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BUILDING SOUTH AFRICA THROUGH BETTER ROADS

THE SOUTH AFRICAN NATIONAL ROADS AGENCY SOC LIMITED

CONTRACT NRA N002-300-2018/1D

FOR

CONSULTING ENGINEERING SERVICES FOR THE PRELIMINARY DESIGN OF THE UPRADE OF NATIONAL ROUTE N2, SECTIONS 30, 31 AND 32, FROM KANGELA (N2/30 KM14) TO PONGOLA (N2/32 KM29.4)

PRELIMINARY DESIGN REPORT (REV0)

PRELIMINARY GEOTECHNICAL DESIGN REPORT

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EXPERIENCE QUALITY INTEGRITY

Structure	Approximate bedrock level BGL (m)	Final depth of borehole BGL (m)	Recommended minimum founding depth BGL (m)	q_{EASBP} (MPa)	Foundation type
Bushlands Interchange	10.30	20.00	3.00	0.20	Spread Footings
* q_{EASBP} – Estimated allowable safe bearing pressure calculated according to the methods of Terzaghi & Peck (1967); Meyerhof (1956, 1965, 1974).					

6.9 Ncemane Overpass N2-30-47.4N

6.9.1 Description of the site

Borehole referenced BHN2-30-47.4 N, is positioned 31m east of the N2 south bound carriageway, above the existing N2 road level. The topography of the site is flat with an elevation value of 93m amsl. Widening is proposed adjacent to the south-bound carriageway and as such the interchange will be extended in an easterly direction. The interchange is occupied by a gravel approach road flanked by game reserves.

6.9.2 Investigation undertaken

Borehole referenced BH-N2-30-47.4N, was drilled to a final depth of 13.55m BGL. SPT tests were undertaken at 1.50m intervals over a depth range of 1.50-4.75m BGL. Due to the highly fractured nature of the rock a UCS test could not be conducted.

6.9.3 Engineering Geological Description

Drilling at the overpass position indicates a relatively thin transported layer between a depth of 0.0 and 1.81m BGL. The colluvial variant was described as a clayey silt and the alluvial variant was described as a silty sand. This is underlain by a clayey silt residual basalt horizon with SPT data indicating “very stiff” soil consistencies between a depth of 1.10-5.50m BGL. The static groundwater level is located at 4.77m BGL.

Highly weathered, highly fractured, very soft to soft rock strength basalt was intersected between a depth of 5.50 and 13.55m BGL. RQD values indicates very poor rock mass quality over a depth range of 5.50-13.55m BGL. The basalt bedrock contained fractures with open apertures filled with clay gouge. Discontinuities were recorded as rough, with joint planes dipping at very low to low angles.

6.9.4 SPT Test Results

The results of the SPT tests is summarized in Table 6.20.

Table 6-20: Ncemane Overpass SPT Test Results

Structure	Depth BGL (m)	Corrected “N” Value	EASBP (kPa)
Ncemane Overpass	1.50-1.95	28	368
	3.00-3.45	19	248
	4.50-4.95	Refusal	-

No laboratory tests were conducted.

6.9.5 Founding Conditions and Recommendations

It is recommended that the foundations for the structure be seated in or on competent, intact, basalt bedrock. Table 6.21 provides recommendations for the minimum founding depth BGL and indicates the corresponding EASBP that can be imposed on the bedrock.

Due to the depth to competent founding bedrock, piling is considered a feasible option for founding the proposed structure. An oscillator type or large diameter auger pile is recommended. Long rock sockets are required to transfer the loads via shaft friction and end bearing to the basalt bedrock. A permanent concrete liner is recommended to protect against groundwater ingress, the liner should terminate above the rock level.

Table 6-21: Ncemane Overpass Preliminary Founding Levels

Structure	Approximate bedrock level BGL (m)	Final depth of borehole BGL (m)	Recommended minimum founding depth BGL (m)	q_{EASBP} (MPa)	Foundation type
Ncemane Overpass	5.50	13.55	7.10	0.10	End Bearing Piles
*q_{EASBP} – Due to the absence of UCS results the Estimated Allowable bearing pressure is based on a visual appraisal of the bedrock conditions.					

6.10 Ubizane Overpass N2-30-51.4 S

6.10.1 Description of the site

Borehole referenced BHN2-30-51.45 N, is positioned 30m east of the N2 south bound carriageway adjacent to the overpass detour road, above the existing N2 road level. The topography of the site is shallow dipping, with an elevation value of 97m amsl. Widening is proposed adjacent to the south-bound carriageway and as such the interchange will be extended in an easterly direction. The interchange is occupied by a detour road flanked by game reserves.

6.10.2 Investigation undertaken

Borehole referenced N2-30-51.4S, was drilled to a final depth of 12.47m BGL, SPT test refusal was encountered in the transported horizon over a depth range of 1.50-1.90m BGL. A UCS rock core sample was retrieved between a depth of 10.52-10.70m BGL for laboratory testing.

6.10.3 Engineering Geological Description

Drilling at the overpass position indicates a thin layer of engineered fill described as a clayey silt between a depth of 0.0 and 0.70m BGL. The fill horizon is underlain by a silty clay colluvial horizon between a depth of 0.58 and 1.55m BGL. A dark brown coloured, clayey silt residual horizon was intersected between a depth of 1.55 and 2.01m BGL. The static groundwater level is located at 5.6m BGL.

Basalt forms the basal bedrock which was intersected between a depth of 2.01-12.47m BGL. Highly weathered, highly fractured, very soft to soft rock strength basalt was intersected between a depth of 2.01-8.28m BGL. In additional the basalt contained dark grey coloured, slightly weathered, highly

fractured, hard rock strength zones which were intersected over depths of 6.51-6.81m BGL, 7.00-7.28m and 7.94-8.28m BGL. Brownish grey coloured, moderately weathered, highly fractured basalt was intersected between a depth of 8.28-12.47m BGL. RQD values indicate fair rock mass quality between a depth of 9.50-12.47m BGL. Joint descriptors over this depth, indicate narrow to wide joint apertures with clay infill, with medium to high angle joint orientations.

6.10.4 Laboratory Test Results

The UCS test results undertaken on a core sample is summarized in Table 6.22.

Table 6-22: Ubizane Overpass Laboratory Test Results

Structure	Depth BGL (m)	Lithology	Density (Kg/m^3)	Load at Failure (KN)	Failure Mode	UCS (MPa)	Rock strength
Ubizane Overpass	10.52-10.70	basalt	2437	21.69	Multiple fracturing	10.33	Soft rock

6.10.5 Founding Conditions and Recommendations

The tested UCS sample, failed in a multiple fracture failure mode which can be attributed to the numerous adversely orientated joint sets recorded in the joint descriptions.

The existing N2 road alignment at the overpass is in a cut. In order to achieve the existing road level during construction of the overpass, blasting will be required in the very hard rock strength basalt.

It is recommended that the foundations for the structure be seated in or on competent, intact, basalt bedrock devoid of highly fractured zones. Table 6.23, provides recommendations for the minimum founding depths BGL and indicates the corresponding EASBP that can be imposed on the bedrock.

Spread footings are recommended, with foundation footings socketed into the basalt bedrock to prevent under scour. Dewatering measures will be required during construction due to the presence of shallow groundwater conditions.

Table 6-23: Ubizane Overpass Preliminary Founding Levels

Structure	Approximate bedrock level BGL (m)	Final depth of borehole BGL (m)	Recommended minimum founding depth BGL (m)	q_{EASBP} (MPa)	Foundation type
Ubizane Overpass	2.01	12.47	3.00	1.00	Spread Footings
* q_{EASBP} – Estimated allowable safe bearing pressure for square pad foundations bearing on rock (for settlement not exceeding 0.5% of foundation width) based on BS8004 1986.					

Deep excavations will be required for the spread footings, excavation side walls will need to be battered back or supported this should be assessed by the competent engineer. All earthworks should be undertaken in accordance with SANS 1200 D.

6.11 Mzinene River Bridge N2-30-54.4 S2

6.11.1 Description of the site

Borehole referenced BHN2-30-54.4 S2, is positioned 13m east of the N2 south bound carriageway. The topography of the site is flat, with an elevation value of 76m amsl. Widening is proposed adjacent to the south-bound carriageway and as such the bridge will be extended in an easterly direction. The bridge is occupied by dense vegetation buffering the Mzinene River.

6.11.2 Investigation undertaken

Borehole referenced N2-30-54.4 S2, was drilled to a final depth of 10.10m BGL, an SPT test was conducted in the transported horizon over a depth range of 3.00-3.40m BGL. A UCS rock core sample was retrieved between a depth of 9.50-9.70m BGL for laboratory testing.

6.11.3 Engineering Geological Description

Drilling at the river bridge position indicates a relatively thin fill layer described as a clayey silt between a depth of 0.0-1.36m BGL. The fill layer is underlain by a “medium dense” soil consistency, clayey sand alluvial horizon between a depth of 1.36-4.30m BGL. A bedload boulder rich alluvial horizon was intersected between a depth of 4.30-5.60m BGL. The static groundwater level is located at 1.90m BGL.

Basalt forms the basal bedrock which was intersected between a depth of 5.60-10.10m BGL. Moderately weathered, very highly fractured, medium rock strength basalt was intersected between a depth of 5.60-9.00m BGL. RQD values indicates very poor rock mass quality between a depth of 5.60-9.00m BGL. Dark grey coloured, slightly weathered, moderately fractured, hard rock strength basalt was intersected between a depth of 9.00-10.10m BGL. RQD values indicates excellent rock mass quality between a depth of 9.00-10.00m BGL. Joint descriptors over this depth, indicate narrow joint apertures with rough discontinuities and high angle joint orientations.

6.11.4 SPT and Laboratory Test Results

The results of the SPT tests is summarized in Table 6.24.

Table 6-24: Mzinene River Bridge SPT Test Results

Structure	Depth BGL (m)	Corrected “N” Value	EASBP (kPa)
Mzinene River Bridge	3.00-3.45	17	221

The UCS test results are summarized in Table 6.25.

Table 6-25: Mzinene River Bridge Laboratory Test Results

Structure	Depth BGL (m)	Lithology	Density (Kg/m^3)	Load at Failure (KN)	Failure Mode	UCS (MPa)	Rock strength
Mzinene River Bridge	9.50-9.70	basalt	2576	73.45	Shear along single plane	36.99	Hard rock

6.11.5 Founding Conditions and Recommendations

It is recommended that the foundations for the structure be seated in or on seated in competent, intact, basalt bedrock devoid of highly fractured zones.

Table 6.26 provides recommendations for the minimum founding depths BGL and indicates the corresponding EASBP that can be imposed on the bedrock.

Due to the depth to competent founding bedrock, piling is considered a feasible option for founding the proposed structure. An oscillator type or large diameter auger pile is recommended. Long rock sockets are required to transfer the loads via a combination of friction and end bearing to the basalt bedrock. A permanent concrete liner is recommended to protect against groundwater ingress, the liner should terminate above the rock level.

Table 6-26: Mzinene River Bridge Preliminary Founding Levels

Structure	Approximate bedrock level BGL (m)	Final depth of borehole BGL (m)	Recommended minimum founding depth BGL (m)	q_{EASBP} (MPa)	Foundation type
Mzinene River Bridge	5.60	10.10	7.00	2.00	End Bearing Piles
* q_{EASBP} – Estimated allowable safe bearing pressure for square pad foundations bearing on rock (for settlement not exceeding 0.5% of foundation width) based on BS8004 1986.					

6.12 Hluhluwe Interchange N2-30-55.3 N

6.12.1 Description of the site

Borehole referenced BHN2-30-55.3 N is positioned 38m east of the N2 south bound carriageway, above the existing N2 road level. The topography of the site is flat, with an elevation value of 93m amsl. Widening is proposed adjacent to the south-bound carriageway and as such the interchange will be extended in an easterly direction. The interchange is occupied by a surfaced approach road flanked by agricultural land.

6.12.2 Investigation undertaken

A single borehole referenced BH-N2-30-55.3N, was drilled to a final depth of 14.50m BGL, a SPT test was conducted in the transported horizon over a depth range of 1.50-3.40m BGL. Due to the highly fractured nature of the rock a UCS test could not be conducted.

6.12.3 Engineering Geological Description

Drilling at the interchange position indicates a relatively thin colluvial horizon described as a clayey silt between a depth of 0.0-1.36m BGL. The colluvial horizon is underlain by a “stiff to very stiff” soil consistency residual horizon, described as clayey silt with soft basalt gravel fragments, occurring over a depth of 1.36-7.00m BGL. The static groundwater level is located at 4.25m BGL.

Basalt forms the basal bedrock, which was intersected between a depth of 7.00-14.50m BGL. Moderately weathered, highly fractured, soft to medium rock strength basalt was intersected

between a depth of 7.00-8.87m BGL. Highly weathered, very highly fractured, soft rock strength basalt was intersected between a depth of 8.87-12.50m BGL. Light grey coloured, moderately weathered, highly fractured, soft to medium rock strength basalt was intersected between a depth of 12.50-14.50m BGL.

6.12.4 SPT Test Results

The results of the SPT tests is summarized in Table 6.27.

Table 6-27: Hluhluwe Interchange SPT Test Results

Structure	Depth BGL (m)	Corrected "N" Value	EASBP (kPa)
Hluhluwe Interchange	1.50-1.95	12	162
	3.00-3.45	18	235

No laboratory tests were conducted.

6.12.5 Founding Conditions and Recommendations

It is recommended that the foundations for the structure be seated in or on competent, intact, basalt bedrock devoid of highly fractured zones. Table 6.28 provides recommendations for the minimum founding depth BGL and indicates the corresponding EASBP that can be imposed on the bedrock.

Due to the depth to competent founding bedrock, piling is considered a feasible option for founding the proposed structure. An oscillator type or large diameter auger pile is recommended. Long rock sockets are required to transfer the loads via a combination of friction and end bearing to the basalt bedrock. A permanent concrete liner is recommended to protect against groundwater ingress, the liner should terminate above the rock level.

Table 6-28: Hluhluwe Interchange Preliminary Founding Levels

Structure	Approximate bedrock level BGL (m)	Final depth of borehole BGL (m)	Recommended minimum founding depth BGL (m)	q_{EASBP} (MPa)	Foundation type
Hluhluwe Interchange	7.00	14.50	9.20	0.10	End bearing piles
***q_{EASBP}** – Due to the absence of UCS results the Estimated Allowable bearing pressure is based on a visual appraisal of the bedrock conditions.					

6.13 Ngweni River Bridge N2-30-62.0 S2

6.13.1 Description of the site

Borehole referenced BHN2-30-62.0 S2, is positioned 19m east of the N2 south bound carriageway, below road level. The topography of the site is flat terrain, with an elevation value of 95m amsl. Widening is proposed adjacent to the south-bound carriageway and as such the bridge will be extended in an easterly direction. The bridge is occupied by dense vegetation buffering the Ngweni River.

Chainage	Trial Pit	Structure	Depth (m)	Abbreviated Profile Descriptions	*Excavation conditions	Foundation Level (m)	Foundation Recommendation
			0.41	clayey sand, residual basalt	soft		
			0.91	clayey sandy gravel, residual basalt	soft		
			1.10	medium rock strength, basalt	intermediate R		
			0.24	clayey silt, colluvium	soft		
			1.40	sandy clay, residual basalt	soft		
N2/31/36+200	TP32	C400	2.65	silty clay, residual basalt	soft	**0.30m in engineered fill**	Remove alluvium to 1.0m beyond the perimeter of the structure and replace with inert backfill compacted to 93% MOD AASHTO at 1 to 2% OMC
			3.15	silty clay residual basalt/pedogenic	soft		
			0.18	clayey silt with pebbles, alluvium	soft		
			2.30	silty clay, alluvium	soft		
N2/31/40+530	TP31	C002	2.85	silty clay, residual basalt	soft	**3.10**	Engineered Fill
			3.05	very soft, basalt	soft		
			0.30	sandy clayey silt, colluvium	soft		
N2/31/45+820	TP30	C401	0.30+	hard to very hard rock strength, doleritic basalt	hard R	**0.30**	Conventional
			0.16	clayey silt, hillwash	soft		
			1.10	silty clay, residual basalt	soft		
N2/31/48+850	TP29	C402	1.59	clayey silt, residual basalt	soft	**2.70**	Engineered Fill
			2.21	clayey sandy gravel, residual basalt/pedogenic	soft		
			2.62	medium rock strength, basalt	intermediate		
			0.35	clayey silt, colluvium	soft		
			0.78	clayey silt, hillwash	soft		
N2/31/49+500	TP28	S6780(a)	1.40	sandy clayey silt, residual basalt	soft	**3.00**	Engineered Fill
			2.70	clayey sandy gravel, completely weathered basalt	soft		
			2.93	soft rock strength, basalt	soft		

Chainage	Trial Pit	Structure	Depth (m)	Abbreviated Profile Descriptions	*Excavation conditions	Foundation Level (m)	Foundation Recommendation
N2/31/49+870	TP27	S6780(b)	0.57	clayey sand, colluvium	soft	**1.16**	Conventional
			1.16	clayey sand, fill	soft		
			1.16+	hard rock strength, basalt	hard		
N2/31/49+880	TP26	C403	0.64	medium rock strength, basalt	intermediate	**1.00**	Conventional
			0.98	medium rock strength, basalt	intermediate R		
N2/31/51+200	TP25	S6780(c)	0.41	clayey silt, colluvium	soft	**2.10**	Engineered Fill
			0.87	clayey silt, fill	soft		
			1.35	sandy gravel, fill	soft		
			1.67	gravelly clayey silt, residual basalt	soft		
			2.03	medium to hard rock strength, basalt	intermediate R		
N2/31/52+200	TP24	C003	0.27	clayey silt, colluvium	soft	**0.81**	Conventional
			0.81	clayey silty sand, residual doleritic basalt	soft		
			1.19	hard rock strength, doleritic/basalt	hard R		
N2/31/52+300	TP23	C404	0.46	clayey silt, colluvium	soft	**2.10**	Engineered Fill
			0.60	gravelly clayey silt, colluvium	soft		
			1.21	clayey silt, residual basalt	soft		
			1.75	silty sandy gravel, completely weathered basalt	soft		
			2.04	soft rock strength, basalt	soft R		
N2/31/54/600	TP22	C405	0.76	clayey silt with pebbles, colluvium	soft	**0.30m in engineered fill**	Remove alluvium to 1.0m beyond the perimeter of the structure and replace with inert backfill compacted to 93% MOD AASHTO at 1 to 2% OMC
			2.3	silty sand with pebbles and cobbles, alluvium	intermediate R		

Chainage	Trial Pit	Structure	Depth (m)	Abbreviated Profile Descriptions	*Excavation conditions	Foundation Level (m)	Foundation Recommendation
N2/31/54+650	TP21	C406	0.49	pebbles, cobbles and boulders in a clayey silt matrix, fill	soft	**0.49**	Conventional
			0.49+	hard rock strength, doleritic basalt	hard R		
N2/31/55+230	TP20	C407	1.23	clayey silt with boulders, fill	soft R	**0.30m in engineered fill**	Remove alluvium to 1.0m beyond the perimeter of the structure and replace with inert backfill compacted to 93% MOD AASHTO at 1 to 2% OMC
N2/31/56+600	TP19	C408	0.17	clayey silt, colluvium	soft	**0.43**	Conventional
			0.43	pebbles, cobbles and boulders in a clayey silt matrix, fill	soft		
			0.44	hard rock strength, doleritic basalt	hard R		
N2/32/61+350	TP18	C411	0.28	clayey silt with cobbles and boulders, fill	soft	**0.80**	Conventional
			0.76	gravelly clayey silt, residual rhyolite	soft		
			0.93	medium to hard rock strength, rhyolite	intermediate R		
N2/31/58+800	TP17	C409	0.08	clayey silt, colluvium	soft	**2.30**	Engineered Fill
			1.12	sandy gravel with cobbles, pebbles and boulders, hillwash	soft		
			1.31	gravelly clayey silt, residual basalt	soft		
			2.24	medium to hard rock strength, basalt	intermediate		
			2.45	medium to hard rock strength, basalt	intermediate R		
N2/31/59+800	TP16	C409	0.16	clayey silt, hillwash	soft		

Chainage	Trial Pit	Structure	Depth (m)	Abbreviated Profile Descriptions	*Excavation conditions	Foundation Level (m)	Foundation Recommendation
			1.96	boulders, cobbles and pebbles in a silty sand matrix, alluvium	soft R	**0.30m in engineered fill**	Remove alluvium to 1.0m beyond the perimeter of the structure and replace with inert backfill compacted to 93% MOD AASHTO at 1 to 2% OMC
N2/31/60+050	TP15	C410	0.37	silty sandy gravel, hillwash	soft	**0.85**	Conventional
			0.54	clayey silt, colluvium	soft		
			0.85	silty sandy gravel with pebbles and cobbles, hillwash/pebble marker	soft		
			0.96	medium to hard rock strength, basalt	intermediate R		
N2/31/62+100	TP14	C412	0.09	clayey silt, fill	soft	**0.89**	Conventional
			0.89	silty sandy gravel, completely weathered basalt	soft		
			1.27	medium rock strength, basalt	intermediate R		
N2/32/1+100	TP13	Pongola River Tributary 1	0.56	clayey gravel, fill	soft	**2.00**	Engineered Fill
			0.89	silty sand, residual basalt	soft		
			1.21	soft rock strength, basalt	soft		
			2.00	medium rock strength, basalt	intermediate		
			2.25	medium rock strength, amygdaloidal basalt	intermediate R		
N2/32/2+020	TP12	C004	0.10	clayey silt, colluvium	soft	**0.30m in engineered fill**	Remove alluvium to 1.0m beyond the perimeter of the structure and replace with inert backfill compacted to 93% MOD AASHTO at 1 to 2% OMC
			0.50	sandy clay, alluvium	soft 0.30m		
			2.40	sandy clay with pebbles and cobbles, alluvium	soft 1.30m		
			3.00	sandy silty clay with pebbles and cobbles, alluvium	soft		
N2/32/2+740	TP11	P720	0.18	clayey silt, colluvium	soft		

Chainage	Trial Pit	Structure	Depth (m)	Abbreviated Profile Descriptions	*Excavation conditions	Foundation Level (m)	Foundation Recommendation
			0.55	sandy clay, alluvium	soft 0.70m	**0.30m in engineered fill**	Remove alluvium to 1.0m beyond the perimeter of the structure and replace with inert backfill compacted to 93% MOD AASHTO at 1 to 2% OMC
			2.65	sandy clay with pebbles, alluvium	soft 1.58m		
			3.00	sandy silty clay with pebbles and cobbles, alluvium	soft		
N2/32/4+940	TP10	C414	0.13	silty gravel, fill	soft	**3.00**	Engineered Fill
			1.63	clayey silt to silty clay, residual doleritic basalt	soft		
			2.81	clayey gravelly silt, residual doleritic/basalt	soft		
			3.00	clayey silty sand, completely weathered basalt/dolerite	soft		
N2/32/5+710	TP9	C006	0.27	clayey sand, colluvium	soft	**1.99**	Engineered Fill
			0.57	clayey silt, colluvium	soft		
			1.99	sandy silt with boulders and gravel, alluvium	soft		
			2.21	medium to hard rock strength, doleritic basalt	intermediate		
N2/32/6+890	TP8	C415	0.35	gravelly sandy clayey silt, colluvium	soft	**1.63**	Engineered Fill
			1.63	silty gravel, completely weathered doleritic basalt	soft		
			2.07	hard rock strength, doleritic basalt	hard R		Engineered Fill
N2/32/7+280	TP7	C007	0.32	gravelly clayey silt, colluvium	soft	**0.76**	Conventional
			0.76	clayey silt, residual doleritic basalt	soft		
			1.06	medium rock strength, doleritic basalt	intermediate R		
	TP6	C416	0.35	clayey silt, colluvium	soft		

Chainage	Trial Pit	Structure	Depth (m)	Abbreviated Profile Descriptions	*Excavation conditions	Foundation Level (m)	Foundation Recommendation
N2/32/8+030			0.69	clayey sand with pebbles, alluvium	soft 1.30m	**0.30m in engineered fill**	Remove alluvium to 1.0m beyond the perimeter of the structure and replace with inert backfill compacted to 93% MOD AASHTO at 1 to 2% OMC
			1.71	pebbles, cobbles and boulders in a sandy silt matrix, alluvium	soft R		
N2/32/9+130	TP5	C008	0.12	boulders in a clayey silt matrix, colluvium	soft	**1.00**	Conventional
			0.48	boulders, pebbles and cobbles in a clayey silt matrix, colluvium	soft		
			0.93	hard rock strength, dolerite	hard R		
N2/32/11+310	EXP1	C417	1.5	medium to hard rock strength, basalt	intermediate	**0.00**	Conventional
N2/32/13+250	TP3	S6780(d)	0.21	sandy silty, topsoil	soft	**2.80**	Engineered Fill
			0.34	gravelly sand, fill	soft		
			0.50	clayey silty sand, fill	soft		
			0.70	clayey sand, fill/ reworked *in-situ*	soft		
			0.79	clayey sandy silt, residual sandstone	soft		
			1.19	clayey silt, residual sandstone	soft		
			2.65	clayey sandy silt, residual sandstone	soft 0.50m		
			2.80	soft rock strength, sandstone	soft		
N2/32/16+300	TP2	S6780(e)	0.21	sand, alluvium	soft	**1.20**	Conventional
			0.81	sandy clay, residual sandstone	soft		
			1.12	medium to hard rock strength, sandstone	intermediate R		
N2/32/18+280	TP1	S6780(f)	0.40	clayey silt, fill	soft	**3.10**	Engineered Fill
			1.90	clayey sandy silt, residual sandstone	soft		
			2.68	clayey sand, residual sandstone	soft		

Chainage	Trial Pit	Structure	Depth (m)	Abbreviated Profile Descriptions	*Excavation conditions	Foundation Level (m)	Foundation Recommendation
			3.05	soft rock strength, sandstone	soft		
KEY:							
R	**REFUSAL**						
0.00m	**WATERTABLE LEVEL**						
***Excavation Conditions According to SANS 1200D, 1990**							

7 GEOTECHNICAL CONSTRAINTS AND PROBLEM AREAS

The centreline investigation indicates the presence of medium expansivity alluvial horizons between Ch.22.5 and Ch.28.5, Section 30. Sandy, silt potentially expansive alluvial variants were frequently intersected between Ch.39-Ch.44.5, Section 30. Relatively deep, highly expansive, residual basalt horizons in excess of 1.50 m below NGL were encountered over Section 31 at Ch.1.4, Ch.9.7, Ch.10.2, Ch.10.7 and Section 32 at Ch.19.2 and Ch.60.5. Subgrade treatment will be required over these sections in order to mitigate swell potential. Areas of problematic subgrade are detailed **in Section 4.8**.

The borrow pit investigation generally indicates that the gravelly basalt is marginally to unsuitable for subbase and in many cases selected subgrade as the results indicate that the materials fail to consistently meet G6 quality specification. Stabilized testing undertaken by Geosure indicates the majority of material do not meet C4 specification after modification with lime and stabilization with cement. The findings of the correlation testing exercise indicate variability in the test results obtained from laboratories. The correlation testing exercise did not conclusively account for certain index test results or validate nor disprove the engineering performance of the sampled material from borrow pits. The element of uncertainty is compounded and reflected in the statistical parameters presented in **Section 5.5** of this report. It is important to make every effort to use the available materials and further investigations must aim to verify their suitability. It is recommended that consideration be given to single stage crushing in borrow pits prior to placing on the road. Subsequent testing must be structured to simulate single stage crushing.

Drilling investigations at Mfekayi Interchange, Hluhluwe River Bridge, Mzinene River Bridge, Ngweni River Bridge, Mduna River Bridge, Sekane River Bridge, Mkuze River Bridge, Mhlanganisi River Bridge and Mpeti River Bridge indicate the presence of boulders. An oscillator type or large diameter auger pile capable of displacing boulders is recommended at these structures. Dewatering measures will be required during the construction phase at structures were spread footings are proposed namely; D759 Interchange, Fernwood Overpass, Bushlands Interchange, Ubizane Overpass, Msunduze River Bridge, Sihlepu Overpass, Jozini Interchange, Candover Interchange, Pongola River Bridge, P720 Interchange, Sitilo River Bridge, D1938 Interchange and Rietspruit River Bridge. With foundation footings socketed into competent bedrock where intersected to prevent under scour, during periods of flooding. Deep excavations will be required for the spread footings, excavation side walls will need to be battered back or supported this should be assessed by the competent engineer. All earthworks should be undertaken in accordance with SANS 1200 D.

Siltstone bedrock of the Mzinene Formation was intersected at the; D759 Interchange, Fernwood Overpass, Nyalazi River Bridge, Mfekayi Interchange, Hluhluwe River Bridge and D1938 Interchange. The siltstone bedrock will need to be protected from the elements if the excavation is left open for an extended period, due to the rapid deterioration of the rock upon exposure to the natural elements. Spread footings have been recommended at the D1938 Interchange, it recommended that a low strength concrete blinding layer be applied to protect the bedrock against the elements during construction.

If additional boreholes are to be drilled in rivers. Special consideration needs to be given to temporary drilling platforms, barges and pile installation methods. Consideration must also be given to the prevention of the inflow of river water and the washing out of the rock toe.

8 RECOMMENDATIONS FOR DETAILED DESIGN GEOTECHNICAL INVESTIGATIONS

Areas of highly expansive and compressible subgrade conditions highlighted in this report will require a detailed investigation in order to fully geotechnical characterize the extent, nature and occurrence of this problematic subgrade. Additional laboratory testing is recommended to specifically assess the settlement and swelling potential of the subgrade.

Based on the laboratory test results, the materials investigation has failed to consistently prove reliable sources of G6 and C4 quality material. The engineering geological performance of the borrow pit material will require more attention during the Detailed Design Phase. Consideration can also be given to exploring outlying dolerite intrusives located in and along Section 32, as potential borrow pits. Furthermore, it is recommended that rotary core drilling be undertaken on rock quarries, the results of which, must be correlated with the seismic refraction survey results presented in this report. Further testing in the designated borrow pits must be undertaken to simulate single stage crushing.

The cut between Ch8.8 to Ch 10.4 on Section 32 was not investigated due to access constraints, this will need to be investigated following finalization of the route alignment. Rotary core drilling will be required on all major cuts. In order to evaluate the excavability of the material on major cuts, seismic refraction surveys are recommended to supplement drilling. It is recommended that slope stability analyses be undertaken on all major cuts. Kinematic analyses are recommended on rock slopes in which cuts are proposed. Detailed design must consider retention structures and stabilization measures during slope stability analyses.

CPTu testing and settlement analyses are recommended only on major embankments, underlain by compressible residual basalt and alluvium profiles which are highlighted in this report.

This geotechnical investigation was undertaken in accordance with SANRAL requirements and considering that the project is in Preliminary Design Stage. As such during the structures investigation no bridge design loads were available at the time and hence it was not possible to evaluate potential differential settlement or determine the proposed pile size. Additional boreholes for structures will be required during Detailed Design Stage. The number of investigation positions should be in accordance with SAPEM Chapter 7 guidelines and SANRAL's Code of Practice (2008). Additional laboratory testing is recommended, in order to correlate the preliminary laboratory test results presented in this report.

9 CONCLUSIONS

This preliminary Geotechnical Design report presented the findings concluded from a geotechnical and materials investigation undertaken on the National Route N2 from Section 30 to 32. The prevailing humid climatic conditions in the areas of Mtubatuba and Hluhluwe is causative, amongst other factors, to the formation of deep residual weathering profiles.

The centreline investigation undertaken along the 152.7 km route indicates a progressive change in litho-stratigraphical units which span a Geological Timescale of 300 Ma. Contributing to the various geological profiles intersected along the route and their contrasting engineering geology properties. The centreline investigation indicates localized problematic soil conditions, over which sections subgrade treatment will be required.

Basalt and doleritic basalt bedrock rock quarries identified along Section 30 and 31, offered a viable aggregate source. The borrow pit investigation targeted gravelly basalt and doleritic basalt variants, laboratory testing undertaken by Geosure generally indicated non-suitable engineering properties for use in both natural and stabilized pavement layerworks. Correlation testing indicated a high variability in laboratory test results, with poor reproducibility and reliability, reducing confidence in the tested parameters.

The SANS 3001 test method excludes the coarser fraction, >37.5mm, of the material for testing. As the material encountered in the borrow pit investigations is predominantly coarse, blocky gravel basalt, much of the better quality rock fragments are excluded from the testing using this method, with the result that much of the material tested failed to meet the design specifications. It is therefore recommended that subsequent testing be structured to simulate single stage crushing, thereby including the coarser, better quality, fraction in the testing, which should result in an improvement in the test results.

Recommendations for further investigations highlighted the possible need to explore more rock quarries and adopt a probabilistic approach during the Detailed Design Phase on new and existing borrow pit sources. Rotary core drilling will be required at all rock quarries and major cuts. In order to conclusively evaluate the founding conditions at structures additional rotary core drilling is recommended, additional laboratory testing is also advisable.

Additional geotechnical and materials investigations that are undertaken during the Detailed Design Phase of the project, must be formulated to address the geotechnical requirements presented in this report and must be in accordance with SANRAL requirements.