GEOTECHNICAL CORE DRILLING OF 4 BRIDGES ALONG 12KM DR08606 FROM STERKSPRUIT TO MLAMLI HOSPITAL, FINAL REPORT

JOE GQABI DISTRICT MUNICIPALITY

EASTERN CAPE PROVINCE

SEPTEMBER 2018

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SEPTEMBER 2018

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List of Abbreviations

GPS	: Global Positioning System
UCS	: Uniaxial Compressive Strength
USCS	: Unified Soil Classification System
CBR	: California Bearing Ratio
SANAS	: South African National Accreditation System
SIACE	: South African Institute of Civil Engineering
DCP	: Dynamic Cone Penetrometer
EASBP	: Estimated Allowable Safe Bearing Pressure
kPa	: Kilopascal
Cfb	: Temperate Oceanic Climate
SPT	: Standard Penetration Test

EXECUTIVE SUMMARY

An engineering geotechnical core drilling (all N size) was undertaken at 4 bridges along 12km DR08606 road from Sterkspruit to Mlamli Hospital, to investigate and identify the depth of bedrock, study its engineering properties (i.e. depth, weathering extent, competency, structural features, etc) for major bridge sites suitable foundation recommendations.

Existing bridge structures noted on site are founded on alluvial material, the soil material in the riverbed are subjected to erosion and scouring by water movement especially during raining season and result into failure of structures. Alluvial materials in the profile are expected to be highly susceptible to scouring and water erosion.

As part of the investigation, a total of 8 core holes were drilled at predetermined positions of the structure's footprint areas. Drilling was done by rod-pull method using 1.5m TNW and NWD4 barrels. Soil and core descriptions were done according to the provisions of the guidelines as proposed by the geotechnical division of SAICE and SAIEG.

The soil profiles encountered in the boreholes comprised alluvial materials overlying shale and sandstone bedrock. The alluvium could be divided into an upper, sandy horizon and coarse (i.e. gravel, cobbles and boulders) horizon.

Considering all the variables in the study area, it was concluded that the moderately weathered, more competent, shale bedrock (with sandstone in some places) presents the most suitable alternative for founding lithology. Other horizons were discounted from contention for quality and safety reasons. Groundwater is expected to be present and may occur as an ingress water from the valley sidewalls.

Considering all parameters and aspects that affect the proposed site, it appears as piling is the optimum solution for founding at all core holes. Allowing for the anticipated presence of water, casing may be required. The piles shall also be designed as end-bearing units which transfer their load directly to competent shale and sandstone bedrock.

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1 INTRODUCTION

An engineering geotechnical core drilling (all N size) was undertaken at 4 bridges along 12km DR08606 road from Sterkspruit to Mlamli Hospital, Eastern Cape Province. The purpose of this investigation is to study sub-surface conditions to obtain reliable subsurface data for foundation solution or design of the proposed structures.

Drilling was done by rod-pull method using 1.5m TNW and NWD4 barrels. This investigation was conducted in accordance with SANRAL – Standard Specifications for subsurface Investigations, 2010. Soil and core descriptions were done according to the provisions of the guidelines as proposed by the geotechnical division of SAICE and SAIEG.

2 PROJECT OBJECTIVES

The primary objectives of this study were to gather information on subsurface conditions at the site, for foundation recommendations of proposed development/structures.

3 SCOPE OF WORK

The scope of work comprises drilling of 8 cored boreholes (2 holes per bridge) all N size to a maximum depth of 20m or 6m through bedrock, this includes:

a) Determine the geological origin of the material on site.
b) Assess the suitability of site for the proposed project e.g. site geology and soil conditions, possible adverse geological conditions, possible unstable ground conditions and existing undermining.
c) Identify problem areas at a sufficiently early stage.
d) Investigate individual sites for suitable bridge foundations.
e) Identify risk and consequence of failure.
f) Facilitate an adequate and economical design.

The scope of work was accomplished by:

a) Drilling and logging of 8 core holes to maximum depth of 13.5m below ground level by rod-pull method using 1.5m TNW and NWD4 barrels;
b) Performing laboratory tests to determine physical or engineering characteristics of the soil;
c) Performing engineering analysis to develop design guidelines and recommendations.

Subsequent sections of this report contain descriptions of the fieldwork, general subsurface conditions, design recommendations, and construction considerations.

4 PHYSIOGRAPHY

4.1 Site Location

The site under investigation is located near Lesotho and Free State border approximately 45 km south-east of Zastron and 80km of Aliwal North within Senqu Local Municipality, Joe Gqabi District Municipality in Eastern Cape Province. The surrounding communities economically depend on job facilities from Sterkspruit Town, Aliwal North and subsistence farming for their basic needs. Sterkspruit is bounded by the southern edge of the Drakensberg Mountains to its south and east (locally, the ridge of the Witteberge mountains), and the Orange river to the west. The location of the site is indicated on figure 1 below.

The Sterkspruit district of the Eastern Cape Province forms a triangular area bounded by Lesotho to its east, the Free State Province to its west, and by farm districts of Lady Grey and Barkly East to its south. This study is based on the 12km DR08606 road from Sterkspruit Town to Mlamli Hospital. The area is located within the Sterkspruit magisterial district, part of the Senqu local municipality, in the northern parts of the Eastern Cape Province.

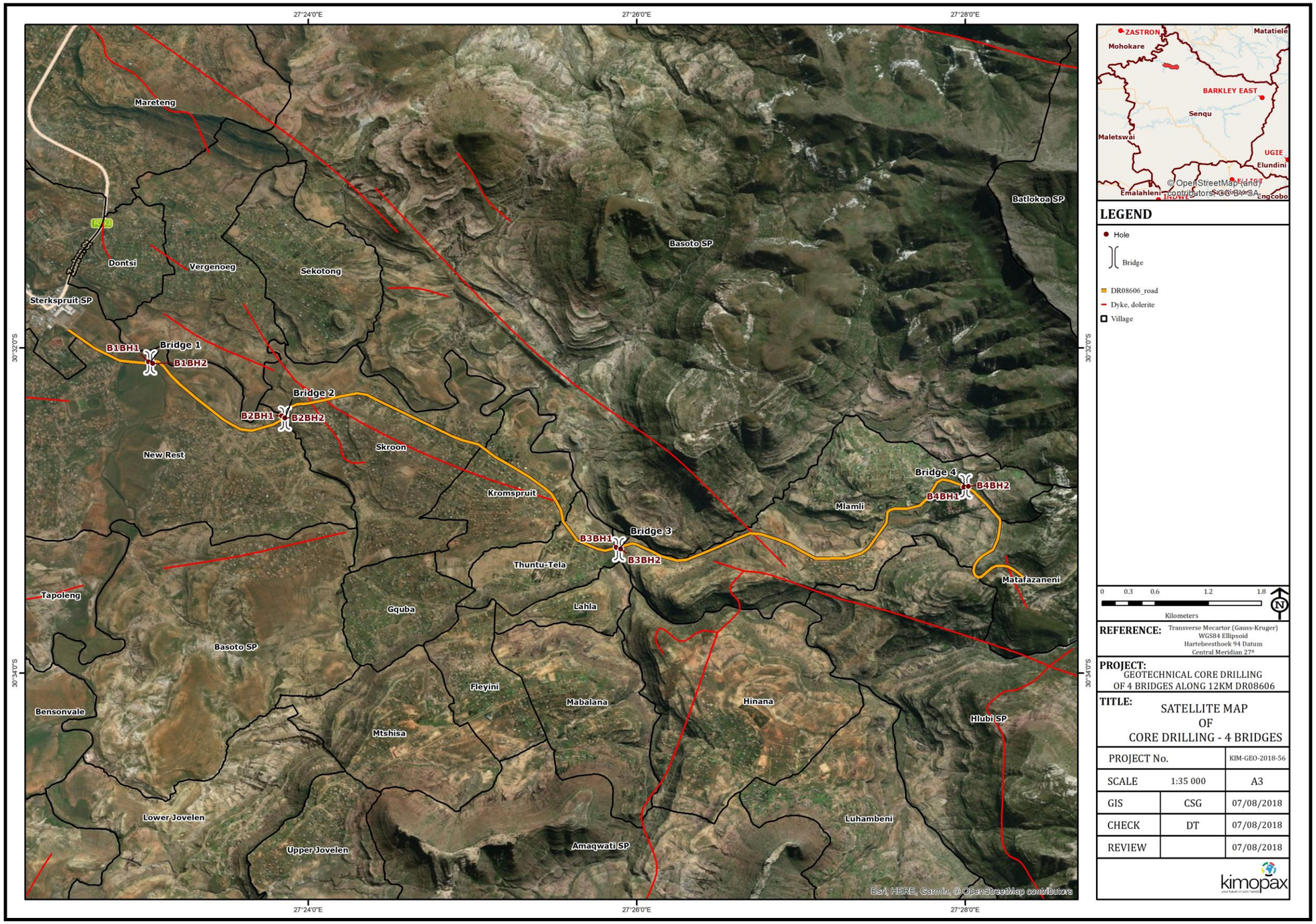

Figure 1: Locality Map of the project area

4.2 Land Use

Subsurface bulk water supply pipeline was noted on site alternating on the left and right edges of centreline. Ready mix concrete plant was also noted on site near bridge 1 (Sterkspruit Rivier).

4.3 Topography and Drainage

The topography of the site can be described as flat, steep sharp slope and more dip gentle slope on mountains which drain in southern direction; therefore, drainage presumably takes place by means of sheet wash. The project area resembles a dendritic drainage pattern with streams running northwest direction. Most of the streams are seasonal as observed during fieldwork. The major streams intersecting the proposed road were flowing to the western direction to Sterkspruit Rivier, which is flowing west-northwest to empty into the Orange River.

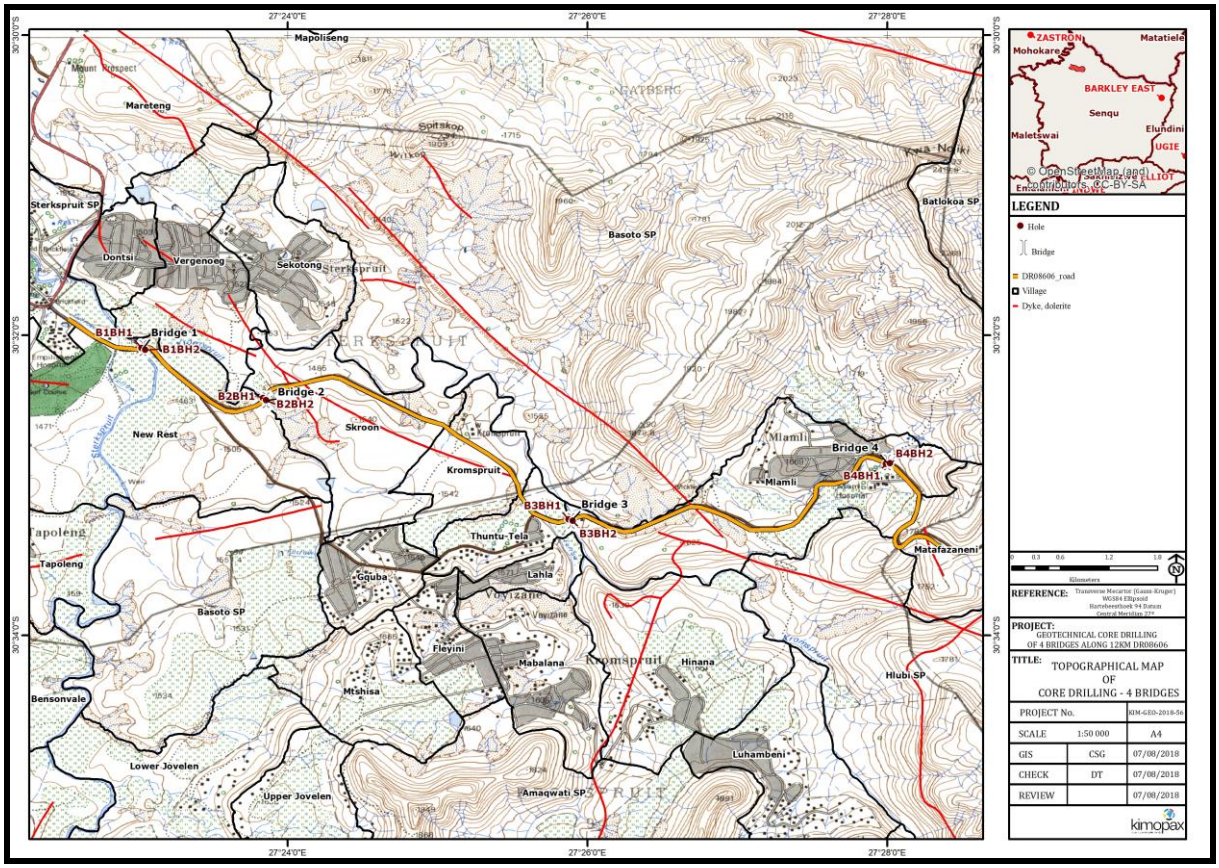

Figure 2: Topographical map of the site under investigation

4.4 Climate

The climate of Sterkspruit is sub-tropical, with cool winters and warm summers. It ranges from humid/sub-humid with mild summers and very cold winters in the southeast to sub-arid with warm summers and cool winters in the north east. According to Köppen and Geiger, this climate

is classified as Cfb. Sterkspruit normally receives about 691mm average rainfall per year, with most rainfall occurring mainly during end-summer. The driest month is July with an average of 12mm precipitation, while the most precipitation falls in February with an average of 105mm. The average midday temperatures range from 14.5°C in June to 26.8°C in January. The region is the coldest during July when the mercury drops to 0.1°C on average during the night.

The climatic N-value (after Weinert 1980) for the area is less than 5, which implies that chemical decomposition is the dominant mode of rock weathering. The importance of this is thus chemical breakdown of rock material will take place, which may result into the formation of expansive clay if the suitable parent material is available.

5 METHOD OF INVESTIGATION

5.1 Existing Sources of Information

The following available sources of information were consulted for compilation of this report:

- 1:250 000 Scale Geological Map: 3026 Aliwal North, published in 1983; and
- 1:50 000 Scale Topographical Map: 3027CB Sterkspruit, published in 1980 (2nd edition).

5.2 Core Drilling

Core drilling was done at four (4) bridges in eight (8) locations i.e. 2 core holes per bridge specified by the client. The eight locations represent footprint positions for the proposed new bridges structures. Drilling was done between 16th July and 01st August 2018. The positions of the core holes are indicated in Table 1 below and on the attached A3 size site plan.

Table 1: Core holes coordinates

Borehole Number	X (E)	Y (S)	Elevation (m)	Final Depth (m)
B1BH1	27.38377°	30.53477°	1438	12
B1BH2	27.38420°	30.53494°	1442	10.5
B2BH1	27.39729°	30.54033°	1445	11.5
B2BH2	27.39761°	30.54053°	1447	10.5
B3BH1	27.43125°	30.55381°	1491	12.5
B3BH2	27.43171°	30.55395°	1492	12
B4BH1	27.46652°	30.54763°	1683	7.5
B4BH2	27.46698°	30.54753°	1687	12.03

The core holes profiles and photographs are included in appendix A with driller's daily journals.

5.3 Material Testing

The investigation was further supplemented by limited materials sampling and testing. Representative samples were taken to the lab and the following tests performed:

- *Chemical Tests:* Four samples (4) were taken from the drill core or soil materials and delivered to the lab for analyses. Chemical tests were done to ascertain the materials potential corrosiveness including soil pH, soil conductivity and resistivity, chloride and sulfate content in soil, as it affects underground reinforcement which may result into structural failure.

- *Unconfined Compressive Strength (UCS):* A total of four samples were extracted from the drill core and submitted to rocklab for analysis. The results of UCS testing are used as an important input to the calculation of rock strength parameter.

6 DISCUSSION

6.1 Groundwater

Groundwater conditions on the site is likely to differ from the regional groundwater condition, since the river forms a temporary base level and accumulates surface water runoff. The prevailing groundwater level will therefore be affected by the river level itself. The depth of water for each borehole was measured using deep meter and is summarised in Table 2 below.

Table 2: Groundwater Water Levels

Borehole Number	Water Levels/Depth from Surface (m)	Water Level Elevation (m above mean sea level))
B1BH1	7.63	1430.37
B1BH2	7.0	1435
B2BH1	8.0	1437
B2BH2	0.47	1446.53
B3BH1	7.0	1484
B3BH2	3.08	1488.92
B4BH1	4.5	1678.5
B4BH2	1.32	1685.68

6.2 Regional Geology

The Sterkspruit area lies in the Karroo Basin which extends some 1300km from the south-west to the north-east of South Africa (Furon, 1963). The area forms part of the Karroo sequence with distinct formations (see figure 3). The mountain peaks are of minor grey-green shales and silts. The Elliot Formation, which is underlain by the Molteno Formation, comprises laterally continuous floodplain mudstones and associated fluvial sandstones. These consist of grayish red and purple mudstones, with minor yellow and grey sandstones (Dingle, et al, 1983). The Molteno Formation occupies the relatively low-lying area of 1300-1500m between the scarps and the Orange river to the west.

Between the peaks and the cave sandstones below lies a layer of Drakensberg basalts. The southwestern margin of the Drakensberg mountains, locally the Witteberge mountains are marked by massive lava flows and sandstones of the Clarens Formation (cave sandstone), which form prominent scarps (Moore, et al, 2006). The Clarens Formation overlies the Elliot Formation on the mountain slopes and is made up of yellow and white massive and cross bedded feldspathic sandstones. Spread out over the low lying and flatter areas are some dolerite dykes.

6.3 Local Geology

As shown in (Fig. 3) the study area is entirely underlain by red and greenish grey mudstone, alternating sandstone (pebbly in places), olive mudstone and dark grey shale (containing plant remains-fossils) with coal seams and thin conglomerates in places of Elliot and Molteno Formation of Karoo Sequence. A network of dolerite sills, sheets and dykes, mainly intrusive into the Karoo Supergroup is also visible in the project area. There were no other prominent geological structures such as fault zones or LANDSAT derived lineaments visible in the project area. The area does not impose any risk resulting in the formation of sinkholes and subsidence's caused by the presence of water-soluble rocks (i.e. dolomite or limestone).

When fresh mudstone occurs as dark grey, fine grained sedimentary rock which weathers to form grayish brown clayey sand, sand-clay mixture. It is like shale but has less lamination. When mudstone is buried within many layers of sediment deposited on top, it may be compressed to form shale, which may break easily into thin flakes. Shale occur as pink to brown, fine, thinly laminated, soft to hard rock, which weathers to silt clay; while dolerite occurs as dark coloured or black, medium grained igneous rock which weathers to form brownish grey clay.

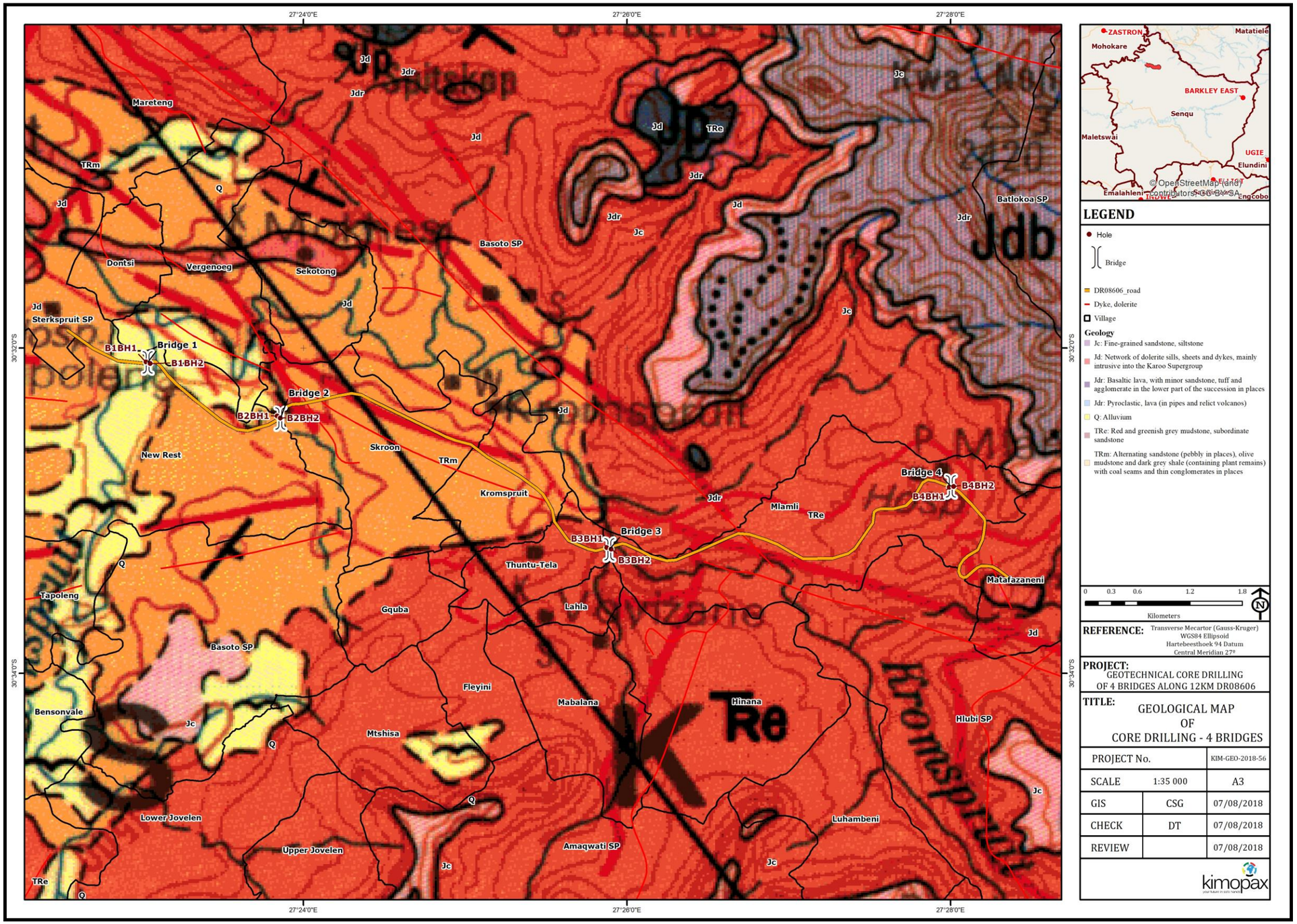

Figure 3: An abstract of geology with geological Groups and Formations within the study area

6.4 Soil Profiles

The soil profile encountered in the boreholes on site can be simplified as follows:

- ***Alluvium***

Alluvium soil form the upper layer for material on site. In general alluvium material on site comprised of reddish and grayish brown sand-clay mixture with minor gravel, fine grass and plant roots. The alluvial material extends to a depth of approximately 5m below ground level (bgl), clearly the thickness of alluvial materials is strongly affected by the shape of the river valley. No samples collected for this material as is not even considered as a horizon suitable to host bridge foundations.

A second horizon of alluvial material was identified and discerned here from the first as it was significantly different. Whereas the first alluvial material largely consisted of soil i.e. sand-clay mixture, the second consisted of sub-rounded/subangular gravel, sandstone, shale and dolerite cobbles or boulders with sandy clay matrix. The horizon did not occur uniformly and was present in some drilled holes, limited in other and completely absent in other holes still.

- ***Shale Bedrock***

Shale bedrock was encountered in all drilled holes and generally described as grayish brown mottled orange, green, red or purple, soft grading with depth to hard, fine to medium grained, highly to moderately weathered shale with dolerite in some places.

- ***Sandstone Bedrock***

Sandstone bedrock did not occur uniformly and was present in some boreholes, limited in other and completely absent in other boreholes. It was generally observed to be light gray mottled green and dark reddish brown, soft to hard, medium grained, moderately to slightly weathered sandstone with shale in places.

6.5 Scouring of Foundation Supports

The properties of the materials in the soil profiles of the site were reviewed with the conditions of failure noted on existing bridge structures. The alluvial materials noted to be highly erodible during raining season. Hence, the soil materials in the riverbed are likely to be subject to erosion and scouring by water movement and must be anticipated. Foundations located on these materials may thus be subject to scour.

Figure 4: A typical view for scouring of foundation supports and failure noted on site

7 FOUNDING CONDITIONS

7.1 Material Description

The description of the material intercepted in the drilled holes is simplified below. The vertical distribution of the materials is summarised in Table 3. The table indicates the lower levels (i.e. material levels) of each of the materials discussed.

7.1.1 Alluvium

As discussed above alluvium soil form the upper layer for material on site and comprised reddish or grayish brown sand-clay mixture. Considering the properties of the alluvial soils as well as the surface topography, founding on the alluvial horizons is not recommended.

Based on the results of the SPT testing the alluvium is of very loose to loose consistency. The bearing capacity associated with such conditions is usually less than 75kPa and therefore not suitable for founding bridge structures. The alluvial beds are located above the normal level of the river. Considering the side slopes of the river canal, foundations placed within the alluvium may be subject to shear failure, particularly in case of flooding when the soils become saturated and are subjected to flood force. Founding in the alluvium is thus not regarded as a viable option.

Table 3: Stratigraphic Summary

Horizon/Layer	Base Level (metres above mean sea level)							
	B1BH1	**B1BH2**	**B2BH1**	**B2BH2**	**B3BH1**	**B3BH2**	**B4BH1**	**B4BH2**
Surface Elevation	1438	1442	1445	1447	1491	1492	1683	1687
Alluvium	1432	1439	1440.5	1444	1485.78	1487.5	1681.5	1684
Highly Weathered Shale	1430.5	1434.5			1484.28	1486		1679.5
Moderately Weathered Shale	1426	1431.5	1437.5		1478.5	1480	1675.5	1678
Moderately Weathered Sandstone			1433.5				1677	
Slightly Weathered Shale				1439.5				1674.97
Slightly Weathered Sandstone				1436.5				

7.1.2 Highly Weathered Shale

Highly weathered shale was encountered below alluvial material and high core loss was noted (presumably weathered, soft rock). This, addition to its composition, means that it is unlikely to be an effective founding horizon.

7.1.3 Moderately Weathered Shale

Considering all the variables in the study area, it was deduced that the moderately weathered, more competent, shale bedrock (with sandstone in some places) presents the most suitable alternative for founding. The bedrock had to be assessed to obtain an indication of the expected strength and founding potential.

Four UCS tests were performed on shale core samples extracted from the drill core. Clearly the sampling was based towards rock core which is intact and of enough length to allow UCS tests. The UCS test results revealed that the shale core samples had uniaxial compressive strengths of

18.2MPa at 6 to 7.5m depth (medium hard rock) and between 56.5 to 102.6MPa (9 to 11.5m depth) indicating that the material is considered hard rock.

Four (4) chemical tests were done on shale core samples to ascertain the materials potential corrosiveness and the results obtained showed that all samples have corrosive tendencies and are mildy to fairly aggressive to concrete and steel.

From the drilled holes the following can be concluded:

- *State of Bedrock:* The general state of bedrock showed consistent variation and good failure strengths i.e. 48.28kN at 6 to 7.5m depth and between 159.20kN to 286.43kN (9 to 11.5m depth).
- *Rock Quality Designation (R.Q.D.):* The state of bedrock is clearly depicted by the R.Q.D and fracture frequencies recorded. The minimum R.Q.D of 19% was recorded for the moderately weathered shale bedrock under consideration here, while a maximum R.Q.D of 100% was recorded. The recorded fracture frequencies ranged from two to greater than twenty fractures per metre, however, in general values were below thirteen.
- *Condition of Discontinuities:* For most part joints were smooth, clean and closed. Weak planes were never noted, as such, the underlying bedrock is not associated with any discontinuities.

8 CONCLUSIONS

Based on the above discussion, the following conclusions can be made:

- *Geology:* The bridge sites are situated on shale and sandstone bedrock associated with the Elliott and Molteno Formation of the Karoo Sequence. The lithology was verified by bedrock. The bedrock also shows red colour which indicates fully oxidized iron and the green colour which indicates iron coatings with partially reduced iron.
- *Soil Profile:* The soil profiles encountered in the boreholes comprised alluvial materials overlying shale and sandstone bedrock. The alluvium could be divided into an upper, sandy horizon and coarse (i.e. gravel, cobbles and boulders) horizon.
- *Groundwater:* Groundwater is expected to be present and may occur as an ingress water from the valley sidewalls. Founding conditions are likely to be below groundwater level.
- *Scour:* Alluvial materials in the profile are expected to be highly susceptible to scouring and water erosion.

- *Founding Conditions:* Of all the materials encountered in the drilled holes profiles the moderately weathered shale or sandstone bedrock located at the base of boreholes is deemed the best option for founding. Other horizons were discounted from contention for quality or safety reasons.

9 RECOMMENDATIONS

It is further recommended that alluvial materials not be considered for founding, due to its susceptibility to scouring.

9.1 Foundation Selection

9.1.1 Piling

- Considering all parameters and aspects that affect the proposed site, it appears as piling is the optimum solution for founding at all drilled holes.
- Allowing for the anticipated presence of water, casing may be required.
- The piles shall also be designed as end-bearing units which transfer their load directly to competent shale and sandstone bedrock.
- End-bearing piles may be installed at levels as indicated below in Table 4: Stratigraphic and Founding Summary.

Table 4: Stratigraphic and Founding Summary

Horizon/Layer	Base Level (metres above mean sea level)							
	B1BH1	**B1BH2**	**B2BH1**	**B2BH2**	**B3BH1**	**B3BH2**	**B4BH1**	**B4BH2**
Surface Elevation	1438	1442	1445	1447	1491	1492	1683	1687
Alluvium	1432	1439	1440.5	1444	1485.78	1487.5	1681.5	1684
Highly Weathered Shale	1430.5	1434.5			1484.28	1486		1679.5
Moderately Weathered Shale	1426	1431.5	1437.5		1478.5	1480	1675.5	1678
Moderately Weathered Sandstone			1433.5				1677	
Slightly Weathered Shale				1439.5				1674.97
Slightly Weathered Sandstone				1436.5				
Proposed Level of Founding*	1429	1433	1436	1438	1482	1483	1674	1678
Founding Method	End-bearing piles socketed into bedrock							

*Excluding socketing depth

10 PRECAUTIONARY MEASURES

The following precautionary measures should be adopted.

- Founding on a competent horizon below the problem horizon.

11 ADDITIONAL INVESTIGATIONS

No additional investigation required for this project

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APPENDIX A:

CORE LOGS AND PHOTOGRAPHS

APPENDIX B:

LABORATORY RESULTS

APPENDIX C:

BOREHOLES LAYOUT

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APPENDIX A:

CORE LOGS AND PHOTOGRAPHS

SCHEME SITE	Geotechnical Core Drilling of 4 Bridges along 12km DR 08606, Sterkspruit	Bridge 1 **BH 1**	Coordinates	S: 30.53477° E: 27.38377°	**SHEET 1 OF 1**	LOGGED BY D. Tsanwani	DATE LOGGED: 08/08/2018
						Core photographed, date: 08/08/2018	

GRAIN SIZE: 1 Fine, 2 Medium, 3 Coarse | ROCK FABRIC TYPE: 1 Massive, 2 Bedded, 3 Folliated, 4 Cleaved, 5 Schistose, 6 Gneissose, 7 Laminated

		RECOVERY			**ROCK FABRIC**			**JOINTS**							
DEPTH METRES	LEGEND	MATER. RECOV.	CORE RECOV.	R.Q.D. (0.10m)	Grain size	Fabric type	Fabric spacing (mm)	No of sets	Inclin.(S)	Spacing (mm)	Roughness	Fill type	Fill thickness (mm)	Fracture frequency	**GENERAL DESCRIPTION** (Weathering, Joint spacing, Colour, Fabric, Strength, Rock name, Interpretive remarks)
0 1.5		14.3%	0%	0	-	-	-	-	-	-	-	-	-	-	Very moist, dark reddish brown, soft, intact, sandy clay with minor fine grass or plant roots. Remarks: Alluvial. Note material loss (loose material, probably washed away during drilling)
3		53%	0%	0	-	-	-	-	-	-	-	-	-	-	Very moist, reddish brown, loose, intact, clayey sand with minor fine plant roots. Remarks: Alluvial. Note material loss (loose material, probably washed away during drilling)
4.5		31.3%	0%	0	-	-	-	-	-	-	-	-	-	-	Very moist, reddish brown, loose, intact, clayey sand with minor dolerite/mudstone cobbles or boulders. Remarks: Alluvial. Note material loss (loose material, probably washed away during drilling)
6		20.7%	20.7%	0%	medium	foliated	<1.0	6	30--60° 60--90°	60--200	rough	quartz	<1.0	12	Moist, moderately weathered, 60 to 200mm joint spacings, dark reddish brown mottled orange, foliated, hard, dolerite with clayey sand matrix. Remarks: Alluvial. Note core loss (presumably weathered, soft rock/material)
7.5		42.7%	42.7%	8%	fine medium	bedded	>5	9	0--30° 30--60° 60--90°	60--200	smooth	none	-	18	Moist, highly weathered, 60 to 200mm joint spacings, dark grayish brown, bedded, soft, shale with dolerite in places. Remarks: Note core loss (presumably weathered, soft rock)
9		79%	79%	19%	fine	bedded	>5	9	0--30° 30--60° 60--90°	60--200	smooth	none	-	17	Moist, moderately weathered, 60 to 200mm joint spacings, dark brown, bedded, medium hard, shale. Remarks: Note core loss (presumably weathered, soft rock)
10.5		87.3%	87.3%	34.7%	fine	bedded	>5	9	0--30° 30--60° 60--90°	60--200	smooth	none	-	>20	Moist, moderately weathered, 60 to 200mm joint spacings, dark brown, bedded, medium hard, shale. Remarks: Note core loss (presumably weathered, soft rock)
12		101.3%	>100%	45%	fine	bedded	>5	6	30--60° 60--90°	60--200	smooth	none	-	20	Moist, moderately weathered, 60 to 200mm joint spacings, dark brown, bedded, medium hard, shale.

END OF HOLE

NOTES:
1) Borehole drilled 6m into solid rock
2) Founding at depth 9m for new bridge structures

BRIDGE 1 BH1

DEPTH 1.50
1.50m-1.90m
SPT
2-3-3-4-6-6
DEPTH 1.95
DEPTH 3.00
2-2-4-5-6-7
DEPTH 3.45
DEPTH 4.50
DEPTH 6.00
DEPTH 6.50
DEPTH 7.50
DEPTH 9.00
DEPTH 10.50
DEPTH 12.00

SCHEME SITE	Geotechnical Core Drilling of 4 Bridges along 12km DR 08606, Sterkspruit	Bridge 1 **BH 2**	Coordinates	S: 30.53494° E: 27.38420°	**SHEET 1 OF 1**	LOGGED BY	D. Tsanwani	DATE LOGGED: 08/08/2018
						Core photographed, date: 08/08/2018		

GRAIN SIZE 1 Fine 2 Medium 3 Coarse | ROCK FABRIC TYPE 1 Massive 2 Bedded 3 Folliated 4 Cleaved 5 Schistose 6 Gneissose 7 Laminated

RECOVERY					ROCK FABRIC					JOINTS					
DEPTH METRES	LEGEND	MATER. RECOV.	CORE RECOV.	R.Q.D. (0.10m)	Grain size	Fabric type	Fabric spacing (mm)	No of sets	Inclin.(S)	Spacing (mm)	Roughness	Fill type	Fill thickness (mm)	Fracture frequency	**GENERAL DESCRIPTION** (Weathering, Joint spacing, Colour, Fabric, Strength, Rock name, Interpretive remarks)
0 1.5		14%	0	0	-	-	-	-	-	-	-	-	-	-	Very moist, reddish brown, loose, intact, silty sand. Remarks: Alluvial. Note material loss (loose material, probably washed away during drilling)
3		20.7%	10.7%	0	-	-	-	-	-	-	-	-	-	-	Moist, dark grayish to reddish brown, loose, intact, silty sand with minor dolerite cobbles. Remarks: Alluvial. Note material loss (loose material, probably washed away during drilling
4.5		34%	34%	0	fine	shattered	>5	12	0--30° 30--60° 60--90°	60 - 200	smooth	none	-	20	Moist, highly weathered, 60 to 200mm joint spacings, grayish brown mottled red, shattered, soft, shale. Remarks: Note core loss (presumably weathered, soft rock,)
6		84%	84%	67.7%	fine	shattered	1--5	3	60--90°	60 - 200	smooth	none	-	12	Moist, moderately weathered, 60 to 200mm joint spacings, light gray blotched red in places, shattered, hard, shale. Remarks: Note core loss (presumably weathered, soft rock)
7.5		>100%	>100%	82.7%	fine	bedded	1--5	6	30--60° 60--90°	60 - 200	smooth	none	-	13	Moist, highly weathered, 60 to 200mm joint spacings,light gray blotched red, bedded, soft, shale
9		98.7%	98.7%	78.7%	fine	bedded	1--5	6	30--60° 60--90°	60 - 200	smooth	none	-	13	Moist, moderately weathered, 60 to 200mm joint spacings, light gray mottled red in places, bedded, hard, shale
10.5		>100%	>100%	92.7%	fine	bedded	1--5	6	0--30° 60--90°	60 - 200	smooth	none	-	10	Moist, moderately weathered, 60 to 200mm joint spacings, light gray blotched red, bedded, hard, shale

END OF HOLE

NOTES

1) Borehole drilled 6m into solid rock

2) Founding at depth 9m for new bridge structures

BRIDGE 1 BH2

DEPTH 0.50
DEPTH 1.50
SPT
DEPTH 1.95
DEPTH 3.00
DEPTH 4.50
DEPTH 6.00
DEPTH 7.50
DEPTH 9.00
DEPTH 10.50

SCHEME SITE	Geotechnical Core Drilling of 4 Bridges along 12km DR 08606, Sterkspruit	Bridge 2 **BH 1**	Coordinates	S: 30.54033° E: 27.39729°	**SHEET 1 OF 1**	LOGGED BY	D. Tsanwani	DATE LOGGED: 08/08/2018
						Core photographed, date: 08/08/2018		

GRAIN SIZE: 1 Fine, 2 Medium, 3 Coarse — ROCK FABRIC TYPE: 1 Massive, 2 Bedded, 3 Folliated, 4 Cleaved, 5 Schistose, 6 Gneissose, 7 Laminated

DEPTH METRES	LEGEND	MATER. RECOV.	CORE RECOV.	R.Q.D. (0.10m)	Grain size	Fabric type	Fabric spacing (mm)	No of sets	Inclin.(S)	Spacing (mm)	Roughness	Fill type	Fill thickness (mm)	Fracture frequency	**GENERAL DESCRIPTION** (Weathering, Joint spacing, Colour, Fabric, Strength, Rock name, Interpretive remarks)
		RECOVERY			**ROCK FABRIC**			**JOINTS**							
0 – 1.5		20%	0%	0	-	-	-	-	-	-	-	-	-	-	Very moist, reddish brown, soft, intact, sandy clay. Remarks: Alluvial. Note material loss (loose material, probably washed away during drilling
1.5 – 3		22.7%	0%	0	-	-	-	-	-	-	-	-	-	-	Tightly packed subrounded and subangular gravel, dolerite cobbles or boulders with a matrix of very moist, reddish brown, clayey sand. Remarks: Alluvial. Note material loss (loose material, probably washed away during drilling)
3 – 4.5		16%	0%	0	-	-	-	-	-	-	-	-	-	-	Tightly packed mudstone, quartzite, dolerite cobbles or boulders with a matrix of very moist, dark grayish brown bltched red, sandy clay. Remarks: Alluvial. Note material loss (loose material, probably washed away during drilling)
4.5 – 6		62.7%	62.7%	30.3%	fine	bedded	1--5	6	30--60° 60--90°	60 - 200	smooth	none	-	>20	Moist, moderately weathered, 60 to 200mm joint spacings, green mottled gray, bedded, soft, shale. Remarks: Note core loss (presumably weathered, soft rock/material)
6 – 7.5		60%	60%	0%	fine	bedded	>5	6	30--60° 60--90°	60 - 200	smooth	none	-	>20	Moist, moderately weathered, 60 to 200mm joint spacings, dark grayish brown mottled red, bedded, soft, shale. Remarks: Note core loss (presumably weathered, soft rock/material)
7.5 – 9		110%	>100%	64.7%	coarse	bedded	>5	3	60--90°	200 - 600	rough	quartz	<5	>20	Moist, moderately weathered, 200 to 600mm joint spacing, light gray, bedded, soft, sandstone with shale in places.
9 – 10.5		105.3%	>100%	80.3%	medium	bedded	1--5	3	60--90°	200 - 600	rough	none	-	>20	Moist, moderately weathered, 200 to 600mm joint spacing, light gray, bedded, medium hard, sandstone with shale in places.
10.5 – 11.5		56%	>100%	17.3%	fine to medium	bedded	1--5	3	60--90°	60 - 200	rough	quartz	<1.0	>20	Moist, moderately weathered, 60 to 200mm joint spacings, light gray mottled green and dark reddish brown, bedded, soft, sandstone with shale in places. Remarks: Note core loss (presumably weathered, soft rock)
11.5	**END OF HOLE**														

NOTES:

1) Borehole drilled 6m into solid rock
2) Founding at depth 9m for new bridge structures

BRIDGE1 BH2

DEPTH 1.50
DEPTH 3.00
DEPTH 8.00
DEPTH 7.50
DEPTH 9.00
DEPTH 10.50
DEPTH 11.50

SCHEME SITE	Geotechnical Core Drilling of 4 Bridges along 12km DR 08606, Sterkspruit	Bridge 2 **BH 2**	Coordinates	S: 30.54053° E: 27.39761°	**SHEET 1 OF 1**	LOGGED BY	D. Tsanwani	DATE LOGGED: 08/08/2018
						Core photographed, date: 08/08/2018		

GRAIN SIZE: 1 Fine, 2 Medium, 3 Coarse

ROCK FABRIC TYPE: 1 Massive, 2 Bedded, 3 Folliated, 4 Cleaved, 5 Schistose, 6 Gneissose, 7 Laminated

DEPTH METRES	LEGEND	RECOVERY: MATER. RECOV.	RECOVERY: CORE RECOV.	RECOVERY: R.Q.D. (0.10m)	ROCK FABRIC: Grain size	ROCK FABRIC: Fabric type	ROCK FABRIC: Fabric spacing (mm)	JOINTS: No of sets	JOINTS: Inclin.(S)	JOINTS: Spacing (mm)	JOINTS: Roughness	JOINTS: Fill type	JOINTS: Fill thickness (mm)	JOINTS: Fracture frequency	**GENERAL DESCRIPTION** (Weathering, Joint spacing, Colour, Fabric, Strength, Rock name, Interpretive remarks)
0 1.5		48%	-	-	-	-	-	-	-	-	-	-	-	-	Very moist, reddish brown mottled gray, firm, intact, sandy clay with minor gravel. Remarks: ALLUVIAL. Note material loss (soft material, presumably washed away during drilling)
3		12%	-	-	-	-	-	-	-	-	-	-	-	-	Very moist, reddish brown mottled gray, firm, intact, sandy clay with minor gravel. Remarks: ALLUVIAL. Note material loss (soft material, probably washed away during drilling)
4.5		41.3%	41.3%	34%	fine	shattered	1--5	6	0--30° 60--90°	< 6 6 to 20	smooth	none	-	8	Moist, moderately weathered, < 20mm joint spacings, dark grayish brown speckled red, shattered, soft, shale with sandstone in places. Remarks: Note core loss (probably weathered, soft rock)
6		100%	100%	66%	fine	bedded	>5	6	30--60° 60--90°	6 to 20	smooth	none	-	14	Moist, slightly weathered, 6 to 20mm joint spacings, dark grayish brown speckled red, bedded, hard, shale.
7.5		101.3%	>100%	61%	fine	bedded	>5	6	30--60° 60--90°	6 to 20	smooth	none	-	15	Moist, slightly weathered, 6 to 20mm joint spacings, dark grayish brown speckled red, bedded, hard, shale
9		105.3%	>100%	82%	Medium	bedded	>5	3	60--90°	20 to 60	Rough	stained	-	9	Moist, slightly weathered, 20 to 60mm joint spacings, light grayish brown mottled red, beddede, very hard sandstone with shale in places
10.5		99.3%	99%	95%	Medium	bedded	1--5	3	60--90°	20 to 60	Rough	stained	-	9	Moist, slightly weathered, 20 to 60mm joint spacings, light grayish brown mottled red, intact, very hard, sandstone with shale in places

END OF HOLE

NOTES

1) Borehole drilled 6m into bedrock

2) Founding at depth 9m for bridge structure

BRIDGE 2 BH2

0.00
NXC
0.90cm
DEPTH 0.90
NXC
DEPTH 1.50
NXC
DEPTH 3.00
DEPTH 4.50
DEPTH 6.00
DEPTH 7.50
DEPTH 9.00
DEPTH 10.50

SCHEME SITE	Geotechnical Core Drilling of 4 Bridges along 12km DR 08606, Sterkspruit	Bridge 3 **BH 1**	Coordinates	S: 30.55381° E: 27.43125°	**SHEET 1 OF 1**	LOGGED BY	D. Tsanwani	DATE LOGGED: 08/08/2018
						Core photographed, date: 08/08/2018		

GRAIN SIZE 1 Fine 2 Medium 3 Coarse | ROCK FABRIC TYPE 1 Massive 2 Bedded 3 Folliated 4 Cleaved 5 Schistose 6 Gneissose 7 Laminated

DEPTH METRES	LEGEND	RECOVERY: MATER. RECOV.	RECOVERY: CORE RECOV.	RECOVERY: R.Q.D. (0.10m)	ROCK FABRIC: Grain size	ROCK FABRIC: Fabric type	ROCK FABRIC: Fabric spacing (mm)	JOINTS: No of sets	JOINTS: Inclin.(S)	JOINTS: Spacing (mm)	JOINTS: Roughness	JOINTS: Fill type	JOINTS: Fill thickness (mm)	JOINTS: Fracture frequency	**GENERAL DESCRIPTION** (Weathering, Joint spacing, Colour, Fabric, Strength, Rock name, Interpretive remarks)
0 1.5		20%	0%	0	-	-	-	-	-	-	-	-	-	-	Closely packed dolerite, conglomerate, sandstone and mudstone cobbles/boulders. Remarks: Alluvial. Note material loss (loose/soft material, presumably washed away during drilling)
3		8.3%	0%	0	-	-	-	-	-	-	-	-	-	-	Closely packed dolerite, conglomerate, sandstone and mudstone cobbles/boulders. Remarks: Alluvial. Note material loss (loose/soft material, presumably washed away during drilling)
4.5		8%	0%	0%	-	-	-	-	-	-	-	-	-	-	Closely packed dolerite, conglomerate, sandstone and mudstone cobbles/boulders. Remarks: Alluvial. Note material loss (loose/soft material, presumably washed away during drilling)
5.22		15.3%	0%	0%	-	-	-	-	-	-	-	-	-	-	Closely packed dolerite cobbles/boulders in a matrix of moist, reddish brown, clay. Remarks: Alluvial. Note material loss (loose/soft material, presumably washed away during drilling)
6.72		30%	30%	7.3%	fine	bedded	>5	6	30--60° 60--90°	60 - 200	smooth	none	-	6	Moist, highly weathered, 60 to 200mm joint spacings,light gray blotched red, bedded, soft, shale. Remarks: Note core loss (presumably weathered, soft rock)
8.22		102%	>100%	82.7%	fine	bedded	1--5	3	60--90°	200 - 600	smooth	none	-	6	Moist, moderately weathered, 200 to 600mm joint spacings, light gray mottled red, bedded, medium hard, shale
9.5		86%	86%	86%	fine	bedded	0.1--1	3	60--90°	200 - 600	smooth	none	-	2	Moist, moderately weathered, 200 to 600mm joint spacings, light gray blotched red, bedded, hard, shale. Remarks: Note core loss (presumably weathered, soft rock)
10.95		97.3%	97.3%	97.3%	fine	bedded	0.1--1	3	60--90°	200 - 600	smooth	none	-	6	Moist, moderately weathered, 200 to 600mm joint spacings, light gray speckled red, bedded, hard, shale. Remarks: Note core loss (presumably weathered, soft rock)
12.5		104.7%	>100%	98%	fine	bedded	1--5	9	0--30° 30--60° 60--90°	200 - 600	smooth	none	-	11	Moist, moderately weathered, 200 to 600mm joint spacings, light gray mottled red, bedded, medium hard, shale

END OF HOLE

NOTES:

1) Borehole drilled 6m into solid rock
2) Founding at depth 9m for new bridge structures

BRIDGE 3 BH1

DEPTH 1.50
DEPTH 3.00
DEPTH 4.50
DEPTH 6.75
DEPTH 8.22
DEPTH 9.50
DEPTH 10.95
DEPTH 12.50

SCHEME SITE	Geotechnical Core Drilling of 4 Bridges along 12km DR 08606, Sterkspruit	Bridge 3 **BH 2**	Coordinates	S: 30.55395° E: 27.43171°	**SHEET 1 OF 1**	LOGGED BY	D. Tsanwani	DATE LOGGED: 08/08/2018
						Core photographed, date: 08/08/2018		

GRAIN SIZE: 1 Fine, 2 Medium, 3 Coarse

ROCK FABRIC TYPE: 1 Massive, 2 Bedded, 3 Folliated, 4 Cleaved, 5 Schistose, 6 Gneissose, 7 Laminated

RECOVERY					ROCK FABRIC			JOINTS							
DEPTH MTERES	LEGEND	MATER. RECOV.	CORE RECOV.	R.Q.D. (0.10m)	Grain size	Fabric type	Fabric spacing (mm)	No of sets	Inclin.(S)	Spacing (mm)	Roughness	Fill type	Fill thickness (mm)	Fracture frequency	**GENERAL DESCRIPTION** (Weathering, Joint spacing, Colour, Fabric, Strength, Rock name, Interpretive remarks)
0 1.5		46.7%	0%	0	-	-	-	-	-	-	-	-	-	-	Moist, reddish brown, soft, intact, sandy clay with traces of dolerite and mudstone cobbles. Remarks: Alluvial. Note material loss (loose material, probably washed away during drilling
3		11%	0%	0	-	-	-	-	-	-	-	-	-	-	Closely packed dolerite cobbles or boulders in a matrix of moist, reddish brown, sandy clay. Remarks: Alluvial. Note material loss (loose material, probably washed away during drilling
4.5		17.7%	0%	0	-	-	-	-	-	-	-	-	-	-	Closely packed dolerite and mudstone boulders with sandy clay matrix. Remarks: Alluvial. Note material loss (loose material, probably washed away during drilling
6		22.2%	18.4%	10.7%	fine medium	bedded	>5	9	0--30° 30--60° 60--90°	20 - 60	smooth rough	none	-	19	Moist, highly weathered, 20 to 60mm joint spacings, orange or yellowish gray blotched reddish brown, bedded, soft, shale with dolerite cobbles and clay matrix. Remarks: Note core loss (presumably weathered, soft rock/material)
7.5		78.7%	78.7%	44.7%	fine	bedded	1--5	9	0--30° 30--60° 60--90°	60 - 200	smooth	none	-	12	Moist, moderately weathered, 60 to 200mm joint spacings, yellowish or orange gray speckled reddish brown, bedded, medium hard, shale. Remarks: Note core loss (presumably weathered, soft rock)
9		106.7%	>100%	70.3%	fine	bedded	1--5	9	0--30° 30--60° 60--90°	60 - 200	smooth	none	-	11	Moist, moderately weathered, 60 to 200mm joint spacings, light gray speckled reddish brown, bedded, hard, shale.
10.5		89.3%	89.3%	50.9%	fine	bedded	>5	3	60--90°	60 - 200	smooth	none	-	> 20	Moist, moderately weathered, 60 to 200mm joint spacings, light gray mottled red and orange in places, bedded, hard, shale. Remarks: Note core loss (presumably weathered, soft rock)
12		106.7%	>100%	93.9%	fine	bedded	1--5	6	30--60° 60--90°	200 - 600	smooth	none	-	8	Moist, moderately weathered, 200 to 600mm joint spacings, light gray speckled red in places, bedded, hard, shale.

END OF HOLE

NOTES:

1) Borehole drilled 6m into solid rock
2) Founding at depth 9m for new bridge structures

BRIDGE 3 BH 2

DEPTH 1.50
DEPTH 3.00
DEPTH 4.50
DEPTH 5.00
DEPTH 8.00
DEPTH 9.50
DEPTH 9.00
DEPTH 10.50
DEPTH 11.00
DEPTH 12.00

SCHEME SITE	Geotechnical Core Drilling of 4 Bridges along 12km DR 08606, Sterkspruit	Bridge 4 **BH 1**	Coordinates	S: 30.54763° E: 27.46652°	**SHEET 1 OF 1**	LOGGED BY	D. Tsanwani	DATE LOGGED: 08/08/2018
						Core photographed, date: 08/08/2018		

GRAIN SIZE: 1 Fine, 2 Medium, 3 Coarse

ROCK FABRIC TYPE: 1 Massive, 2 Bedded, 3 Folliated, 4 Cleaved, 5 Schistose, 6 Gneissose, 7 Laminated

RECOVERY					ROCK FABRIC			JOINTS								
DEPTH METRES	LEGEND	MATER. RECOV.	CORE RECOV.	R.Q.D. (0.10m)	Grain size	Fabric type	Fabric spacing (mm)	No of sets	Inclin.(S)	Spacing (mm)	Roughness	Fill type	Fill thickness (mm)	Fracture frequency	**GENERAL DESCRIPTION** (Weathering, Joint spacing, Colour, Fabric, Strength, Rock name, Interpretive remarks)
0 1.5		55.7%	55.7%	43.5%	coarse	cleaved	>5	3	60--90°	60 - 200	rough	quartz	<1.0	10	Moist, moderately weathered, 60 to 200mm joint spacings, dark reddish brown mottled gray and white, cleaved, very hard , dolerite and sandstone cobbles/boulders with a matrix of moist, reddish brown, clayey silty sand. Remarks: Alluvial. Note core/material loss (probably weathered, soft/loose material washed away during drilling)
3		102.7%	>100%	99.3%	medium	bedded	1--5	3	60--90°	600 - 2000	rough	clay	<1.0	4	Moist, moderately weathered, 600 to 2000mm joint spacings, light orange - yellowish gray mottled dark reddish brown, bedded, very hard, sandstone
4.5		100.7%	>100%	100%	medium	bedded	>5	6	0--30° 60--90°	600 - 2000	rough	stained	-	5	Moist, moderately weathered, 600 to 2000mm joint spacings, light orange - yellowish gray mottled dark reddish brown, bedded, very hard, sandstone
6		84.7%	84.7%	58%	fine medium	bedded	>5	6	30--60° 60--90°	60 - 200	smooth & rough	stained	-	10	Moist, moderately weathered, 60 to 200mm joint spacings, light orange - yellowish gray blotched red in places, bedded, very hard, sandstone with shale in places. Remarks: Core loss (presumably weathered, soft rock)
7.5		87.3%	87.3%	65.3%	fine	bedded	1--5	6	30--60° 60--90°	60 - 200	smooth	none	-	14	Moist, moderately weathered, 60 to 200mm joint spacings, purple/red mottled gray, bedded, hard, shale. Remarks: Core loss (presumably weathered, soft rock)

END OF HOLE

NOTES

1) Borehole drilled 6.5m into solid rock

2) Founding at depth 9m for new bridge structure

BRIDGE 4 BH1

SCHEME SITE	Geotechnical Core Drilling of 4 Bridges along 12km DR 08606, sterkspruit	Bridge 4 **BH 2**	Coordinates	S: 30.54753° E: 27.46698°	**SHEET 1 OF 1**	LOGGED BY	D. Tsanwani	DATE LOGGED: 08/08/2018
						Core photographed, date: 08/08/2018		

GRAIN SIZE: 1 Fine, 2 Medium, 3 Coarse | ROCK FABRIC TYPE: 1 Massive, 2 Bedded, 3 Folliated, 4 Cleaved, 5 Schistose, 6 Gneissose, 7 Laminated

DEPTH METRES	LEGEND	RECOVERY: MATER. RECOV.	RECOVERY: CORE RECOV.	RECOVERY: R.Q.D. (0.10m)	ROCK FABRIC: Grain size	ROCK FABRIC: Fabric type	ROCK FABRIC: Fabric spacing (mm)	JOINTS: No of sets	JOINTS: Inclin.(S)	JOINTS: Spacing (mm)	JOINTS: Roughness	JOINTS: Fill type	JOINTS: Fill thickness (mm)	JOINTS: Fracture frequency	**GENERAL DESCRIPTION** (Weathering, Joint spacing, Colour, Fabric, Strength, Rock name, Interpretive remarks)
0 1.5		26.7%	-	-	-	-	-	-	-	-	-	-	-	-	Very moist,grayish brown, firm, intact, sandy clay with minor sandstone and dolerite cobbles. Remarks: ALLUVIAL. Note material loss (soft/loose material, probably washed away during drilling
3		13.3%	-	-	-	-	-	-	-	-	-	-	-	-	Tightly packed sandstone and dolerite cobbles with a matrix of moist, grayish brown blotched red, sandy clay. Remarks. Alluvial. Note material loss (soft/loose material, presumably washed away during drilling)
4.5		78.7%	78.7%	76.3%	fine	bedded	<0.1	3	60--90°	20 - 60	smooth	none	-	3	Moist, highly weathered, 20 to 60mm joints spacings, purple/red mottled gray, bedded, soft, shale. Remarks: Note core loss (presumably weathered, soft rock)
6		68%	20.7%	0%	fine	bedded	>5	12	0--30° 30--60° 60--90°	< 6	smooth	none	-	12	Moist, highly weathered, < 6mm joints spacing, purple/red mottled gray, bedded, soft, shale. Remarks: Note core loss (presumably weathered, soft rock)
7.5		42.7%	42.7%	27%	fine	bedded	1--5	12	0--30° 30--60° 60--90°	6 to 20	smooth	stained	-	8	Moist, highly weathered, 6 to 20mm joints spacing, purple/red mottled grayish brown, bedded, soft, shale with dolerite in places. Remarks: Note core loss (presumably weathered, soft rock)
9		96%	96%	96%	fine	bedded	0.1--1	6	30--60° 60--90°	6 to 20 20 to 60	smooth	none	-	8	Moist, moderately weathered, < 60mm joints spacing, light gray mottled reddish brown, bedded, medium hard, shale. Remarks: Note core loss (presumably weathered, soft rock)
10.5		100.7%	>100%	100%	medium	bedded	1--5	3	30--60° 60--90°	60 to 200 200 to 600	smooth	stained	-	4	Moist, slightly weathered, 60 to 600mm joints spacing, light orange gray mottled dark reddish brown, bedded, very hard shale with sandstone in places
12.03		102.7%	>100%	100%	medium	bedded	<0.1	3	60--90°	200 to 600	rough	stained	-	2	Moist, slightly weathered, 200 to 600mm joints spacing, light orange gray mottled reddish brown, bedded, very hard, sandstone

END OF HOLE

NOTES

1) Borehole drilled 6m into solid rock
2) Foundation at depth 9m for bridge structure

BRIDGE 4 BH2

DEPTH 0.75
DEPTH 1.50
DEPTH 3.00
DEPTH 4.50
DEPTH 6.00
DEPTH 6.60
DEPTH 7.50
DEPTH 9.00
DEPTH 10.50
DEPTH 12.03

DAILY DRILLERS JOURNAL

4464

Geopractica CONTRACTING

Daily Drillers Journal

Site Location	Road. D.F. 08 606.	Client	LIMOPAK
Project			
BH No.	BH2/ Bridge 1	Page	1 of 1

BH Survey Details	Job No.	Date
Co - Ordinates X = _____ Y = _____	1015	30/07/2018 To 01/08/2018
Quantity of Core Boxes = 2	Rig No	D45.
Inclination (deg. off vertical) = 0	Pump no.	—
Orientation (bearing in deg.) = N/A	Driller	THABO

Drill run From	To	Advance m	Core rec auger/ wash	Casing / drill size	Drill Bit Used	Test / Sampling SPT Count						Shelby	Material Description	Water colour	% Water loss
0.00	0.30	0.30	0.21	DIS									Brown sand.	—	—
0.30	1.50	1.20	wash	NXC									No sample.	Brown	0.00
1.50	1.95	0.45	SPT	SPT		2	3	3	3	4	6.		Brown sand.	—	—
1.95	3.00	1.05	0.15	NWD4									Grey boulders.	Grey	0.00
3.00	4.50	1.50	0.53.	NWD4									brown, Redish and Grey Mud rock	Brown	0.00
4.50	6.00	1.50	1.26.	NWD4									Greenish and Redish Shale stone,	Grey.	0.00
6.00	7.50	1.50	1.50.	NWD4									Colour blocked Shale Stone.	Grey	0.00.
7.50	9.00	1.50	1.44	NWD4									Colour blocked Shale Stone,	Grey	0.00.
9.00	10.50.	1.50	1.55	NWD4									Colour blocked Shale Stone,	Grey	0.00.

Comments

Daily Check	Diesel	Oil levels	Fan belts	Grease	Water	Breakages	Bits & Shoes	Loggers name	Casing - Final depth & sizes	Water Depth	Time
Drill rig (tick when OK)	✓	✓	✓	✓	✓	✓	✓	THABO	0.00 To 4.50.	700m	14h00
Pumps (tick when OK)	✓	✓	✓								

Log issued by name & signtr	Date	Log Reciwved By Name Signature	Pizzometer	Depth
Pmochean	30/07/2018 To 01/08/2018.			

4462

Geopractica CONTRACTING

Daily Drillers Journal

Site Location	Road D1 08° 6.06.	Client	Kimopax
Project			
BH No.	BH 2 / Bridge no2.	Page	1 of 1

BH Survey Details	Job No.	Date
Co - Ordinates X = _____ Y = _____	1015	26/07/2018 To 28/07/2018
Quantity of Core Boxes = 2	Rig No	DPS
Inclination (deg. off vertical) = 0	Pump no.	—
Orientation (bearing in deg.) = N/A	Driller	Thabo

Drill run From	To	Advance m	Core rec auger/ wash	Casing / drill size	Drill Bit Used	Test / Sampling SPT Count						Shelby	Material Description	Water colour	% Water loss
0.00	1.50	1.50	0.32	NXC									Brown sand and boulders	Brown	0.00
1.50	3.00	1.50	0.33	NXC									Brown sand and boulders	Brown	0.00
3.00	4.50	1.50	0.24	NWD4									Grey boulders.	Grey	0.00
4.50	6.00	1.50	0.90	NWD4									Solid Grey rock.	Grey	0.00
6.00	7.50	1.50	0.93	NWD4									Grey rock and boulders.	Grey	0.00
7.50	9.00	1.50	1.50	NWD4									Brown sand Stone.	Brown	0.00
9.00	10.50	1.50	1.50	NWD4									Cream White sand stone.	White	0.00
10.50	11.50	1.00	0.83	NWD4									Cream White sand stone and shale	Brown	0.00

Comments

Daily Check	Diesel	Oil levels	Fan belts	Grease	Water	Breakages	Bits & Shoes	Loggers name	Casing - Final depth & sizes	Water Depth	Time
Drill rig (tick when OK)	✓	✓	✓	✓	✓	✓	✓	Thabo	0.00 To 4.50	3.00m	15h00.
Pumps (tick when OK)	✓	✓	✓							Pizzometer	Depth

Log issued by name & signtr	Gmuchoari	Date	26/07/2018 28/07/2018	Log Reciwved By Name Signature	

4461

Geopractica CONTRACTING

Daily Drillers Journal

Site Location	Road Dr 08 606.	Client	KIMOPAX
Project	Bridge NO3		
BH No.	BHN01 / Bridge NO3.	Page 1 of 1	

BH Survey Details
Co - Ordinates
X = _____
Y = _____

Job No.	Date
1015	21/07/2018 TO 25/07/2018

Quantity of Core Boxes = 2

Inclination (deg. off vertical) = 0

Orientation (bearing in deg.) = N/A

Rig No	D45
Pump no.	—
Driller	THABO

Drill run From	To	Advance m	Core rec auger/ wash	Casing / drill size	Drill Bit Used	Test / Sampling SPT Count						Shelby	Material Description	Water colour	% Water loss
0.00	1.50	1.50	0.25.	NXC									Grey boulders,	Grey-	0,00
1.50	3.00	150	0.17.	NXC.									Grey boulders.	Grey	0.00
3.00	4.50	1.50	0.13.	NXC									Grey boulders.	Grey.	0.00
4.50	5.22.	0.72	0.22	TNW									brown an Grey boulders,	brown	0.00
5.22	6.72	1.50	0.45.	TNW									Redish Shale stone	Redish	0,00
6.72.	8.22	1.50.	1.50.	TNW									Greenish shale stone and redish	Greenish	0.00
8.22	9.50.	1.28	1.28.	TNW									Redish shale stone and Greenish	Redish	0,00
9.50.	10.95	1.45	1.46.	TNW.									Greenish shale stone and Redish.	Redish	0.00
10.95	12.50.	1.55.	1.55.	TNW									Greenish shale stone.	Greenish	0,00

Comments

Daily Check	Diesel	Oil levels	Fan belts	Grease	Water	Breakages	Bits & Shoes	Loggers name	Casing - Final depth & sizes	Water Depth	Time
Drill rig (tick when OK)	✓	✓	✓	✓	✓	✓	✓	THABO	0,00m To 5,00m	7.00M	15h30
Pumps (tick when OK)	✓	✓	✓								

Log issued by name & signtr	Gmochoari	Date	21/07/2018 TO 25/07/2018	Log Reciwved By Name Signature	Pizzometer	Depth

4460

Geopractica CONTRACTING

Daily Drillers Journal

Site Location	Road, DA 03. 606.	Client	Kimo PGK
Project	Bridge N04.		
BH No.	N01, Bridge N04.	Page 1 of 1	

BH Survey Details	Job No.	Date
Co - Ordinates X = _____ Y = _____	1015	19/07/2018 to 20/07/2018
Quantity of Core Boxes = 2	Rig No	D45
Inclination (deg. off vertical) = 0	Pump no.	—
Orientation (bearing in deg.) = N/A	Driller	THABO.

Drill run From	To	Advance m	Core rec auger/ wash	Casing / drill size	Drill Bit Used	Test / Sampling SPT Count						Shelby	Material Description	Water colour	% Water loss
0.00	1.50	1.50	0,86	NXC									Brown soil and Grey boulders.	Grey.	0,00
1.50	3.00	1.50	1.53	TNW.									Cream white sand stone,	Cream white,	0.00
3.00	4.50	1.50	1.50.	TNW.									Cream White sand stone,	Cream White.	0.00
4.50	6.00	1.50	1.26	TNW									Cream White sand stone,	Cream White	0.00
6.00	7.50	1.50	1.33.	TNW.									Redish shale stone,	Redish	0.00.
7.50.															

Comments

Daily Check	Diesel	Oil levels	Fan belts	Grease	Water	Breakages	Bits & Shoes	Loggers name	Casing - Final depth & sizes	Water Depth	Time
Drill rig (tick when OK)	✓	✓	✓	✓	✓	✓	✓	THABO	0.00 To 1.50.	14.50m	09h00.
Pumps (tick when OK)	✓	✓	✓							Pizzometer	Depth

Log issued by name & signtr	Mochoori	Date	19/07/2018 to 20/07/2018	Log Reciwved By Name Signature	

5312

Geopractica CONTRACTING

Daily Drillers Journal

Site Location	ROAD DR08606 (STERKSPRUIT)	Client	KIMOPAX
Project			
BH No.	BRIDGE 2 – BH No: 2	Page 01	of 01

BH Survey Details	Job No.	Date
Co - Ordinates X = _____ Y = _____	1015	25/07/2018 To 27/07/2018
Quantity of Core Boxes = 02	Rig No	D401
Inclination (deg. off vertical) = 0	Pump no.	D425
Orientation (bearing in deg.) = N/A	Driller	TSEPO

Drill run From	To	Advance m	Core rec auger/ wash	Casing / drill size	Drill Bit Used	Test / Sampling SPT Count						Shelby	Material Description	Water colour	% Water loss
0.00	0.90cm	0.90cm	0.41cm	NXC									BROWN CLAY SAND WITH BOULDERS	BROWN	NO
0.90cm	1.50m	0.60cm	0.30cm	NXC									" " " "	"	"
1.50m	3.00m	1.50m	0.19cm	NXC									" " " "	"	"
3.00m	4.50m	1.50m	0.60cm	NWD4									GREYISH SHELL ROCK	LIGHT BROWN	"
4.50m	6.00m	1.50m	1.50m	NWD4									" " "	" "	"
6.00m	7.50m	1.50m	1.42m	NWD4									" " "	" "	"
7.50m	9.00m	1.50m	1.56m	NWD4									GREYISH SHELL and SANDSTONE	" "	"
9.00m	10.50m	1.50m	1.48m	NWD4									GREYISH SANDSTONE	" "	"
													END OF HOLE		

Comments

Daily Check	Diesel	Oil levels	Fan belts	Grease	Water	Breakages	Bits & Shoes	Loggers name	Casing - Final depth & sizes	Water Depth	Time
Drill rig (tick when OK)	✓	✓	✓	✓		✓	✓	TSEPO	3m	0.47cm	
Pumps (tick when OK)	✓	✓	✓								

Log issued by name & signtr	TSEPO	Date	25/07/2018 To 27/07/2018	Log Reciwved By Name Signature	Pizzometer / Depth

5313

Geopractica CONTRACTING

Daily Drillers Journal

Site Location	ROAD DR08606 (STERKSPRUIT)	Client	KIMOPAX
Project			
BH No.	BRIDGE 1 – BH No1	Page 01	of 01

BH Survey Details
Co - Ordinates
X = _____
Y = _____

Job No. 1015

Date 30/07/2018 To 01/07/2018

Quantity of Core Boxes = 02

Rig No D401

Inclination (deg. off vertical) = 0

Pump no. D425

Orientation (bearing in deg.) = N/A

Driller TSEPO

Drill run From	Drill run To	Advance m	Core rec auger/ wash	Casing / drill size	Drill Bit Used	Test / Sampling SPT Count						Shelby	Material Description	Water colour	% Water loss
0.00	1.50m	1.50m	0.21cm	NXC									BROWN SANDY SOIL	BROWN	NO
1,50m	1.95m	0.45cm		SPT		2	3	3	4	6	6		" " "		
1.95m	3.00m	1.05m	0.65cm										" " "	BROWN	NO
3.00m	3.45m	0.45cm		SPT		2	2	4	5	6	7		" " "		
3.45m	4.50m	1.05m	0.34cm	TNW									GREYISH DOLARITE BOULDERS	GREYISH	80%
4,50m	6.00m	1.50m	0.30cm	TNW									" " "	"	85%
6.00m	6,50m	0.50cm	0.16cm	TNW									" " "	"	85%
6,50m	7,50m	1.00m	0.60cm	NWD4									BOULDERS & GREYISH SHELL ROCK		100%
7,50m	9.00m	1.50m	1.20m	NWD4									HARD BROWNISH SHELL ROCK	LIGHT BROWNISH	90%
9.00m	10,50m	1.50m	1.30m	NWD4									HARD FRACTURED SHELL ROCK	"	90%
10,50m	12,00m	1,50m	1,50m	NWD4									HARD BROWNISH SHELL ROCK	"	"
													END OF HOLE		

Comments I DRILL ONLY 1,5m BY 1000LTS OF WATER BECAUSE OF WATER LOSS

Daily Check	Diesel	Oil levels	Fan belts	Grease	Water	Breakages	Bits & Shoes	Loggers name	Casing - Final depth & sizes	Water Depth	Time
Drill rig (tick when OK)	✓	✓	✓	✓		✓	✓	TSEPO	7,5m	7,63m	
Pumps (tick when OK)	✓	✓	✓								

Log issued by name & signtr	TSEPO	Date	30/07/2018 To 01/07/2018	Log Reciwved By Name Signature	Pizzometer / Depth

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Geopractica CONTRACTING

Daily Drillers Journal

Site Location	ROAD DR08606 (STERKSPRUIT)	Client	KIMOPAX
Project			
BH No.	BRIDGE 3 - BH NO 2	Page 01	of 01

BH Survey Details	Job No.	Date
Co - Ordinates X = _____ Y = _____	1015	23/07/18
Quantity of Core Boxes = 02	Rig No	D401
Inclination (deg. off vertical) = 0	Pump no.	D425
Orientation (bearing in deg.) = N/A	Driller	TSEPO

Drill run From	Drill run To	Advance m	Core rec auger/ wash	Casing / drill size	Drill Bit Used	Test / Sampling SPT Count						Shelby	Material Description	Water colour	% Water loss
0.00	1.50m	1.50m	0.69cm	NXC									BROWNISH SAND WITH BOULDERS	BROWN	NO
1.50m	3.00m	1.50m	0.17cm	NXC									BROWNISH BOULDERS	"	"
3.00m	4,50m	1.50m	0.29cm	NWD4									GREYISH BOULDERS	"	"
4,50m	5,20m	0.70cm	0.12cm	NWD4									BROWN & GREYISH BOULDERS	"	"
5,20m	6.00m	0,80cm	0,60cm	NWD4									BROWNISH & GREYISH SHELL ROCK	"	"
6.00m	7.50m	1.50m	1,20m	NWD4									BROWNISH & GREYISH SAND STONE	"	"
7,50m	9.00m	1.50m	1.57m	NWD4									GREYISH SANDSTONE WITH SHELL	"	"
9.00m	10,50m	1,50m	1,32m	NWD4									GREYISH & BROWNISH SHELL ROCK	"	"
10.50m	11.00m	0.50cm	0.55cm	TNW									" " " "	"	"
11.00m	12.00m	1.00m	1.07m	NWD4									" " " "	"	"
													END OF HOLE		

Comments

Daily Check	Diesel	Oil levels	Fan belts	Grease	Water	Breakages	Bits & Shoes	Loggers name	Casing - Final depth & sizes	Water Depth	Time
Drill rig (tick when OK)	✓	✓	✓	✓	✓	✓	✓	TSEPO	4,50m	3,08m	
Pumps (tick when OK)	✓	✓	✓								

Log issued by name & signtr	TSEPO	Date	23/07/2018	Log Reciwved By Name Signature	Pizzometer / Depth

5310

Geopractica CONTRACTING

Daily Drillers Journal

Site Location	ROAD. DR08606 (STERKSPRUIT)	Client	KIMOPAX
Project			
BH No.	BRIDGE 4 - BH No 2	Page 01	of 01

BH Survey Details	Job No.	Date
Co - Ordinates X = _____ Y = _____	1015	19/07/2018 To 20/07/2018
Quantity of Core Boxes = 02	Rig No	D401
Inclination (deg. off vertical) = 0	Pump no.	0425
Orientation (bearing in deg.) = N/A	Driller	TSEPO

Drill run From	Drill run To	Advance m	Core rec auger/ wash	Casing / drill size	Drill Bit Used	Test / Sampling SPT Count						Shelby	Material Description	Water colour	% Water loss
0.00	0.75cm	0.75cm	0.27cm	NXC									BROWNISH CLAY SAND WITH BOULDERS	BROWN	No
0.75cm	1.50m	0.75cm	0.08cm	NXC									BOULDERS	"	"
1.50m	3.00m	1.50m	0.14cm	NXC									"	"	"
3.00m	4.50m	1.50m	1.18m	NWD4									BROWNISH & REDDISH MUD ROCK	REDDISH	"
4.50m	6.00m	1.50m	1.10m	NWD4									REDDISH SHELL ROCK WITH MUD ROCK	"	"
6.00m	6.60m	0.60cm	0.27cm	TNW									BOULDERS WITH REDDISH SHELL ROCK	"	"
6.60m	7.50m	0.90cm	0.35cm	NWD4									REDDISH SHELL ROCK	"	"
7.50m	9.00m	1.50m	1.40m	TNW									REDDISH & GREYISH SHELL ROCK	"	"
9.00m	10.50	1.50m	1.50m	TNW									LIGHT BROWNISH SAND STONE	BROWNISH	"
10.50m	12.03m	1.53m	1.53m	TNW									" " " "	"	"
													END OF HOLE		

Comments

Daily Check	Diesel	Oil levels	Fan belts	Grease	Water	Breakages	Bits & Shoes	Loggers name	Casing - Final depth & sizes	Water Depth	Time
Drill rig (tick when OK)	✓	✓	✓	✓		✓	✓	TSEPO	4.50m	1.32m	
Pumps (tick when OK)	✓	✓	✓								

Log issued by name & signtr	TSEPO	Date	19/07/2018 to 20/07/2018	Log Reciwved By Name Signature	Pizzometer / Depth

APPENDIX B:

LABORATORY RESULTS

UNCONFINED COMPRESSIVE STRENGTH (UCS)

ROCKLAB REPORT **CONFIDNTIAL**
2018-KIMOPAX-01

Issued by:

ROCKLAB
(ROCK MECHANICS & EXCAVATION LABORATORIES)
230 ALBERTUS STREET
LA MONTAGNE 0184
PRETORIA
SOUTH AFRICA
TEL: +27 12 813 4910
E-MAIL: CHENJ@ROCKLAB.CO.ZA

RESULTS OF ROCK PROPERTIES TESTS

Sampling Site:

BY

DR J. F. CHEN

Submitted to:

KIMOPAX

23 AUGUST 2018

C O N T E N T S

TABLE 1 - RESULTS OF UNIAXIAL COMPRESSIVE STRENGTH TESTS

APPENDIX 1 FAILURE CODES OF ROCK COMPRESSION TESTS

TABLE 1 RESULTS OF UNIAXIAL COMPRESSIVE STRENGTH TESTS

ROCKLAB
DIVISION OF SOILLAB (PTY) LTD
Tel: 0027 12 813 4910
E-mail: Chenj@rocklab.co.za

Client: KIMOPAX Sampling Site: 23-08-2018

SPECIMEN PARTICULARS				SPECIMEN DIMENSIONS					SPECIMEN TEST RESULTS			
Rocklab Specimen No. 7625-	Sample ID	Sample Depth m	Rock Type	Diameter mm	Height mm	Ratio of Height to Diameter	Mass g	Density g/cm³	Failure Load kN	Strength (UCS) MPa	Failure Code	Note
UCS-01	Bridge 4, BH 1	6 - 7.5		58.15	157.2	2.7	1091.25	2.61	48.28	18.2	XA	
UCS-02	Bridge 4, BH 2	9 - 10.5		59.88	164.4	2.7	1076.75	2.33	159.20	56.5	XA	
UCS-03	Bridge 1, BH 2	9 - 10.5		47.33	120.3	2.5	552.43	2.61	106.05	60.3	XA	
UCS-04	Bridge 3, BH 2	10.5 - 11.5		59.63	89.7	1.5	638.62	2.55	286.43	102.6	XA	

Note: All tests were conducted according to the ISRM's (International Society for Rock Mechanics) specification.

APPENDIX 1

CLASSIFICATION OF ROCK SPECIMEN FAILURE MODE INFLUENCED / NOT INFLUENCED BY DISCONTINUITIES DURING COMPRESSION TESTING

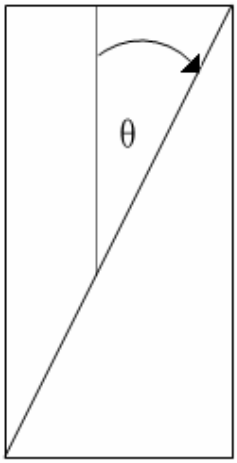
FAILURE NOT INFLUENCED BY DISCONTINUITIES (INTACT)

TYPE CODE	DESCRIPTION OF SUB CODES	
	A	B
X	SLIDING SHEAR FAILURE	COMPLETE CONE DEVELOPMENT
Y	SPLITTING	BREAKING INTO A LOT OF PIECES

FAILURE INFLUENCED BY DISCONTINUITIES

TYPE CODE	DESCRIPTION OF SUB CODES	
	A	B
	PARTIAL FAILURE ON DISCONTINUITY	FAILURE COMPLETELY ON DISCONTINUITY
1	AT 0-10° TO AXIS	AT 0-10° TO AXIS
2	AT 11-20° TO AXIS	AT 11-20° TO AXIS
3	AT 21-30° TO AXIS	AT 21-30° TO AXIS
4	AT 31-40° TO AXIS	AT 31-40° TO AXIS
5	AT 41-50° TO AXIS	AT 41-50° TO AXIS
6	AT 51-70° TO AXIS	AT 51-70° TO AXIS
7	AT 71-90° TO AXIS	AT 71-90° TO AXIS
0	Multiple Discontinuities	Multiple Discontinuities

Example: Failure Type3B: Failure completely on a discontinuity with an orientation of between 21° and 30° to the specimen axis.



CHEMISTRY

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M&L LABS

Ref No. : 10627350
Issued at : Johannesburg
Date : 04/09/2018

Certificate/Report

RESULTS REPORTED RELATED ONLY TO ITEMS TESTED

COMPANY NAME : KIMOPAX(PTY)LTD
ADDRESS : 62 BOMZA BAY ROAD BEACN BAY 5205
SUBJECT : ANALYSIS OF 4 SOIL SAMPLES
MARKED : AS BELOW
INSTRUCTED BY : DAKALO TSANWANI
ORDER NO. :
RECEIVED ON : 16/08/2018
LAB NO(S) : E012194-E012193
DATE ANALYSED : 03/09/2018

Analysis on a10% aqueos extract of the sample as recieved:

Lab No: SAMPLE MARKS	METHOD REFERENCES	E12191 BRIDGE1 BH1CS@ 4.5-6m	E12192 BRIDGE4 BH1CS@ 6-7.5m	E12192 BRIDGE 1 BH2CS@	E12194 BRIDGE 3 BH2CS@
Calcium Carbonate Saturated Ph @ 25°C	(PCI 9,28)	8.4	8.6	8.5	8.5
pH Value @ 25°C	(SABS 11)	7.9	8.2	8.2	8.2
Conductivity mS/m @ 25°C	(APHA 2510B)	20.5	20.7	20.5	20.3
Total Dissolved Solids	(SABS 213)	106	108	106	112
Calcium,Ca		25	18.1	21	20
Calcium Hardness as CaCO3	(SABS 216)	62	45	52	50
Magnesium, Mg	(SABS 1071)	4.1	2.7	6.0	6.1
Free and Saline Ammonia as NH4	(SABS 217)	<0.1	<0.1	<0.1	<0.1
Total Alkalinity as CaCO3		52	54	56	55
P Alk as CaCO3		NIL	NIL	NIL	NIL
Bicarbonate,HCO3		63	66	68	67
Carbonate, CO3		NIL	NIL	NIL	NIL
Chloride,Cl	(SABS 202)	8.7	8.8	8.9	8.9
Sulfate,SO4	(SABS 212)	14.8	13.3	13.4	13.6
Potential Sulfate, Sulfide, S	(SABS 1056)	<0.2	<0.2	<0.2	<0.2
Albuminoid Ammonia as N	(SABS 218)	0.2	0.2	0.2	0.2
Total Ammonium Ion Content NH4		0.2	0.2	0.2	0.2
pH of Saturation pHs		8.3	8.4	8.3	8.3
Langelier Index (pH - pHs)		-0.4	-0.2	-0.1	-0.1
Leaching Corrosion Sub. Index		761	687	615	617
Spalling Corrosion Sub. Index		3	3	3	3
Final Aggressiveness Index		764	690	618	620
Chloride Corrosion Sub. Index		1.7	1.8	1.8	1.8

The results are expressed in mg/l where applicable.

Comments:

1.(a) The Langelier (Saturation) Index indicates that the samples have corrosive tendencies.

(b)The Final Aggressiveness Index indicates that the samples E12192-E12194 are mildly to fairly aggressive to concrete and steel.

(c)Sample E12191 is highly aggressive to concrete and steel.

Method Reference: Deterioration of concrete in aggressive water by JJ Basson.

Note: The analyses were carried out on a 1:10 SOIL:WATER extract using Rand Water Board Domestic Water

ALISON ACKERMAN
OPERATIONAL MANAGER

Authorised Signature (original blue ink)

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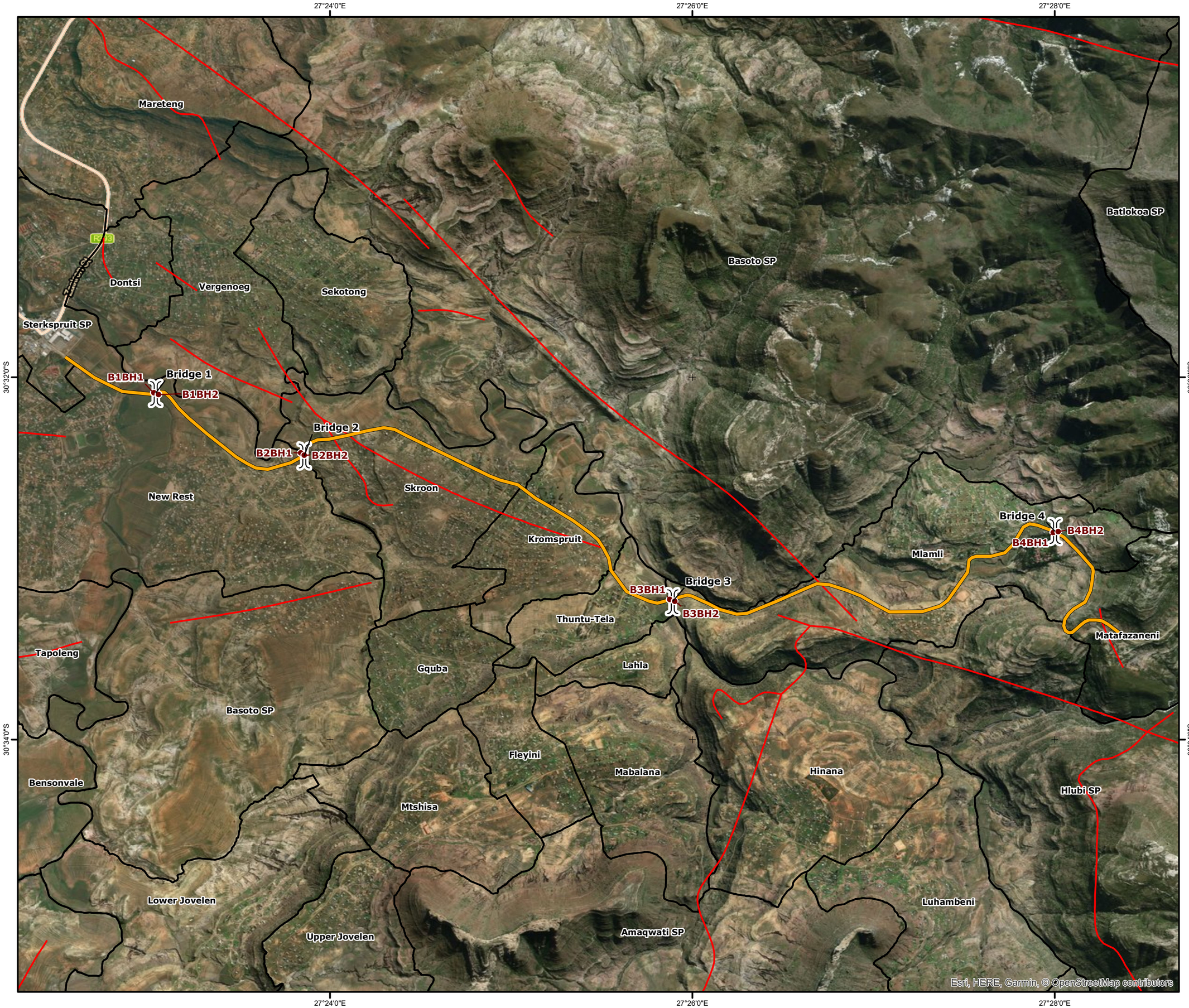
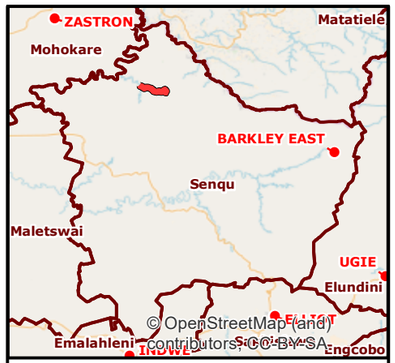
APPENDIX C:

BOREHOLES LAYOUT





LEGEND

- Hole
- Bridge
- DR08606_road
- Dyke, dolerite
- Village

0 0.3 0.6 1.2 1.8
Kilometers

REFERENCE: Transverse Mecartor (Gauss-Kruger)
WGS84 Ellipsoid
Hartebeesthoek 94 Datum
Central Meridian 27º

PROJECT: GEOTECHNICAL CORE DRILLING OF 4 BRIDGES ALONG 12KM DR08606

TITLE: SATELLITE MAP OF CORE DRILLING - 4 BRIDGES

PROJECT No.		KIM-GEO-2018-56
SCALE	1:35 000	A3
GIS	CSG	07/08/2018
CHECK	DT	07/08/2018
REVIEW		07/08/2018

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