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Report to Vuba Imagineers on the Results of a Geotechnical Investigation for the Proposed Gumede Bridge Located in Ward 16 within the Umdoni Municipality, KwaZulu-Natal

Reference: 086-20.R01 Revision 0

Dated: 17 June 2020

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Report Title	Report to Vuba Imagineers on the Results of a Geotechnical Investigation for the Proposed Gumede Bridge Located in Ward 16 within the Umdoni Municipality, KwaZulu-Natal		
Report Reference	086-20.R01	**Responsible Persons**	Mr R.C Sithole
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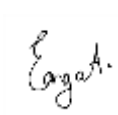
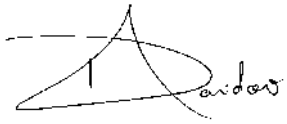
Revision	Date	Revision Details/Status	Author	Reviewer
0	17/06/2020	Geotechnical report with recommendations issued to the Client.	Miss E. Angath	Mr D. Naidoo

Current Revision
0

Approval

Author Signature		**Reviewer Signature**	
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Report to Vuba Imagineers on the Results of a Geotechnical Investigation for the Proposed Gumede Bridge Located in Ward 16 within the Umdoni Municipality, KwaZulu-Natal

Reference: 086-20.R01 Rev 0 **Date: 17 June 2020**

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Abbreviations and definitions

AASHTO	American Association of State Highway and Transportation
CBR	California Bearing Ratio
CFA	Pressure Grouted Auger
DCI	Driven Cast Insitu
DCP	Dynamic Cone Penetrometer
E	East
EGL	Existing ground level
EXP	Exposure
Geosure	Geosure (Pty) Ltd
GM	Grading modulus
GPS	Global Positioning System
h	Horizontal
IMC	Insitu moisture content
IP	Inspection pit
km	Kilometre(s)
kN/m²	Kilonewtons per metre square
LL	Liquid limit
LS	Linear shrinkage
m	Metre (s)
m/s	Metres per second
MDD	Maximum dry density
Ml	Mega litre
mm	Millimetre(s)
MPA	MegaPascal
No.	Number
NP	Non plastic
OMC	Optimum Moisture Content
PI	Plasticity index
SANS	South African National Standards
S	South
TLB	tractor loader backhoe
TMH	Technical Manual for Highways
TRH	Technical Recommendations for Highways (1985)
UCS	Unconfined compressive strength
USCS	Unified Soil Classification System
v	Vertical
Unified Soil Classification System	
SC	Clayey sand
SM	Silty sand
SP	Poorly graded sands

Report to Vuba Imagineers on the Results of a Geotechnical Investigation for the Proposed Gumede Bridge Located in Ward 16 within the Umdoni Municipality, KwaZulu-Natal

Reference: 086-20.R01 Rev 0 **Date: 17 June 2020**

1. TERMS OF REFERENCE

Geosure (Pty) Ltd, hereafter referred to as *Geosure*, was requested by Mr R.C Sithole of Vuba Imagineers, to provide a proposal cost estimate to carry out a geotechnical investigation for the proposed Gumede Bridge in Ward 16 within the Umdoni Municipality, KwaZulu-Natal.

Geosure provided a proposal and cost estimate in a letter referenced p165-20 (Gumede Bridge)/mb dated 13 March 2020. Due to changes in the scope of work from Vuba Imagineers, a revised proposal and cost estimate was issued in a letter referenced p165-20 Rev 1(Gumede Bridge)/mb dated 18 March 2020. Geosure issued a further revision to the proposal and cost estimate in a letter referenced p165-20 Rev 2(Gumede Bridge)/mb dated 18 March 2020 after subsequent communication with Vuba Imagineers.

Vuba Imagineers subsequently appointed Geosure to carry out the investigation as proposed via signed acceptance dated 23 March 2020 of Geosure's "*Terms and Conditions for Geotechnical Support Services*".

2. SCOPE OF REPORT

This report details the results of a geotechnical investigation for the proposed Gumede Bridge located in Ward 16 within the Umdoni Municipality, KwaZulu-Natal, hereafter referred to as the site.

The ground conditions identified during investigation are described and comment is made on the general stability of the site. Recommendations for earthworks, materials excavatability/rippability, foundations and drainage are provided.

3. GUIDELINES FOR INVESTIGATION

The fieldwork for the investigation was carried out according to guidelines relevant to geotechnical investigations of this nature.

The formation and weathering of geological materials are discontinuous processes and unexpected variations in soil, rock and groundwater regimes may occur even on sites where the conditions seem to be uniform or consistent. Variations in what is reported here may become evident during construction and it is thus imperative that an appropriately qualified and experienced geotechnical professional inspects all critical stages of development including, but not limited to, excavations to assess the conditions encountered and to assist in the interpretation of observations at variance with the information supplied in this report.
This report was prepared for use by Vuba Imagineers (Pty) Ltd for the purpose stated and should not be relied upon for any other purpose.

4. INFORMATION SUPPLIED / REFERENCED

The following information was referenced to assist with the investigation and reporting:

i. Digital copies (.pdf) of drawing referenced S603/R, Plan No. LP01_S603 titled "*Gumede Bridge Crossing*", dated 20 February 2020 and prepared by Stott, Milton & Conway Professional Land Surveyors to a scale of 1:250.

ii. A digital copy of an undated drawing referenced LP01_S603_20200316 showing the survey information.

iii. Digital copy of low-resolution satellite imagery sourced from Google Earth, titled "*Gumede Bridge- Foundation Investigation*".

iv. A regional geological map titled "*3030 Port Shepstone*", dated 1988 and prepared by the Council for Geoscience to a scale of 1:250 000.

v. Low-resolution satellite imagery sourced from Google Earth.

5. SITE DESCRIPTION

The site is located approximately 11km north of the town of Scottburgh at the approximate latitude and longitude 30°14'0.67" South and 30°43'59.37" East, respectively. The Kwahluzingqondo Secondary School occurs some 450m to the west of the site.

The proposed bridge position crosses a river / stream that are approximately 5m wide. A collapsed concrete bridge which restricts bi-directional traffic flow occurs at the site along the existing gravel road alignment.

Vegetation across the site comprised short grass, occasional tress and dense reeds situated along the river embankments.

The regional and local contexts of the site are shown in Plate 1 and Plate 2, respectively. A General view across the site is shown in Plate 3 and Plate 4.

A general layout of the site is shown in Figure 1, given at the end of this report.

Plate 1: Plan showing the regional context of the site (satellite imagery sourced from Google Earth: 2020)

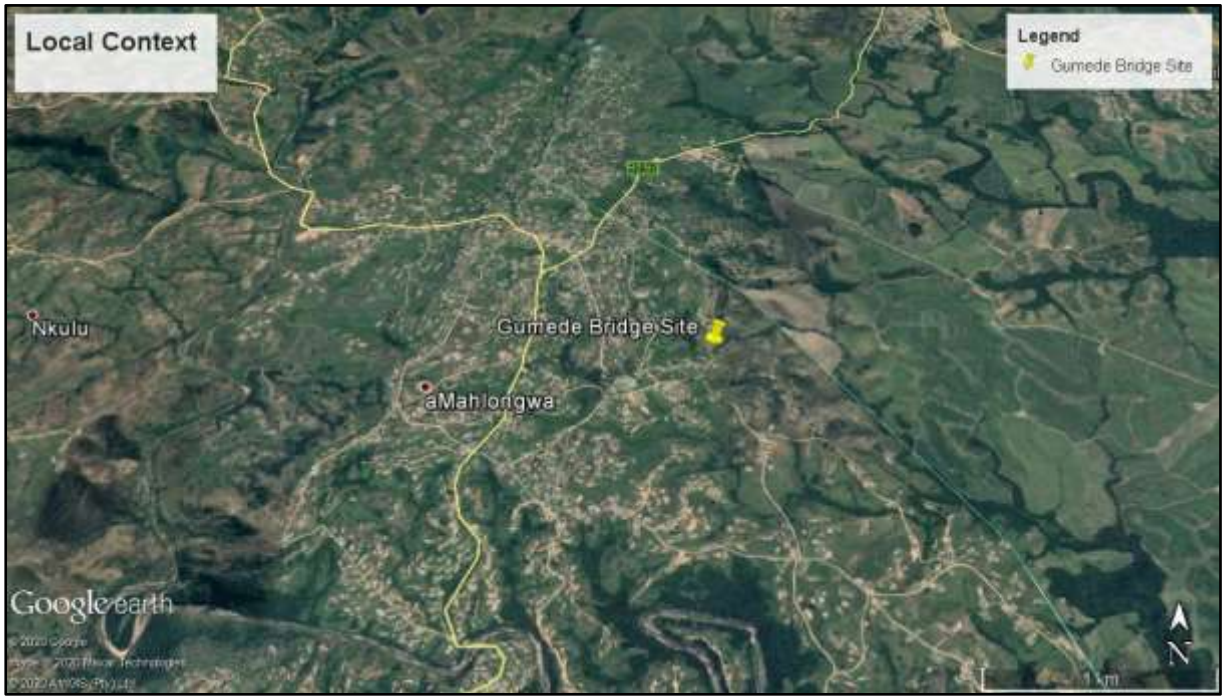


Plate 2: Plan showing the local context of the site (satellite imagery sourced from Google Earth: 2020)

Plate 3: General view across the site viewing in a southerly direction. Note collapsed bridge.

Plate 4: General view of collapsed concrete river bridge

6. FIELDWORK

The fieldwork was carried out on 12 May 2020 and comprised the following:

i. Terrain Analysis;
ii. Inspection Pits; and
iii. Dynamic Cone Penetrometer (DPL) Tests.

6.1 Terrain Analysis

Suitable exposures for profiling were not encountered during the investigation; however observations pertaining to topography and associated landforms were recorded.

6.2 Inspection Pits

Two (2 No.) inspection pits, designated IP1 and IP2, were excavated by means of a track mounted excavator at the approximate positions shown in Figure 1.

The inspection pits were advanced to final/refusal depths of 2.20m (IP1 refers) and 4.65m (IP2 refers) below EGL.

The inspection pits were profiled in accordance to the South African Geoterminology Guidelines (2002)[1], sampled for laboratory testing and backfilled. The detailed profiles are given in Appendix A.

6.3 Dynamic Cone Penetrometer Light (DPL) Tests

Eight (8 No.) DPL tests, designated DPL1 through DPL8, were carried out at the approximate positions given in Figure 1.

DPL tests were advanced to refusal/final depths in the range 0.6m (DPL3 refers) to 4.5m (DPL8 refers) below EGL.

The results of the DPL tests comprising plots of blow counts versus depth are given in Appendix B.

7. GEOLOGY AND ANTICIPATED SUBSURFACE CONDITIONS

According to the Council for Geoscience's regional geological sheet "*3030 Port Shepstone*", the general area of the site is underlain by tillite of the Dwyka Group, as shown below in Plate 5. The site was observed to be underlain by fill, colluvial and alluvial soils that overlie residual soils that grade with depth into weathered tillite rock.

[1] Geoterminology Workshop (2002) – Guidelines for Soil and Rock Logging – SAIEG – AEG – SAICE (Geotechnical Division) pp 47.

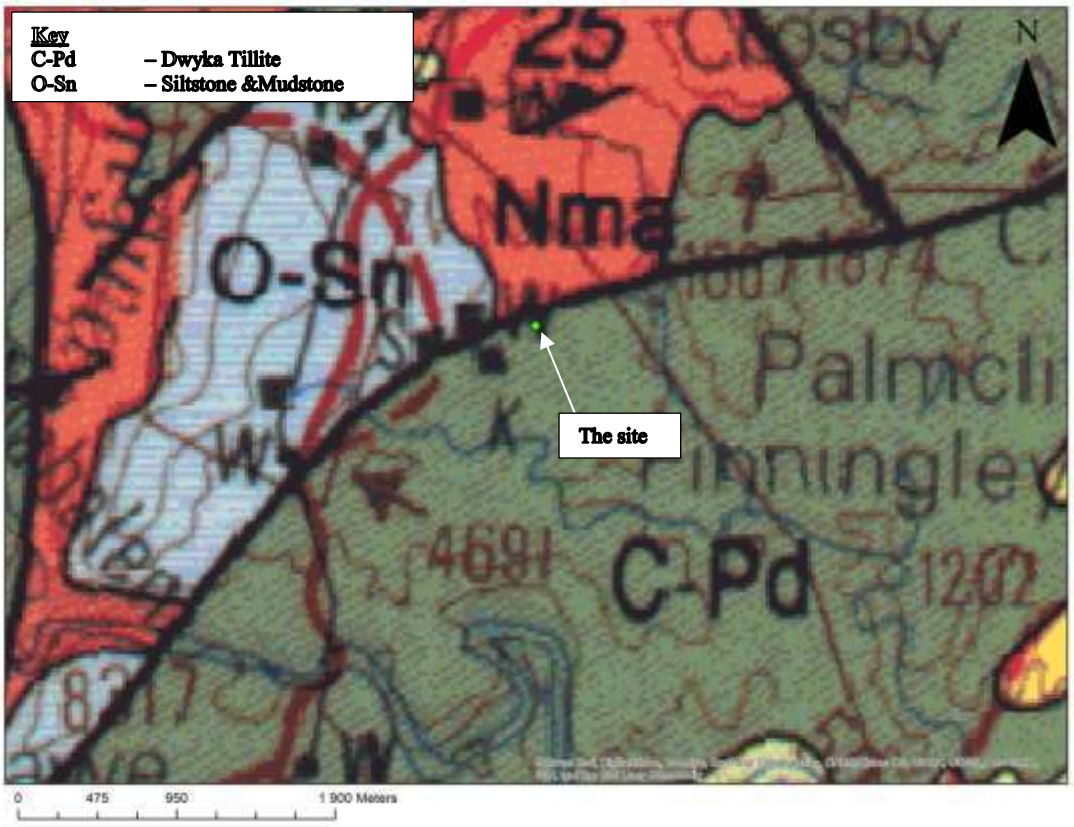


Plate 5: Extract of regional geological sheet "*3030 Port Shepstone*" (Council for Geoscience)

Generalised descriptions of the soil units encountered at the proposed bridge site are given below:

i. **Unit 1: Fill-** Slightly moist to moist**,** light grey to greyish brown, loose, fine to medium grained, slightly clayey silty SAND with zones of sandy clay. These soils were encountered in IP2 only from EGL and observed to extend to a depth of 1.25m below EGL.

ii. **Unit 2: Colluvium** – Slightly moist, greyish brown, loose, fine to medium grained, silty clayey SAND to clayey SAND containing feruginised CLAY with fine plant roots. These soils were encountered in IP1 only from EGL and extended to a depth of 0.47m below EGL.

iii. **Unit 3: Alluvium –** moist to very moist, dark greyish brown, very soft to soft, fine grained, silty SANDY CLAY containing many fine medium roots with slight organic odour / moist, dark grey, loose, medium to coarse grained, slightly gravelly clayey SAND. The alluvium was observed in IP1 and IP2, and extended to depths in the range 0.9m (IP1 refers) to 3.34m (IP2 refers) below EGL.

iv. **Unit 4: Residual Tillite** – Moist to wet, light grey to yellowish brown mottled light and dark grey, firm to very stiff, slightly gravelly sandy silty CLAY containing angular tillite gravel and cobbles with limited pockets of clayey sand. The residual tillite soils were observed to underlie the alluvial soils and graded with depth into weathered tillite rock.

v. **Unit 5: Tillite Rock –** Yellowish brown stained dark brown and grey, highly to moderately weathered, highly to moderately fractured, very soft to soft rock containing limited clay-lined fracture surfaces with grey and yellowish brown silty clay. The tillite rock was observed at depths of 1.30m (IP1 refers) and 4.55m (IP2 refers) below EGL.

Photographs showing the general soil profiles observed at the site are given below in Plates 6 and 7.

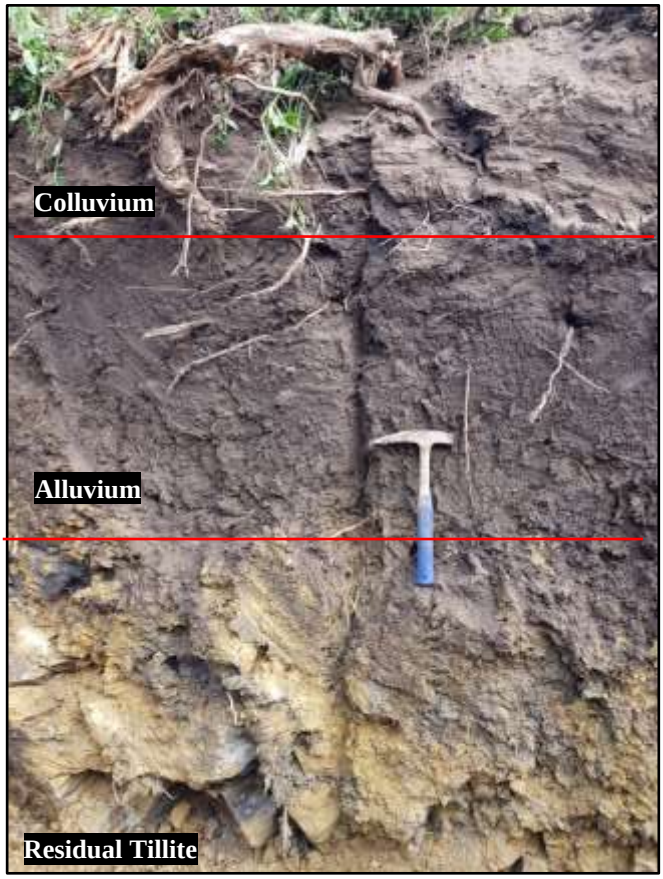


Plate 6: Soils observed at IP1

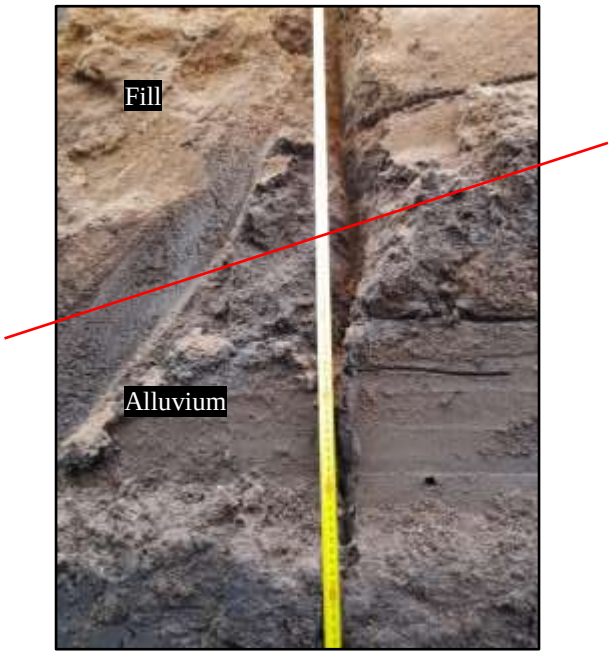


Plate 7: Section of soils observed at IP2

The refusal depths of the DPL tests correlate reasonably well with the observed depths of tillite rock in the inspection pits and therefore inferring from the results of the DPL tests weathered tillite is rock is likely to be in the range 0.6m to 4.5m below EGL, provided the DPL probes did not refuse on obstructions like builder's rubble, gravel and/or boulders.

8. GROUNDWATER

The site traverses a stream and occurs in a low-lying area which appears to be periodically exposed to cycles of inundation. Hence, shallow groundwater conditions are anticipated with strong surface water flows during and after periods of rainfall.

Slight groundwater seepage was observed in inspection pits IP1 and IP2 at the time of the investigation at depths of 1.0m (IP1 refers) and 1.15m (IP2 refers) below EGL. Moderate groundwater seepage was observed in IP2 at a depth of 4.31m.

9. LABORATORY TESTS

The following laboratory tests were carried out on samples retrieved from the site:

i. Grading Analysis and Atterberg Limit determination;
ii. Hydrometer Analysis of fines to 1.5 microns;
iii. Modified AASHTO tests;
iv. California Bearing Ratio (CBR) tests; and
v. Soil Moisture Contents.

The results of the laboratory tests are summarised overleaf in Table 1. Detailed laboratory test results are given in Appendix C.

Table 1: Summary of Results of Particle Size Distribution Analysis, Atterberg Limit Determinations, Insitu Moisture Contents, Modified AASHTO Densities, California Bearing Ratios, and Material Classifications

IP No.	Depth (m)	Description	Particle Size %				Atterberg Limits %			GM	OMC (IMC) %	MDD (kg/m^3)	% Swell	CBR (%)						Material Code & Classification
			Clay	Silt	Sand	Gravel	LL	PI	LS					90	93	95	97	98	100	
FILL																				
IP2	0.01-0.90	Greyish brown speckled orange, silty SAND.	14		62	24	NP	NP	0.0	1.71	6.4	2101	0.0	19	33	49	72	87	128	A-1-b (0) SM G5
IP2	0.90-1.25	Light grey to grey, slightly clayey SAND with zones of sandy clay.	11	33	32	24	34	5	2.5	1.14	(18.2)	-	-	-	-	-	-	-	-	A-4 (1) SM
COLLUVIUM																				
IP1	0.01-0.47	Greyish brown silty clayey SAND to clayey SAND.	50		44	6	22	8	4.0	0.72	10.1	1936	1.4	2.0	3.8	5.8	8.7	11	16	A-4 (1) CL >G10
ALLUVIUM																				
IP2	1.25-3.34	Dark grey, slightly gravelly clayey SAND to sandy CLAY.	15	17	63	5	22	10	5.0	1.10	(6.7)	-	-	-	-	-	-	-	-	A-2-4 (0) SC
RESIDUAL TILLITE																				
IP1	0.90-1.30	Yellowish brown & orange yellow mottled light and dark grey, slightly gravelly sandy silty CLAY.	22		16	62	26	10	5.5	2.09	8.6	2060	1.4	3.4	4.1	4.6	5.2	5.6	6.3	A-2-4(0) GC G10
IP2	3.34-4.55	Light grey mottled orange, slightly sandy to sandy silty CLAY.	35		55	10	24	12	6.0	1.11	9.3	2043	1.6	1.2	1.7	2.1	2.7	3.1	3.9	A-2-6 (0) SC >G10

LL - Liquid Limit
PI - Plasticity Index
A-7-6 (13) - AASHTO Classification
NP - Non Plastic
OMC - Optimum Moisture Content
LS - Linear Shrinkage
\- - Not tested
G5 - Classification according to TRH14 (1985)
GM - Grading Modulus
MDD - Maximum Dry Density
CL - Unified Classification

10. DISCUSSION

10.1 Proposed Development

Information received by Geosure indicates that the development will comprise the construction of a bridge.

Further design details including the layout, span and foundation loads of the bridge were not confirmed at the time of reporting.

Geosure will need to be given the opportunity to review the foundation recommendations set down in this report, as an extension to the appointment once detailed information regarding the foundation loads is confirmed with Geosure. As such, amendments to the recommendations given in this report may be necessary.

10.2 General Stability of the Site

The low lying nature of the site which is traversed by a shallow stream lends itself to a risk of flooding inundation and potential damage by erosion, the extent of which should be determined by a hydrological specialist.

Based on the results of the fieldwork undertaken during this investigation, it is considered, nonetheless, that the site is generally stable and suitable for the development as proposed, provided the recommendations given in this report are adhered to. These measures amount to no more than sound construction practices appropriate to the site conditions anticipated and the extent of details of the proposed development confirmed with Geosure at the time of the preparation of this report.

10.3 Material Classification and Recommendations for Usage

The materials sampled from the site have been classified in terms of the laboratory test results and visual assessment made during the field investigation. The inferred characteristics of the materials and their suitability for use in construction are summarised overleaf in Table 2.

Subgrade material classifications should be verified by process and acceptance control laboratory testing undertaken during construction prior to the material being considered for use.

Table 2: Field Characteristics of Materials Tested and Recommended Usage

Material Type	Description	Classification Details	Recommended Use
Fill	Silty SAND	A-1-b (0) PI = Non Plastic GM = 1.71 CBR@90% = 19 CBR@93% = 33 TRH14 (1985) = G5	These soils are generally considered good subgrade material and can be used as a select or general fill where encountered at or below subgrade level, subject to further testing.
		A-4 (1) PI = 5 GM = 1.14	
Colluvium	Clayey SAND	A-4 (1) PI = 8 GM = 0.72 CBR@90% = 2.0 CBR@93% = 3.8 TRH14 (1985) = >G10	Due to the high organic content, these soils are considered poor subgrade material and should be undercut and replaced with good quality granular material where encountered at or below subgrade level.
Alluvium	Sandy CLAY	Not tested	Due to the clayey content, these soils are considered poor subgrade material and should be undercut and replaced with good quality material where encountered at or below subgrade level.
Residual Tillite	Sandy silty CLAY	A-2-4(0) PI = 10 GM = 2.09 CBR@90% = 3.4 CBR@93% = 4.1 TRH14 (1985) = G10	These soils are considered poor subgrade material and should be undercut and replaced with good quality granular material where encountered at or below subgrade level.
		A-2-6 (0) PI = 12 GM = 1.11 CBR@90% = 1.2 CBR@93% = 1.7 TRH14 (1985) = >G10	
Tillite Rock	Highly to moderately fractured, very soft to soft rock	Not tested	Material could be used as a general fill subject to results of laboratory testing.

10.4 Excavation Characteristics

The colluvium, fill, alluvium, residual tillite and very soft to soft tillite rock are anticipated to classify as "Soft" excavation in terms of SANS 1200, down to the depths investigated i.e. in the range 1.3m to 4.55m below EGL. Such material can normally be excavated by plant similar to a Track mounted excavator.

Beneath the depth range given above, "Intermediate" to "Hard" material excavation categories are inferred to apply.

Nonetheless, limited "Intermediate" and "Boulder" excavations to the depths investigated cannot be discounted and it is recommended that a contingency amount be allowed for "Intermediate" and "Boulder – Class B" excavations at shallower depths due to likely geological variations. Old foundation and builder's rubble may obstruct excavations. Importantly, slow excavation rates due to the groundwater flows should be anticipated.

10.5 General Earthworks

All earthworks should be carried out in a manner to promote stable development of the site. It is recommended that earthworks be carried out along the guidelines given in SANS 1200 (current version).

10.5.1 Coffer Dam

Containment of the anticipated surface water and sub-surface groundwater inflow is essential by means of a coffer dam to engineer's detail or by dewatering.

10.5.2 Fill Embankments

Density control testing of placed fill material should be undertaken at regular intervals during fill construction.

Where natural ground slopes are steeper than 1 vertical to 6 horizontal (> 9 °), the fill must be benched into the slope, to engineer's detail.

Placement of fill layers should be undertaken in layers not exceeding 200mm thick when placed loose and compacted using suitable compaction plant to achieve at least 93% of Modified AASHTO maximum dry density at within 1 – 2 percent (wet / dry) of OMC. Boulders larger than ⅔ of the layer thickness must not be included in the fill material.

For fill embankments, terraces should be graded to direct water to drainage channels away from the fill edges, and small earth bunds should be constructed along the crests of fills, to prevent overtopping and erosion of fill embankment slopes. These bunds should be a minimum 450mm wide and 300mm high.

All toes of fill embankments near the rivers will need to be protected against erosion from the rivers.

10.5.3 Cut Slopes

Cut slopes in soils should be formed to batters not exceeding 1 vertical to 2 horizontal (≤ 26°) and to a height not greater than 3m where stabilizing solutions are not provided.

Cut slopes in competent weathered rock, where encountered, should be no steeper than 1v to 0.75h (≤ 53°) and to a height not greater than 3.0m where retaining walls are not provided. Where joints or bedding planes are exposed during excavation it is recommended that a geotechnical specialist is appointed to assess their effects on the stability of the cutting and the global stability of the slope.

Where excavations intersect or approach the water table, the sidewalls will tend to become unstable and need to be drained and laterally supported or battered back at slopes of the order of 1v in 5h.

10.5.4 Inspection and Approval

Heights of cut and fill embankment greater than 3m should be inspected and approved by a geotechnical professional.

It remains, however, the responsibility of the contractor/engineer on site to ensure excavations are safe and shored in line with requirements as set down in the current "Occupational Health and Safety" Act 85 (1993 as amended).

10.5.5 River Revetment

All cut slopes and fill embankments within the vicinity of the stream will need to be protected, against erosion from the stream, to engineer's detail.

10.6 Inferred Founding Conditions

The inferred geotechnical conditions observed on site at the positions investigated are characterised by the following:

i. Low bearing capacities of the fill, alluvial, colluvium and residual soils.

ii. Loosely consolidated sandy / gravelly alluvial soils that may exhibit a collapse settlement potential in response to increases in ground moisture content which usually results in significant total and differential settlement under applied loads.

iii. High risk of shallow and persistent surface water and groundwater activity generally across the site.

iv. Trench/excavation sidewalls excavated into the loosely consolidated soil cover are likely to be unstable and require shoring / battering back to engineer's detail.

v. The depth to rock was observed to increase in a northerly direction across the stream i.e. from 1.3m at IP1 to 4.55m below EGL at IP2.

vi. Although not observed, alluvial boulders may be present.

vii. Builder's rubble within the fills and old foundations may obstruct excavations.

10.7 Foundation Recommendations

All foundations should be designed to act in end bearing on competent approved rock. Rock was observed to extend to depths in the range 1.3m (IP1 refers) to 4.55m (IP2 refers) below EGL.

It is recommended that foundations be taken down through the fill, colluvial, alluvial and residual horizons and placed on competent weathered rock.

It is considered that the following foundation types will be suited to the proposed developments and underlying founding conditions:

i. Spread/Pad Footing;
ii. Caissons; and/or
iii. Piled Foundation.

10.7.1 Spread / Pad Foundations

It is considered that spread footings may be feasible provided the following conditions can be met:

i. Water seepage into excavations can be controlled;
ii. Potential collapse of the excavation sidewalls can be prevented; and
iii. The depth to the competent rock horizon is within practical construction limits (refer to IP1).

Temporary support for excavation sidewalls and de-watering will be required. Consideration should also be given to creation of a low dam or coffer dam around the foundation during construction, so that the site can be de-watered or the water level controlled and construction can proceed largely in the dry.

The footings must be founded on competent weathered bedrock of at least very soft rock strength, where a maximum allowable bearing pressure of 250kN/m^2 is considered applicable. It is further recommended that the footings be anchored to the bedrock by dowelling at least 2.0m into the rock beneath the footing. The final depth of dowelling will need to be determined by the structural/civil engineer depending on the results of a flood hydraulic analysis and anticipated debris loads of the river acting on the structure.

Settlement of such footings should be negligible (< 5mm) provided the concrete is cast directly onto clean competent rock.

It is recommended that all foundation excavations be inspected and approved by Geosure (Pty) Ltd prior to blinding and casting concrete.

10.7.2 Caissons

Caissons may be considered as an alternative to the spread footings and may be more practical to use where the depth to bedrock is significant.

The caissons must be taken down into competent weathered bedrock of at least very soft rock strength, where a maximum allowable bearing pressure of 250kN/m^2 is considered applicable, and will need to be anchored to the bedrock by dowelling at least 2.0m into the rock. The final depth of dowelling will need to be determined by the structural/civil engineer depending on the results of a flood hydraulic analysis and anticipated debris loads of the River.

Use of caissons could avoid the need for lateral support, but it is considered that de-watering will be necessary. Care should to be taken when sinking the caisson through alluvial boulders in order to minimise the risk of "hang up" on large boulders, and local damage to the cutting edge and the adjacent caisson wall. Installation of the caisson through these layers is likely to be time consuming.

Settlement of caissons should be negligible (< 5mm) provided the concrete is cast directly onto clean competent rock. It is recommended that all foundation excavations be inspected and approved by Geosure (Pty) Ltd prior to blinding and casting concrete.

10.7.3 Piled Foundations

Alternatively, and preferably, consideration could be given to supporting the bridge piers on a piled foundation where the depth to rock horizon exceeds the economic development of spread foundations or caissons (refer to IP2).

The following pile types may be considered as potential founding solutions for the proposed structure:

i. Reinforced concrete shafts cast in a permanent steel lining installed within a temporary steel casing advanced by oscillation or otherwise with augering, grabbing, chiselling or drilling as necessary to reach the required founding depth.

ii. Steel tube piles advanced by driving with pre-drilling as necessary to reach the required founding depth without permanent deformation or buckling and filled with reinforced concrete.

Other pile types may be considered provided that the installation equipment and procedures can:

i. ensure that the piles will be advanced to the required founding depth;
ii. ensure the structural integrity and durability of the pile shafts; and
iii. ensure the absence of disturbed material below the pile base.

For the above pile types founded within the bedrock, it is anticipated that the maximum settlement will be less than 5mm. The need to install piles at raked angles to counteract horizontal loads will need to be determined from the hydraulic and structural analysis.

Whilst Pressure Grouted Auger (CFA) and Driven Cast Insitu (DCI) piles are considered an economical solution, the risk of refusing on boulders cannot be discounted. CFA piles are unlikely to penetrate to sufficient depths into the bedrock to sustain tensile or bending loads. The DCI piles may be driven to bedrock but are not likely to penetrate the weathered bedrock. This is a critical aspect if some piles are required to act in tension

caused by debris loads on the bridge structure. In addition, the aspect of scour of the alluvial soils may also require that piles be socketed into the bedrock.

It is therefore recommended that only the following pile types be considered:

i. Auger Piles; or
ii. Rotapiles.

Provided the piles are socketed into or driven to refusal on competent weathered bedrock of at least medium hard rock strength (where a maximum nett allowable bearing pressure of 1000 kN/m^2 is considered applicable) the approximate loads given in Table 3 may be adopted for the design of piles.

Table 3: Details of Various Pile Types

Pile Type	Diameter (mm) (lined)	*Approximate Allowable Pile Load (kN)	Maximum Rake
#Auger Piles	300 400 500 600 750	200 – 550 375 – 1000 600 – 1500 1600 – 2250 2500 - 3500	1: 4
Rotapiles	255 305 355 406 457 610	300-450 450-600 600-900 800-1200 1000-1500 1500-2500	1: 4 1: 4 1: 8 1: 8 1: 8 1: 8

* - Working Loads calculated using a shaft stress of 8MPa can be considered when socketed into hard rock.
# - Intermediate pile sizes available.

For both pile types permanent lining is recommended in order to protect the wet concrete of the pile shaft from likely strong flow of groundwater.

Consideration will need to be given to the correct selection of an appropriate pile size for the rotapile as slender pile sizes may be prone to buckling effects and will need to be carefully considered.

Piles will need to be socketed into competent bedrock. Penetration into the bedrock will depend on the hardness of the rock and fracture frequency. Consideration should be given to socketing piles into bedrock by at least 2m to 3m, subject to review by the pile design engineer.

A detailed pile design will need to be carried out by the contractor. This design should be submitted to Geosure for comment.

10.8 Drainage

It is essential, for the stable development of the site, to protect the structure and adjacent earthworks from damage by surface and groundwater flows.

Suitable measures to engineer's detail are required to manage potential hydraulic flood scour during and after construction.

Earthworks and drainage measures should be designed by an Engineer in such a way as to prevent ponding of, or high concentrations of, stormwater or groundwater anywhere on the site, both during and after completion of the development.

Any terraces should be shaped to a gradient to prevent water ponding on the surface and should be graded to direct water away from the fill edges and foundations.

11. SUMMARY OF FINDINGS AND RECOMMENDATIONS

This report details the results of a shallow geotechnical investigation for the proposed Gumede Bridge located within Ward 16 of the Umdoni Municipality, KwaZulu-Natal.

Based on the results of the fieldwork undertaken during this investigation, it is considered that this site is generally stable and suitable for the proposed development, provided that the recommendations given in this report are adhered to.

The site at the positions investigated is observed to be underlain by colluvium, fill, alluvium, residual tillite and weathered tillite rock. The tillite rock was observed at depths of 1.30m (IP1 refers) and 4.55m (IP2 refers) below EGL.

The site traverses a stream and occurs in a low-lying area which appears to be periodically exposed to cycles of inundation. Hence, shallow groundwater conditions are anticipated with strong surface water flows during and after periods of rainfall.

It is imperative that the well-developed groundwater condition and risk of inundation be taken into account during design and construction of the proposed structure. In this regard, it is considered that temporary dewatering of excavations and/or the use of a coffer dam will be required during construction.

It is considered that the following foundation types will be suited to the proposed developments and underlying founding conditions:

i. Spread/Pad Footing;
ii. Caissons; and/or
iii. Piled Foundation.

Taking into consideration the shallow groundwater table, it is considered that a piled foundation solution may prove to be the more practical solution for this site. In this regard, the auger pile and rotapile are likely to be suitable pile types for the site conditions. Spread footing and caissons can be considered along the southern abutment provided the surface and groundwater can be controlled.

All earthworks should be carried out in a manner to p61romote stable development of the site. It is recommended that earthworks be carried out along the guidelines given in SANS 1200 (current version).

Earthworks and drainage measures should be designed, by an Engineer, in such a way as to prevent ponding of, or high concentrations of, stormwater or groundwater anywhere on

the site, both during and after the development. Suitable measures to engineer's detail are required to manage potential hydraulic flood scour.

The ground conditions given in this report refer specifically to the field tests carried out on site. It is therefore, quite possible that conditions at variance with those given in this report could be encountered elsewhere on site during construction. It is also important that Geosure be appointed to carry out periodic inspections during construction. Any change from the anticipated ground conditions could then be taken into account to avoid unnecessary expense.

APPENDIX A

INSPECTION PIT PROFILES

GEOSURE (Pty) Ltd
P O Box 1461, Westville, 3630, South Africa
Tel: (031) 266-0458
email: geosure@ iafrica.com

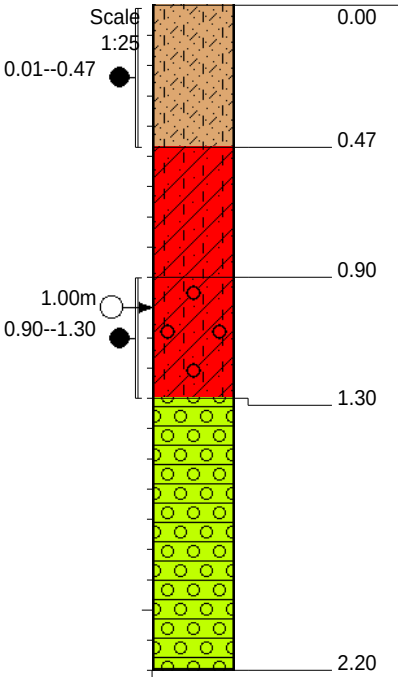
Geotechnical, Environmental &
Groundwater Engineering
Pile Integrity Testing & Civil
Engineering Laboratory

Fax: 086 689-5506
www.geosure.co.za

Vuba Imagineers
Proposed Gumede Bridge,
Umdoni Muncipality, Ward 16,
Kwa-Zulu Natal

HOLE No: IP1
Sheet 1 of 1

JOB NUMBER: 086-20



0.00	Slightly moist, greyish brown, loose, fine to medium grained, silty clayey SAND to clayey SAND containing feruginised CLAY with fine plant roots. Colluvium.
0.47	Moist to very moist, dark greyish brown, very soft to soft, fine grained, silty SANDY CLAY containing many fine medium roots and subrounded coarse GRAVEL with slight organic smell. Alluvium.
0.90	Moist to wet, yellowish brown and orange yellow mottled light and dark grey, firm to very stiff, slightly gravelly sandy silty CLAY containing occasional to frequently angular tillite gravel and cobbles. Residual Tillite.
1.30	Yellowish brown stained dark brown and grey, highly to moderately weathered, highly to moderately fractured, very soft to soft rock containing limited clay, lined fractured surfaces with grey and yellowish brown silty clay. TILLITE. Dwyka Group.
2.20	

NOTES

1) Slight groundwater seepage observed at 1,00m.

2) Samples taken at:
S1 0,01--0,47 (2 x Bulk)
S2 0,90--1,30 (3 x Bulk) (1 x Ind)

3) Refusal depth at 2,20m.

CONTRACTOR : Ackin Investments 2108 cc
MACHINE : Sumi Tomo SH210
DRILLED BY :
PROFILED BY : E.Angath

TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 12 May 2020
DATE : 12 May 2020

DATE : 19/06/20 14:47
TEXT : ..C:\LOGS\PITS.TXT

ELEVATION : -
X-COORD : 30 43'59.37"E
Y-COORD : 30 14'0.67"S

HOLE No: IP1

GEOSURE (Pty) Ltd
P O Box 1461, Westville, 3630, South Africa
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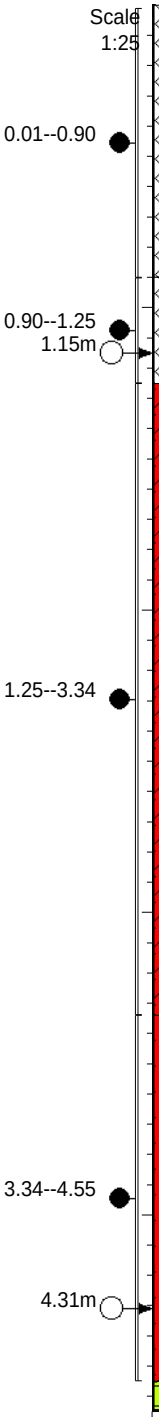
Geotechnical, Environmental & Groundwater Engineering
Pile Integrity Testing & Civil Engineering Laboratory

Fax: 086 689-5506
www.geosure.co.za

Vuba Imagineers
Proposed Gumede Bridge,
Umdoni Muncipality, Ward 16,
Kwa-Zulu Natal

HOLE No: IP2
Sheet 1 of 1

JOB NUMBER: 086-20



0.00 Slightly moist, greyish brown speckled orange, loose, fine to medium grained, silty SAND. FILL.

0.90 Moist to very moist, light grey to grey, loose, medium to coarse grained, slightly clayey silty SAND to clayey SILT with zones of sandy clay, Transitional zone contaminated. FILL.

1.25 Moist, dark grey, firm to very firm, medium to coarse grained, slightly gravelly clayey SAND and CLAY to SANDY CLAY. Alluvium.

3.34 Slightly moist to moist, light grey mottled orange, firm to very firm, slightly sandy to sandy silty CLAY with limited pockets of clayey sand. Residual Tillite.

4.55 Yellowish brown stained brown, moderately weathered, soft rock containing limited grey brown silty clay. TILLITE. Dwyka Group.

4.65

NOTES

1) Slight groundwater seepage observed at 1,15m.

2) Moderate groundwater seepage observed at 4,31m.

3) Samples taken at:
S1 0,01--0,90 (2 x Bulk)
S2 0,90--1,25 (1 x Ind)
S3 1,25--3,34 (1 x Ind)
S4 3,34--4,55 (2 x Bulk) (1 x Ind)

4) Refusal depth at 4,65m.

CONTRACTOR : Ackin Investments 2108 cc
MACHINE : Sumi Tomo SH210
DRILLED BY :
PROFILED BY : E.Angath

TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 12 May 2020
DATE : 12 May 2020

DATE : 19/06/20 14:47
TEXT : ..C:\LOGS\PITS.TXT

ELEVATION : -
X-COORD : 30 44' 0.07"E
Y-COORD : 30 14' 0.32"S

HOLE No: IP2

APPENDIX B

RESULTS OF DYNAMIC CONE PENETROMETER LIGHT (DPL) TESTS

GEOSURE (PTY) LTD.

Geotechnical Engineering Consultants

Tel: (031) 266 0458 Fax: 086 689 5506 Email: info@geosure.co.za

Client: Vuba Imagineers **Ref.No.** 086-20

Project: Proposed Gumede Bridge, Umdoni Municipality **Date:** 12-May-2020

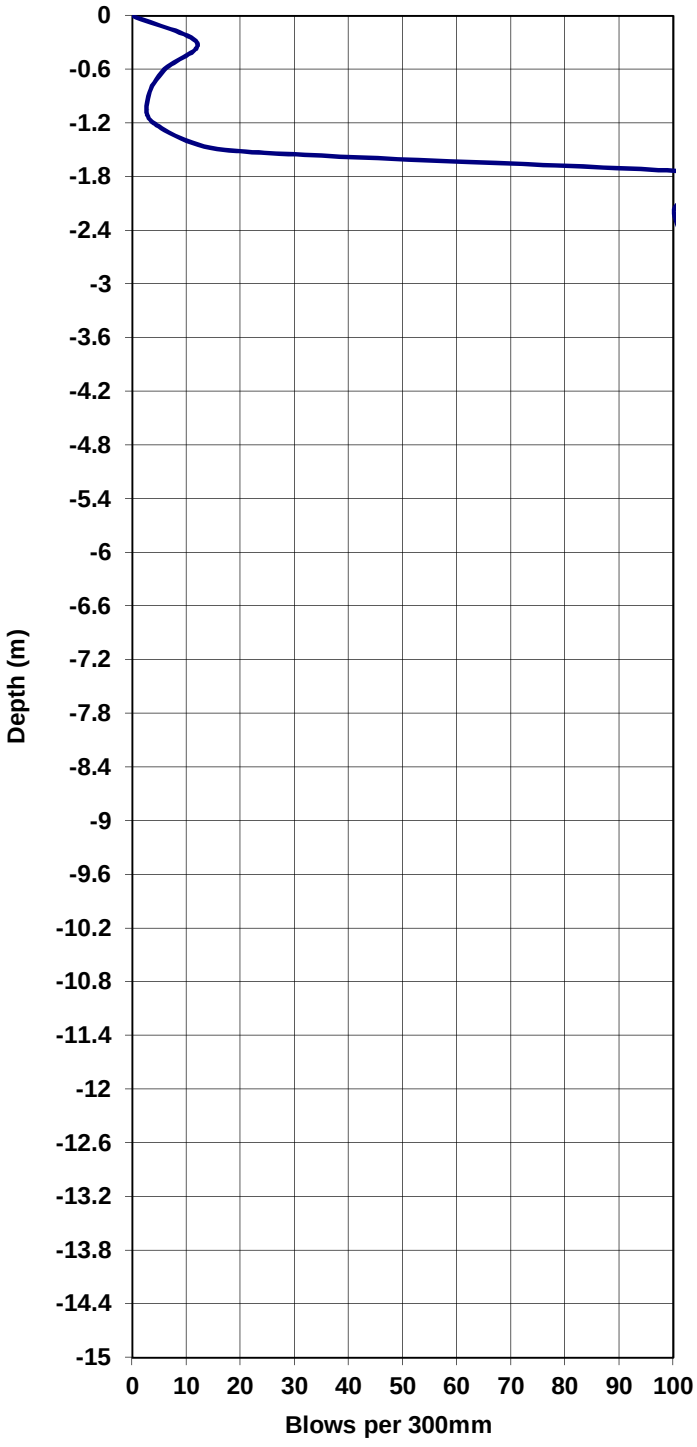
Section: Ward 16, Kwa-Zulu Natal **Operator:** E.Angath/R.Madokwe

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 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	12	Loose	<30 deg
0.6	6	Very Loose	<29 deg
0.9	3	Very Loose	<29 deg
1.2	4	Very Loose	<29 deg
1.5	17	Med.Dense	31 deg
1.8	116	Very Dense	>38 deg
	Refusal		



GEOSURE (PTY) LTD.

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Tel: (031) 266 0458 Fax: 086 689 5506 Email: info@geosure.co.za

Client: Vuba Imagineers **Ref.No.** 086-20

Project: Proposed Gumede Bridge, Umdoni Municipality **Date:** 12-May-2020

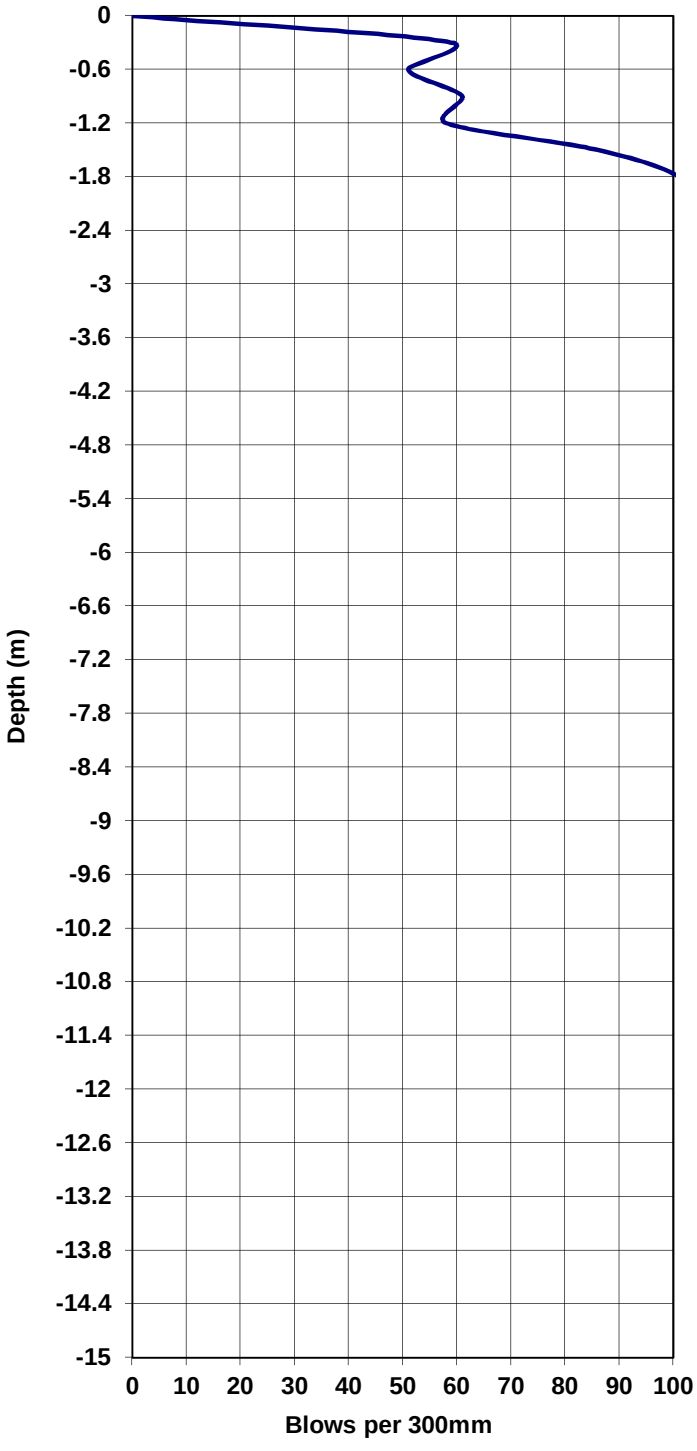
Section: Ward 16, Kwa-Zulu Natal **Operator:** E.Angath/R.Madokwe

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 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	59	Dense	37 deg
0.6	51	Dense	36 deg
0.9	61	Dense	37 deg
1.2	58	Dense	37 deg
1.5	86	Dense	38 deg
	Refusal		



GEOSURE (PTY) LTD.

Geotechnical Engineering Consultants

Tel: (031) 266 0458 Fax: 086 689 5506 Email: info@geosure.co.za

Client: Vuba Imagineers
Project: Proposed Gumede Bridge, Umdoni Municipality
Section: Ward 16, Kwa-Zulu Natal

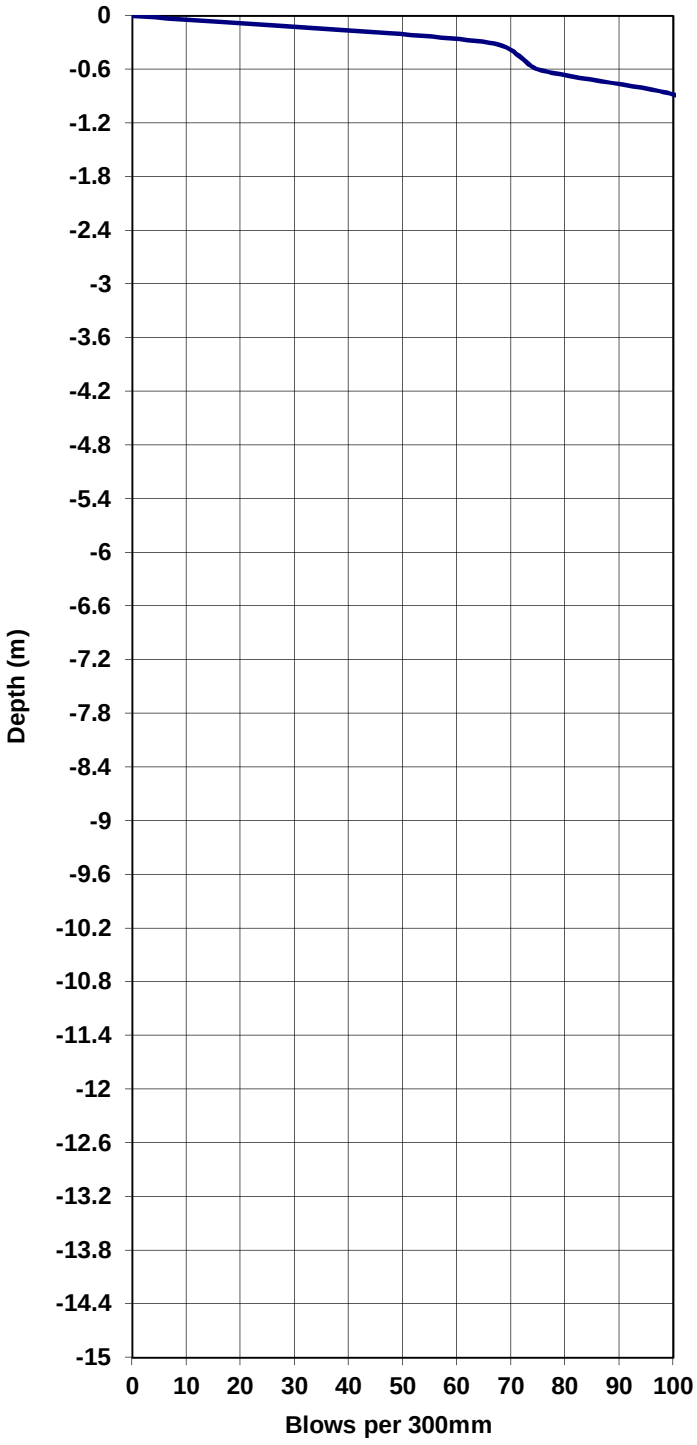
Ref.No. 086-20
Date: 12-May-2020
Operator: E.Angath/R.Madokwe

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 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	66	Dense	37 deg
0.6	75	Dense	37 deg
	Refusal		



GEOSURE (PTY) LTD.

Geotechnical Engineering Consultants

Tel: (031) 266 0458 Fax: 086 689 5506 Email: info@geosure.co.za

Client: Vuba Imagineers
Project: Proposed Gumede Bridge, Umdoni Municipality
Section: Ward 16, Kwa-Zulu Natal

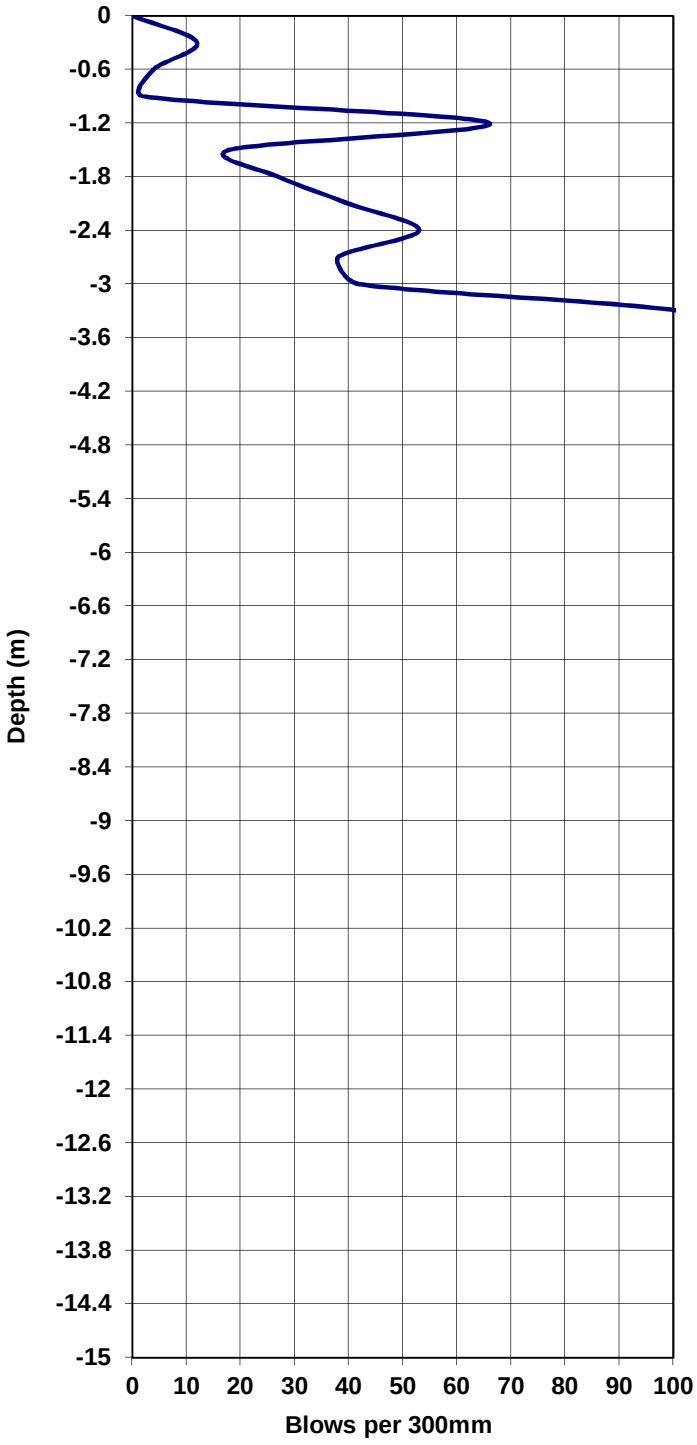
Ref.No. 086-20
Date: 12-May-2020
Operator: E.Angath/R.Madokwe

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 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	12	Loose	<30 deg
0.6	4	Very Loose	<29 deg
0.9	2	Very Loose	<29 deg
1.2	66	Dense	37 deg
1.5	18	Med.Dense	31 deg
1.8	27	Med.Dense	34 deg
2.1	40	Med.Dense	36 deg
2.4	53	Dense	37 deg
2.7	38	Med.Dense	36 deg
3	42	Dense	36 deg
	Refusal		



GEOSURE (PTY) LTD.

Geotechnical Engineering Consultants

Tel: (031) 266 0458 Fax: 086 689 5506 Email: info@geosure.co.za

Client: Vuba Imagineers
Project: Proposed Gumede Bridge, Umdoni Municipality
Section: Ward 16, Kwa-Zulu Natal

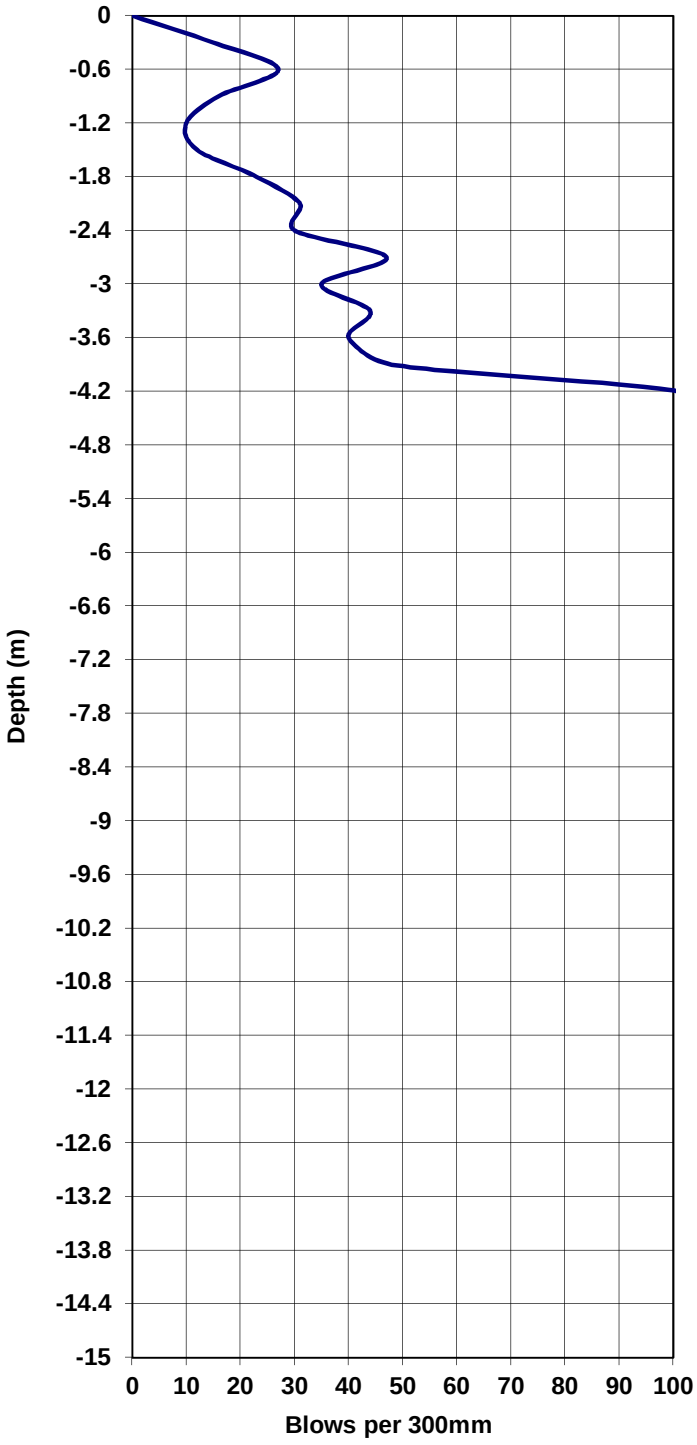
Ref.No. 086-20
Date: 12-May-2020
Operator: E.Angath/R.Madokwe

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 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	15	Loose	<30 deg
0.6	27	Med.Dense	34 deg
0.9	16	Med.Dense	30 deg
1.2	10	Loose	<30 deg
1.5	12	Loose	<30 deg
1.8	23	Med.Dense	33 deg
2.1	31	Med.Dense	35 deg
2.4	30	Med.Dense	34 deg
2.7	47	Dense	36 deg
3	35	Med.Dense	35 deg
3.3	44	Dense	36 deg
3.6	40	Med.Dense	36 deg
3.9	48	Dense	36 deg
	Refusal		



GEOSURE (PTY) LTD.

Geotechnical Engineering Consultants

Tel: (031) 266 0458 Fax: 086 689 5506 Email: info@geosure.co.za

Client: Vuba Imagineers **Ref.No.** 086-20

Project: Proposed Gumede Bridge, Umdoni Municipality **Date:** 12-May-2020

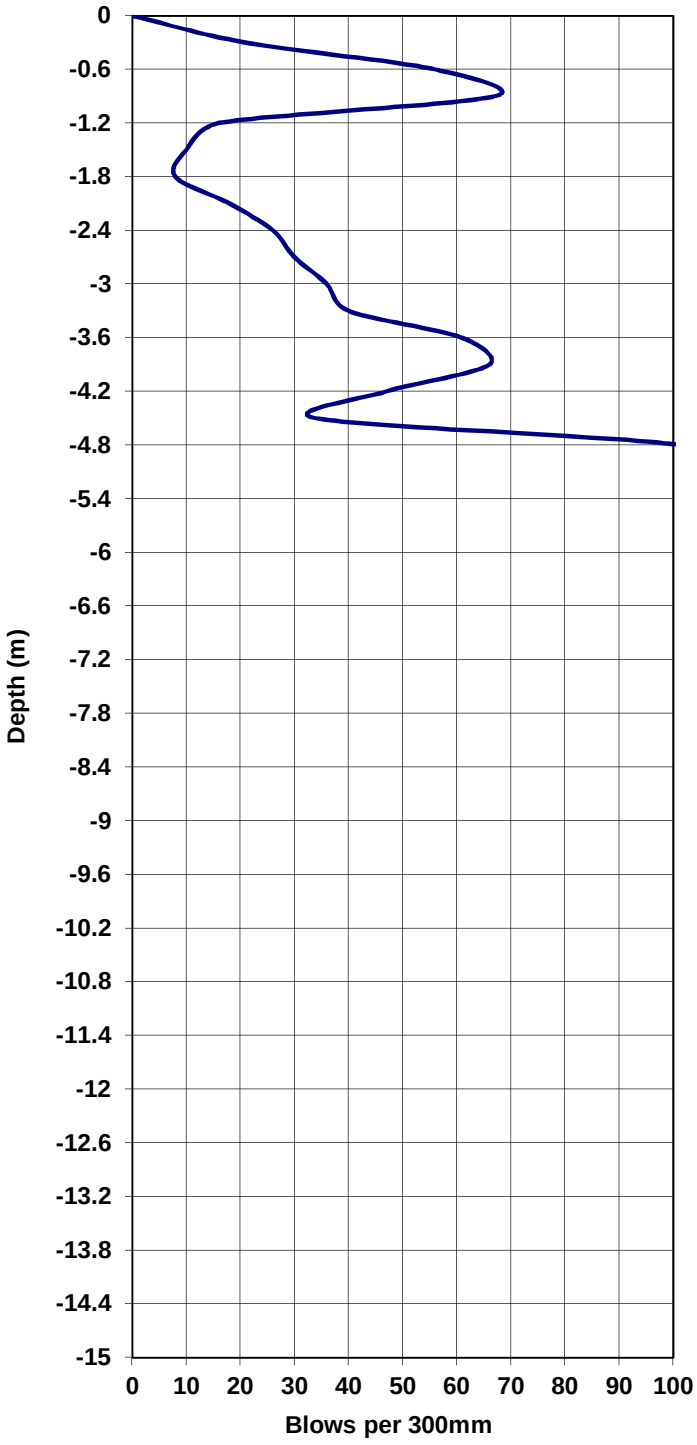
Section: Ward 16, Kwa-Zulu Natal **Operator:** E.Angath/R.Madokwe

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 6***

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	21	Med.Dense	32 deg
0.6	56	Dense	37 deg
0.9	67	Dense	37 deg
1.2	16	Med.Dense	30 deg
1.5	10	Loose	<30 deg
1.8	8	Loose	<30 deg
2.1	18	Med.Dense	31 deg
2.4	26	Med.Dense	34 deg
2.7	30	Med.Dense	34 deg
3	36	Med.Dense	35 deg
3.3	40	Med.Dense	36 deg
3.6	61	Dense	37 deg
3.9	66	Dense	37 deg
4.2	47	Dense	36 deg
4.5	34	Med.Dense	35 deg
	Refusal		



GEOSURE (PTY) LTD.

Geotechnical Engineering Consultants

Tel: (031) 266 0458 Fax: 086 689 5506 Email: info@geosure.co.za

Client: Vuba Imagineers **Ref.No.** 086-20

Project: Proposed Gumede Bridge, Umdoni Municipality **Date:** 12-May-2020

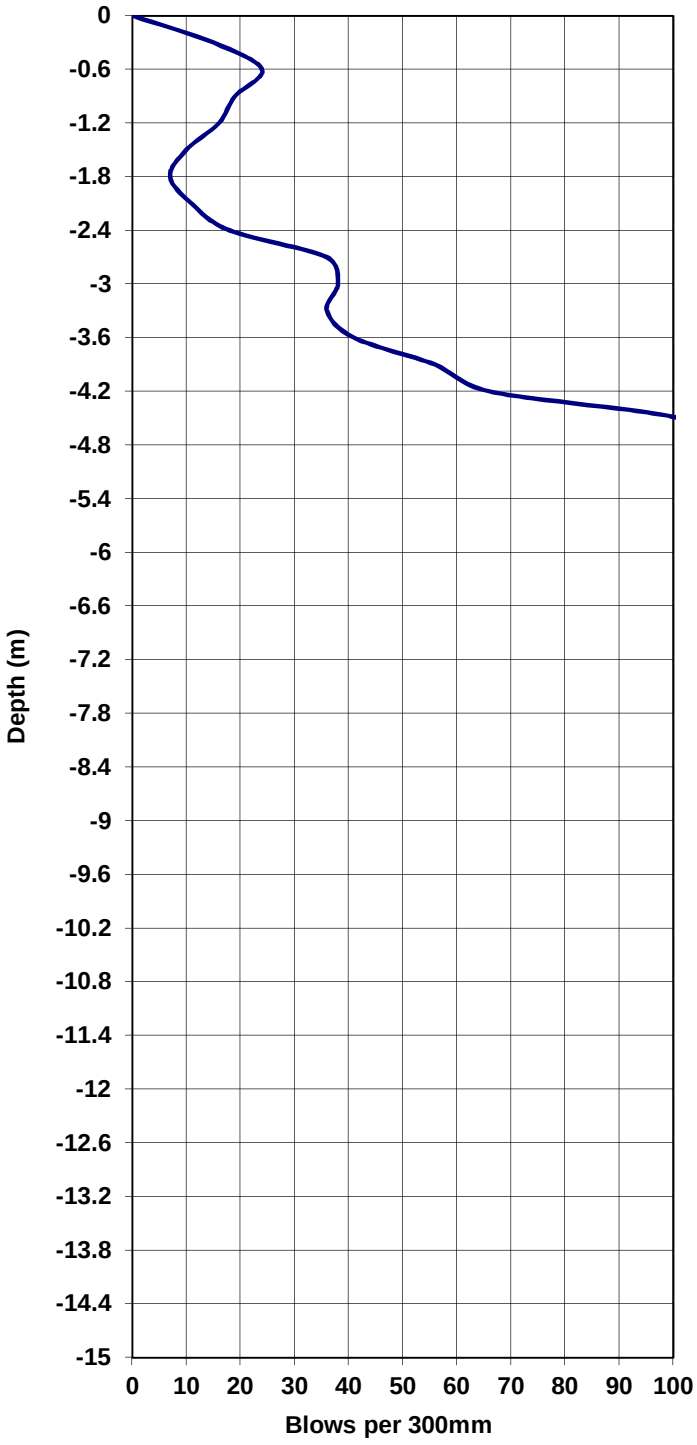
Section: Ward 16, Kwa-Zulu Natal **Operator:** E.Angath/R.Madokwe

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 7***

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	15	Loose	<30 deg
0.6	24	Med.Dense	33 deg
0.9	19	Med.Dense	32 deg
1.2	16	Med.Dense	30 deg
1.5	10	Loose	<30 deg
1.8	7	Loose	<30 deg
2.1	11	Loose	<30 deg
2.4	18	Med.Dense	31 deg
2.7	36	Med.Dense	35 deg
3	38	Med.Dense	36 deg
3.3	36	Med.Dense	35 deg
3.6	41	Dense	36 deg
3.9	56	Dense	37 deg
4.2	66	Dense	37 deg
	Refusal		



GEOSURE (PTY) LTD.

Geotechnical Engineering Consultants

Tel: (031) 266 0458 Fax: 086 689 5506 Email: info@geosure.co.za

Client: Vuba Imagineers
Project: Proposed Gumede Bridge, Umdoni Municipality
Section: Ward 16, Kwa-Zulu Natal

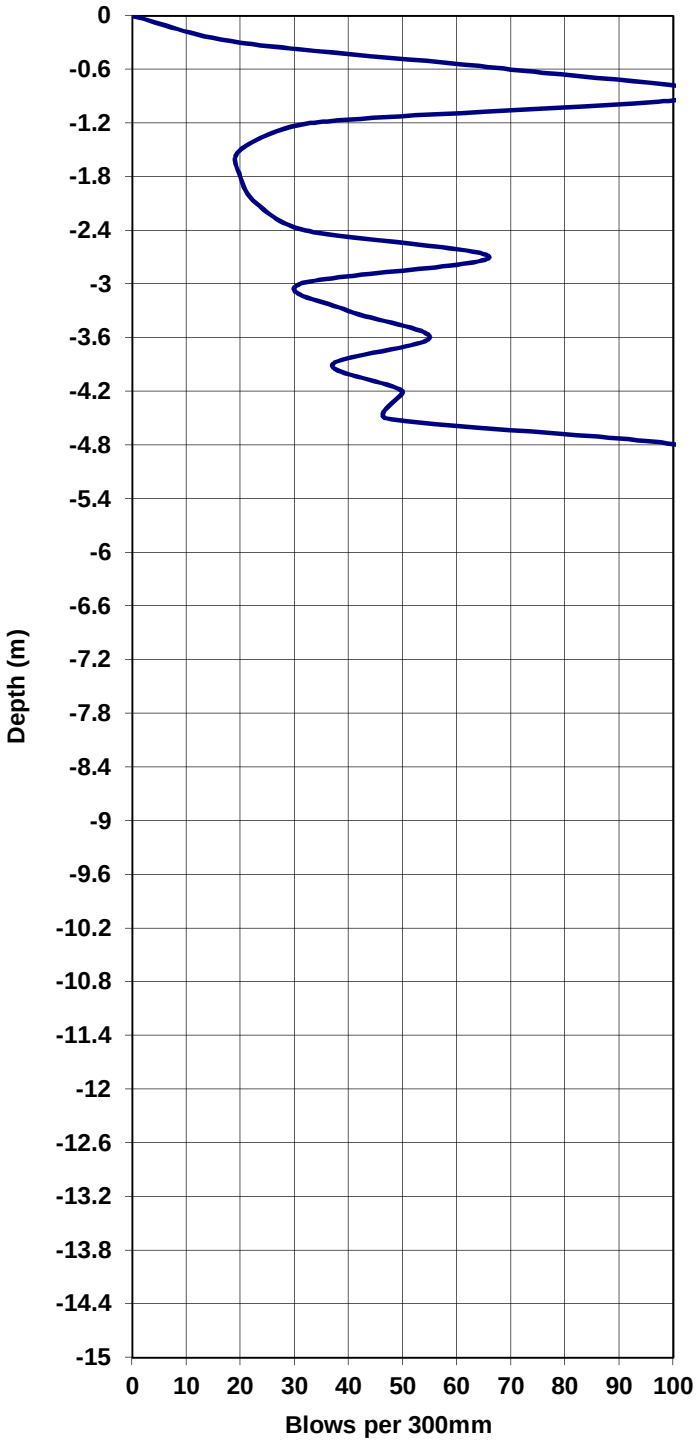
Ref.No. 086-20
Date: 12-May-2020
Operator: E.Angath/R.Madokwe

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 8***

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	20	Med.Dense	32 deg
0.6	70	Dense	37 deg
0.9	106	Very Dense	>38 deg
1.2	33	Med.Dense	35 deg
1.5	20	Med.Dense	32 deg
1.8	20	Med.Dense	32 deg
2.1	23	Med.Dense	33 deg
2.4	32	Med.Dense	35 deg
2.7	66	Dense	37 deg
3	31	Med.Dense	35 deg
3.3	40	Med.Dense	36 deg
3.6	55	Dense	37 deg
3.9	37	Med.Dense	35 deg
4.2	50	Dense	36 deg
4.5	47	Dense	36 deg
	Refusal		



APPENDIX C

RESULTS OF LABORATORY TESTS

Consulting Engineering Geologists, Geotechnical Engineers, Geotechnicians & Geotechnical Quality Assurance Specialists

GEOSURE (Pty) Ltd

sanas Testing Laboratory T0483

CLIENT : Geosure (Pty) Ltd
PHYSICAL ADDRESS : 122 Intersite Avenue, Springfield Park,
Umgeni
Durban, 4001
ATTENTION : Mr D. Naidoo
PROJECT : Proposed Gumede Bridge, Ward 16

TEST REPORT REFERENCE NUMBER: 48733

Dear Sir/Madam,
Enclosed herewith, please find the original reports pertaining to the above-mentioned project.

Date Received	**14.05.2020**
Date Tested	28.05.2020 to 08.06.2020
Sample Location	Refer to Report
Sampling Method	N/A
Sample Condition	Moist
Sampling Environmental Condition	N/A
Sampler(s) Name	Client
Total Number of Pages	13

Test Carried Out			
SANS3001 GR1	✓	TMH1 Method C3	
SANS3001 GR10, GR12	✓	TMH1 Method C4a	
SANS3001 GR30	✓	TMH1 Method B6	
SANS3001 GR40	✓	Hydrometer Analysis - ASTM D422	✓
TMH1 Method A10(b)		SABS1200 (Compactibility Factor)#	
TMH1 Method A13T + A14app		SANS 5862-1	
TMH1 Method A15d		SANS 5860, 5861-1, 5861-2, 5861-3	
TMH1 Method A13T + A16T		TMH1 Method B9	

✓ - Tick denotes tests that were carried out. #Denotes non accredited tests

We would like to take this opportunity of thanking you for your continued support.
Should you have any queries please do not hesitate to contact me.

Yours faithfully

Technical Signatory,
Dheeran Ramcharan for Geosure (Pty) Ltd.

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Consulting Engineering Geologists, Geotechnical Engineers, Geotechnicians & Geotechnical Quality Assurance Specialists
GEOSURE (Pty) Ltd
sanas T0483

Reg.No.: 92/03145/07
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WEBSITE: www.geosure.co.za

Client : **Geosure (Pty) Ltd** **Our Ref.** : **48733**

Project : **Proposed Gumede Bridge, Ward 16** **Your Ref.** : **086-20**

Date Tested : **28.05.2020 to 02.06.2020**

Attention : **Mr D. Naidoo** **Date Reported** : **09.06.2020**

Sample No.			T24988	T24989			
Field No.			IP2	IP2			
Position in Field			Layer 2	Layer 3			
Depth (m)			0.90-1.25	1.25-3.34			
Material Description			Light grey to grey slightly clayey SAND with zones of sandy clay. Fill	Dark grey slightly gravelly clayey SAND and CLAY to sandy CLAY. Alluvium			
Sieve Analysis (Wet Preparation) - SANS3001 GR 1 - Percent Passing Sieve Size							
% Passing	**100.0**	**mm**	100	100			
	75.0	**mm**	100	100			
	63.0	**mm**	100	100			
	50.0	**mm**	100	100			
	37.5	**mm**	100	100			
	28.0	**mm**	100	100			
	20.0	**mm**	100	100			
	14.0	**mm**	100	100			
	5.00	**mm**	90	99			
	2.00	**mm**	76	95			
	0.425	**mm**	62	62			
	0.250	**mm**	57	49			
	0.150	**mm**	54	39			
	0.075	**mm**	49	34			
Hydrometer Analysis - ASTM - D422 - Percent Passing Particle Diameter (<0.425mm)							
% Passing	**0.060**	**mm**	44	32			
	0.050	**mm**	40	31			
	0.040	**mm**	37	29			
	0.026	**mm**	33	28			
	0.015	**mm**	28	24			
	0.010	**mm**	23	21			
	0.0074	**mm**	20	20			
	0.0036	**mm**	14	17			
	0.0020	**mm**	11	15			
	0.0015	**mm**	9	14			
Mechanical analysis - SANS3001 GR1 - Percent of Soil Mortar (<2 mm) for Grain Size range							
Coarse Sand		**%**	19	35			
Coarse Fine Sand		**%**	6	14			
Medium Fine Sand		**%**	5	10			
Fine Fine Sand		**%**	7	6			
Silt & Clay		**%**	64	36			
Grading Modulus			1.14	1.10			
Atterberg Limits - SANS3001 GR10, GR12 (<0.425mm)							
Liquid Limit		**%**	34	22			
Plasticity Index		**%**	5	10			
Linear Shrinkage		**%**	2.5	5.0			
AASHTO Classification (Group Index)*			A-4 (1)	A-2-4 (0)			
Unified Classification*			SM	SC			
Moisture Content		**%**	18.2	6.7			

Remarks: Date Received: 14.05.2020

Sampled by Client.

*Opinions expressed herein fall outside the scope of SANAS accreditation.

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Consulting Engineering Geologists, Geotechnical Engineers, Geotechnicians & Geotechnical Quality Assurance Specialists
GEOSURE (Pty) Ltd

sanas T8483

Reg.No.: 92/03145/07

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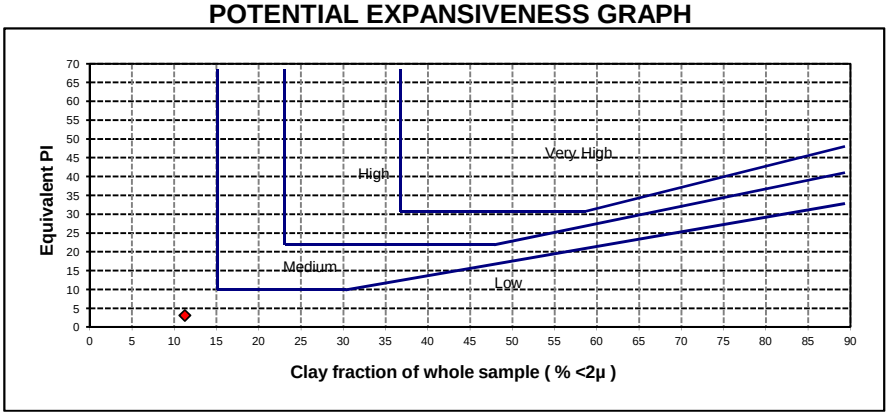
Client : Geosure (Pty) Ltd
Project : Proposed Gumede Bridge, Ward 16
Attention : Mr D. Naidoo

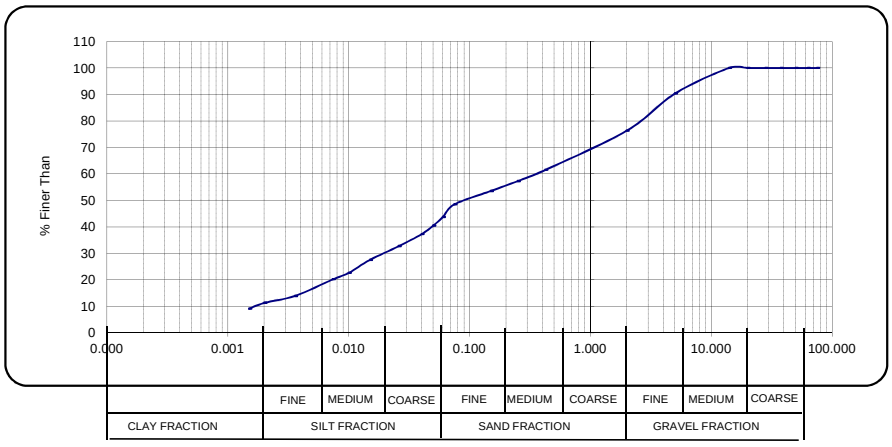
Job No. : 48733
Your Ref.No. : 086-20
Date Tested : 28.05.2020 to 02.06.2020
Date Reported : 09.06.2020

Sample Number : T24988
Field No. : IP2
Sample Description : Light grey to grey slightly clayey SAND with zones of sandy clay. Fill
Equivalent PI : 3 **Clay fraction of whole sample (% <2μ)** : 11

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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Reg.No.: 92/03145/07

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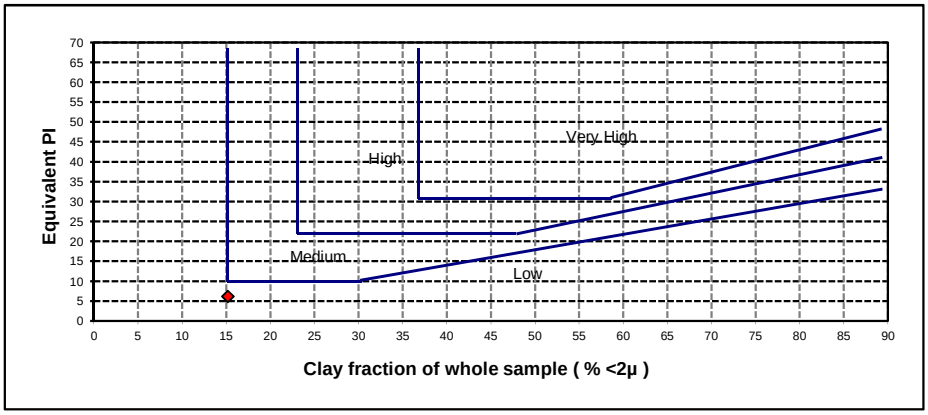
Client : Geosure (Pty) Ltd
Project : Proposed Gumede Bridge, Ward 16
Attention : Mr D. Naidoo

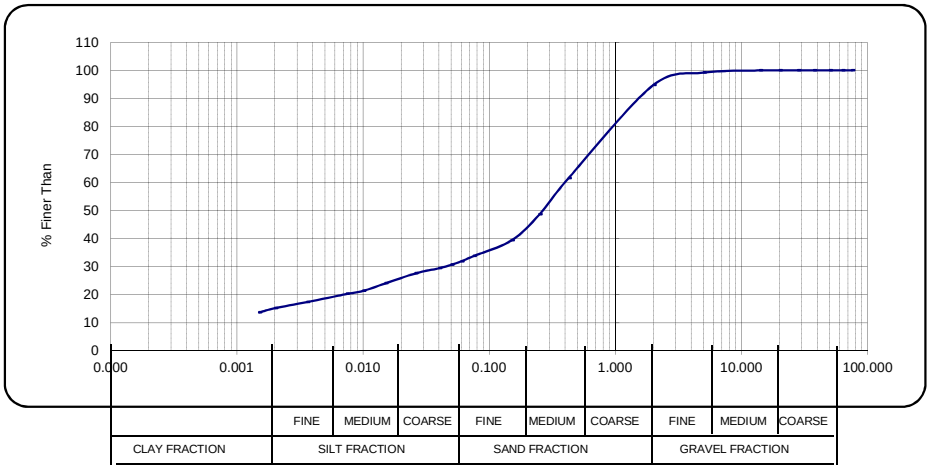
Job No. : 48733
Your Ref.No. : 086-20
Date Tested : 28.05.2020 to 02.06.2020
Date Reported : 09.06.2020

Sample Number : T24989
Field No. : IP2
Sample Description : Dark grey slightly gravelly clayey SAND and CLAY to sandy CLAY. Alluvium
Equivalent PI : 6 **Clay fraction of whole sample (% <2μ)** : 15

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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Project : **Proposed Gumede Bridge, Ward 16** — **Our Ref No. : 48733**
Attention : **Mr D. Naidoo** — **Date Reported : 10/06/2020**

Test Report - SANS 3001

Sample No.	T24985	T24986	T24987	T24990	
Field No.	IP1	IP1	IP2	IP2	
Position	Layer 1	Layer 3	Layer 1	Layer 4	
Depth (m)	0.01-0.47	0.90-1.30	0.01-0.90	3.34-4.55	
Method of Preparation	N/A	Scalped	N/A	N/A	
Material Description	Greyish brown silty clayey SAND to clayey SAND. Colluvium	Yellowish brown and orange yellow mottled light and dark grey slightly gravelly sandy silty CLAY. Residual Tillite	Greyish brown speckled orange silty SAND. Fill	Light grey mottled orange slightly sandy to sandy silty CLAY. Residual Tillite	

Sieve Analysis - Percent Passing Sieve Size						
Sieve Aperture (mm)	**100.00**		100			
	75.00		82			
	63.00		77			
	53.00		77			
	50.00		75			
	37.50	100	72			
	28.00	99	64			
	26.50	99	64	100	100	
	20.00	98	57	99	94	
	19.00	98	57	99	94	
	14.00	98	54	98	94	
	13.20	98	54	98	94	
	5.00	97	44	90	93	
	4.750	97	44	90	93	
	2.000	94	38	76	90	
	0.425	84	32	39	64	
	0.075	50	22	14	35	
Grading Modulus		0.72	2.09	1.71	1.11	
Mechanical analysis - Percent of Soil Mortar (<2 mm) for Grain Size range						
Coarse Sand	**2.000 - 0.425**	10	17	48	29	
Coarse-Fine Sand	**0.425 - 0.250**	10	8	12	13	
Medium-Fine Sand	**0.250 - 0.150**	11	8	12	11	
Fine-Fine Sand	**0.150 - 0.075**	15	10	9	9	
Silt and Clay	**< 0.075**	53	56	18	39	
Atterberg Limits SANS 3001 on <0.425 mm fraction						
Liquid Limit	% or symbol	22	26	NP	24	
Plasticity Index	% or symbol	8	10	NP	12	
Linear Shrinkage	%	4.0	5.5	0.0	6.0	
Maximum Dry Density and Optimum Moisture Content						
Maximum Dry Density (kg/m³)		1936	2060	2101	2043	
Optimum moisture content (%)		10.1	8.6	6.4	9.3	
California Bearing Ratio						
CBR @100% Compaction	%	16	6.3	128	3.9	
CBR @ 98% Compaction	%	11	5.6	87	3.1	
CBR @ 97% Compaction	%	8.7	5.2	72	2.7	
CBR @ 95% Compaction	%	5.8	4.6	49	2.1	
CBR @ 93% Compaction	%	3.8	4.1	33	1.7	
CBR @ 90% Compaction	%	2.0	3.4	19	1.2	
Swell @100% Compaction	%	1.4	1.4	0.0	1.6	
COLTO Classification (1998)†**		Cannot be Determined	Cannot be Determined	G6 (#)	Cannot be Determined	
TRH 14 Classification (1985)**		Poorer than G10	G10	G5	Poorer than G10.	
AASHTO Classification (Group Index)**		A-4 (1)	A-2-4 (0)	A-1-b (0)	A-2-6 (0)	
Unified Classification **		CL	GC	SM	SC	

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Remarks: ***Subject to further testing as required by TRH14.**

† Subject to further testing as required by COLTO. COLTO above uses only: Atterberg Limits (<0.425 mm fraction; not arithmetic mean), Nominal Max Size, Grading Curve, Coarse Sand Ratio, Grading Modulus, Strength (CBR), and Swell.

Check that Max Size <= 2/3 of compacted layer thickness.

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Version 5.05 - 14 February 2018

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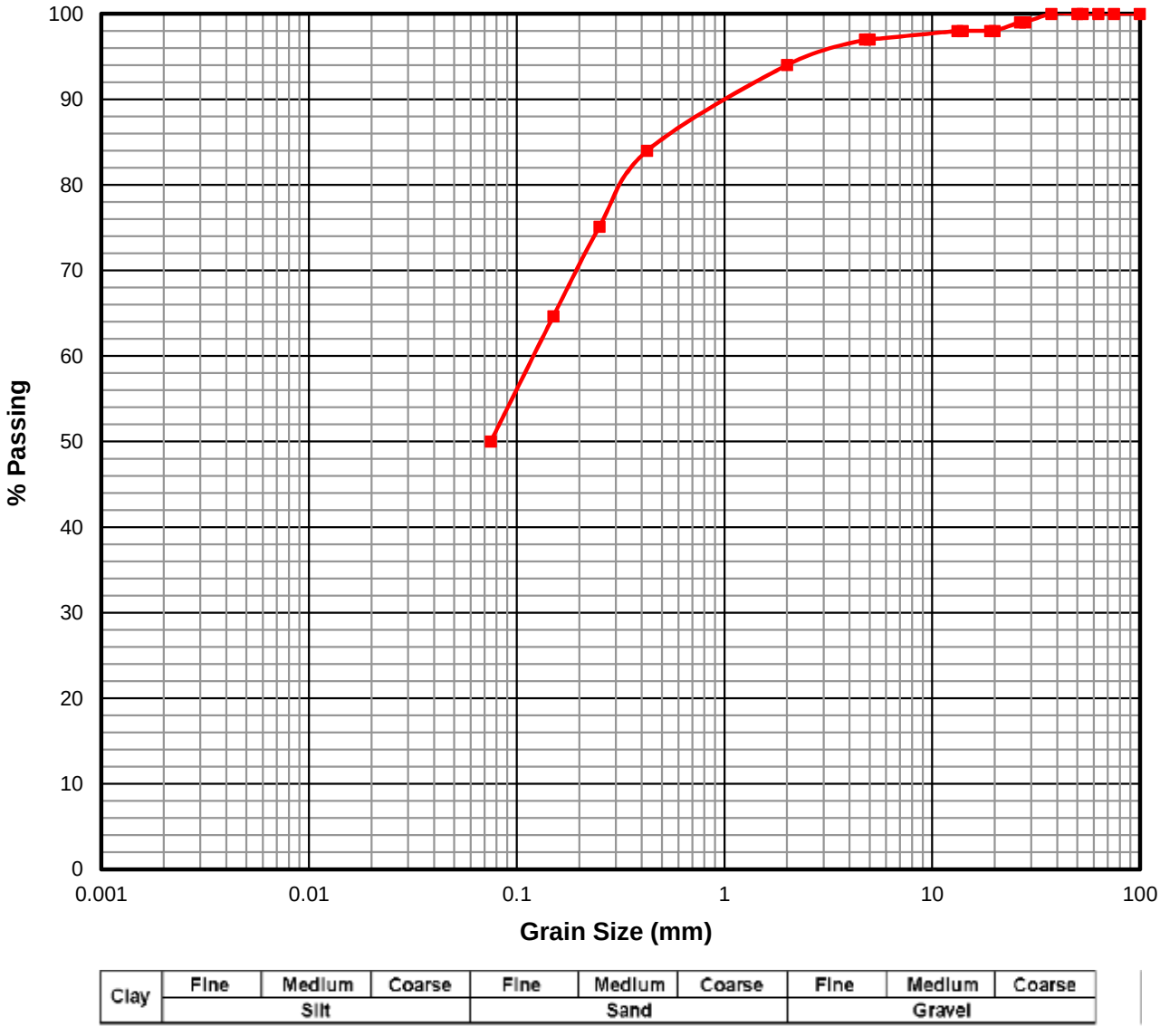
Client : **Geosure (Pty) Ltd**
Project : **Proposed Gumede Bridge, Ward 16**
Attention : **Mr D. Naidoo**

Your Ref No.: -
Our Ref No. : 48733
Date Reported : 10/06/2020

Grading Curve for Sample T24985 – SANS 3001



ick Red Line is the Grading Curve (COLTO Classification = Cannot be Determined) (TRH 14 Classification = Poorer than G1

Sieve Aperture Size	0.075	0.150	0.250	0.425	2.00	4.75	5.00	13.20	14.00	19.00	20.00	26.50	28.0	37.5	50.0	53.0	63	75	100
Percentage Passing	50%	65%	75%	84%	94%	97%	97%	98%	98%	98%	98%	99%	99%	100%	100%	100%	100%	100%	100%

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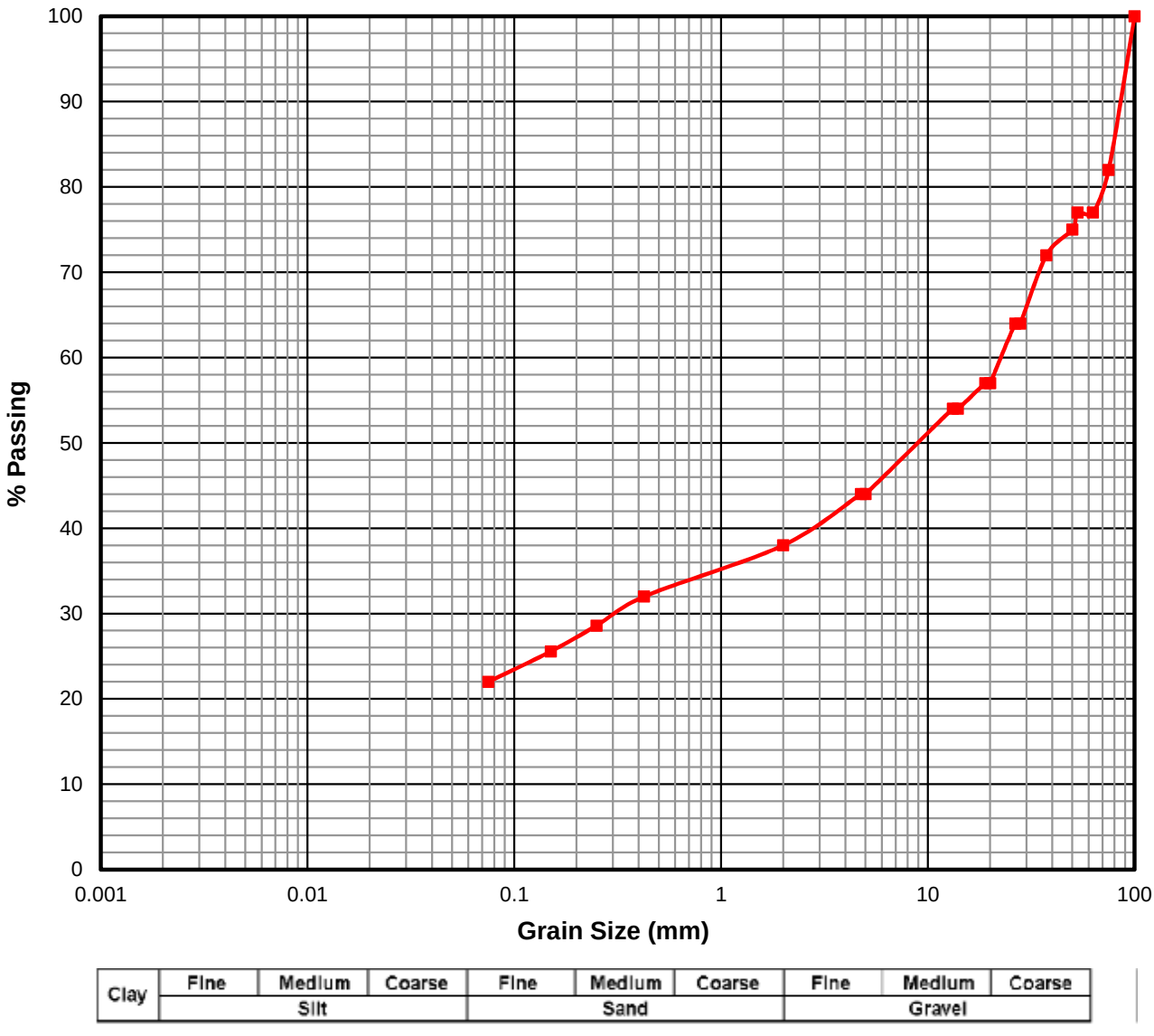
Grading Curve for Sample T24986 – SANS 3001



Thick Red Line is the Grading Curve (COLTO Classification = Cannot be Determined) (TRH 14 Classification = G10)

Sieve Aperture Size	0.075	0.150	0.015	0.026	0.05	0.06	5.00	13.20	14.00	19.00	20.00	26.50	28.0	37.5	50.0	53.0	63	75	100
Percentage Passing	22%	26%	29%	32%	38%	44%	44%	54%	54%	57%	57%	64%	64%	72%	75%	77%	77%	82%	100%

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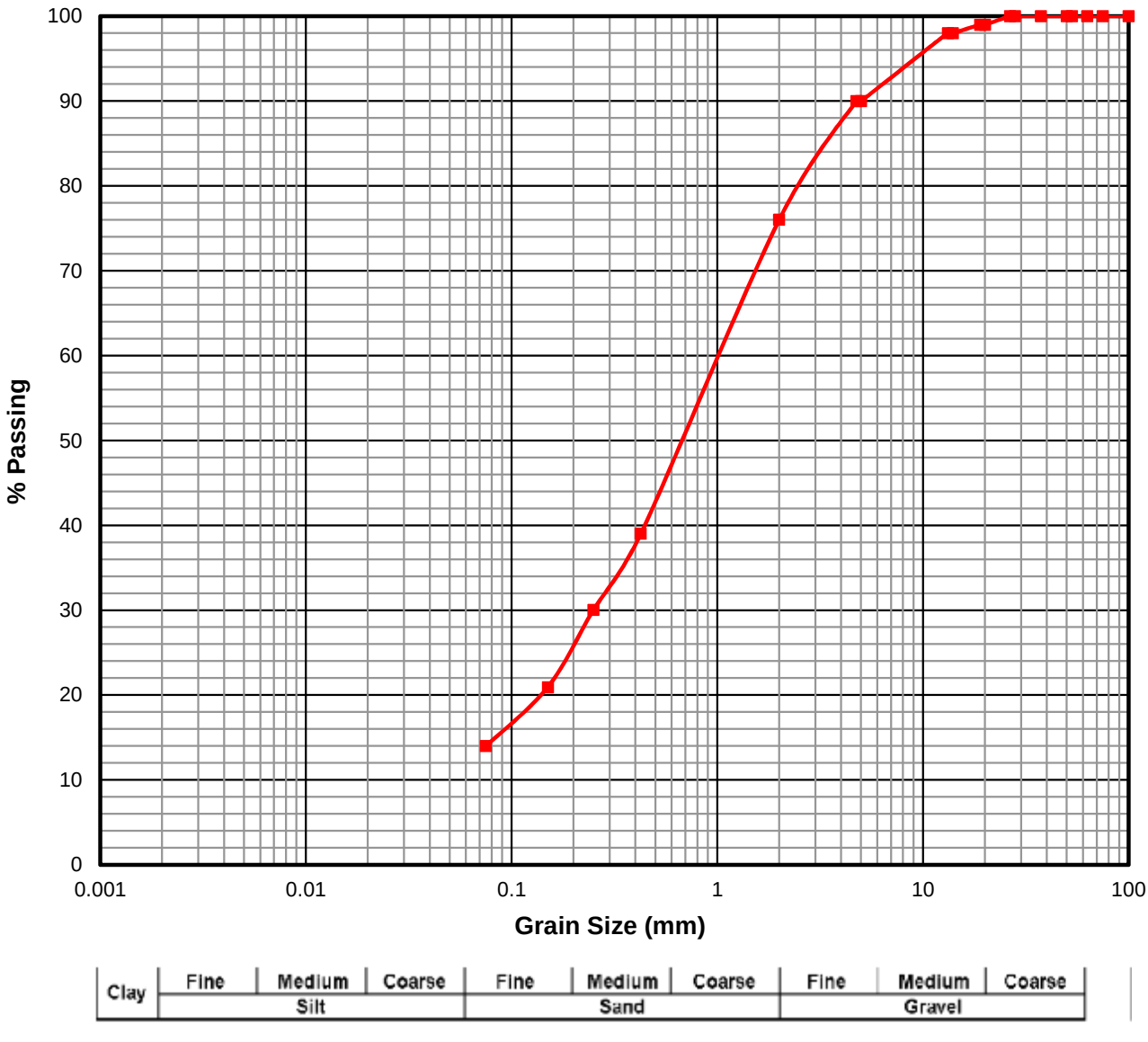
Attention : **Mr D. Naidoo** **Date Reported : 10/06/2020**

Grading Curve for Sample T24987 – SANS 3001



Thick Red Line is the Grading Curve (COLTO Classification = G6 (#)) (TRH 14 Classification = G5)

Sieve Aperture Size	0.075	0.150	0.250	0.425	2.00	4.75	5.00	13.20	14.00	19.00	20.00	26.50	28.0	37.5	50.0	53.0	63	75	100
Percentage Passing	14%	21%	30%	39%	76%	90%	90%	98%	98%	99%	99%	100%	100%	100%	100%	100%	100%	100%	100%

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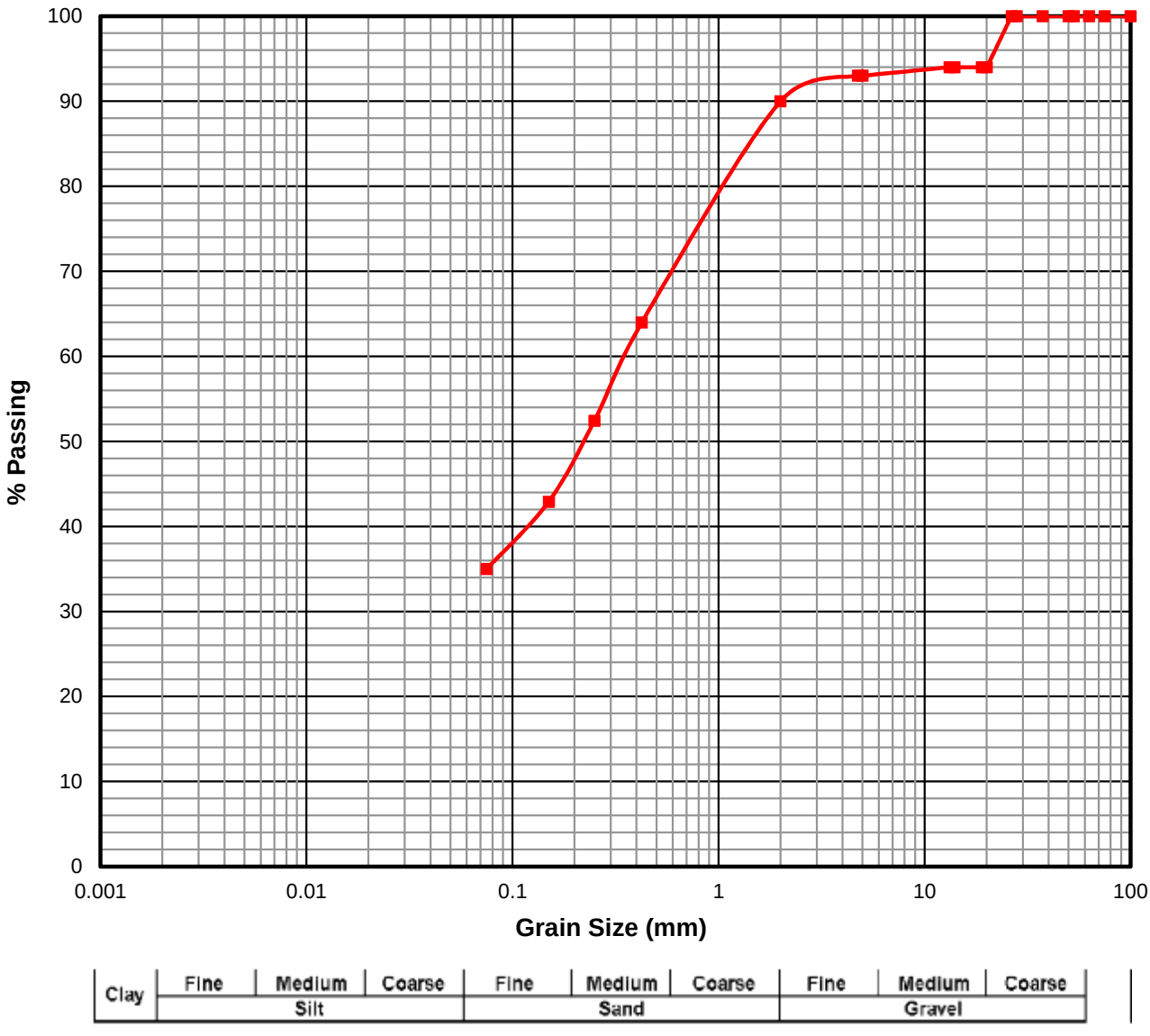
Attention : **Mr D. Naidoo** **Date Reported : 10/06/2020**

Grading Curve for Sample T24990 – SANS 3001



ck Red Line is the Grading Curve (COLTO Classification = Cannot be Determined) (TRH 14 Classification = Poorer than G1

Sieve Aperture Size	0.075	0.150	0.250	0.425	2.00	4.75	5.00	13.20	14.00	19.00	20.00	26.50	28.0	37.5	50.0	53.0	63	75	100
Percentage Passing	35%	43%	52%	64%	90%	93%	93%	94%	94%	94%	94%	100%	100%	100%	100%	100%	100%	100%	100%

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Project : **Proposed Gumede Bridge, Ward 16** | **Our Ref No.** : **48733**
Attention : **Mr D. Naidoo** | **Date Reported** : **09.06.2020**

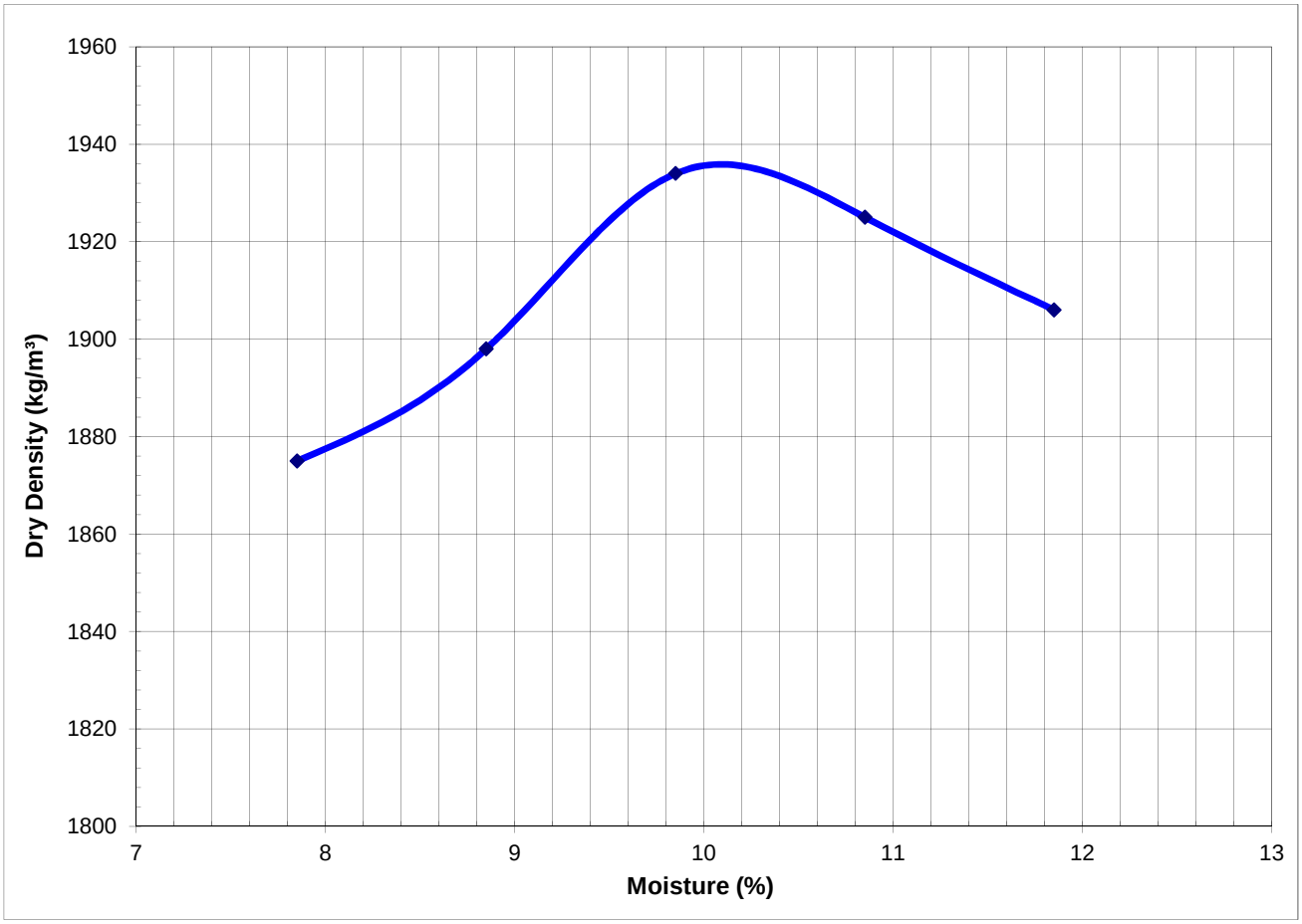
SANS 3001 Moisture/Density Relationship

Sample No.	: T24985	Field No.	: IP1
Method of preparation	: N/A	Depth (m)	: 0.01-0.47
Natural/Stabilised	: Natural	Origin	: Layer 1
Material Description	: Gr.Br.silty clayey SAND to clayey SAND. Colluvium	Compaction Effort	: Mod AASHTO

Maximum Dry Density (kg/m³) **1936** **Optimum Moisture Content (%)** **10.1**

Plotted Values:

Moisture (%)	7.9	8.9	9.9	10.9	11.9
Dry Density (kg/m³)	1875	1898	1934	1925	1906



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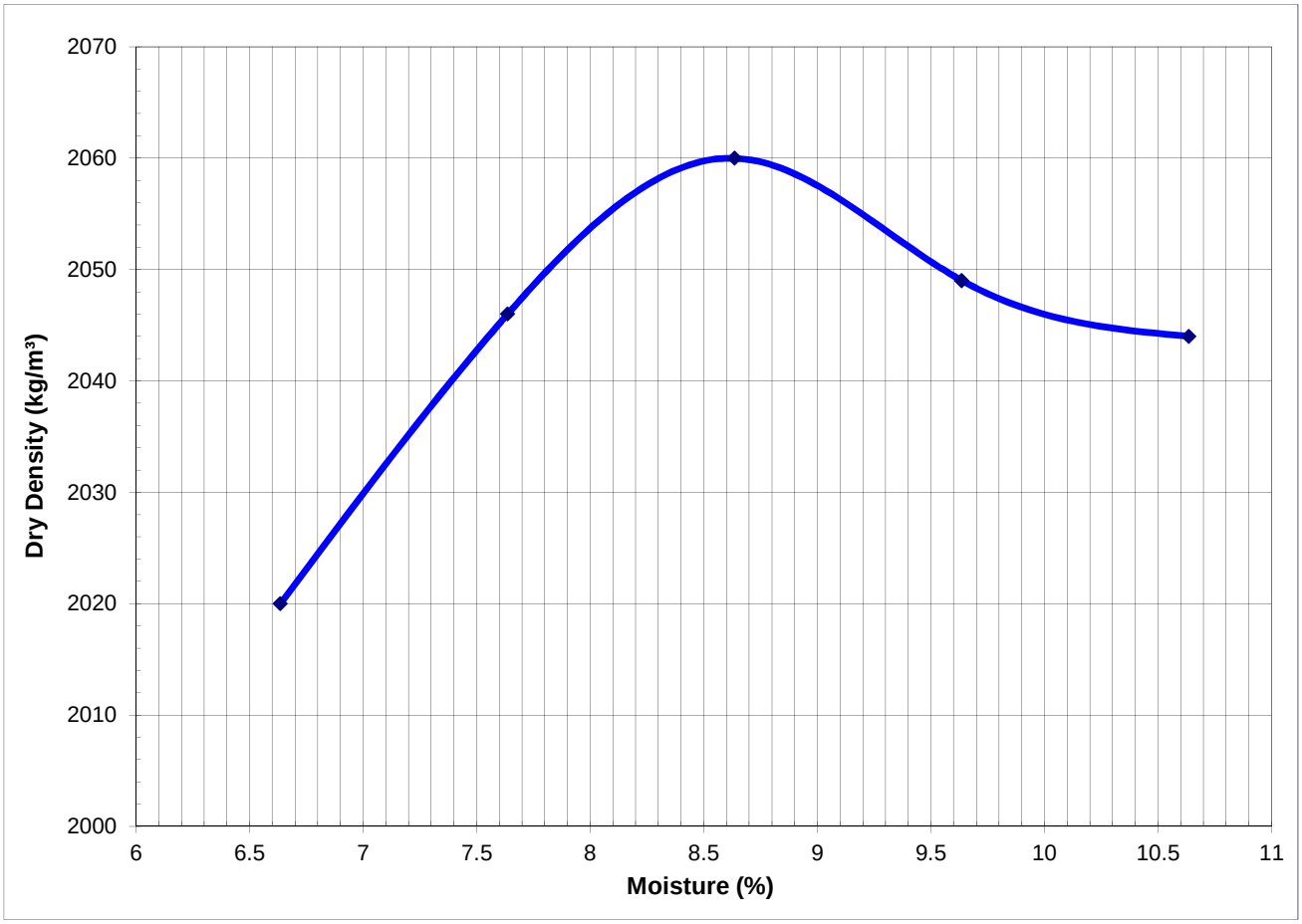
SANS 3001 Moisture/Density Relationship

Sample No.	: T24986	Field No.	: IP1
Method of preparation	: Scalped	Depth (m)	: 0.90-1.30
Natural/Stabilised	: Natural	Origin	: Layer 3
Material Description	: Yell.Br.Or.Yell.Mott.Lt.Dk.Gr.Sl.gravelly sandy silty	Compaction Effort	: Mod AASHTO

Maximum Dry Density (kg/m³) **2060** **Optimum Moisture Content (%)** **8.6**

Plotted Values:

Moisture (%)	6.6	7.6	8.6	9.6	10.6
Dry Density (kg/m³)	2020	2046	2060	2049	2044



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Client : **Geosure (Pty) Ltd** | **Your Ref No.** : **086-20**
Project : **Proposed Gumede Bridge, Ward 16** | **Our Ref No.** : **48733**
Attention : **Mr D. Naidoo** | **Date Reported** : **09.06.2020**

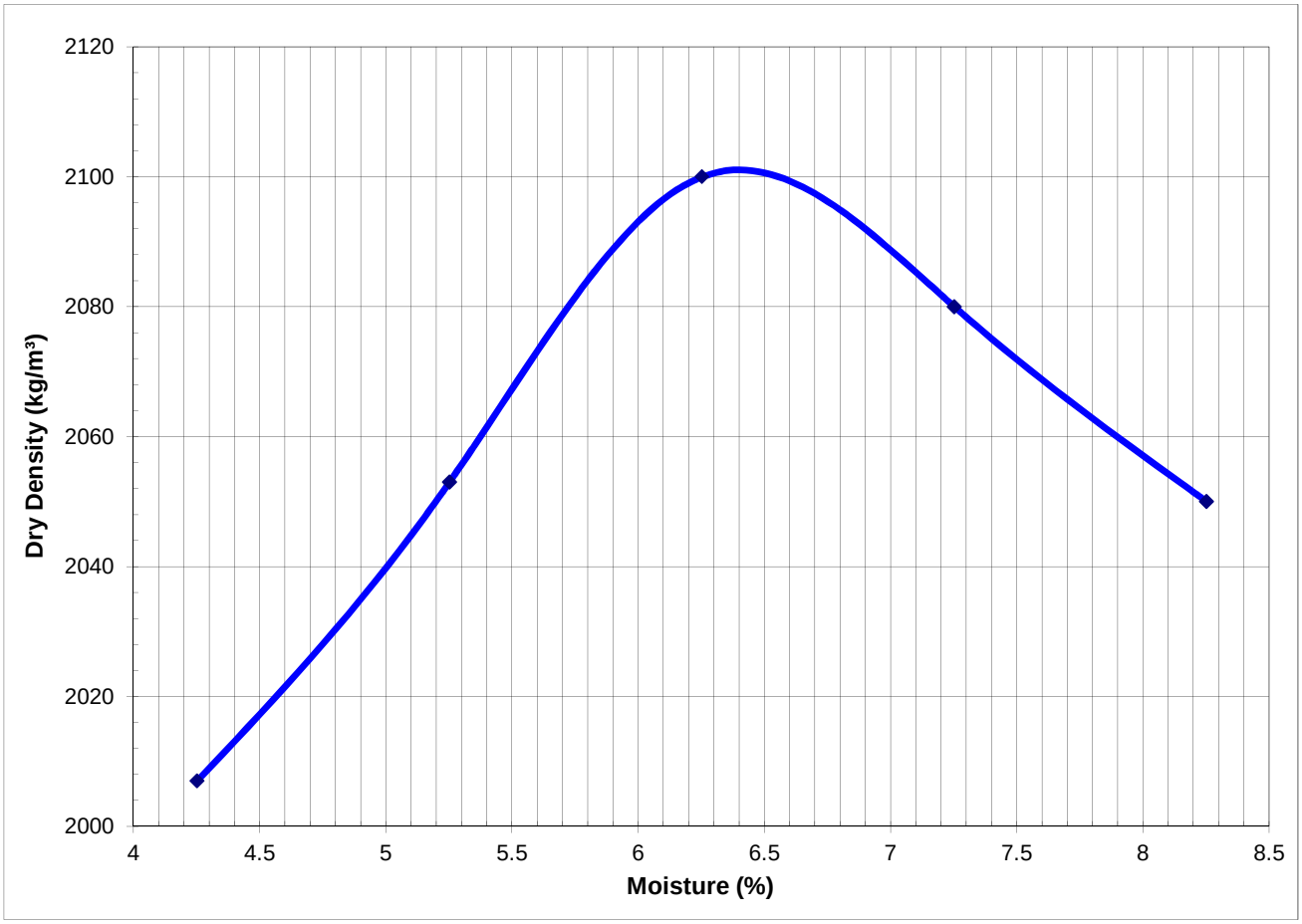
SANS 3001 Moisture/Density Relationship

Sample No.	: T24987	Field No.	: IP2
Method of preparation	: N/A	Depth (m)	: 0.01-0.90
Natural/Stabilised	: Natural	Origin	: Layer 1
Material Description	: Gr.Br.Spec.Or.silty SAND. Fill	Compaction Effort	: Mod AASHTO

Maximum Dry Density (kg/m³) **2101** **Optimum Moisture Content (%)** **6.4**

Plotted Values:

Moisture (%)	4.3	5.3	6.3	7.3	8.3
Dry Density (kg/m³)	2007	2053	2100	2080	2050



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Client	**: Geosure (Pty) Ltd**	**Your Ref No.**	**: 086-20**
Project	**: Proposed Gumede Bridge, Ward 16**	**Our Ref No.**	**: 48733**
Attention	**: Mr D. Naidoo**	**Date Reported**	**: 09.06.2020**

SANS 3001 Moisture/Density Relationship

Sample No.	: T24990	Field No.	: IP2
Method of preparation	: N/A	Depth (m)	: 3.34-4.55
Natural/Stabilised	: Natural	Origin	: Layer 4
Material Description	: Lt.Gr.Mott.Or.Sl.sandy to sandy silty CLAY. Res. Ti	Compaction Effort	: Mod AASHTO

Maximum Dry Density (kg/m³) 2043 **Optimum Moisture Content (%) 9.3**

Plotted Values:

Moisture (%)	7.5	8.5	9.5	10.5	11.5
Dry Density (kg/m³)	1957	2022	2041	2002	1967

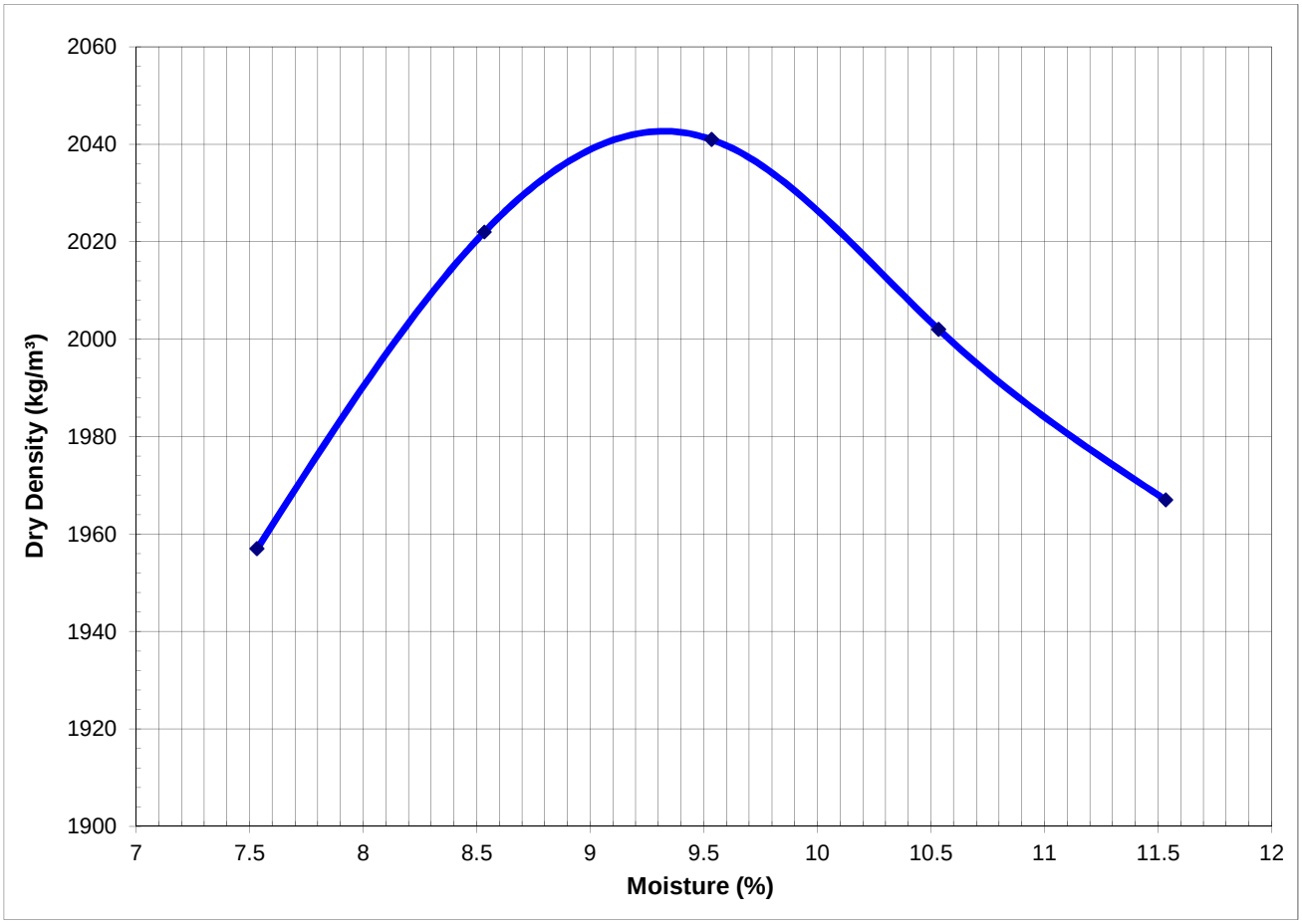

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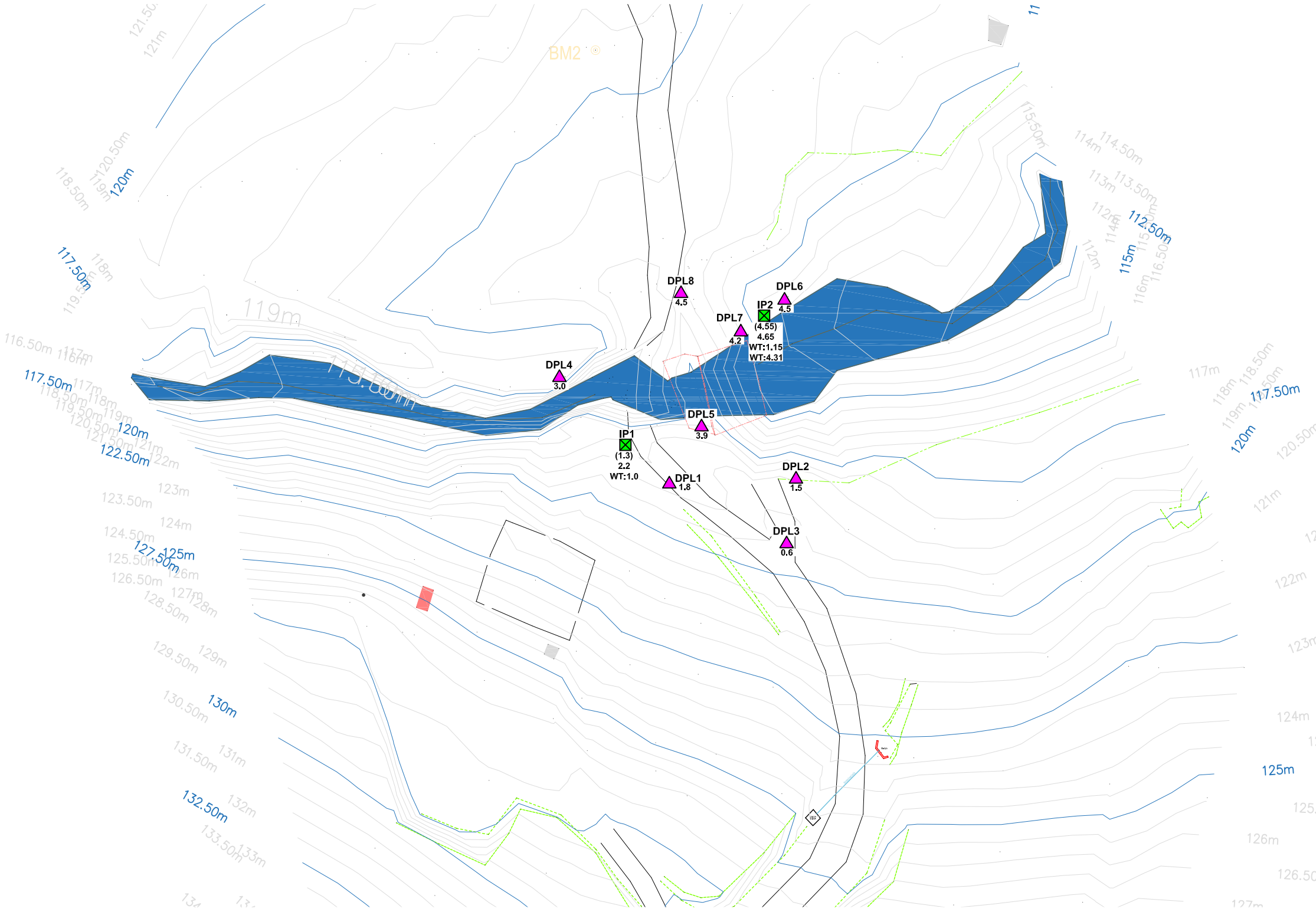
FIGURE 1

SITE PLAN



KEY:

IP1 (1.3) 2.2 — Approximate position of Inspection Pit showing depth to rock () and depth to refusal in metres below existing ground level.

DPL1 1.8 — Approximate position of Dynamic Cone Penetrometer Light (DPL) Test showing depth to refusal in metres below existing ground level.

WT:1.0 — Denotes depth to ground water seepage in metres below existing ground level.

Site plan showing approximate positions of:

Inspection Pits; and
Dynamic Cone Penetrometer Light (DPL) Tests.

SCALE 1:500

0 5 10
Metres

Vuba Imagineers

Proposed Gumede Bridge,
Umdoni Municipality
Geotechnical Investigation

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DATE: 12-05-2020
DRAWN BY: V.G
CHECKED BY: E.A
REFERENCE NO, 086-20

Figure 1