MANGANORE to FERRUM

KIMBERLEY STRENGHTENING PHASE 4

INITIAL BASE LINE ENGINEERING GEOLOGICAL INVESTIGATION

to DETERMINE and EVALUATE the POTENTIAL for the PLACEMENT

of ELECTRIC POWER LINES and PYLONS

from MANGANORE to FERRUM SUBSTATION,

NORTHERN CAPE PROVINCE.

Report by

GEOSET CC

Georeference: 2822 Postmasburg & 2722 Kuruman

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REPORT ON THE KIMBERLEY STRENGHTENING PHASE 4: INITIAL BASE LINE ENGINEERING GEOLOGICAL INVESTIGATION to DETERMINE and EVALUATE the POTENTIAL for the PLACEMENT of ELECTRIC POWER LINES and PYLONS from MANGANORE to FERRUM SUBSTATION, NORTHERN CAPE PROVINCE.

Executive Summary

A baseline engineering geological investigation was conducted on the proposed development of an ESKOM power line with pylons to determine the geotechnical aspects which may influence this planned development in the area. The area is underlain by recent Aeolian dune sand, underlain by calcrete and the Griqualand West Supergroup with the Campbell Group consisting of the Ghaap Plateau and Schmidtsdrift Formations where the Vryburg and Ulco member is represented by siltstone, shale, quartzite, gritstone and conglomerate, and fine grained dolomite and stromatolitic limestone with chert and banded ironstone. The bedrock is generally covered by transported material usually consisting of dune sand underlain by calcrete. The mechanical properties of the soil layers should be determined by means of laboratory tests performed on disturbed samples taken during the profiling of trial pits during the final phase of investigation. The site information is evaluated through the application of standard evaluation techniques for the construction of masonry structures. Provisional development zones were determined, indicating the expected geotechnical conditions of each site class: **Potentially low to medium expansive and compressible and highly collapsible** soil with thickness up to 750mm which classified as site **class C2H1** (with up to **10mm** differential movement measured at surface) requiring **special foundations** varying through to site **class HCR** (with less than **7,5mm** soil movement measured at surface) requiring **normal or modified normal construction** or a soil raft, with associated site drainage provisions as described within each defined zone. Substantial financial implications are expected in Geotechnical **Zone PR** where scattered rock, shallow rock and rock outcrop are expected but will possibly prove as excellent and stable foundation material for the pylons. A **dolomite stability evaluation Zone PD** may be required to ensure the safe placement of the pylons.

These proposed mitigation and precautionary measures need to be adhered to for successful alignment and the development of the proposed pylons along the corridors.

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1. INTRODUCTION AND TERMS OF REFERENCE

On request of Me. Annelize Grobler of Landscape Dynamics in Pretoria, a baseline engineering geological investigation was conducted for the proposed corridors for the placement of ESKOM electric power lines and pylons between the Manganore to Ferrum Substations, and communication between us and the abovementioned parties lead to the field visit, commencing on 29 January 2014.

The aim of this investigation was to identify and evaluate any possible engineering geological problems to enable the selection of the best alternative corridor for the route of the new power lines.

This report is based on the in-situ evaluation of all the representative soil horizons exposed from the ground profile, visual evaluation during the site visit and other relevant geotechnical conditions on the site and the interpretation of all relevant baseline information.

2. INFORMATION USED IN THE STUDY

The following was consulted during the investigation:

1.3.1 The geological map South Africa. Scale 1:1 000 000. The Geological Survey of South Africa.

1.3.2 The topography & vector topography maps 2822 Postmasburg & 2722 Kuruman. Scale 1:250 000. The Chief Directorate: Surveys and Land Information, Mowbray, presented by Planet GIS Explorer.

1.3.3 The topography maps 2822 Postmasburg & 2722 Kuruman. Scale 1:50 000.The Chief Directorate: Surveys and Land Information, Mowbray, presented by Planet GIS Explorer.

1.3.4 Google Map satellite images, used as base field maps.

1.3.5 An electronic Topography map from Landscape Dynamics indicating the final alternative corridors of the ESKOM Lines, Scale 1:50 000.

3. SITE DESCRIPTION

3.1 PHYSIOGRAPHY

3.1.1 Topography

The site is located on flat areas to a very gentle to low gradient slopes with small koppies or hills, with average elevations of 1440 metres above mean sea level at the Manganore Substation, below the koppie, and 1220 MASL at the Ferrum Substation, confirming the relative flatness of the area. The Ghaap Plateau and the smaller Klipfonteinheuwels (at Manganore Substation) mountain ranges are intersected by the power lines.

3.1.2 Climate

The region is characterized by summer rainfall with thunderstorms, with annual low rainfall figures of 414m at Kimberley, 455 at Kuruman and 386mm at Sishen, recorded at the closest weather stations. Winters are dry with frost common. The warmest months are normally December and January and the coldest months are

June and July.

An analysis of the data confirms a Weinert's N-Value in the order of 10 for Kimberley. The climate changes slightly from south to north where the climatic Weinert N-value ranges from a more humid area with value of around 11 at the Manganore Substation to 10 near Ferrum. This gives an indication of the expected soil cover in relation to the weathering profile of the rock where a N-value of higher than 10 usually has a shallower soil profile relating to mechanical disintegration where only a limited amount of secondary minerals such as illite may develop. The dominant mechanical disintegration will result in shallower residual soil horizons as expected along the corridors.

Storm water drainage and road pavement design must incorporate the climatic extremes above as well as the relative flatness of the areas.

4. NATURE OF INVESTIGATION

4.1 SITE INVESTIGATION

All available information was studied before and during the site visit.

The investigation commenced with a desk study, where all relevant information is collected and compiled on a base map. The site was divided into land forms, after which the accuracy of the information was checked by means of the field visit.

Test pits should be dug during the next phase of investigation in order to determine the soil cover thickness and depth to bedrock, and representative soil and even rock samples should be collected and tested to determine their physical properties.

The soil profiles should be described by a professionally registered geotechnical engineer or engineering geologist according to the methods described by Jennings *et al* (Jennings 1973). This method describes each horizon in terms of moisture content, colour, consistency, structure, type of soil and origin of the soil.

4.2 LABORATORY TESTS

Disturbed samples of the soil materials should be taken for laboratory analysis by an accredited laboratory. The gradings of the soils will be determined by sieve and hydrometer analysis, resulting in cumulative grading curves.

The mechanical properties of the soil material will be evaluated through grading analysis, determined by sieve and hydrometer particle size separation, as well as foundation indicator tests, comprising determination of the Atterberg Limits and the linear shrinkage. These values can be used to calculate the potential expansiveness of the soils.

The potential expansiveness of a soil depends upon its clay content, the type of clay mineral, its chemical composition and mechanical character. A material is potentially expansive if it exhibits the following properties (Kantey and Brink, 1952):

- a clay content greater than 12 percent,
- a plasticity index of more than 12,
- a liquid limit of more than 30 percent, and
- a linear shrinkage of more than 8 percent.

The potential expansiveness (low, medium, high, very high) is calculated by means of Van der Merwe's method (Van der Merwe, 1964), where the equivalent plasticity index versus the clay content of the material is plotted on a graph divided into heave categories. If any sample in the study area classifies as potentially expansive, the amount of heave or mobilization in mm measured on the surface will be calculated.

Consolidation and collapse settlement will be quantified from laboratory tests on undisturbed samples.

Some compaction tests should be performed to consider the material’s potential to be useable as in situ sub-base for pavement construction purposes or which may be used in platform construction.

5. <u>SITE GEOLOGY AND GROUNDWATER CONDITIONS</u>

5.1 Geology

We prepared a general Geology map by scanning the Published maps with a scale 1:1 000 000 to include the entire area of investigation, approximately indicated by the green dotted line in the figure, presented in Figure 3.

The correlation with the normal 1:250 000 Topography map Figure 1 also assisted with the interpretation along the corridors, and the larger scale topographical maps with scale of 1:50 000 will also be used in the final geotechnical field assessment, should it be required.

We also compiled a map by scanning the Published Geology Map with a scale of 1:1000 000, and enlarged it to 1:250 000, to be presented in Figure 4, with detailed geology to reveal all lithology along the specific corridors. Apart from the detailed geology, this map also has many features regarding topography comprising drainage with all the features such as the pans, perennial or non perennial, all the farm boundaries, the main topographical contours indicating all the elevated areas such as mountains, hills, rivers and even relative flat areas can be identified.

The general thickness of the soil cover will be of limited depth and in general marginally decrease moving from south to north and east to west, and will increasingly be covered by recent Aeolian dune sand, underlain by calcrete usually presented as hard pan calcrete.

Although the geology map indicates the presence of dune sand as Qs: Aeolian dune sand of red and grey colour, and calcrete as Qk: Calcrete, calcified pandune and surface limestone, it is evident that the aeolian dune sand covers the calcrete in many places which is found in depth, and it is present along these corridors.

The southeastern area is underlain by recent Aeolian dune sand on the farms Morokwa 672 and Kadgame 558. It is underlain by calcrete or dolomite, dolomitic limestone, chert and lenses of limestone and shale and chert, of the Ghaap Plateau and Schmidtsdrift and Vryheid Formations of the Campbell Group of the Griqualand West Supergroup. The Ulco (Vgh/Vgu) Member of the Ghaap Plateau was found north of Manganore and consist of fine grained dolomite and stromatolitic limestone interbedded with chert, with a banded iron formation at the top, underlain by the

Vryburg Formation (Va/Vv) comprising siltstone, shale, quartzite, gritstone and conglomerate.

The Asbestos Hills Ironstone Formation of the Griquatown Group, Griqualand West Supergroup is located east of the road to Sishen and it consists of banded ironstone, with amphibolites and crocidolite.

The upper soil may only consist of Aeolian dune sand and should be removed for construction on underlying competent bedrock or calcrete.

Some economic deposits of calcrete or limestone, as well as diamonds and iron ore may occur along the corridors, and it should be addressed during the final geotechnical ground survey, should it be required. The locality of diamondiferous gravel mines or kimberlite were noted on the farm Thaakwameng 675 east of the corridors, with no known economic deposit within the proposed corridors.

Asbestos and crocidolite were mined at the old asbestos mines, and iron ore at Sishen, but no mining activities were noted along the proposed corridors.

The bedrock is in many portions covered by transported material which may consist mainly of dune sand.

5.2 Groundwater Conditions

Drainage mainly takes place through sheet wash and a few drainage channels and pans are present adjacent to the corridors. Drainage occurs in a easterly direction to the GaMagara River, a tributary to the Kuruman River and the Molopo River, noted far nortwest of the investigated area. The river crossing at the GaMagara River on the farm Demaneng 546 may require extra attention and the 1: 100 year flood lines should be determined and used in spacing the pylons.

The permanent water table on site is expected to be deeper than 1,5m below natural ground surface.

A perched water table within the Aeolian sand may exist on shallow bedrock with low permeability characteristics of the rock mass, during long periods of consistent rain.

6. GEOTECHNICAL EVALUATION

6.1 ENGINEERING AND MATERIAL CHARACTERISTICS

6.1.1 SOIL PROFILES

All terrain land forms or mapping units should be sampled and more than adequate characterization of each represented soil horizon should be determined through evaluation of the gathered information.

The typical natural soil profiles of the test pits with substantial soil cover must be represented as an overall impression by the profiler and the complete logs should be considered for specific details, and some photos should be taken of rock outcrop and shallow rock for a visual characterization.

In many areas difficult excavation can be expected along the corridors, and a competent TLB, pneumatic tools and even blasting may be required to reach installation depths for services, or for the placement of the pylons. Refusal of a normal TLB is expected in almost all test pits, typically at depths less than 1,5m in depth. To ensure the stability of excavations, it will need standard sidewall protection in excavations exceeding 1,5m.

6.2 SLOPE STABILITY AND EROSION

The potential for lateral soil movement or erosion is medium, and the Aeolian sand can easily be washed away during thunderstorms. Except for local slope instability within opened trenches specifically within shale or layered mudstone, and the possible collapse of unstable open pit side walls encountered, no other slope instability is expected within these relative flat areas.

All open excavations exceeding 1,5m in depth must be supported.

6.3 EXCAVATION CLASSIFICATION WITH RESPECT TO SERVICES

Problems regarding excavatability can be expected along the routes, with some outcrop and sub outcrop areas possibly classified as medium hard rock excavation in restricted and non-restricted excavation (SANS 1200 D).

The area may be classified regarding excavation properties and it can range from easily excavated by hand to intermediate excavation where a competent TLB, pneumatic tools and even where blasting is required.

Unstable pit side walls may be encountered and to ensure the stability of excavations, it will need standard sidewall protection in excavations exceeding 1,5m.

6.4 IMPACT OF THE GEOTECHNICAL CHARACTER OF THE CORRIDORS ON THE PLACEMENT OF PILONS

During the final engineering geological investigation it is essential to determine and quantify the extent of potential problems associated with the area. The ideal conditions may be listed as follows:

* A smooth surface gradient with slopes less than 12°. Accessibility should not be restricted by topography (plateau areas).
* No potential for slope instability features - landslides, mud flows.
* Easy excavation for foundations and installation of pylons.
* Foundations above the ground water level or perched water table, with not too low permeability.
* Development above or outside the 1:100 year flood line.
* Adequate surface and subsurface drainage conditions, with minimal erosion potential.
* No presence of problematic soils, for example heaving clays, compressible clays, sand with some collapse potential, or dispersive soils, that will require expensive remedial measures.
* No potential for surface subsidence due to the presence of dolomite (sinkholes) or undermining.
* No damaging differential subsidence or movement (less than 5mm total movement at the surface allowed).
* The site should be placed away from potential pollutants such as waste disposal or sewer sites.

6.4.1 EVALUATION FOR THE PLACEMENT OF PYLONS

No seepage or the presence of perennial fluctuations of ground water was encountered on site, but a seasonal perched water table may exist on top of the bedrock or within the pedogenetic layer comprising nodular or hard pan calcrete.

Special care must be taken to ensure adequate surface drainage to prevent the accumulation of water next to structures.

The area may contain low and low to medium expansive soil, and together with a medium compressible and a highly collapse potential, some foundations will need special precautionary measures to minimize soil movement associated with a variation in moisture content of the soil.

Some problems regarding excavatability can be expected on calcrete and within the ironstone and dolomite and special equipment such as large excavators and blasting will be required for the placement of services.

A dolomite stability evaluation may be required as large areas within the investigated area contains dolomite and limestone of the Griqualand West Supergroup, as some sinkholes and dolines can be expected and can possibly form, especially within the mined areas where the water table is drawn down to enable the mining and as such combined with blasting act as a trigger mechanism for the activation of a sinkhole.

Retaining walls as well as slope stabilization measures are recommended on all constructed embankments exceeding 1,5m, as unstable pit walls may be encountered.

Storm water control measures such as ponding pools are recommended to control peak flows during thunderstorms. All embankments must be adequately compacted and vegetated with grass to limit any excessive erosion and scouring of the landscape.

Mining activities on site and a long history of mining and some contaminated land in the area were found, and iron ore, limestone and gypsum mining as well as alluvial and Kimberlite diamond mining occur in the area.

The likelihood for the development of borrow pits along the routes should be investigated to provide construction material, or this can be sourced from overburden material from the existing mines.

All road building and construction materials will in the interim be sourced from established commercial activities in and around the existing mines.

The placement of the ESKOM pylons is possible along the routes if the recommended precautionary measures and possibly difficult excavation of service and foundation construction is anticipated.

7. EXPECTED SITE CLASSIFICATION

By grouping together all the land facets with the same geotechnical characteristics, the site can be divided into development zones, this being the main objective or result of the engineering geological investigation. Each zone can therefore be defined as a grouping of areas with specific geotechnical properties placing similar constraints upon development. With the above-mentioned criteria in mind, the study area can be divided into typical development zones for development (SAICE, SAIEG & NHBRC, 1995):

Land suitable for development: Standard foundation techniques and normal construction with normal site drainage and standard building practice will be adequate for development.

Land suitable for development with precaution or risk: A few precautionary measures for problematic soils in this zone are necessary before urban development can be initiated, with a higher than normal cost implication to overcome geotechnical constraints. The risk of restricted excavatability for the placing of services induces a higher cost for development.

Land not suitable for development typically comprises of the drainage features that are susceptible to annual flooding below the 1:100 year flood line, and is also associated with perched water tables. Land in close proximity of unstable ground such as a potential slope failure or mud flow induced by rainfall is also not suitable for development.

On account of the field observations, laboratory results, previous experience and engineering properties of the soil, zones should be created by interpreting the tabular explanation of classification in Appendix C (SAIEG,1997).

The site information is evaluated through the application of standard evaluation techniques for the construction of masonry structures. Provisional development zones were determined, indicating the expected geotechnical conditions of each site class, associated with the geology.

Suitable with precaution or risk

Site Class C2H1/PD (Geology map indicated as T-Qk) **Potentially low to medium expansive and compressible and highly collapsible** soil with thickness up to 750mm which may be classified as site **class C2H1** (with up to **10mm** differential movement measured at surface) requiring **special foundations** and foundation inspection by a competent person. A dolomite stability evaluation may be required to prevent the forming of dolines and sinkholes

Suitable with risk

Site Class HCR/PD (Geology map indicated as Qk, Ra, Vo & Vgu) This site **class HCR** (with less than **7,5mm** soil movement measured at surface) will require **normal or modified normal construction** or a soil raft, with the possibility of shallow rock, with associated site drainage provisions. A dolomite stability evaluation may be required to prevent the forming of dolines and sinkholes.

Site Class PR (Geology map indicated as Vo/Ra, Vgu)

Substantial financial implications are expected in Geotechnical Zone PR where shallow rock scattered rock and rock outcrop are expected, but it will possibly prove as excellent and stable foundation material for the pylons.

These proposed mitigation and precautionary measures need to be adhered to for successful development of the proposed pylons along the corridors.

8. DRAINAGE

The corridors are located on shallow slopes less than 4%, with some steeper slopes next to the ironstone koppies, usually unaffected by the placement of the pylons next to them.

Drainage takes place through sheet wash, and a prominent drainage channel intersects the corridors, with some large erosion noted near the GaMagara River. Drainage generally occurs in a northern direction towards the GaMagara River, and then north towards the Kuruman and Molopo Rivers. A vector drainage map is represented in figure 2 where some drainage features can be observed.

No seepage or the presence of perennial fluctuations of ground water was encountered on site, but a seasonal perched water table may exist on top of the shallow bedrock sandstone, mudstone, lava, lime stone, dolomite, ironstone or where calcrete nodules or hard pan calcrete is expected.

Ground water in the form of seepage may be intersected in some test pits during the final field investigation, and some problems are foreseen and normal water tightening techniques such as damp course on foundation levels may be required.

The aeolian sand is expected to exhibit a moderate to high permeability, which possibly accounts for the absence of a connected network of proper drainage features between the drainage features.

Special care must be taken to ensure adequate surface drainage to prevent the accumulation of water next to structures. Storm water diversion measures such as ponding pools are recommended to control peak flows during thunderstorms. All embankments should be adequately compacted and planted with grass to stop any excessive erosion and scouring of the landscape.

9. <u>CONCLUSIONS</u>

1. An area of about 67km along the proposed alternative corridors between the Manganore and Ferrum Substations was investigated to determine the expected engineering geological properties that will influence the placement of pylons.

2. The area is underlain by recent Aeolian dune sand, underlain by calcrete or the Griqualand West Supergroup with the Campbell Group consisting of the Ghaap Plateau and Schmidtsdrift Formations where the Vryburg and Ulco member is represented by siltstone, shale, quartzite, gritstone and conglomerate, and fine grained dolomite and stromatolitic limestone with chert and banded ironstone. Kimberlite pipes and fissures were noted. The bedrock is generally covered by transported material usually consisting of dune sand underlain by hard pan calcrete.

3. A dolomite stability evaluation may be required as large areas within the investigated area contains dolomite and limestone of the Griqualand West Supergroup, as some sinkholes and dolines can be expected and can possibly form, especially within the mined areas where the water table is drawn down to enable the mining and as such combined with blasting act as a trigger mechanism for the activation of a sinkhole.

4. Some problems regarding excavatability to 1,5m in depth can be expected along the corridors.

5. Zoning of the site may reveal zones with constraints regarding the **expansive potential or heave and compressibility or collapse potential** of the soil, as well as areas with **restricted excavation**.

6. Provisional development zones were determined, indicating the expected geotechnical conditions of each site class: **Potentially low to medium expansive and compressible and highly collapsible** soil with thickness up to 750mm which classified as site **class C2H1** (with up to **10mm** differential movement measured at surface) requiring **special foundations** varying

through to site **class HCR** (with less than **7,5mm** soil movement measured at surface) requiring **normal or modified normal construction** or a soil raft, with associated site drainage provisions. Substantial financial implications are expected in Geotechnical **Zone PR** where scattered rock, shallow rock and rock outcrop are expected, but will possibly prove as excellent and stable foundation material for the pylons. A **dolomite stability evaluation in Zone PD** may be required to ensure the safe placement of the pylons.

7. Foundations will require normal to modified normal foundation techniques described within each defined zone. Proper compaction techniques and lightly reinforced strip footings with articulation joints at some internal and all external doors and openings with light reinforcement (brickforce) in masonry may be required. Site drainage and plumbing and service precautions must be used.

8. These proposed mitigation and precautionary measures need to be adhered to for successful placement of the pylons.

9. **This investigation was done to reveal the geotechnical properties on site with the techniques as described to state our opinion. Although every possible factor during the investigation was dealt with, it is possible to encounter variable local conditions. This will require the inspection of foundations by a competent person to verify expected problems.**

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APPENDICES

APPENDIX A: FIGURES

Figure 1: Kimberley Strengthening Phase 4: Manganore to Ferrum: The topography map 2822 Postmasburg & 2722 Kuruman, with a scale of 1:250 000. The Geological Survey of South Africa.

Figure 2: Kimberley Strengthening Phase 4: Manganore to Ferrum: The vector topography map 2822 Postmasburg & 2722 Kuruman, with a scale of 1:250 000. The Geological Survey of South Africa.

Figure 3: Kimberley Strengthening Phase 4: Manganore to Ferrum: The geological map South Africa. Scale 1:1 000 000. The Geological Survey of South Africa.

Figure 4: Kimberley Strengthening Phase 4: Manganore to Ferrum: Geology Map, Scale 1:250 000.

Figure 5: Kimberley Strengthening Phase 4: Manganore to Ferrum: Expected Engineering Geological Zone Map.

APPENDIX B: TABULAR EXPLANATION OF ZONING

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Table 1. Categories of Urban Engineering Geological Investigation

Table 2. Geotechnical Classification for Urban Development: Partridge, Wood & Brink (1993)

Table 3. Residential Site Class Designations: SAICE, SAIEG & NHBRC (1995)

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Table 1. CATEGORIES OF URBAN ENGINEERING GEOLOGICAL INVESTIGATION

Type	Planning Investigations		Urban Development Investigations		Specialised Investigations
Description	**Regional Engineering Geological Mapping (REGM)**	**Mapping for Urban Planning**	**Urban Development Investigation**	**Urban Development Investigation**	**Specialised Geotechnical Investigation**
Size of study area and field work	More than 1000 ha. Walk-over survey and limited test pits and soil sampling.	Less than 1000 ha. Walk-over survey.	Less than 10 ha. Test pits, trial holes and soil sampling.	More than 10 ha. Walk-over survey with trial pits and test holes and soil sampling.	Not relevant. Specific to type of specialised investigation.
Suggested number of test pits	A minimum of 3 test pits per land facet type.	None suggested. However, a limited number of test pits may be required at the discretion of the consultant.	Between 6 and 10 test pits.*	Between 1 and 6 test pits per 10 ha. depending on the size and variability of the area to as much as 1 test pit per hectare for highly variable sites.*	Dependent on the type of specialised investigation performed.
Mapping unit	Land systems and land facets.	Terrain types: 1 - most favourable 2 - intermediate 3 - least favourable	Soil classes: C, H, S and P and other (e.g. excavation, drainage features)	Soil classes: C, H, S and P and other (e.g. excavation, drainage features)	Not applicable.
Reference	Brink, Partridge and Williams (1982)	Partridge, Wood and Brink (1993)	SAICE Code of Practice (1995)	SAICE Code of Practice (1995)	Not relevant.
Consultants	Engineering geologists.	Engineering geologists and to a lesser extent geotechnical engineers.	Both engineering geologists and geotechnical engineers.	Both engineering geologists and geotechnical engineers.	Geotechnical engineers and to a lesser extent engineering geologists.

* Note that these figures are not intended to be absolute and should serve only as a guideline.

Table 2. GEOTECHNICAL CLASSIFICATION FOR URBAN DEVELOPMENT (after Partridge, Wood and Brink 1993)

	CONSTRAINT	Most favourable (1)	Intermediate (2)	Least favourable (3)
A	Collapsible Soil	Any collapsible horizon or consecutive horizons totalling a depth of less than 750 mm in thickness.*	Any collapsible horizon or consecutive horizons with a depth of more than 750 mm in thickness.	A least favourable situation for this constraint does not occur.
B	Seepage	Permanent or perched water table more than 1,5 m below ground surface.	Permanent or perched water table less than 1,5 m below ground surface.	Swamps and marshes.
C	Active soil	Low soil-heave potential predicted. *	Moderate soil heave potential predicted.	High soil-heave potential predicted.
D	Highly compressible soil	Low soil compressibility expected.*	Moderate soil compressibility expected.	High soil compressibility expected.
E	Erodability of soil	Low.	Intermediate.	High.
F	Difficulty of excavation to 1,5 m depth	Scattered or occasional boulders less than 10% of the total volume.	Rock or hardpan pedocretes between 10 and 40 % of the total volume.	Rock or hardpan pedocretes more than 40 % of the total volume.
G	Undermined ground	Undermining at a depth greater than 100 m below surface (except where total extraction mining has not occurred.)	Old undermined areas to a depth of 100 m below surface where stope closure has ceased.	Mining within less than 100 m of surface or where total extraction mining has taken place.
H	Instability in areas of soluble rock	Possibly unstable.	Probably unstable.	Known sinkholes and dolines.
I	Steep slopes	Between 2 and 6 degrees (all regions).	Slopes between 6 and 18 degrees and less than 2 degrees (Natal and Western Cape). Slopes between 6 and 12 degrees and less than 2 degrees (all other regions).	More than 18 degrees (Natal and Western Cape). More than 12 degrees (all other regions).
J	Areas of unstable natural slopes	Low risk.	Intermediate risk.	High risk (especially in areas subject to seismic activity).
K	Areas subject to seismic activity	10% probability of an event less than 100 cm/s^2 within 50 years.	Mining-induced seismic activity more 100 cm/s^2.	Natural seismic activity more than 100 cm/s^2.
L	Areas subject to flooding	A "most favourable" situation for this constraint does not occur.	Areas adjacent to a known drainage channel or floodplain with slope less than 1%.	Areas .within a known drainage channel or floodplain.

* These areas are designated as 1A, 1C, 1D, or 1F where localised occurrences of the constraint may arise.

Table 3. RESIDENTIAL SITE CLASS DESIGNATIONS (SAICE, 1995)

TYPICAL FOUNDATION MATERIAL	CHARACTER OF FOUNDING MATERIAL	EXPECTED RANGE OF TOTAL SOIL MOVEMENTS (mm)	ASSUMED DIFFERENTIAL MOVEMENT (% OF TOTAL)	SITE CLASS
Rock (excluding mud rocks which exhibit swelling to some depth)	STABLE	NEGLIGIBLE	-	R
Fine-grained soils with moderate to very high plasticity (clays, silty clays, clayey silts and sandy clays)	EXPANSIVE SOILS	< 7,5 7,5 - 15 15 - 30 > 30	50% 50% 50% 50%	H H1 H2 H3
Silty sands, sands, sandy and gravelly soils	COMPRESSIBLE AND POTENTIALLY COLLAPSIBLE SOILS	< 5.0 5,0 - 10 > 10	75% 75% 75%	C C1 C2
Fine-grained soils (clayey silts and clayey sands of low plasticity), sands, sandy and gravelly soils	COMPRESSIBLE SOIL	< 10 10 - 20 > 20	50% 50% 50%	S S1 S2
Contaminated soils Controlled fill Dolomitic areas Land fill Marshy areas Mine waste fill Mining subsidence Reclaimed areas Very soft silt/silty clays Uncontrolled fill	VARIABLE	VARIABLE		P

NOTES:

1. The classifications C,H,R and S are not intended for dolomitic area sites unless specific investigations are carried out to assess the stability (risk of sinkholes and doline formation) of the dolomites. Where this risk is found to be acceptable, the site shall be designated as Class P (dolomitic areas).
2. Site classes are based on the assumption that differential movements, experienced by single-storey residential buildings, expressed as a percentage of the total soil movements are equal to about 50% for soils that exhibit expansive or compressive characteristics and 75% for soils that exhibit both compressible and collapse characteristics. Where this assumption is incorrect or inappropriate, the total soil movements must be adjusted so that the resultant different movement implied by the table is equal to that which is expected in the field.
3. In some instances, it may be more appropriate to use a composite description to describe a site more fully e.g. C1/H2 or S1 and/or H2. Composite Site Classes may lead to higher differential movements and result in design solutions appropriate to a higher range of differential movement e.g. a Class R/S1 site. Alternatively, a further site investigation may be necessary since the final design solution may depend on the location of the building on a particular site.
4. Where it is not possible to provide a single site designation and a composite description is inappropriate, sites may be given multiple descriptions to indicate the range of possible conditions e.g. H-H1-H2 or C1-C2.
5. Soft silts and clays usually exhibit high consolidation and low bearing characteristics. Structures founded on these horizons may experience high settlements and such sites should be designated as Class S1 or S2 a as relevant and appropriate.
6. Sites containing contaminated soils include those associated with reclaimed mine land, land down-slope of mine tailings and old land fills.
7. Where a site is designated as Class P, full particulars relating to the founding conditions on the site must be provided.
8. Where sites are designated as being Class P, the reason for such classification shall be placed in brackets immediately after the suffix - i.e. P(contaminated soils). Under certain circumstances, composite description may be more appropriate - e.g. P(dolomite areas)-C1.
9. Certain fills may contain contaminates which present a health risk. The nature of such fill should be evaluated and should be clearly demarcated as such.