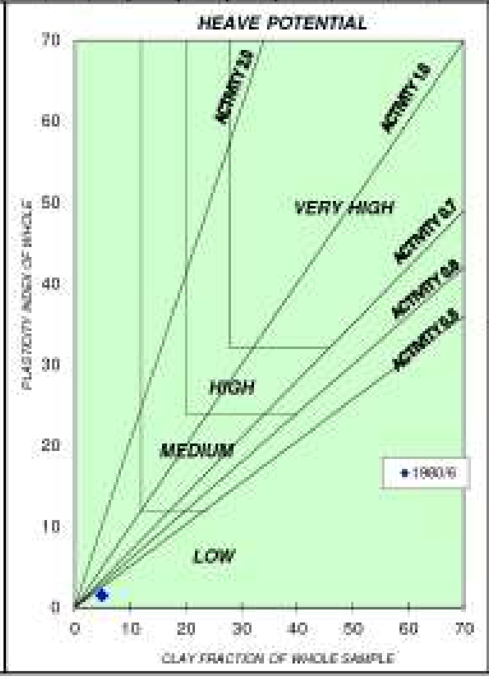
GRAVEL, SOIL AND SAND ANALYSIS

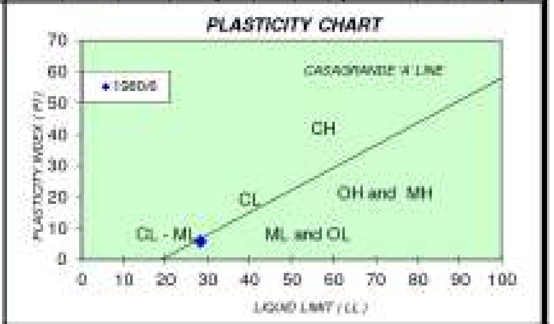
Contract : Reddersburg | Client : GIBB ENINEERING & SCIENCE | Date : 26-Mar-14

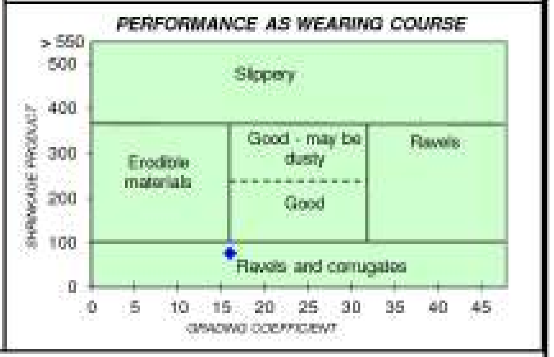
Description : TP 3 from 0.4-0.7 m below NGL | Job No : 1980

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis – Cumulative percentage passing: 53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm	0,005 mm	0,002 mm	Soil Mortar Analysis % of mat. <2,00 mm: Coarse - sand <2,0 >0,425mm	Fine - sand <0,425 >0,05mm	Silt <0,05 >0,005mm	Clay <0,005 mm	Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits: Liquid Limit	Plasticity Index	Linear Shrinkage	Classifications: Unified Soil	TRH 14	US Highway	Group Index
0.4-0.7	1980/6	drk Brown Well graded silty/clayey gravel	100	76	73	65	60	44	36	27	12	10.7	6.7	5.0	27.1	43.5	11.0	18.5	0.033	408.4	1.2	2.25	28	6	2.9	GW/GM/G	-	A-1-a	0









Remarks:

pH : -

Electrical Conductivity : -

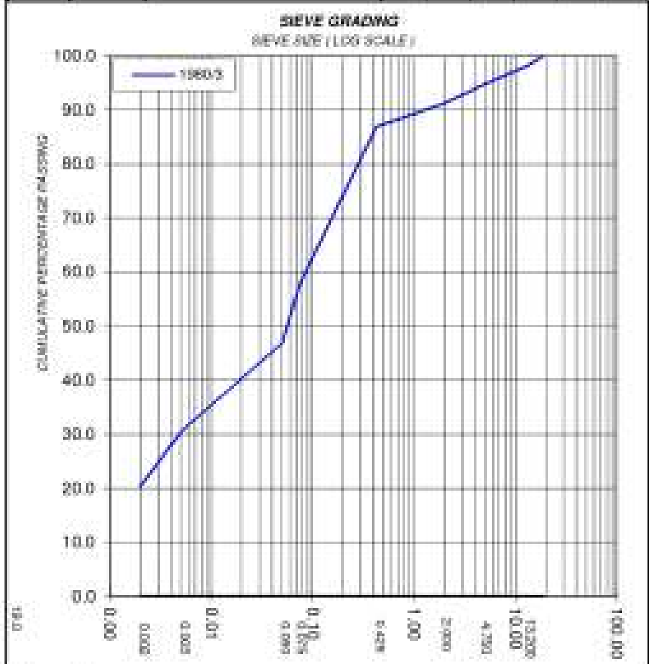
JOB 1980-6 TP3_F-IND_0.4-0.7

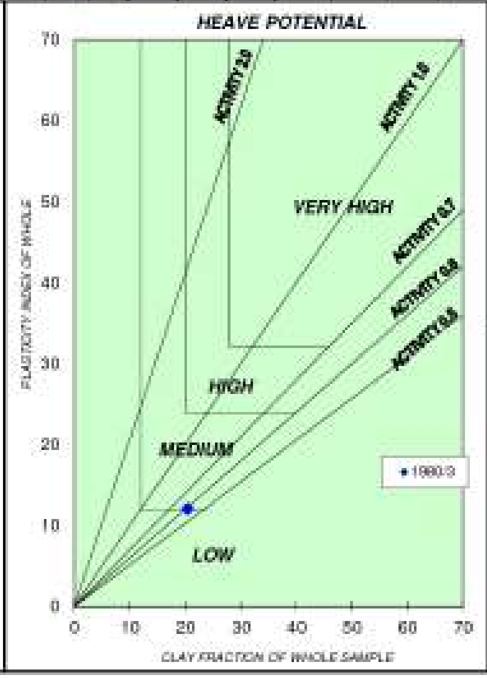
LETABA LAB

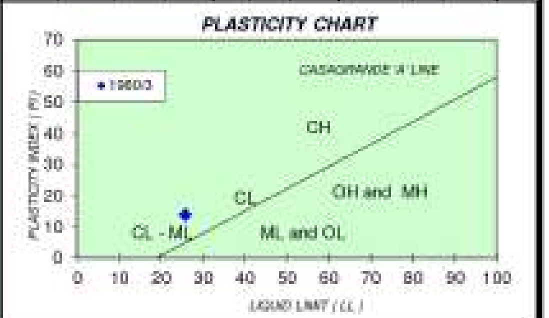
GRAVEL, SOIL AND SAND ANALYSIS

Contract : **Reddersburg**
Client : **GIBB ENINEERING & SCIENCE**
Date : **26-Mar-14**
Description : **TP 4 from 0-0.6 m below NGL**
Job No : **1980**

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing: 53.0 mm	37.5 mm	26.5 mm	19.0 mm	13.2 mm	4.75 mm	2.00 mm	0.425 mm	0.075 mm	0.05 mm	0.005 mm	0.002 mm	Soil Mortar Analysis % of mat. <2,00 mm: Coarse - sand <2.0 >0.425mm	Fine - sand <0.425 >0.05mm	Silt <0.05 >0.005mm	Clay <0.005 mm	Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits: Liquid Limit	Plasticity Index	Linear Shrinkage	Classifications: Unified Soil	TRH 14	US Highway	Group Index
0-0.6	1980/3	lt Brown Inorganic clay				100	98	95	91	87	58	46.9	30.4	20.4	4.7	43.9	18.1	33.3	<0.002	85.3	0.3	0.64	26	14	6.9	CL	-	A-6	6







Remarks:
THIS MATERIAL IS NOT SUITABLE FOR WEARING COARSE AS THE SHRINKAGE PRODUCT IS GREATER THAN 550

pH : -

Electrical Conductivity : -

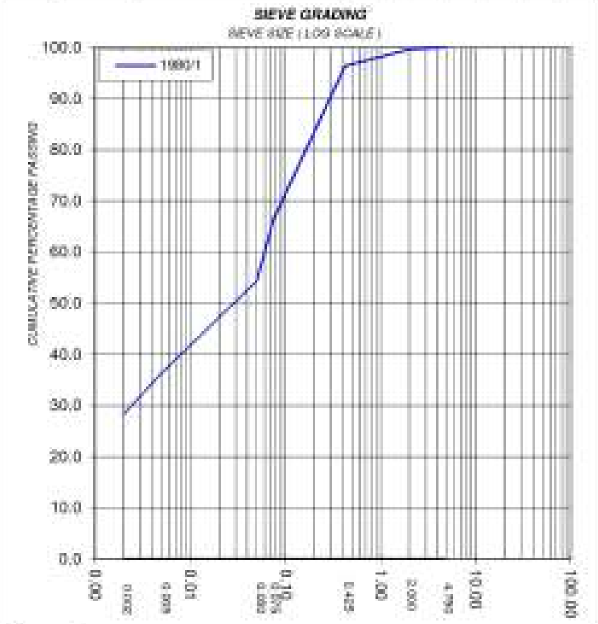
JOB 1980-3 TP4_F-IND_0-0.6

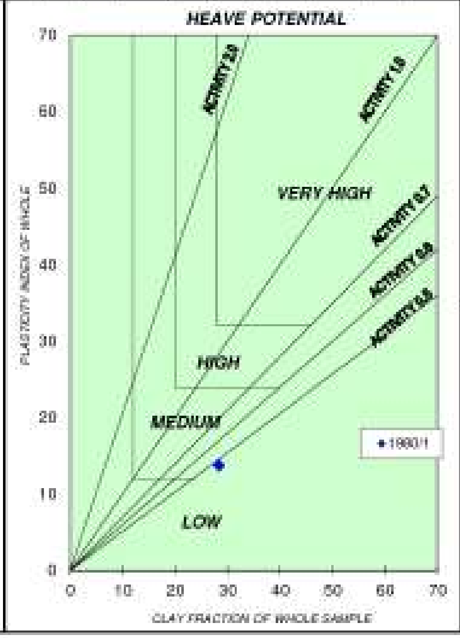
LETABA LAB

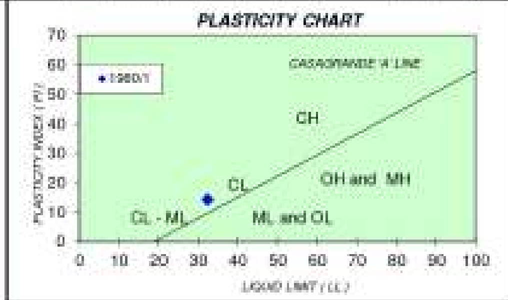
GRAVEL, SOIL AND SAND ANALYSIS

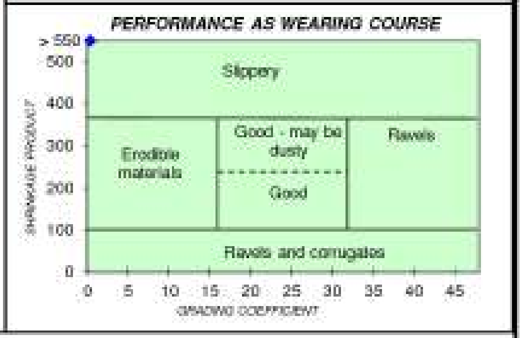
Contract :	Reddersburg	Client : GIBB ENINEERING & SCIENCE	Date : 26-Mar-14
Description :	TP 5 from 0-0.6 m below NGL		Job No : 1980

Depth (m)	Sample No.	Description (Unified Soil Classification)	Sieve analysis Cumulative percentage passing: 53,0 mm	37,5 mm	26,5 mm	19,0 mm	13,2 mm	4,75 mm	2,00 mm	0,425 mm	0,075 mm	0,05 mm	0,005 mm	0,002 mm	Soil Mortar Analysis % of mat. <2,00 mm: Coarse - sand <2,0 >0,425mm	Fine - sand <0,425 >0,05mm	Silt <0,05 >0,005mm	Clay <0,005 mm	Effective size	Uniformity - coef.	Curvature coef.	Grading modulus	Atterberg Limits: Liquid Limit	Plasticity Index	Linear Shrinkage	Classifications: Unified Soil	TRH 14	US Highway	Group Index
0-0.6	1980/1	dk Brown Inorganic clay						100	100	96	66	54.4	36.4	28.4	3.3	42.1	18.1	36.5	<0.002	60.3	0.1	0.38	32	14	7.1	CL	-	A-6	8









Remarks:

THIS MATERIAL IS NOT SUITABLE FOR WEARING COARSE AS THE SHRINKAGE PRODUCT IS GREATER THAN 550

pH : -

Electrical Conductivity : -

JOB 1980-1 TP5_F-IND_0-0.6

Appendix C

DPL Results

LETABA LAB CC
CIVIL ENGINEERING MATERIALS LABORATORY

P.O. Box 22874 Extonweg 9301
Long Str. 158 Hilton Park Unit C4 Bloemfontein, 9300
Tel. No: 051 - 433 4057
Fax. No: 051 - 433 4236
Cel. No: 084 405 4711
e-mail : jayson@letabalab.co.za

Client: Gibb Engineering & Science
Contract: Reddersburg
Description: DPL done from existing ground level
Refusal at : 2065mm

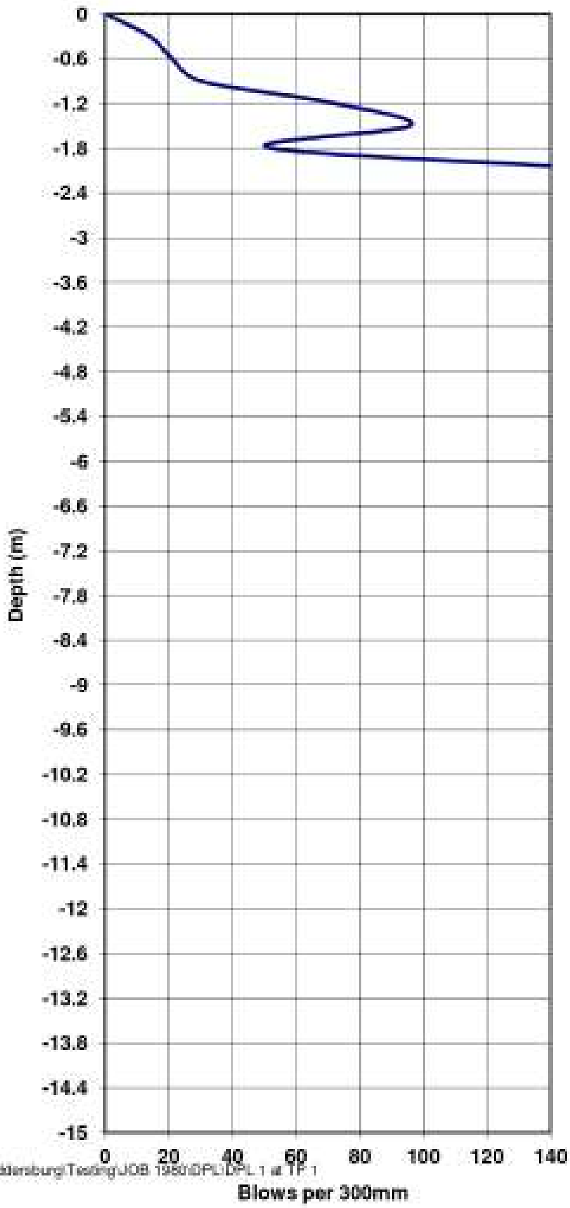
Job No: 1980
Date: 26-Mar-2014
Operator: Letaba Lab

Light Dynamic Penetrometer Probe .... ***Test No. DPL 1 at TP 1***

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angel
Rods: 16mm diameter, 22mm diameter couplings

Depth metres	Blows per 300mm	Inferred Consistency	Insitu Shear Strength
0			
0.3	14	Loose	<30 deg
0.6	21	Med.Dense	32 deg
0.9	30	Med.Dense	34 deg
1.2	72	Dense	37 deg
1.5	96	Dense	38 deg
1.8	52	Dense	37 deg
2.1	170	Very Dense	>38 deg
	END		



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P.O. Box 22874 Extonweg 9301
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Tel. No: 051 - 433 4057
Fax. No: 051 - 433 4236
Cel. No: 084 405 4711
e-mail : jayson@letabalab.co.za

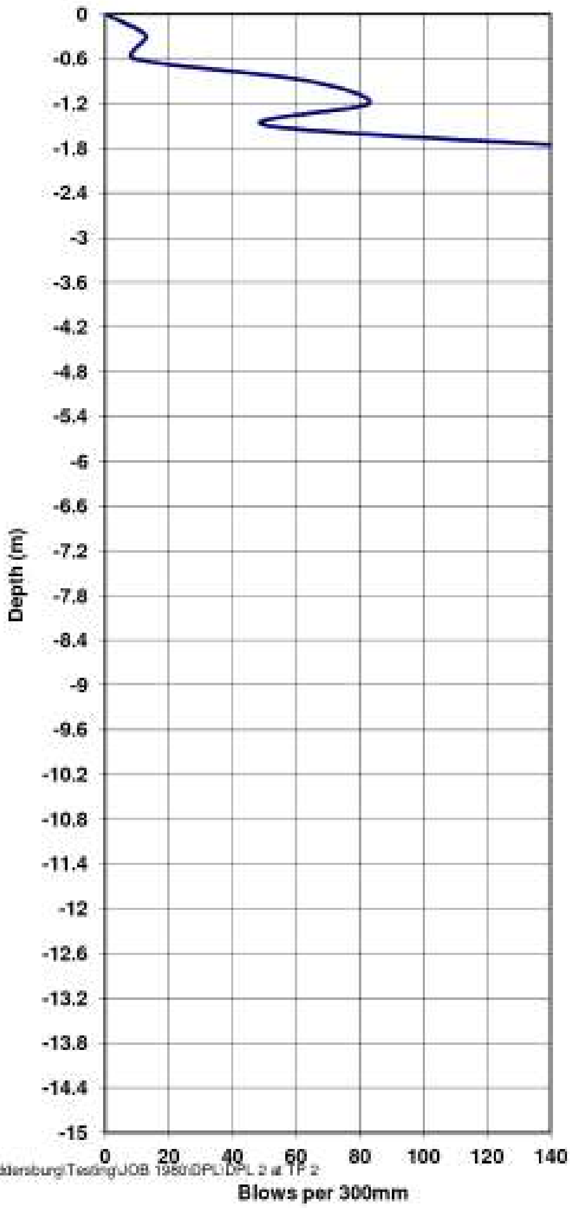
Client: Gibb Engineering & Science
Contract: Reddersburg
Description: DPL done from existing ground level
Refusal at : 1745mm
Job No: 1980
Date: 26-Mar-2014
Operator: Letaba Lab

Light Dynamic Penetrometer Probe .... Test No. DPL 2 at TP 2

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angel
Rods: 16mm diameter, 22mm diameter couplings

Depth metres	Blows per 300mm	Inferred Consistency	Insitu Shear Strength
0			
0.3	13	Loose	<30 deg
0.6	9	Loose	<30 deg
0.9	64	Dense	37 deg
1.2	83	Dense	38 deg
1.5	51	Dense	36 deg
1.8	160	Very Dense	>38 deg
	END		



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Fax. No: 051 - 433 4236
Cel. No: 084 405 4711
e-mail : jayson@letabalab.co.za

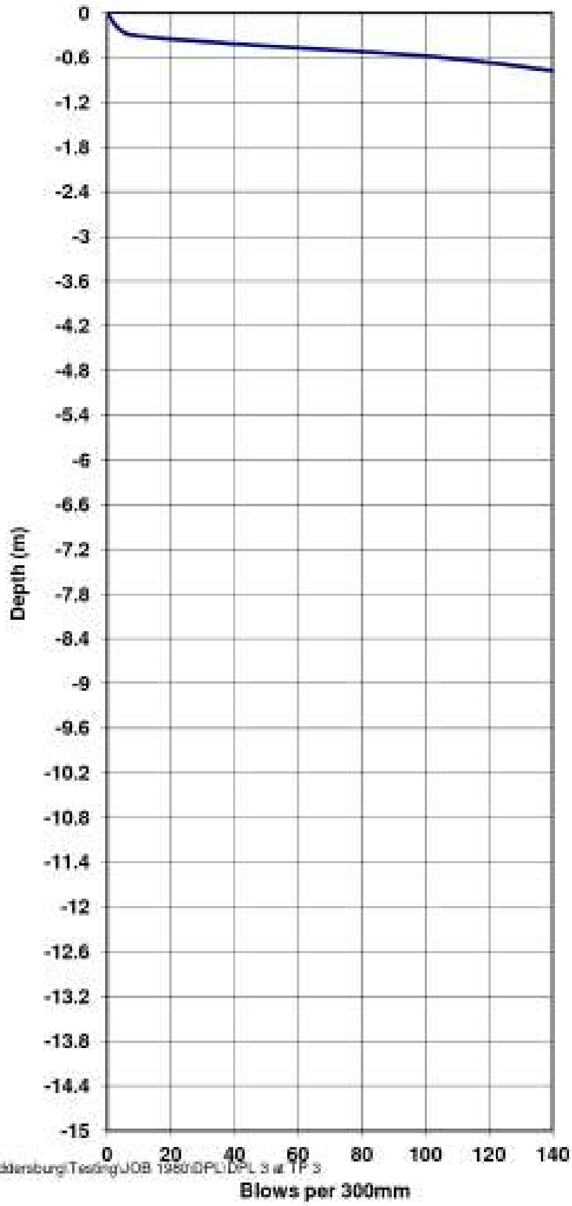
Client:	Gibb Engineering & Science	Job No:	1980
Contract:	Reddersburg	Date:	26-Mar-2014
Description:	DPL done from existing ground level	Operator:	Letaba Lab
Refusal at :	810mm		

Light Dynamic Penetrometer Probe .... ***Test No. DPL 3 at TP 3***

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angel
Rods: 16mm diameter, 22mm diameter couplings

Depth metres	Blows per 300mm	Inferred Consistency	Insitu Shear Strength
0			
0.3	8	Loose	<30 deg
0.6	105	Very Dense	>38 deg
0.9	160	Very Dense	>38 deg
	END		



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Fax. No: 051 - 433 4236
Cel. No: 084 405 4711
e-mail : jayson@letabalab.co.za

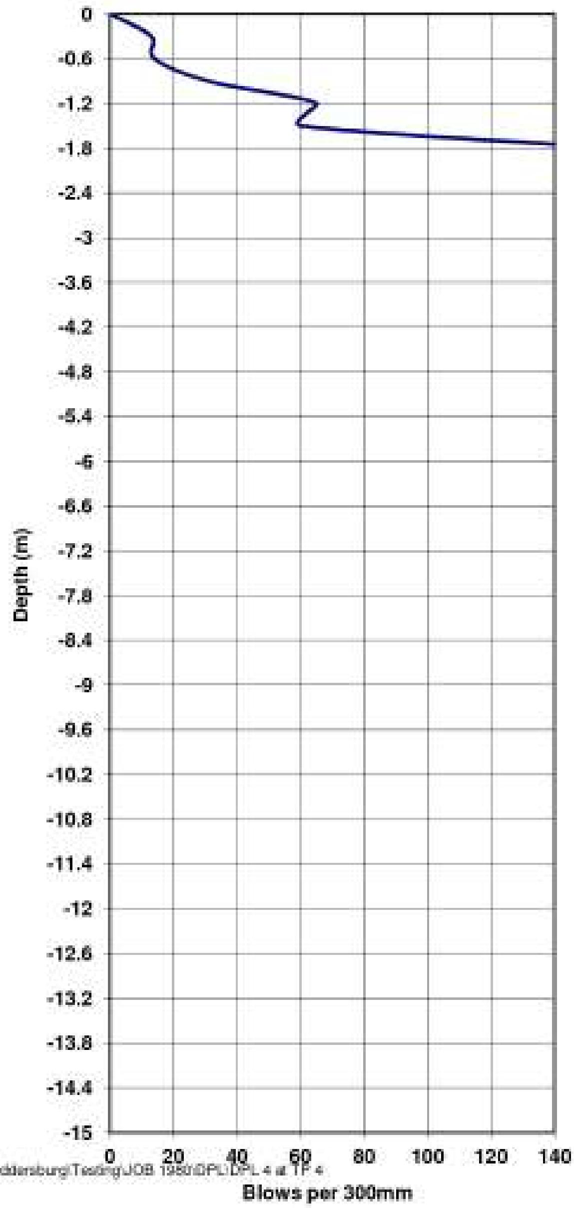
Client: Gibb Engineering & Science
Contract: Reddersburg
Description: DPL done from existing ground level
Refusal at : 1775mm
Job No: 1980
Date: 26-Mar-2014
Operator: Letaba Lab

Light Dynamic Penetrometer Probe .... **Test No. DPL 4 at TP 4**

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angel
Rods: 16mm diameter, 22mm diameter couplings

Depth metres	Blows per 300mm	Inferred Consistency	Insitu Shear Strength
0			
0.3	13	Loose	<30 deg
0.6	14	Loose	<30 deg
0.9	31	Med.Dense	35 deg
1.2	65	Dense	37 deg
1.5	60	Dense	37 deg
1.8	160	Very Dense	>38 deg
	END		



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Tel. No: 051 - 433 4057
Fax. No: 051 - 433 4236
Cel. No: 084 405 4711
e-mail : jayson@letabalab.co.za

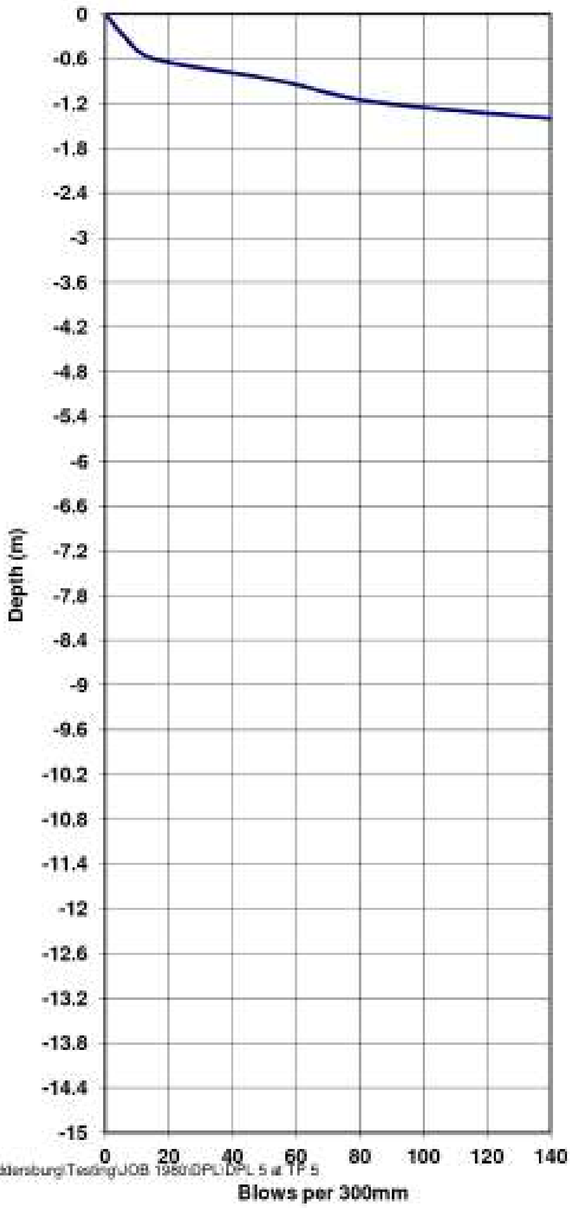
Client:	Gibb Engineering & Science	Job No:	1980
Contract:	Reddersburg	Date:	26-Mar-2014
Description:	DPL done from existing ground level	Operator:	Letaba Lab
Refusal at :	1485mm		

Light Dynamic Penetrometer Probe .... **Test No. DPL 5 at TP 5**

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angel
Rods: 16mm diameter, 22mm diameter couplings

Depth metres	Blows per 300mm	Inferred Consistency	Insitu Shear Strength
0			
0.3	6	Very Loose	<29 deg
0.6	15	Loose	<30 deg
0.9	55	Dense	37 deg
1.2	88	Dense	38 deg
1.5	170	Very Dense	>38 deg
	END		



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