4. References

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Appendix G8

Wetland delineation

WETLAND DELINEATION OF THE PROPOSED DEVELOPMENT ROOIHUISKRAAL EXTENSION 29

PREPARED FOR

Bokomoso Landscape Architects and Environmental Consultants

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Report Reference:	SAS 210074
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1. Introduction

Bokomoso Landscape Architects and Environmental Consultants requested a wetland delineation of the proposed Rooihuiskraal extension 29 development. The purpose of the report is to determine the boundary of the wetland areas and to determine the position of a suitable buffer around the wetland areas on the subject property since construction within this area will not only prove difficult in some areas, but will impinge on the sensitive wetland habitats on the proposed development site.

The property is represented on an aerial photograph (Figure 1). The subject property is located to the north of the N14 highway and surrounded by existing residential developments. The Rietspruit River runs through the subject property in a westerly direction.

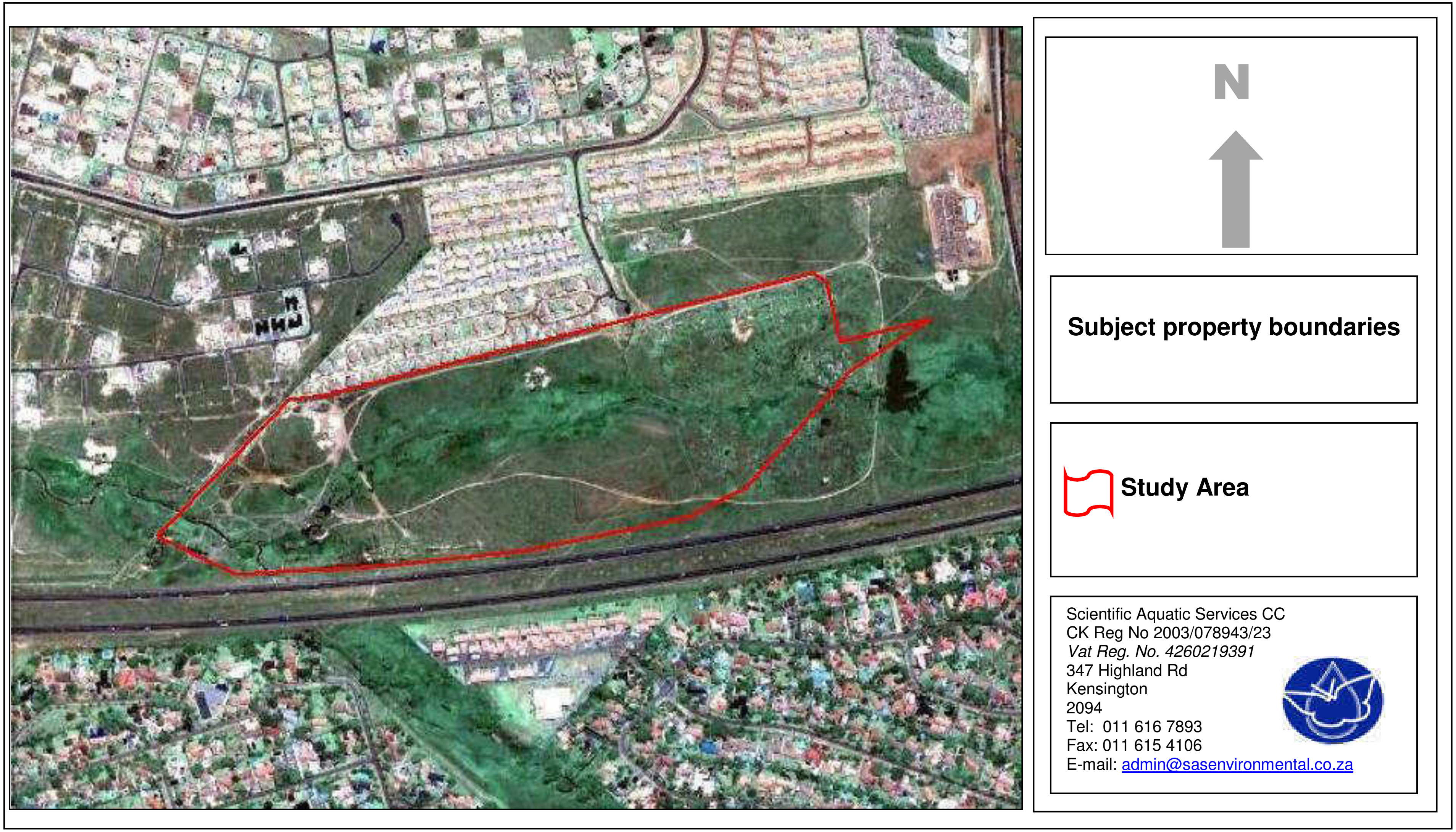

Figure 1: Aerial photograph depicting subject property boundaries (red)

1.2 Terms of reference

Bokomoso Landscape Architects and Environmental Consultants appointed Scientific Aquatic Services to undertake a delineation of the wetland features located on the subject property. The assessment is to provide detailed information on the boundaries of the wetland in order to assist with the proposed development.

2. Method of Delineation

For the purposes of this investigation a wetland was defined according to the definition in the National Water Act as: “land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.”

Wetland/riparian zone delineation took place according to the method presented in the final draft of “A practical field procedure for identification and delineation of wetlands and riparian areas” published by the department of Water Affairs and Forestry in 2005. The foundation of the method is based on the fact that wetlands have several distinguishing factors including the following:

- The presence of water at or near the ground surface
- Distinctive hydromorphic soils
- Vegetation adapted to saturated soils
- The presence of alluvial soils in stream systems

By observing the evidence of these features, in the form of indicators, wetlands can be delineated and identified. If the use of these indicators and the interpretation of the findings are applied correctly, then the resulting delineation can be considered accurate (DWAF 2005).

Wetlands and riparian zones can be divided into three zones (DWAF 2005). The permanent zone of wetness is nearly always saturated. The seasonal zone is saturated for a significant part of the rainy season and the temporary zone surrounds the seasonal zone and is only saturated for a short period of the year but is saturated for a sufficient period of time, under normal circumstances, to allow for the formation of hydromorphic soils and the growth of wetland vegetation. The object of this study was to identify the outer boundary of the temporary zone and then to identify a suitable buffer zone around the wetland area.

During the assessment the following wetland indicators were used:

- The proposed development site had significant amounts of invader species and vegetation associated with disturbed areas. The terrestrial grass community is dominated by *Hyparrhenia hirta.* Vegetation was generally used as the primary indicator of the wetland temporary zone boundary. *Eragrostis gummiflua, Trachypogon spicatus* and *Themeda triandra* was the most useful wetland vegetation species during the assessment and used as indicator of the outer boundary of the temporary zone.
- Terrain units were used to identify parts of the landscape where wetlands were more likely to form. The wetland on the upper gradients of the subject property can be characterized as unchannelled valley bottom wetland and channelled valley bottom wetland towards the lower gradients of the site in the western areas of the subject property.
- The soil form was used as the secondary indicator. For the soil form indicator the presence of gleyed soils (most of the iron has been leached out of the soil leading to a greyish/greenish/bluish colour) and mottling were investigated to aid in identifying areas with wetland characteristics where there was uncertainty on the location of the boundary of the temporary wetland zone based on the vegetation characteristics.
- The presence of surface water in the area was also useful in identifying the boundary of the temporary zone of the wetland.

3. Results

3.1 Vegetation characteristics

Upon the assessment of the area the various wetland vegetation components were assessed. Dominant species were characterised as either wetland or terrestrial species. The wetland species were then further categorised as temporary, seasonal and permanent zone species. This characterisation is presented in the table below with the terrestrial species identified on the subject property. In many cases where the riparian vegetation was less disturbed the edge of the temporary wetland zone could be easily observed from the vegetation characteristics.

Permanent	**Seasonal**	**Temporary**	**Terrestrial species**
Typha capensis	*Verbena bonariensis*	*Themeda triandra*	*Hyparrhenia hirta*
Cyperus sp.	*Cyperus sp.*	*Eragrostis gummiflua*	
	Imperata cylindrica	*Trachypogon spicatus*	

3.2 General observations

- A 15m buffer around this feature is deemed adequate to protect it from the effects of the proposed development provided that the impact minimisation measures presented in the section below are adhered to.
- There is a fair diversity of grassland vegetation within the wetland areas. Some ecologically important species such as *Eucomis autumnalis* and *Hypoxis hemerocallidea* were observed within the wetland boundaries. All individuals of the above mentioned species encountered during the development activities should be rescued and relocated to buffer areas, which is considered sensitive.
- The subject property had significant amounts of invader species and vegetation associated with disturbed areas. Dolomite stones have been dumped in the vicinity of the wetland area leading to a significant disturbance of both the wetland and terrestrial vegetation of the area as well as the natural drainage and runoff of water in these areas. Soil characteristics in this area have also been significantly altered.
- It was concluded that the grassland vegetation were the most accurate means of identifying the outer boundary of the temporary wetland zone, but due to the significant disturbance of vegetation found on the subject property inaccuracies are possible especially in the eastern sections of the subject property where the disturbance of the area was more severe.

3.3 Design and impact minimisation

From the above assessment, some guidelines for the proposed development design are proposed. The design should ensure that the following criteria are met to ensure the ongoing functioning of the various zones of the wetland in the vicinity of the proposed development:

- The 15m buffer around the wetland area should be maintained as private or public open space in the lower areas of the development where less disturbance of the wetland has occurred while in the upper areas where waste rock dumping has occurred no buffer on the wetland area is deemed necessary as long as all the waste rock in the area is removed during the construction phase of the development and that the remaining wetland area remain undisturbed.
- Adequate stormwater management must be incorporated into the design of the proposed development in order to prevent erosion and the associated sedimentation of the wetland areas.
    - Sheet runoff from paved surfaces and access roads needs to be curtailed.
    - Runoff from paved surfaces should be slowed down by the strategic placement of berms.

  - The wetland buffer zones should be left undisturbed to allow the climax terrestrial vegetation community to establish in these areas.
  - As much vegetation growth as possible should be promoted within the proposed development area in order to protect soils and to reduce the percentage of the surface area which is paved. In this regard special mention is made of the need to use indigenous vegetation species as the first choice during landscaping.
  - Any discharge of runoff into the wetland system must be done in such a way as to prevent erosion. In this regard special mention is made of the use of energy dissipating structures in storm water discharge. Consideration to the use of attenuation facilities must also be given.
- During construction erosion berms should be installed to prevent gully formation. The following points should serve to guide the placement of erosion berms:
  - Where the track has slope of less than 2%, berms every 50m should be installed.
  - Where the track slopes between 2% and 10%, berms every 25m should be installed.
  - Where the track slopes between 10%-15%, berms every 20m should be installed.
  - Where the track has slope greater than 15%, berms every 10m should be installed.
- It must be insured that connectivity of the wetland feature to the wetland features beyond the subject property boundary are maintained.
- All areas affected by construction should be rehabilitated upon completion of the construction phase of the development. Areas should be reseeded with indigenous grasses as required.
- During the construction phase no vehicles should be allowed to indiscriminately drive through the wetland areas or the 15m buffer surrounding the wetland areas.
- Fires within the wetland and associated buffer zone must be prevented at all times.

3.4 Wetland delineation

Figure 2 below serve to conceptually present the location of the wetland zone boundary on the property and the 15 meter buffer zone as well as the area where no buffer is deemed necessary as long as the area adjacent to the wetland is rehabilitated.

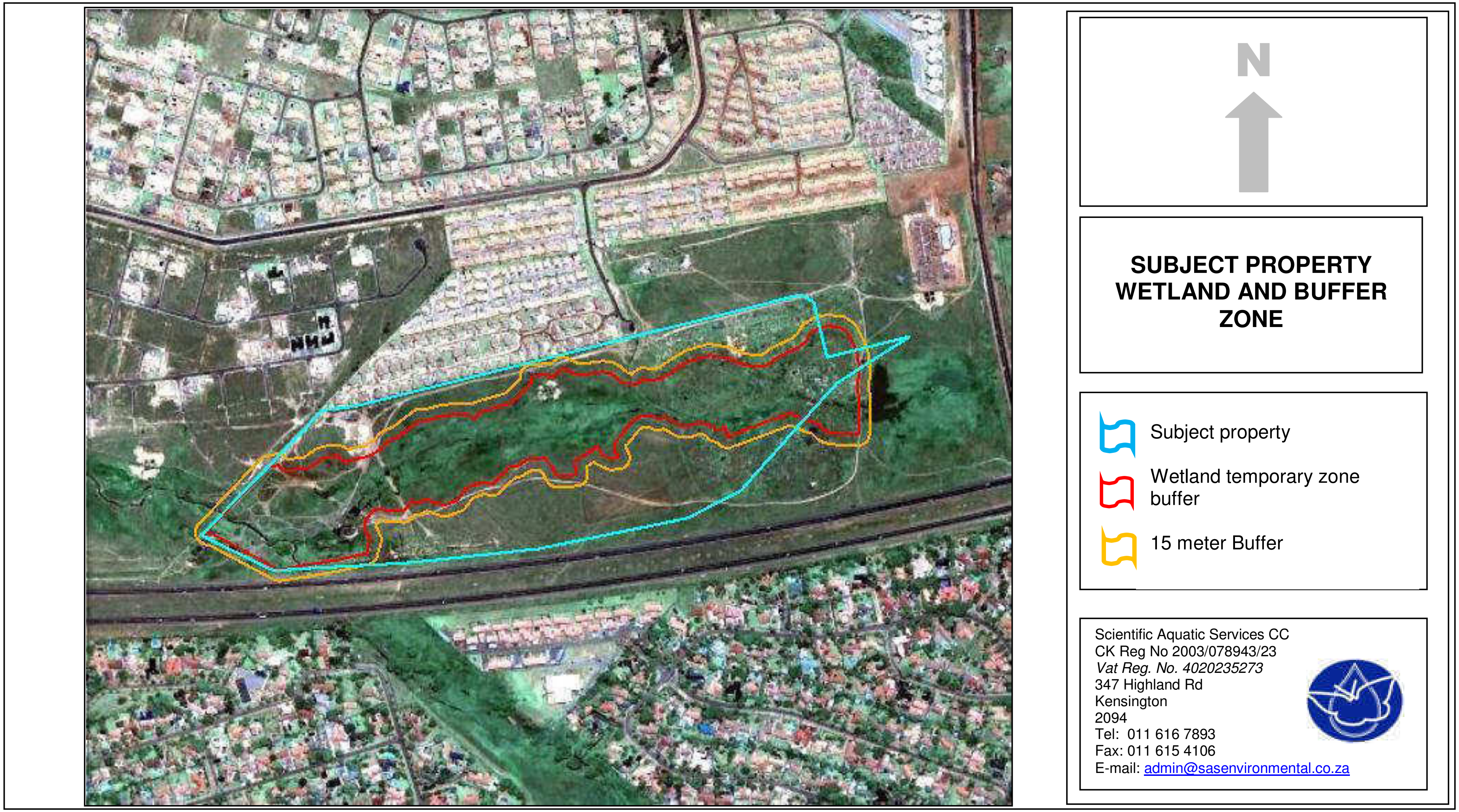

Figure 2: Temporary wetland zone and 15m buffer position for the proposed Rooihuiskraal extension 29 development site.

4. References

Acocks, J.P.H. (1988). Third Edition. ***Veld Types of South Africa.*** Memoirs of the Botanical Survey of South Africa No. 57, Botanical Research Institute, RSA

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Appendix G9

Hydropedology Wetland Impact Assessment

REPORT

HYDROPEDOLOGY WETLAND IMPACT ASSESSMENT AND MANAGEMENT REPORT:

ROOIHUISKRAAL EXTENSION 29, GAUTENG PROVINCE

28th September, 2014

Compiled by:
J.H. van der Waals
(PhD Soil Science, Pr.Sci.Nat.)
Member of:
Soil Science Society of South Africa (SSSSA)

Accredited member of:
South African Soil Surveyors Organisation (SASSO)

Registered with:
The South African Council for Natural Scientific Professions
Registration number: 400106/08

Declaration

I, Johan Hilgard van der Waals, declare that:

- I act as the independent specialist in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing
  - any decision to be taken with respect to the application by the competent authority; and
  - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of Section 24F of the Act.

J.H. VAN DER WAALS
TERRA SOIL SCIENCE

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HYDROPEDOLOGY WETLAND IMPACT ASSESSMENT AND MANAGEMENT REPORT: ROOIHUISKRAAL EXTENSION 29, GAUTENG PROVINCE

1. INTRODUCTION

1.1 TERMS OF REFERENCE

Terra Soil Science was appointed by **Bokamoso** to conduct a hydropedology based wetland delineation, forensic wetland investigation, status and functional assessment of the wetland on the Rooihuiskraal Ext. 29 site in the Gauteng Province. The focus of the investigation is to address aspects that include wetland distribution and functioning, landscape hydropedology and impacts of the urban and site development on the hydrological functioning of the wetland.

1.2 AIM OF THIS REPORT

The aim of this report is to provide a perspective on the distribution, status and functioning of the wetland on the Rooihuiskraal Ext. 29 development site, provide a description and contextualisation of the hydropedology of the site, describe the historical impacts and to provide specific management recommendations regarding the hydrology of the wetland and site post development.

1.3 DISCLAIMER

This report was generated under the regulations of NEMA (National Environmental Management Act) that guides the appointment of specialists. The essence of the regulations are 1) independence, 2) specialisation and 3) duty to the regulator. The independent specialist has, in accordance with the regulations, a duty to the competent authority to disclose all matters related to the specific investigation should he be requested to do such (refer to declaration above).

It is accepted that this report can be submitted for peer review (as the regulations also allow for such). However, the intention of this report is not to function as one of several attempts by applicants or competent authorities to obtain favourable delineation outcomes. Rather, the report is aimed at addressing specific site conditions in the context of current legislation, guidelines and best practice with the ultimate aim of ensuring the conservation and adequate management of the water resource on the specific site.

Due to the specific legal liabilities wetland specialists face when conducting wetland delineations and assessments this author reserves the right to, in the event that this report becomes part of a delineation comparison exercise between specialists, submit the report to the competent authorities, without entering into protracted correspondence with the client, as an independent report.

1.4 METHODOLOGY

The report was generated through:

1. The collection and presentation of baseline land type and topographic data for the site;
2. The thorough consideration of the statutory context of wetlands assessment and the process of wetland delineation;
3. The identification of water related landscape parameters (conceptual and real) for the site;
4. Aerial photograph interpretation of the site;
5. Assessment of historical impacts and changes on the site through the accessing of various historical aerial photographs and topographic maps;
6. Focused soil and site survey in terms of soil properties as well as drainage feature properties;
7. Assessment of the functioning, status and hydropedology of the wetlands on the site; and
8. Presentation of the findings of the various components of the investigation.

2. SITE LOCALITY AND DESCRIPTION

2.1 SURVEY AREA BOUNDARY

The site lies between 25° 53’ 14’’ and 25° 53’ 21’’ south and 28° 07’ 49’’ and 28° 08’ 32.9’’ east in Rooihuiskraal in the Gauteng Province (**Figure 1**).

2.2 LAND TYPE DATA

Land type data for the site was obtained from the Institute for Soil Climate and Water (ISCW) of the Agricultural Research Council (ARC). The land type data is presented at a scale of 1:250 000 and entails the division of land into land types, typical terrain cross sections for the land type and the presentation of dominant soil types for each of the identified terrain units (in the cross section). The soil data is classified according to the Binomial System (MacVicar et al., 1977). The soil data was interpreted and re-classified according to the Taxonomic System (Soil Classification Working Group, 1991).

The site falls into the **Bb1** land type but borders on an area of the **Ab1** and **Ab2** land types (Land Type Survey Staff, 1972 - 2006). **Figure 2** provides the land type distribution around the site. The **Bb1** land type is restricted to the Halfway House Granite Dome with the typical bleached sandy soils and the **Ab1** and **Ab2** land types are dominated by dolomite and chert. The **Bb1** land type is discussed in more detail later in the report.

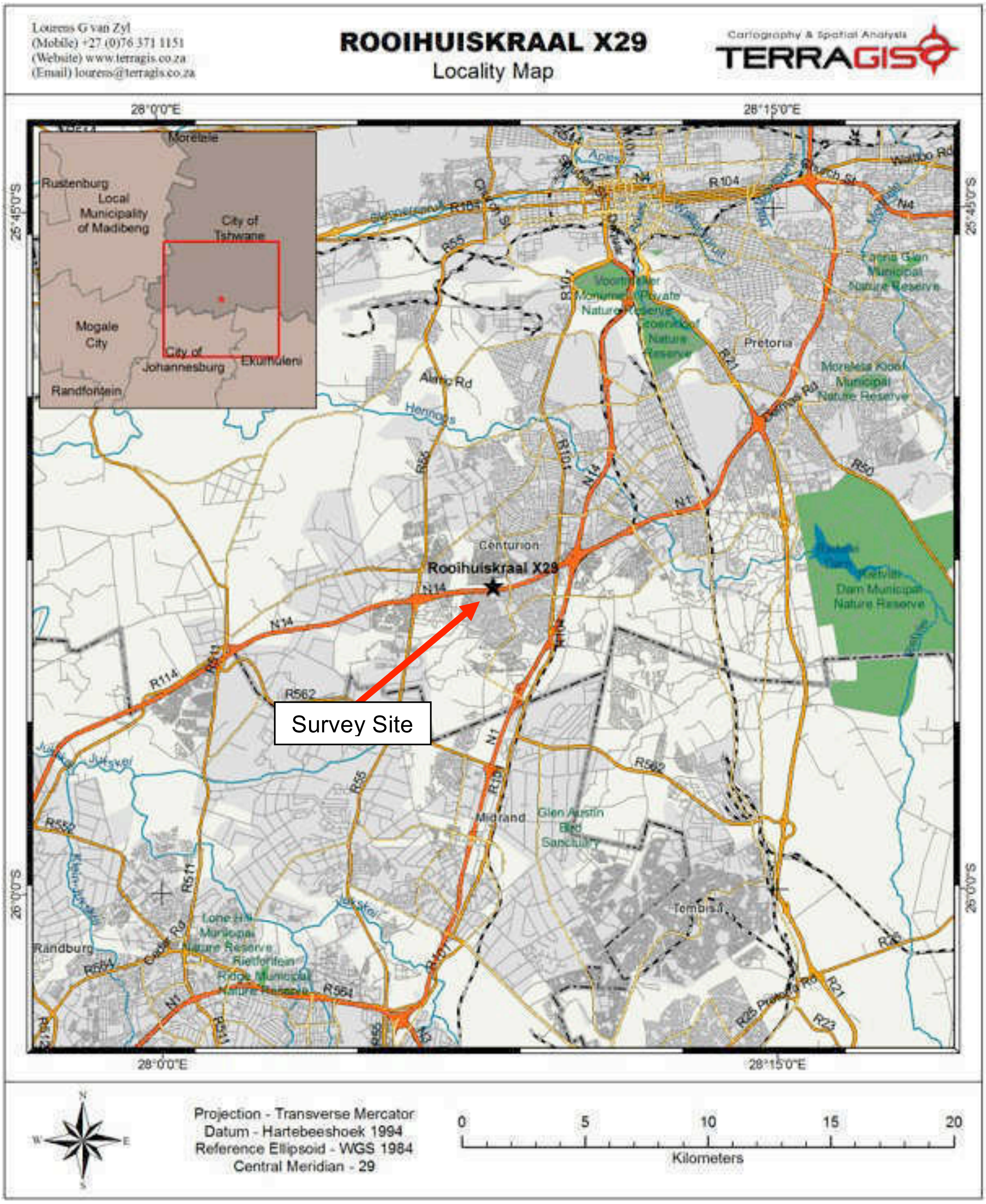

Figure 1 Locality of the survey site

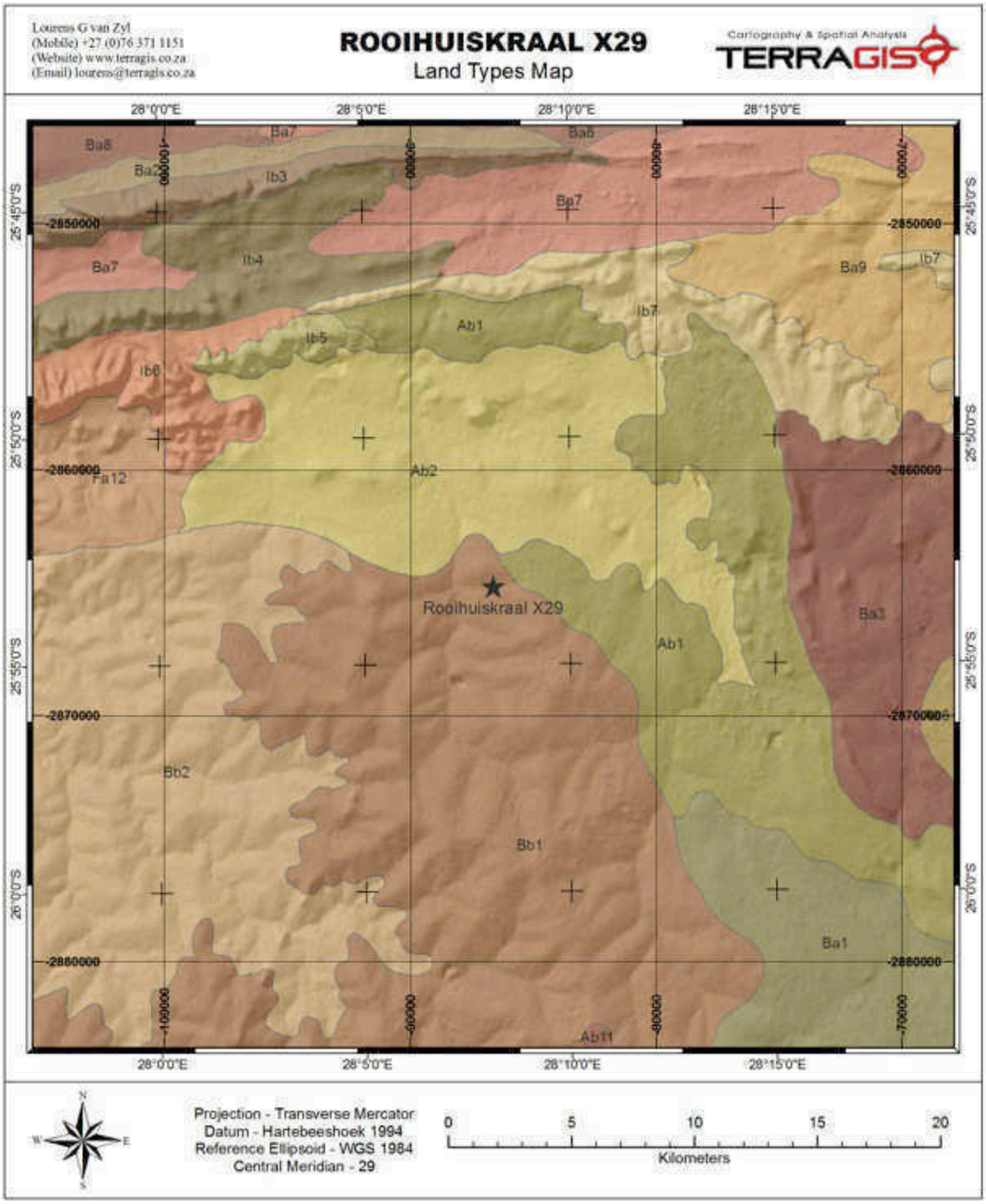

Figure 2 Land type map of the survey site and surrounding area

2.3 TOPOGRAPHY

The topography of the site is undulating. The contour map for the site is provided in **Figure 3**. From the contour data a digital elevation model (DEM) was generated. The topographic data was further interpreted and the approaches and results are discussed later in the report.

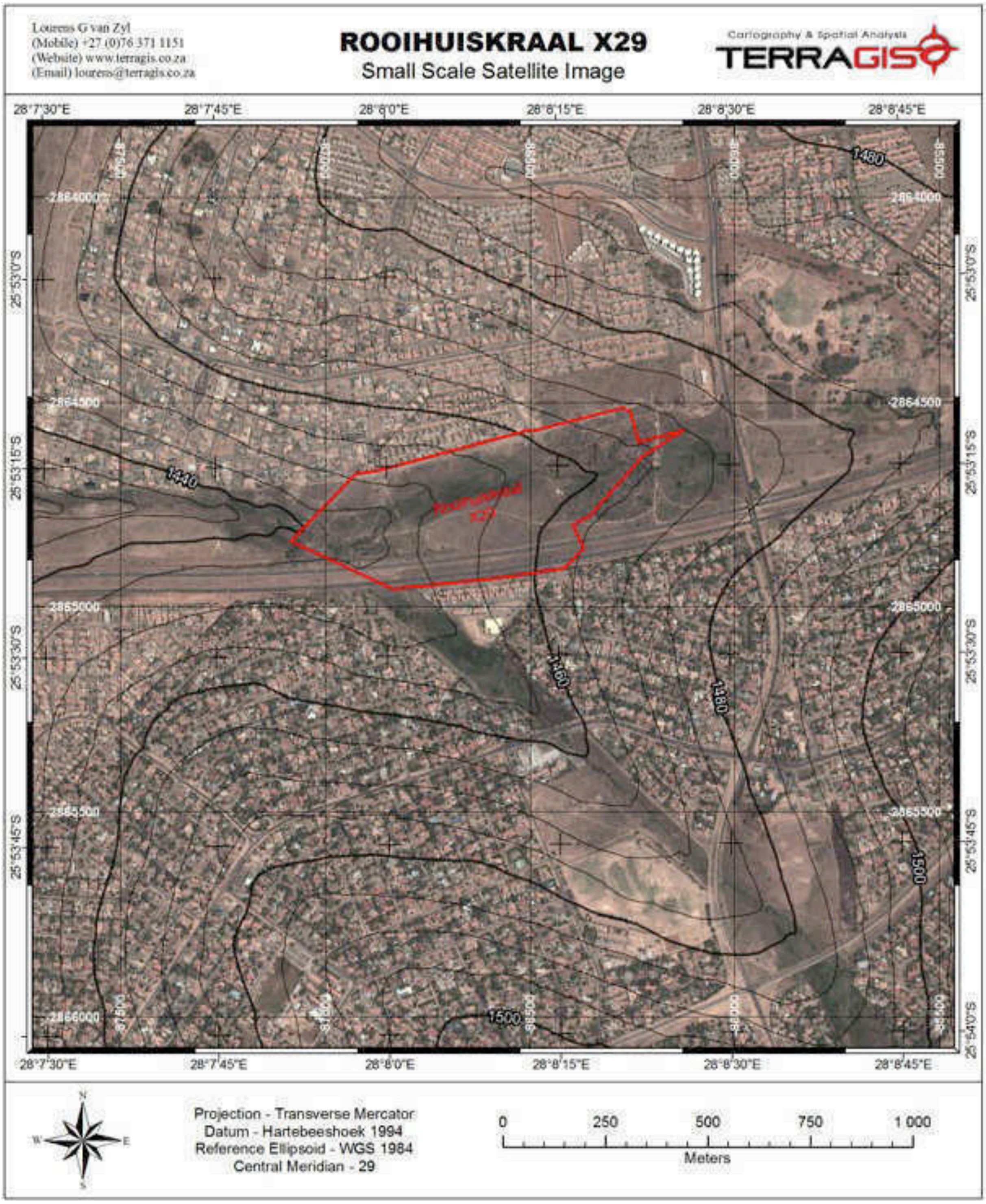

Figure 3 Contours of the survey area superimposed on an aerial photograph

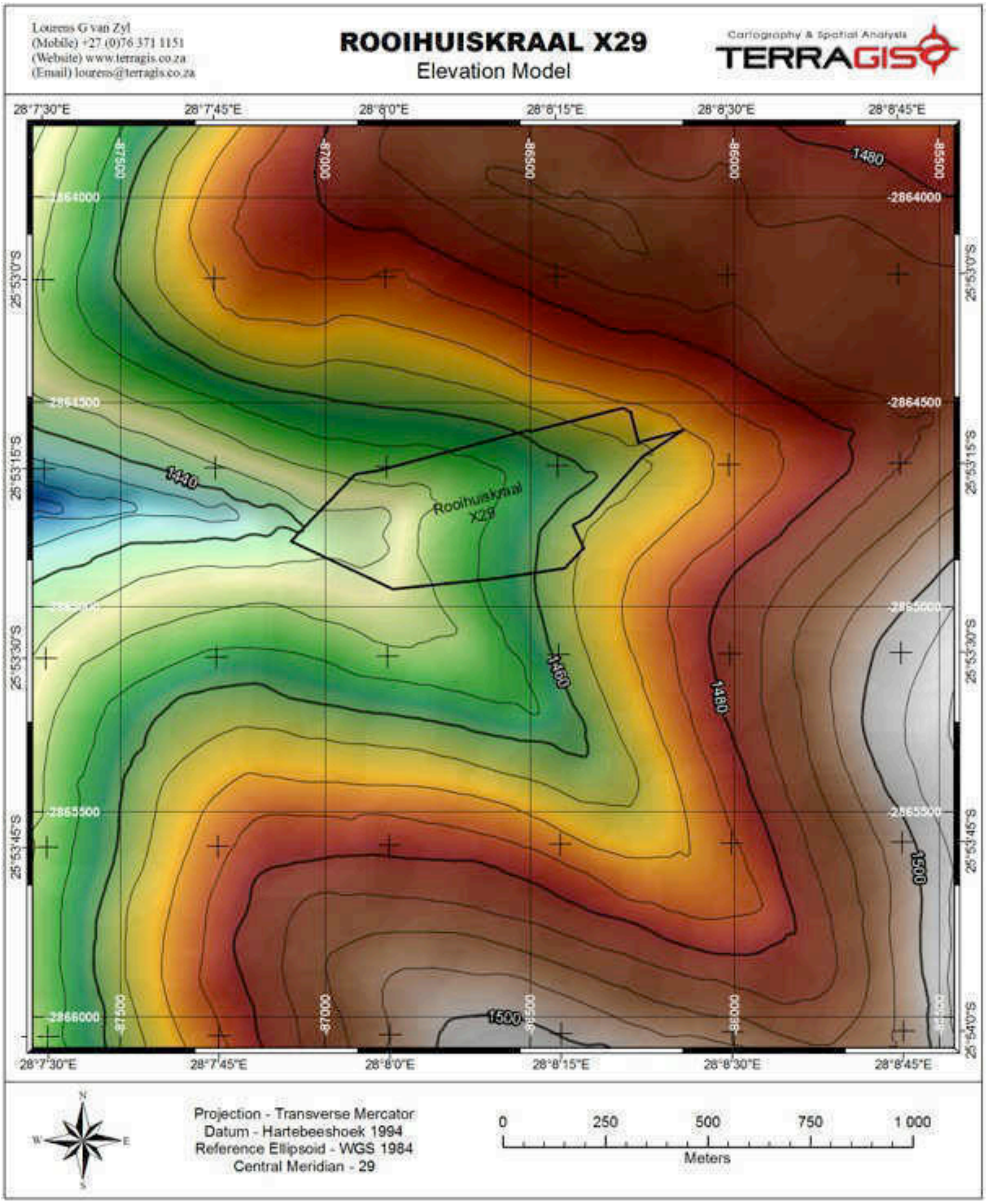

Figure 4 DEM of the survey site

3. PROBLEM STATEMENT

The delineation of wetland in the HHGD area is challenging due to a range of factors that lead to difficulty in distinguishing between wetland and terrestrial zones. One of the main factors contributing to the difficulty is the specific geological context of the HHGD. From a soil form and wetness perspective the specific land type exhibits some form of "wetland" characteristic, according to the present wetland delineation guidelines (DWAF, 2005), in at least 75 % of the landscape. This aspect has led to significant challenges and friction regarding the interpretation of the guidelines as well as the specific soils in the area. The following section provides a perspective of the statutory as well as biophysical context of wetland delineation in the HHGD area. This investigation will therefore focus on the delineation of the wetland features based on soil hydromorphy, landscape hydrology as well as various historical modifiers through a dedicated assessment and elucidation of hydropedological processes experienced in the catchment and on the site.

4. STATUTORY CONTEXT

The following is a brief summary of the statutory context of wetland delineation and assessment. Where necessary, additional comment is provided on problematic aspects or aspects that, according to this author, require specific emphasis.

4.1 WETLAND DEFINITION

Wetlands are defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

"Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."

4.2 WATERCOURSE DEFINITION

"Catchment" is defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

"…, in relation to a watercourse or watercourses or part of a watercourse, means the area from which any rainfall will drain into the watercourse or watercourses or part of a watercourse, through surface flow to a common point or common points;"

"Watercourse" is defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

"*(a)* a river or spring;
(b) a natural channel in which water flows regularly or intermittently;
(c) a wetland, lake or dam into which, or from which, water flows; and
(d) any collection of water which the Minister may, by notice in the *Gazette*, declare to be a water course,
and a reference to a watercourse includes, where relevant, its bed and banks;"

4.3 THE WETLAND DELINEATION GUIDELINES

In 2005 the Department of Water Affairs and Forestry published a manual entitled “A practical field procedure for identification and delineation of wetland and riparian areas” (DWAF, 2005). The “…manual describes field indicators and methods for determining whether an area is a wetland or riparian area, and for finding its boundaries.” The definition of a wetland in the guidelines is that of the NWA and it states that wetlands must have one or more of the following attributes:

- “**Wetland (hydromorphic) soils** that display characteristics resulting from prolonged saturation”
- “The presence, at least occasionally, of **water loving plants (hydrophytes)**”
- “A **high water table** that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50cm of the soil.”

The guidelines further list four indicators to be used for the finding of the outer edge of a wetland. These are:

- Terrain Unit Indicator. The terrain unit indicator does not only identify valley bottom wetlands but also wetlands on steep and mild slopes in crest, midslope and footslope positions.
- Soil Form Indicator. A number of soil forms (as defined by MacVicar et al., 1991) are listed as indicative of permanent, seasonal and temporary wetland zones.
- Soil Wetness Indicator. Certain soil colours and mottles are indicated as colours of wet soils. The guidelines stipulate that this is the primary indicator for wetland soils. (Refer to the guidelines for a detailed description of the colour indicators.) In essence, the reduction and removal of Fe in the form of “bleaching” and the accumulation of Fe in the form of mottles are the two main criteria for the identification of soils that are periodically or permanently wet.
- Vegetation Indicator. This is a key component of the definition of a wetland in the NWA. It often happens though that vegetation is disturbed and the guidelines therefore place greater emphasis on the soil form and soil wetness indicators as these are more permanent whereas vegetation communities are dynamic and react rapidly to external factors such as climate and human activities.

The main emphasis of the guidelines is therefore the use soils (soil form and wetness) as the criteria for the delineation of wetlands. The applicability of these guidelines in the context of the survey site will be discussed in further detail later in the report.

Due to numerous problems with the delineation of wetlands there are a plethora of courses being presented to teach wetland practitioners and laymen the required techniques. Most of the courses and practitioners focus on ecological or vegetation characteristics of landscapes and soil characteristics are often interpreted incorrectly due to a lacking soil science background of these practitioners. As such this author regularly presents, in conjunction with a colleague (Prof. Cornie van Huysteen) from the University of the Free Sate, a course on the aspects related to soil classification and wetland delineation.

4.4 THE RESOURCE DIRECTED MEASURES FOR PROTECTION OF WATER RESOURCES

The following are specific quotes from the different sections of the "Resource Directed Measures for Protection of Water Resources." as published by DWAF (1999).

4.4.1 The Resource Directed Measures for Protection of Water Resources: Volume 4: Wetland Ecosystems.

From the Introduction:

"This set of documents on Resource Directed Measures (RDM) for protection of water resources, issued in September 1999 in Version 1.0, presents the procedures to be followed in undertaking **preliminary determinations of the class, Reserve and resource quality objectives for water resources**, as specified in sections 14 and 17 of the South African National Water Act (Act 36 of 1998).

The development of procedures to determine RDM was initiated by the Department of Water Affairs and Forestry in July 1997. Phase 3 of this project will end in March 2000. Additional refinement and development of the procedures, and development of the full water resource classification system, will continue in Phase 4, until such time as the detailed procedures and full classification system are ready for publication in the Government Gazette.

It should be noted that until the final RDM procedures are published in the Gazette, and prescribed according to section 12 of the National Water Act, all determinations of RDM, whether at the rapid, the intermediate or the comprehensive level, will be considered to be preliminary determinations."

4.4.2 The Resource Directed Measures for Protection of Water Resources: Generic Section "A" for Specialist Manuals – Water Resource Protection Policy Implementation Process

"Step 3: Determine the reference conditions of each resource unit"

"What are reference conditions?"

"The determination of reference conditions is a very important aspect of the overall Reserve determination methodology. Reference conditions describe the natural unimpacted characteristics of a water resource. Reference conditions quantitatively describe the ecoregional type, specific to a particular water resource."

4.4.3 The Resource Directed Measures for Protection of Water Resources: Appendix W1 (Ecoregional Typing for Wetland Ecosystems)

Artificial modifiers are explained namely:

"Many wetlands are man-made, while others have been modified from a natural state to some degree by the activities of humans. Since the nature of these alterations often greatly influences the character of such habitats, the inclusion of modifying terms to accommodate human influence is important. In addition, many human modifications, such as dam walls and drainage ditches, are visible in aerial photographs and can be easily mapped. The following Artificial Modifiers are defined and can be used singly or in combination wherever they apply to wetlands:
Farmed: the soil surface has been physically altered for crop production, but hydrophytes will become re-established if farming is discontinued
Artificial: substrates placed by humans, using either natural materials such as dredge spoils or synthetic materials such as concrete. Jetties and breakwaters are examples of Non-vegetated Artificial habitats
Excavated: habitat lies within an excavated basin or channel
Diked/Impounded: created or modified by an artificial barrier which obstructs the inflow or outflow of water
Partially Drained: the water level has been artificially lowered, usually by means of ditches, but the area is still classified as wetland because soil moisture is sufficient to support hydrophytes."

4.4.4 The Resource Directed Measures for Protection of Water Resources: Appendix W4 IER (Floodplain Wetlands) Present Ecological Status (PES) Method

In Appendix W4 the methodology is provided for the determination of the present ecological status (PES) of a palustrine wetland.

The present ecological state (PES) of the wetland was determined according to the method described in "APPENDIX W4: IER (FLOODPLAIN WETLANDS) PRESENT ECOLOGICAL STATUS (PES) METHOD" of the "Resource Directed Measures for Protection of Water Resources. Volume 4: Wetland Ecosystems" as published by DWAF (1999). However, the PES methodology already forms an adaptation from the methodology to assess palustrine wetlands. Hillslope seepage wetlands have a range of different drivers and as such some modification of the criteria has been made by this author to accommodate the specific hydropedology drivers of hillslope seepage wetlands.

The criteria as described in Appendix 4 is provided below with the relevant modification or comment provided as well.

The summarised tasks in the PES methodology are (for detailed descriptions refer to the relevant documentation):

1. Conduct a literature review (review of available literature and maps) on the following:
    a. Determine types of development and land use (in the catchment in question).

b. Gather hydrological data to determine the degree to which the flow regime has been modified (with the "virgin flow regime" as baseline). The emphasis is predominantly on surface hydrology and hydrology of surface water features as well as the land uses, such as agriculture and forestry, that lead to flow modifications. Important Note: The hydropedology of landscapes is not explicitly mentioned in the RDM documentation and this author will make a case for its consideration as probably the most important component of investigating headwater systems and seepage wetlands and areas.
c. Assessment of the water quality as is documented in catchment study reports and water quality databases.
d. Investigate erosion and sedimentation parameters that address aspects such as bank erosion and bed modification. Important Note: The emphasis in the RDM documentation is again on river and stream systems with little mention of erosion of headwater and seepage zone systems. Again a case will be made for the emphasis of such information generation.
e. Description of exotic species (flora and fauna) in the specific catchment in question.

2. Conduct and aerial photographic assessment in terms of the parameters listed above.
3. Conduct a site visit and make use of local knowledge.
4. Assess the criteria and generate preliminary PES scores.
5. Generation of report.

Table 1 presents the scoresheet with criteria for the assessment of habitat integrity of palustrine wetlands (as provided in the RDM documentation).

Table 1 "Table W4-1: Scoresheet with criteria for assessing Habitat Integrity of Palustrine Wetlands (adapted from Kleynhans 1996)"

Criteria and attributes	**Relevance**	**Score**	**Confidence**
Hydrologic			
Flow modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.		
Permanent Inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.		
Water Quality			
Water Quality Modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland		
Sediment load modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.		

Hydraulic/Geomorphic			
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.		
Topographic Alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railwaylines and other substrate disruptive activities which reduces or changes wetland habitat directly or through changes in inundation patterns.		
Biota			
Terrestrial Encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant speciesdue to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.		
Indigenous Vegetation Removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.		
Invasive plant encroachment	Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).		
Alien fauna	Presence of alien fauna affecting faunal community structure.		
Overutilisation of biota	Overgrazing, Over-fishing, etc		
TOTAL MEAN			

Scoring guidelines per attribute:
natural, unmodified = 5; Largely natural = 4, Moderately modified = 3; largely modified = 2; seriously modified = 1; Critically modified = 0.
Relative confidence of score:
Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1.

Important Note: The present ecological state (PES) determination is, as discussed earlier in the report, based on criteria originally generated for palustrine and floodplain wetlands. Seepage wetlands very rarely have the same degree of saturation or free water and consequently often do not have permanent wetland zones. These wetlands are therefore often characterised by seasonal or temporary properties and as such a standard PES approach is flawed. The existing criteria is provided below as is a comment on the applicability as well as proposed improvements.

Criteria

Hydrological Criteria

- "Flow modification: Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland." Comment: Although the description is wide it is very evident that seepage or hillslope wetlands do not become inundated but rather are fed by hillslope return flow processes. The main criterion should therefore be the surface and subsurface hydrological linkages expressed as a degree of alteration in terms of the surface, hydropedology and groundwater hydrology.

- "Permanent inundation: Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota." Comment: Mostly not applicable to hillslope seepage wetlands.

Water Quality Criteria

- "Water quality modification: From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland." Comment: Water quality in this context applies generally but cognisance should be taken of seepage water quality that can be natural but significantly different to exposed water bodies. The main reason for this being the highly complex nature of many redox processes within the hillslope.
- "Sediment load modification: Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats." Comment: This is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences.

Hydraulic / Geomorphic Criteria

- "Canalisation: Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects shoud be elucidated and contextualised.
- "Topographic Alteration: Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railwaylines and other substrate disruptive activities which reduces or changes wetland habitat directly or through changes in inundation patterns." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects shoud be elucidated and contextualised.

Biological Criteria

- "Terrestrial encroachment: Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects shoud be elucidated and contextualised.

- “Indigenous vegetation removal: Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.”
- “Invasive plant encroachment: Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).”
- “Alien fauna: Presence of alien fauna affecting faunal community structure.”
- “Overutilisation of biota: Overgrazing, Over-fishing, etc.”

Scoring Guidelines

Scoring guidelines per attribute:
Natural, unmodified = 5
Largely natural = 4
Moderately modified = 3
Largely modified = 2
Seriously modified = 1
Critically modified = 0

Relative confidence of score:
Very high confidence = 4
High confidence = 3
Moderate confidence = 2
Marginal/low confidence = 1

4.4.5 The Resource Directed Measures for Protection of Water Resources: Appendix W5 IER (Floodplain Wetlands) Determining the Ecological Importance and Sensitivity (EIS) and the Ecological Management Class (EMC)

In Appendix W5 the methodology is provided for the determination of the ecological importance and sensitivity (EIS) and ecological management class (EMC) of floodplain wetlands.

"Ecological importance" of a water resource is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. "Ecological sensitivity" refers to the system’s ability to resist disturbance and its capability to recover from disturbance once it has occurred. The Ecological Importance and sensitivity (EIS) provides a guideline for determination of the Ecological Management Class (EMC).” Please refer to the specific document for more detailed information.

The following primary determinants are listed as determining the EIS:

1. Rare and endangered species
2. Populations of unique species
3. Species / taxon richness
4. Diversity of habitat types or features
5. Migration route / breeding and feeding site for wetland species

6. Sensitivity to changes in the natural hydrological regime
7. Sensitivity to water quality changes
8. Flood storage, energy dissipation and particulate / element removal

The following modifying determinants are listed as determining the EIS:

1. Protected status
2. Ecological integrity

4.5 SUMMARY AND PROPOSED APPROACH

When working in environments where the landscape and land use changes are significant (such as urban and mining environments) it is important to answer the following critical questions regarding the assessment and management planning for wetlands:

1. What is the reference condition?
2. What is the difference between the reference condition and the current condition and how big is this difference from a hydrological driver perspective?
3. What are the hydrological drivers (as a function of geology, topography, rainfall and soils) and what are the relative contributions of these drivers to the functioning of the wetland system?
4. What is the intended or planned land use in the wetland as well as terrestrial area and how will these developments impact on the hydrology of the landscape and wetlands?
5. How can the intended land use be plied to secure the best possible hydrological functioning of the landscape in terms of storm water attenuation, erosion mitigation and water quality?

The key to the generation of adequate information lies in the approach that is to be followed. In the next section an explanation about and motivation in favour of will be provided for a hydropedology assessment approach. Due to the detailed nature of the information that can be generated through such an approach it is motivated that all wetland assessments be conducted with the requirements of criminal law in mind. The main reason for this is the fact that many well-meaning administrative exercises often yield not tangible results due to the gap in terms of information that is required should there be a compliance process followed.

To Summarise:

During wetland assessments and delineations it is important to provide a perspective on assessment tools, the original or reference state of the wetland, the assessment process and outcome as well as the intended or possible state of the wetland and site post development. Urban and mining developments are good examples of cases where surrounding developments and land use changes have significant effects on wetland integrity and water quality emanating from the site.

5. CHALLENGES REGARDING WETLAND DELINEATION ON THE HALFWAY HOUSE GRANITE DOME

Disclaimer: The following section represents a discussion that I use as standard in describing the challenges regarding wetland delineation and management in the Halfway House Granite Dome (HHGD) area. This implies that the section is verbatim the same as in other reports provided to clients and the authorities. Copyright is strictly reserved.

In order to discuss the procedures followed and the results of the wetland identification exercise it is necessary at the outset to provide some theoretical background on soil forming processes, soil wetness indicators, water movement in soils and topographical sequences of soil forms (catena).

5.1 PEDOGENESIS

Pedogenesis is the process of soil formation. Soil formation is a function of five (5) factors namely (Jenny, 1941):

- Parent material;
- Climate;
- Topography;
- Living Organisms; and
- Time.

These factors interact to lead to a range of different soil forming processes that ultimately determine the specific soil formed in a specific location. Central to all soil forming processes is water and all the reactions (physical and chemical) associated with it. The physical processes include water movement onto, into, through and out of a soil unit. The movement can be vertically downwards, lateral or vertically upwards through capillary forces and evapotranspiration. The chemical processes are numerous and include dissolution, precipitation (of salts or other elements) and alteration through pH and reduction and oxidation (redox) changes. In many cases the reactions are promoted through the presence of organic material that is broken down through aerobic or anaerobic respiration by microorganisms. Both these processes alter the redox conditions of the soil and influence the oxidation state of elements such as Fe and Mn. Under reducing conditions Fe and Mn are reduced and become more mobile in the soil environment. Oxidizing conditions, in turn, lead to the precipitation of Fe and Mn and therefore lead to their immobilization. The dynamics of Fe and Mn in soil, their zones of depletion through mobilization and accumulation through precipitation, play an important role in the identification of the dominant water regime of a soil and could therefore be used to identify wetlands and wetland conditions.

5.2 WATER MOVEMENT IN THE SOIL PROFILE

In a specific soil profile, water can move upwards (through capillary movement), horizontally (owing to matric suction) and downwards under the influence of gravity.

The following needs to be highlighted in order to discuss water movement in soil:

- Capillary rise refers to the process where water rises from a deeper lying section of the soil profile to the soil surface or to a section closer to the soil surface. Soil pores can be regarded as miniature tubes. Water rises into these tubes owing to the adhesion (adsorption) of water molecules onto solid mineral surfaces and the surface tension of water.

  The height of the rise is inversely proportional to the radius of the soil pore and the density of the liquid (water). It is also directly proportional to the liquid's surface tension and the degree of its adhesive attraction. In a soil-water system the following simplified equation can be used to calculate this rise:

  $$\text{Height} = 0.15/\text{radius}$$

  Usually the eventual height of rise is greater in fine textured soil, but the rate of flow may be slower (Brady and Weil, 1999; Hillel, 1983).

- Matric potential or suction refers to the attraction of water to solid surfaces. Matric potential is operational in unsaturated soil above the water table while pressure potential refers to water in saturated soil or below the water table. Matric potential is always expressed as a negative value and pressure potential as a positive value.

  Matric potential influences soil moisture retention and soil water movement. Differences in the matric potential of adjoining zones of a soil results in the movement of water from the moist zone (high state of energy) to the dry zone (low state of energy) or from large pores to small pores.

  The maximum amount of water that a soil profile can hold before leaching occurs is called the field capacity of the soil. At a point of water saturation, a soil exhibits an energy state of 0 $J.kg^{-1}$. Field capacity usually falls within a range of -15 to -30 $J.kg^{-1}$ with fine textured soils storing larger amounts of water (Brady and Weil, 1999; Hillel, 1983).

- Gravity acts on water in the soil profile in the same way as it acts on any other body; it attracts towards earth's centre. The gravitational potential of soil water can be expressed as:

  $$\text{Gravitational potential} = \text{Gravity} \times \text{Height}$$

  Following heavy rainfall, gravity plays an important part in the removal of excess water from the upper horizons of the soil profile and recharging groundwater sources below.

  Excess water, or water subject to leaching, is the amount of water that falls between soil saturation (0 $J.kg^{-1}$) or oversaturation (> 0 $J.kg^{-1}$), in the case of heavy rainfall resulting in a pressure potential, and field capacity (-15 to -30 $J.kg^{-1}$). This amount of water differs according to soil type, structure and texture (Brady and Weil, 1999; Hillel, 1983).

- Under some conditions, at least part of the soil profile may be saturated with water, resulting in so-called saturated flow of water. The lower portions of poorly drained soils are often saturated, as are well-drained soils above stratified (layers differing in soil texture) or impermeable layers after rainfall.

The quantity of water that flows through a saturated column of soil can be calculated using Darcy's law:

$$Q = Ksat.A.\Delta P/L$$

Where Q represents the quantity of water per unit time, Ksat is the saturated hydraulic conductivity, A is the cross sectional area of the column through which the water flows, ΔP is the hydrostatic pressure difference from the top to the bottom of the column, and L is the length of the column.

Saturated flow of water does not only occur downwards, but also horizontally and upwards. Horizontal and upward flows are not quite as rapid as downward flow. The latter is aided by gravity (Brady and Weil, 1999; Hillel, 1983).

- Mostly, water movement in soil is ascribed to the unsaturated flow of water. This is a much more complex scenario than water flow under saturated conditions. Under unsaturated conditions only the fine micropores are filled with water whereas the macropores are filled with air. The water content, and the force with which water molecules are held by soil surfaces, can also vary considerably. The latter makes it difficult to assess the rate and direction of water flow. The driving force behind unsaturated water flow is matric potential. Water movement will be from a moist to a drier zone (Brady and Weil, 1999; Hillel, 1983).

The following processes influence the amount of water to be leached from a soil profile:

- Infiltration is the process by which water enters the soil pores and becomes soil water. The rate at which water can enter the soil is termed infiltration tempo and is calculated as follows:

  $$I = Q/A.t$$

  Where I represents infiltration tempo ($m.s^{-1}$), Q is the volume quantity of infiltrating water (m^3), A is the area of the soil surface exposed to infiltration (m^2), and t is time (s).

  If the soil is quite dry when exposed to water, the macropores will be open to conduct water into the soil profile. Soils that exhibit a high 2:1 clay content (swelling-shrinking clays) will exhibit a high rate of infiltration initially. However, as infiltration proceeds, the macropores will become saturated and cracks, caused by dried out 2:1 clay, will swell and close, thus leading to a decline in infiltration (Brady and Weil, 1999; Hillel, 1983).

- Percolation is the process by which water moves downward in the soil profile. Saturated and unsaturated water flow is involved in the process of percolation, while the rate of percolation is determined by the hydraulic conductivity of the soil.

  During a rain storm, especially the down pouring of heavy rain, water movement near the soil surface mainly occurs in the form of saturated flow in response to gravity. A sharp boundary, referred to as the wetting front, usually appears between the wet soil and the underlying dry soil. At the wetting front, water is moving into the underlying soil in response to both matric and gravitational potential. During light rain, water movement at the soil surface may be ascribed to unsaturated flow (Brady and Weil, 1999; Hillel, 1983).

The fact that water percolates through the soil profile by unsaturated flow has certain ramifications when an abrupt change in soil texture occurs (Brady and Weil, 1999; Hillel, 1983). A layer of course sand, underlying a fine textured soil, will impede downward movement of water. The macropores of the coarse textured sand offer less attraction to the water molecules than the macropores of the fine textured soil. When the unsaturated wetting front reaches the coarse sand, the matric potential is lower in the sand than in the overlying material. Water always moves from a higher to a lower state of energy. The water can, therefore, not move into the coarse textured sand. Eventually, the downward moving water will accumulate above the sand layer and nearly saturate the fine textured soil. Once this occurs, the water will be held so loosely that gravitational forces will be able to drag the water into the sand layer (Brady and Weil, 1999; Hillel, 1983).

A coarse layer of sand in an otherwise fine textured soil profile will also inhibit the rise of water by capillary movement (Brady and Weil, 1999; Hillel, 1983).

Field observations and laboratory-based analysis can aid in assessing the soil-water relations of an area. The South African soil classification system (Soil Classification Working Group, 1991.) comments on certain field observable characteristics that shed light on water movement in soil. The more important of these are:

- Soil horizons that show clear signs of leaching such as the E-horizon – an horizon where predominantly lateral water movement has led to the mobilisation and transport of sesquioxide minerals and the removal of clay material;
- Soil horizons that show clear signs of a fluctuating water table where Fe and Mn mottles, amongst other characteristics, indicate alternating conditions of reduction and oxidation (soft plinthic B-horizon);
- Soil horizons where grey colouration (Fe reduction and redox depletion), in an otherwise yellowish or reddish matrix, indicate saturated (or close to saturated) water flow for at least three months of the year (Unconsolidated/Unspecified material with signs of wetness);
- Soil horizons that are uniform in colouration and indicative of well-drained and aerated (oxidising) conditions (e.g. yellow brown apedal B-horizon).

5.3 WATER MOVEMENT IN THE LANDSCAPE

Water movement in a landscape is a combination of the different flow paths in the soils and geological materials. The movement of water in these materials is dominantly subject to gravity and as such it will follow the path of least resistance towards the lowest point. In the landscape there are a number of factors determining the paths along which this water moves. **Figure 6** provides a simplified schematic representation of an idealised landscape (in “profile curvature”. The total precipitation (rainfall) on the landscape from the crest to the lowest part or valley bottom is taken as 100 %. Most geohydrologists agree that total recharge, the water that seeps into the underlying geological strata, is less than 4 % of total precipitation for most geological settings. Surface runoff varies considerably according to rainfall intensity and distribution, plant cover and soil characteristics but is taken as a realistic 6 % of total precipitation for our idealised landscape.

The total for surface runoff and recharge is therefore calculated as 10 % of total precipitation. If evapotranspiration (from plants as well as the soil surface) is taken as a very high 30 % of total precipitation it leaves 60 % of the total that has to move through the soil and/or geological strata from higher lying to lower lying areas. In the event of an average rainfall of 750 mm per year it results in 450 mm per year having to move laterally through the soil and geological strata. In a landscape there is an accumulation of water down the slope as water from higher lying areas flow to lower lying areas.

To illustrate: If the assumption is made that the area of interest is 100 m wide it follows that the first 100 m from the crest downwards has 4 500 m^3 (or 4 500 000 litres) of water moving laterally through the soil (100 m X 100 m X 0.45 m) per rain season. The next section of 100 m down the slope has its own 4 500 m^3 of water as well as the added 4 500 m^3 from the upslope section to contend with, therefore 9 000 m^3. The next section has 13 500 m^3 to contend with and the following one 18 000 m^3. It is therefore clear that, the longer the slope, the larger the volume of water that will move laterally through the soil profile.

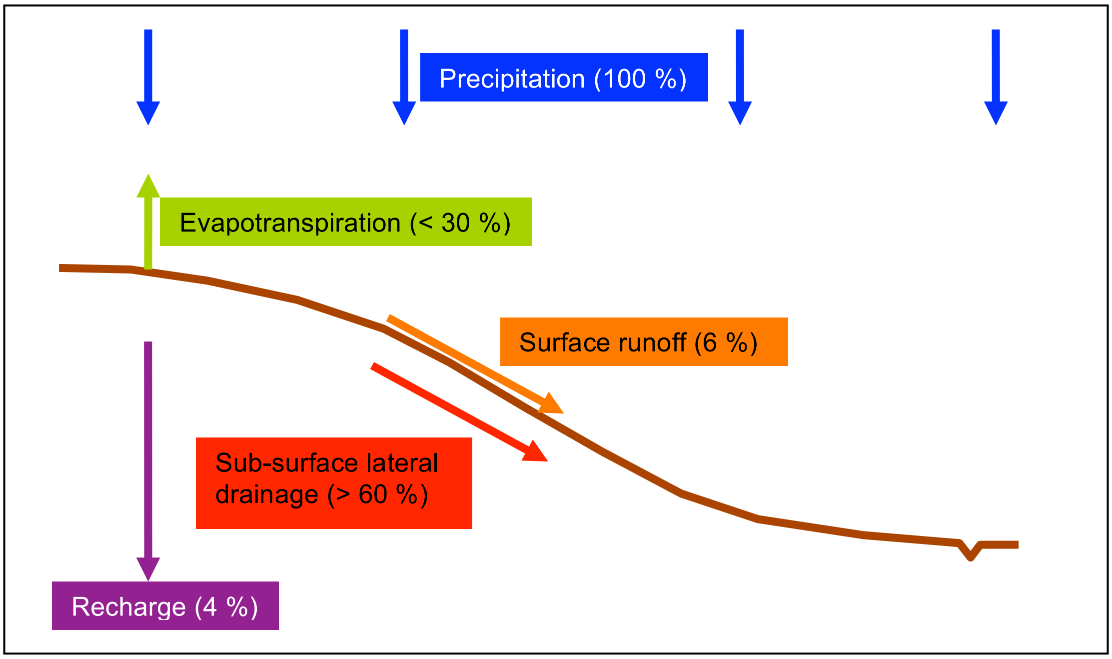

Figure 6 Idealised landscape with assumed quantities of water moving through the landscape expressed as a percentage of total precipitation (100 %).

Flow paths through soil and geological strata, referred to as “interflow” or “hillslope water”, are very varied and often complex due to difficulty in measurement and identification. The difficulty in identification stems more from the challenges related to the physical determination of these in soil profile pits, soil auger samples and core drilling samples for geological strata. The identification of the morphological signs of water movement in permeable materials or along planes of weakness (cracks and seams) is a well-established science and the expression is mostly referred to as “redox morphology”. In terms of the flow paths of water large variation exists but these can be grouped into a few simple categories. **Figure 7** provides a schematic representation of the different flow regimes that are usually encountered. The main types of water flow can be grouped as 1) recharge (vertically downwards) of groundwater; 2) lateral flow of water through the landscape along the hillslope (interflow or hillslope water); 3) return flow water that intercepts the soil/landscape surface; and 4) surface runoff. Significant variation exists with these flow paths and numerous combinations are often found. The main wetland types associated with the flow paths are: a) valley bottom wetlands (fed by groundwater, hillslope processes, surface runoff, and/or in-stream water); b) hillslope seepage wetlands (fed by interflow water and/or return flow water); and wetlands associated with surface runoff, ponding and surface ingress of water anywhere in the landscape.

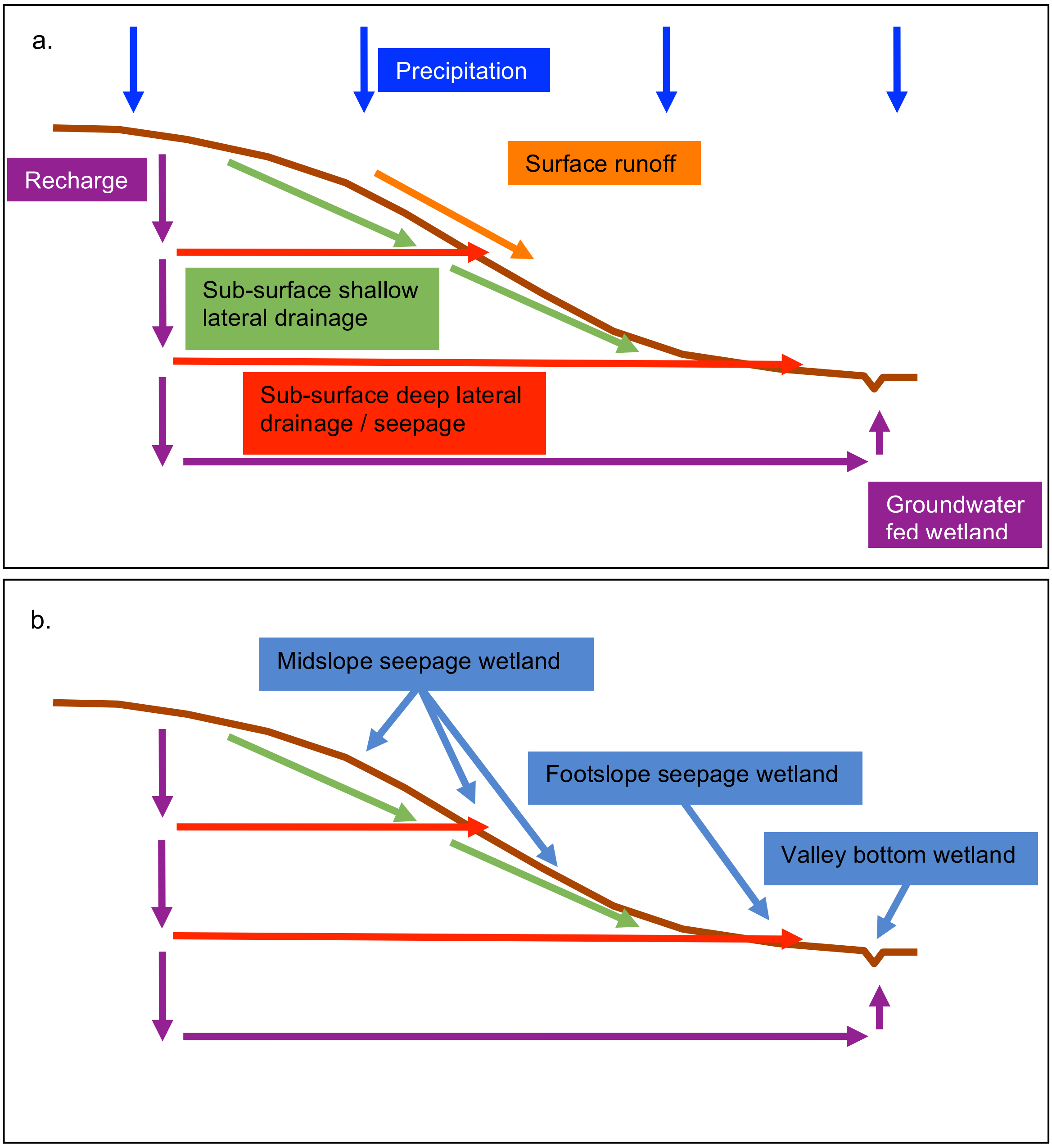

Figure 7 Different flow paths of water through a landscape (a) and typical wetland types associated with the water regime (b)

Amongst other factors, the thickness of the soil profile at a specific point will influence the intensity of the physical and chemical reactions taking place in that soil. **Figure 8** illustrates the difference between a dominantly thick and a dominantly thin soil profile. If all factors are kept the same except for the soil profile thickness it can be assumed with confidence that the chemical and physical reactions associated with water in the landscape will be much more intense for the thin soil profile than for the thick soil profile. Stated differently: The volume of water moving through the soil per surface area of an imaginary plane perpendicular to the direction of water flow is much higher for the thin soil profile than for the thick soil profile. This aspect has a significant influence on the expression of redox morphology in different landscapes of varying soil/geology/climate composition.

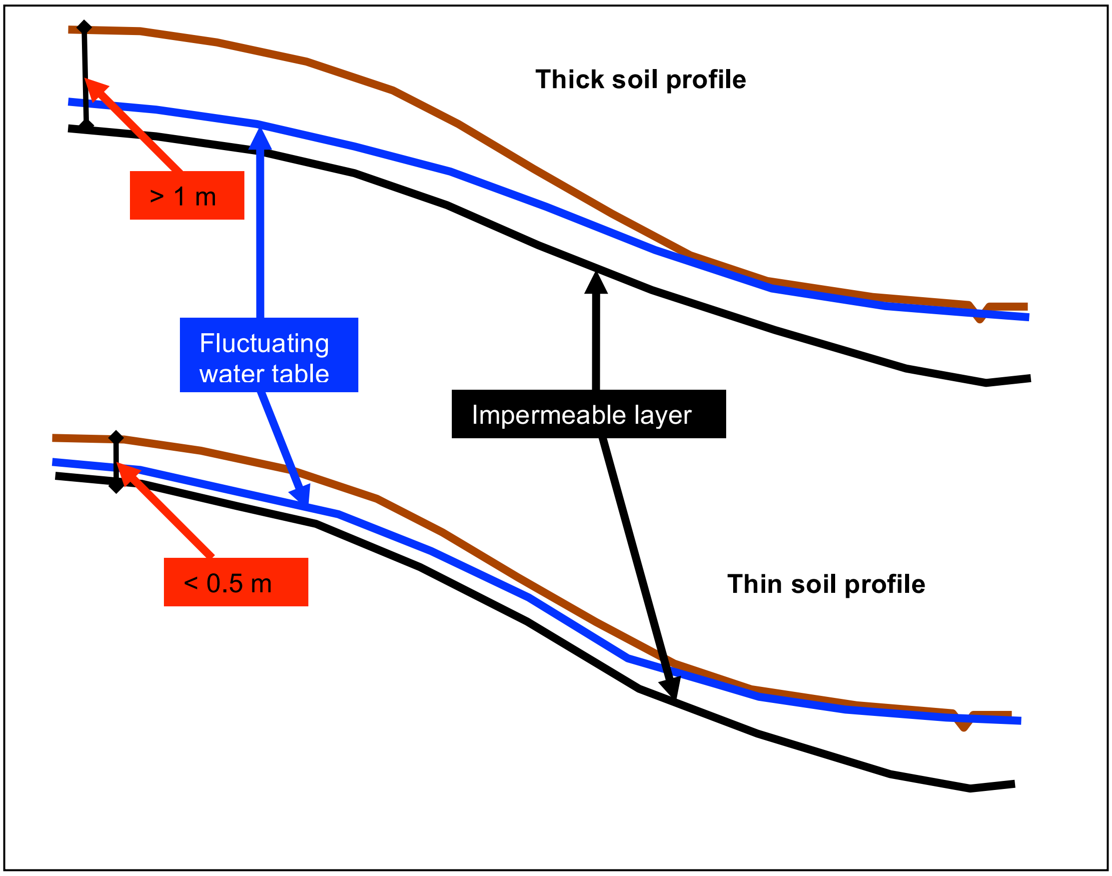

Figure 8 The difference in water flow between a dominantly thick and dominantly thin soil profile.

5.4 THE CATENA CONCEPT

Here it is important to take note of the "catena" concept. This concept is one of a topographic sequence of soils in a homogenous geological setting where the water movement and presence in the soils determine the specific characteristics of the soils from the top to the bottom of the topography. **Figure 9** illustrates an idealised topographical sequence of soils in a catena for a quartz rich parent material. Soils at the top of the topographical sequence are typically red in colour (Hutton and Bainsvlei soil forms) and systematically grade to yellow further down the slope (Avalon soil form). As the volume of water that moves through the soil increases, typically in midslope areas, periodic saturated conditions are experienced and consequently Fe is reduced and removed in the laterally flowing water. In the event that the soils in the midslope positions are relatively sandy the resultant soil colour will be bleached or white due to the colour dominance of the sand quartz particles. The soils in these positions are typically of the Longlands and Kroonstad forms. Further down the slope there is an accumulation of clays and leaching products from higher lying soils and this leads to typical illuvial and clay rich horizons. Due to the regular presence of water the dominant conditions are anaerobic and reducing and the soils exhibit grey colours often with bright yellow and grey mottles (Katspruit soil form). In the event that there is a large depositional environment with prolonged saturation soils of the Champagne form may develop (typical peat land). Variations on this sequence (as is often found on the Mpumalanga Highveld) may include the presence of hard plinthic materials instead of soft plinthite with a consequent increase in the occurrence of bleached soil profiles. Extreme examples of such landscapes are discussed below.

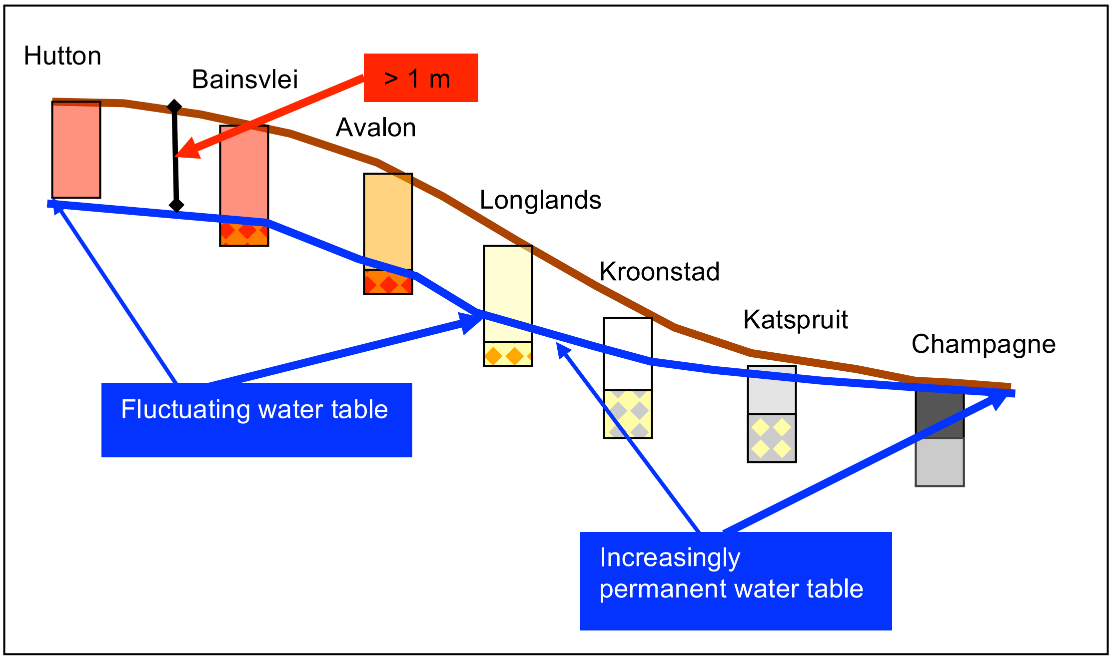

Figure 9 Idealised catena on a quartz rich parent material.

5.5 THE HALFWAY HOUSE GRANITE DOME CATENA

The Halfway House Granite Catena is a well-studied example of a quartz dominated Bb catena. As a result of the elucidation of the wetland delineation parameters and challenges in the specialist testimony in the matter between The State versus 1. Stefan Frylinck and 2. Mpofu Environmental Solutions CC (Case Number 14/1740/2010) it will be discussed in further detail here.

The typical catena that forms on the Halfway House granite differs from the idealised one discussed above in that the landscape is an old stable one, often with extensive subsoil ferricrete (or hard plinthic) layers where perched water tables occur. The parent material is relatively hard and the ferricrete layer is especially resistant to weathering. The quartz rich parent materials have a very low Fe content/”reserve”, and together with the age of the material leads to the dominance of bleached sandy soils. The implication is that the whole catena is dominated by bleached sandy soils with a distinct and shallow zone of water fluctuation. This zone is often comprised of a high frequency of Fe/Mn concretions and sometimes exhibits feint mottles. In lower lying areas the soils tend to be deeper due to colluvial accumulation of sandy soil material but then exhibit more distinct signs of wetness (and pedogenesis). **Figure 10** provides a schematic representation of the catena.

The essence of this catena is that the soils are predominantly less than 50 cm thick and as such have a fluctuating water table (mimicking rainfall events) within 50 cm of the soil surface. One of the main criteria used during wetland delineation exercises as stipulated by the guidelines (DWAF, 2005) is the presence of mottles within 50 cm of the soil surface (temporary and seasonal wetland zones). Even from a theoretical point of view the guidelines cannot be applied to the above-described catena as soils at the crest of the landscape would already qualify as temporary wetland zone soils (upon request many such examples can be supplied). The practical implication of this statement as well as practical examples will be discussed in the next section.

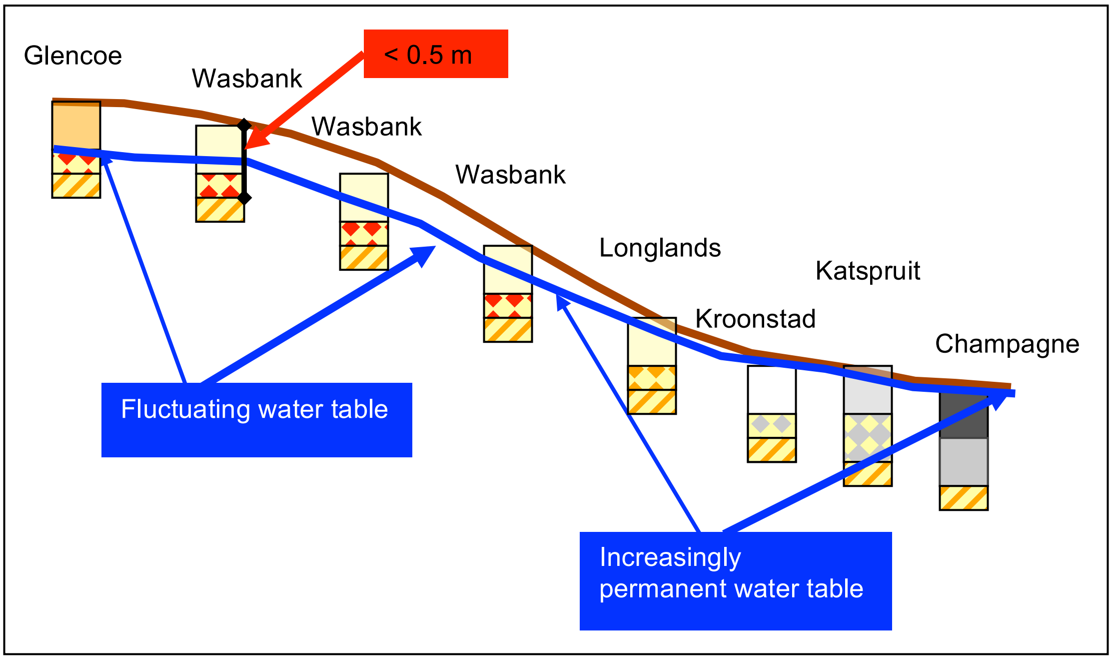

Figure 10 Schematic representation of a Halfway House Granite catena.

5.6 CONVEX VERSUS CONCAVE LANDSCAPES IN THE HALFWAY HOUSE GRANITE CATENA

An additional factor of variation in all landscapes is the shape of the landscape along contours (referred to a “plan curvature”). Landscapes can be either concave or convex, or flat. The main difference between these landscapes lies in the fact that a convex landscape is essentially a watershed with water flowing in diverging directions with a subsequent occurrence of “dryer” soil conditions. In a concave landscape water flows in converging directions and soils often exhibit the wetter conditions of “signs of wetness” such as grey colours, organic matter and subsurface clay accumulation. **Figure 11** presents the difference between these landscapes in terms of typical soil forms encountered on the Halfway House granites. In the convex landscape the subsurface flow of water removes clays and other weathering products (including Fe) in such a way that the midslope position soils exhibit an increasing degree of bleaching and relative accumulation of quartz (E-horizons). In the concave landscapes clays and weathering products are transported through the soils into a zone of accumulation where soils start exhibiting properties of clay and Fe accumulation. In addition, coarse sandy soils in convex environments tend to be thinner due to the removal of sand particles through erosion and soils in concave environments tend to be thicker due to colluvial accumulation of material transported from upslope positions. Similar patterns are observed for other geological areas with the variation being consistent with the soil variation in the catena.

Often these concave and convex topographical environments occur in close proximity or in one topographical sequence of soils. This is often found where a convex upslope area changes into a concave environment as a drainage depression is reached (**Figure 11**). The processes in this landscape are the same as those described for the convex and concave landscapes above.

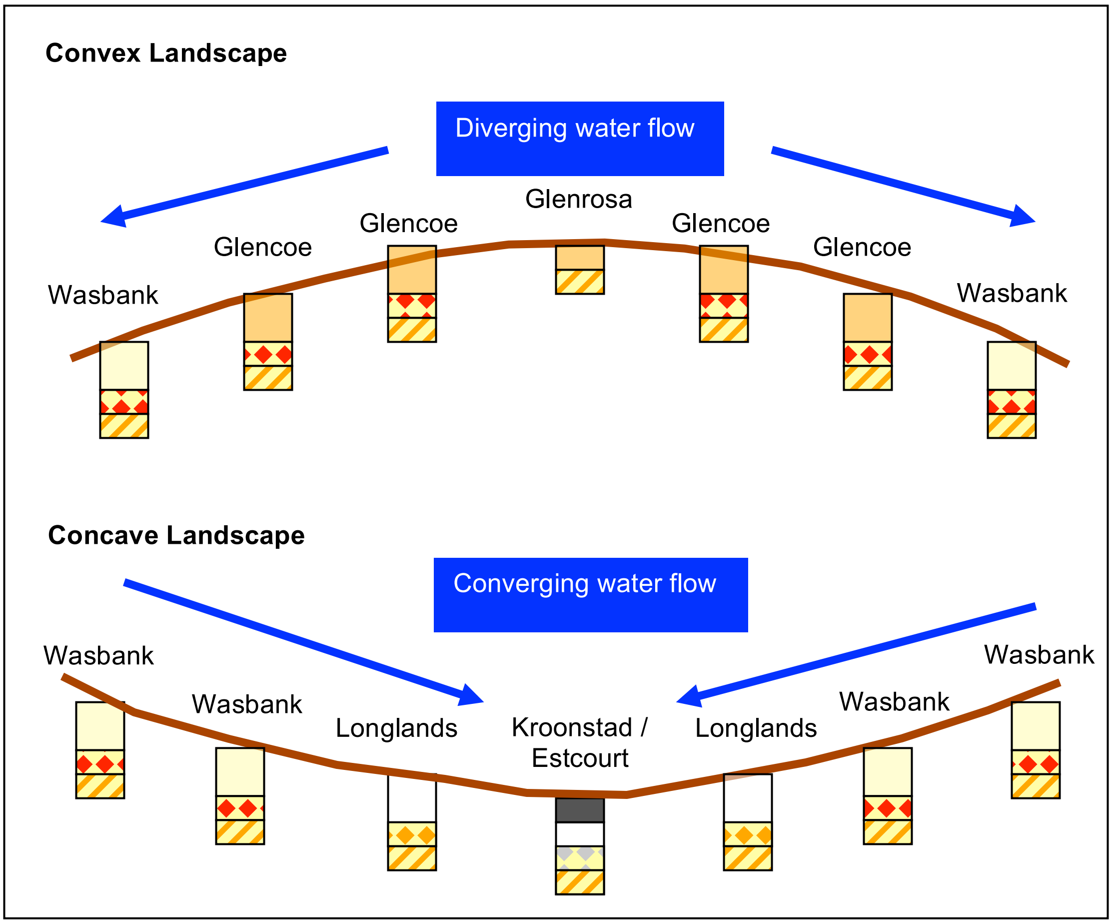

Figure 11 Schematic representation of the soils in convex and concave landscapes in the Halfway House Granite catena.

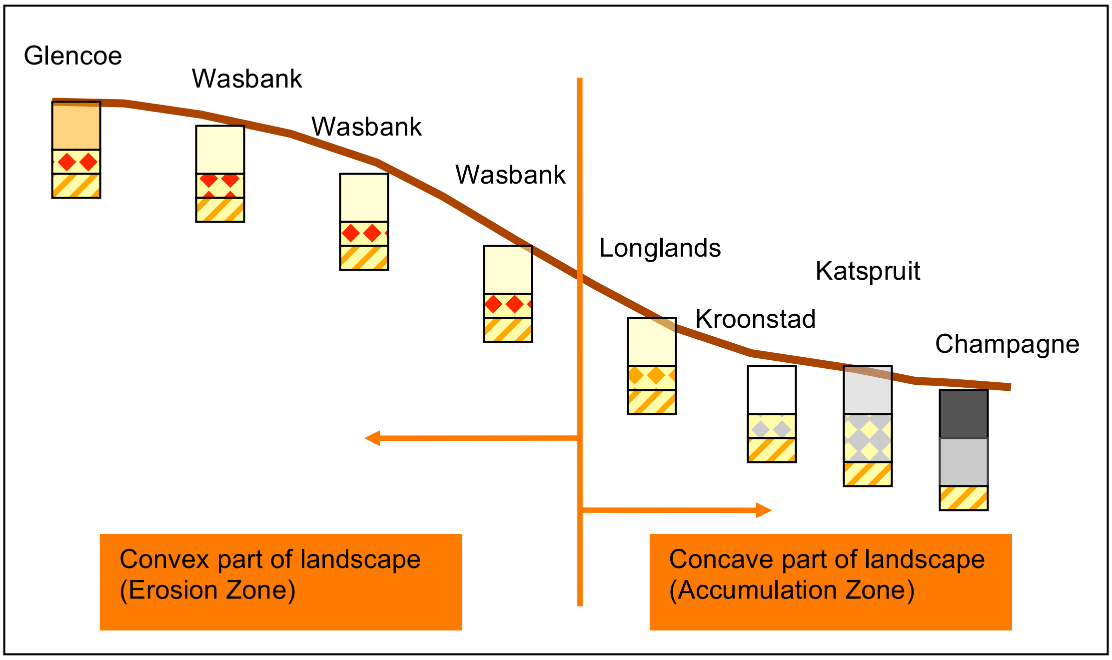

Figure 12 Schematic representation of the soils in a combined convex and concave landscape in the Halfway House Granite catena.

5.7 IMPLICATIONS FOR WETLAND DELINEATION AND APPLICATION OF THE GUIDELINES

When the 50 cm criterion is used to delineate wetlands in the HHGD environment, the soils in convex positions often "qualify" as temporary wetland soils due to their relatively thin profile and the presence of concretions (often weathering to yield "mottles") within this zone. In conjunction with a low Fe content in the soils and subsequent bleached colours (as defined for E-horizons) in the matrix a very large proportion of the landscape "qualifies" as temporary wetland zones. On the other hand, the soils in the concave environments, especially in the centre of the drainage depression, tend to be thicker and the 50 cm criterion sometimes does not flag these soils as being wetland soils due to the depth of the signs of wetness (mottles) often occurring only at depths greater than 80 cm. Invariably these areas are always included in wetland delineations due to the terrain unit indicator flagging it as a wetland area and drainage feature.

The strict application of the wetland delineation guidelines in the Halfway House Granite area often leads to the identification of 70 % or more of a landscape as being part of a wetland. For this reason a more pragmatic approach is often followed in that the 50 cm criterion is not applied religiously. Rather, distinctly wet horizons and zones of clay accumulation within drainage depressions are identified as distinct wetland soils. The areas surrounding these are assigned to extensive seepage areas that are difficult to delineate and on which it is difficult to assign a realistic buffer area. The probable best practice is to assign a large buffer zone in which subsurface water flow is encouraged and conserved to lead to a steady but slow recharge of the wetland area, especially following rainfall events. In the case where development is to take place within this large buffer area it is preferred that a "functional buffer" approach be followed. This implies that development can take place within the buffer area but then only within strict guidelines regarding storm water management and mitigation as well as erosion prevention in order to minimise sediment transport into stream and drainage channels and depressions.

5.8 IMPLICATIONS FOR WETLAND CONSERVATION IN URBAN ENVIRONMENTS

Whether an area is designated a wetland or not loses some of its relevance once drastic influences on landscape hydrology are considered. If wetlands are merely the expression of water in a landscape due to proximity to the land surface (viz. the 50 cm mottle criterion in the delineation guidelines) it follows that potentially large proportions of the water moving in the landscape could fall outside of this sphere – as discussed in detail above. **Figures 13** and **14** provide schematic representations (as contrasted with **Figure 7**) of water dynamics in urban environments with distinct excavations and surface sealing activities respectively.

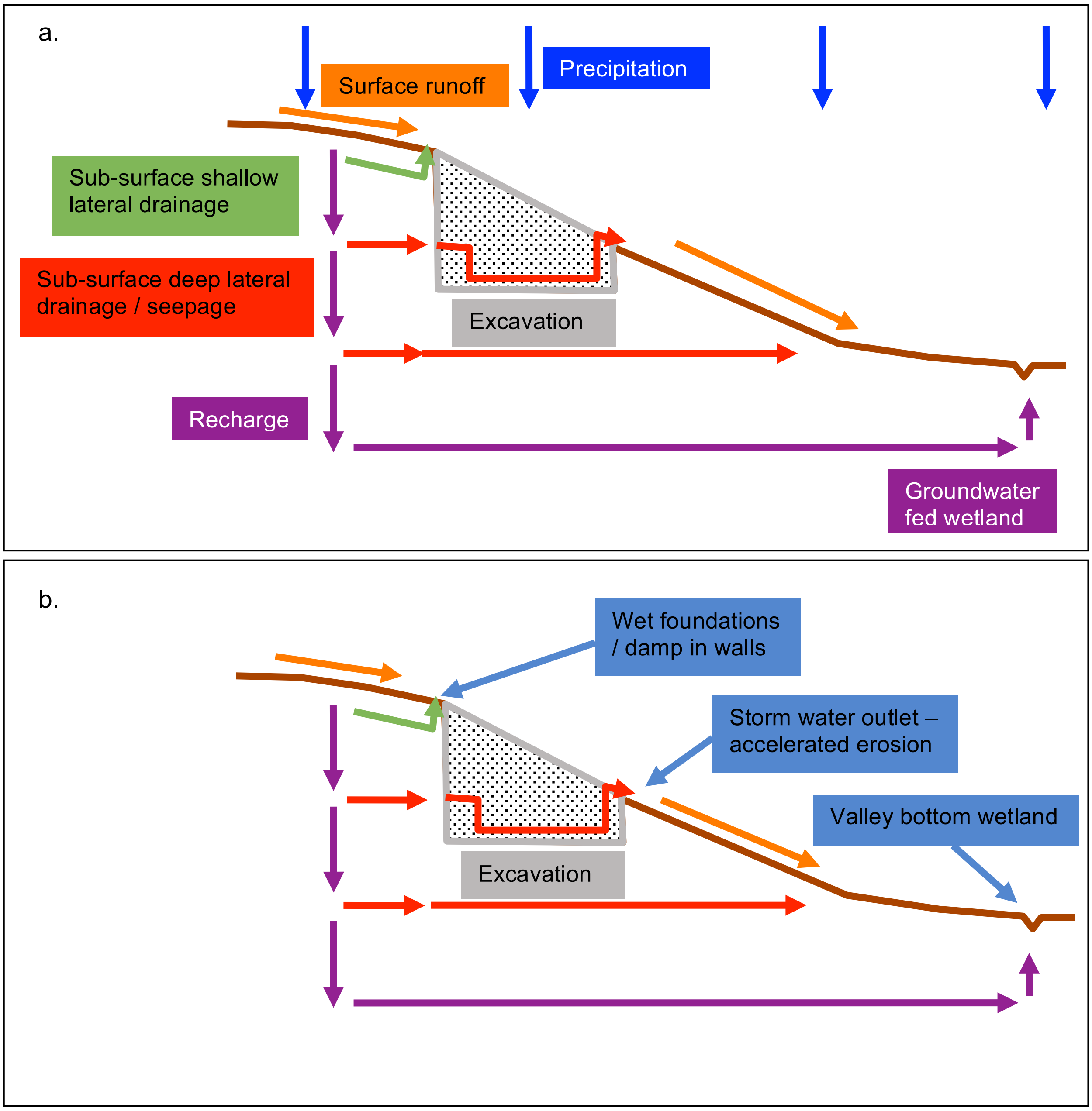

Figure 13 Different flow paths of water through a landscape with an excavated foundation (a) and typical wetland types associated with the altered water regime (b)

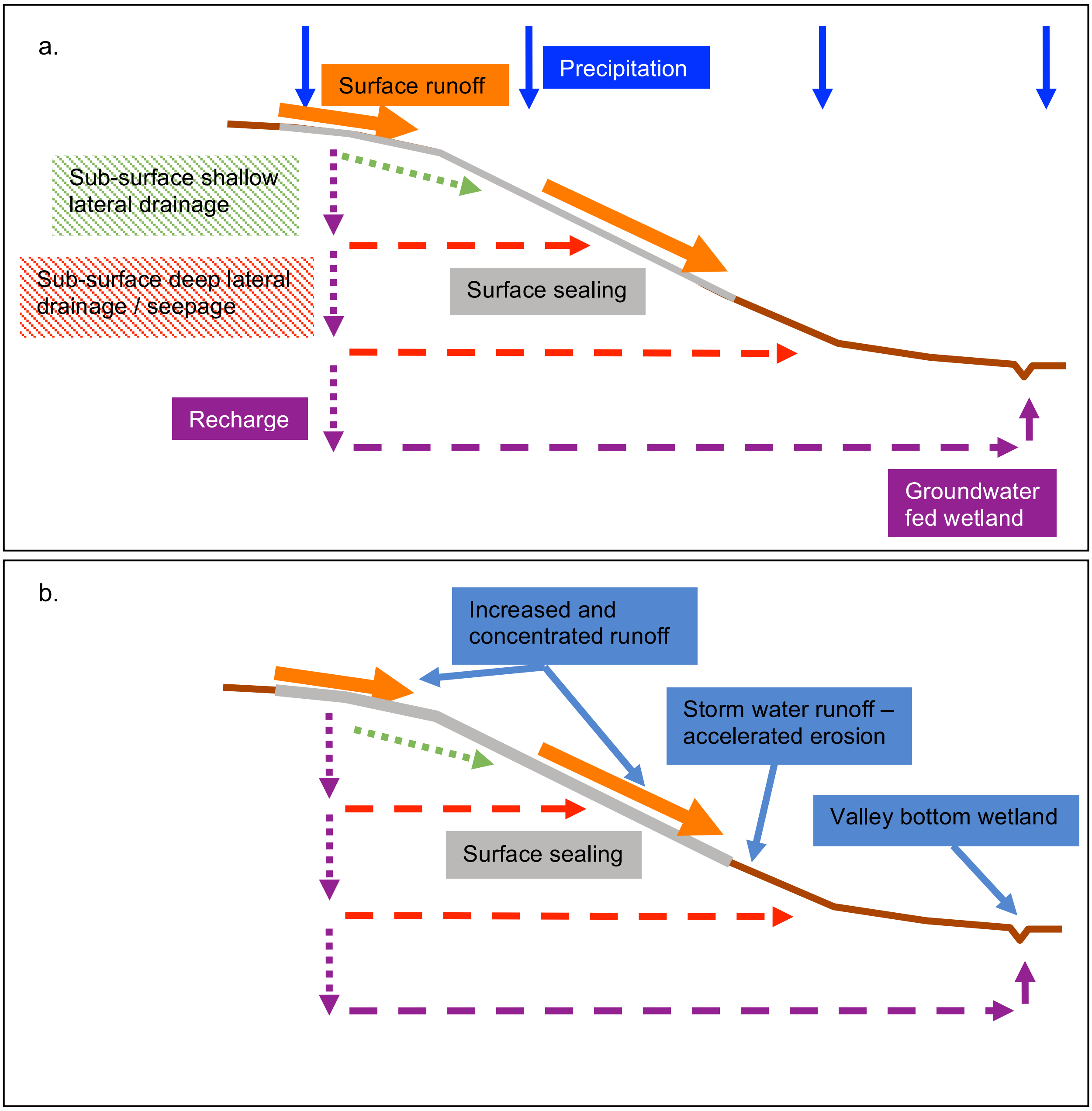

Figure 14 Different flow paths of water through a landscape with surface sealing (buildings and paving) (a) and typical wetland types associated with the altered water regime (b)

Through the excavation of pits (**Figure 13**) for the construction of foundations for infrastructure or basements for buildings the shallow lateral flow paths in the landscape are severed. As discussed above these flow paths can account for up to 60 % of the volume of water entering the landscape in the form of precipitation. These severed flow paths often lead to the ponding of water upslope from the structure with a subsequent damp problem developing in buildings. Euphemistically we have coined the term "wet basement syndrome" (WBS) to describe the type of problem experienced extensively on the HHGD. A different impact is experienced once the surface of the land is sealed through paving (roads and parking areas) and the construction of buildings (in this case the roof provides the seal) (**Figure 14**). In this case the recharge of water into the soil and weathered rock experienced naturally is altered to an accumulation and concentration of water on the surface with a subsequent rapid flowing downslope. The current approach is to channel this water into storm water structures and to release it in the nearest low-lying position in the landscape. These positions invariable correlate with drainage features and the result is accelerated erosion of such features due to a drastically altered peak flow regime.

The result of the above changes in landscape hydrology is the drastic alteration of flow dynamics and water volume spikes through wetlands. This leads to wetlands that become wetter and that experience vastly increased erosion pressures. The next section provides a perspective on the erodibility of the soils of the HHGD. It is important to note the correlation between increasing wetness, perching of water and erodibility.

5.9 SOIL EROSION ON THE HALFWAY HOUSE GRANITE DOME

Infiltration of water into a soil profile and the percolation rate of water in the soil are dependent on a number of factors with the dominant one being the soil's texture (**Table 2**). Permeability and the percolation of water through the soil profile are governed by the least permeable layer in the soil profile. The implication of this is that soil horizons that overlie horizons of low permeability (i.e. hard rock, hard plinthite, G-horizon) are likely to become saturated with water relatively quickly - particularly if the soil profile is shallow and a large amount of water is added. Another impermeable layer is one that is saturated with water and such a layer acts the same way as the ones mentioned earlier. In cases where internal drainage is hampered by an impermeable layer such as hard rock (the Dresden or Wasbank soil forms) evaporation and lateral water movement are the only processes that will drain the soil profile of water.

Table 2 Infiltration/permeability rates for soil textural classes (Wischmeier, Johnson & Cross 1971)

Texture class	Texture	Permeability Rate (mm/hour)	Permeability Class
Coarse	Gravel, coarse sand	>508	Very rapid
	Sand, loamy sand	152 – 508	Rapid
Moderately coarse	Coarse sandy loam Sandy loam Fine sandy loam	51 - 152	Moderately rapid
Medium	Very fine sandy loam Loam Silt loam Silt	15 – 51	Moderate
Moderately fine	Clay loam Sandy clay loam Silty clay loam	5.1 – 15.2	Moderately slow
Fine	Sandy clay Silty clay Clay (>60%)	1.5 – 5.1	Slow
Very fine	Clay (>60%) Clay pan	< 1.5	Very slow

Infiltration of water into a soil profile is dependent on the factors leading to the downward movement of water. In cases where impermeable layers exist water will infiltrate into the profile until it is saturated. Once this point is reached water infiltration will cease and surface runoff will become the dominant water flow mechanism. A similar situation will develop if a soil has a slow infiltration rate of water due to fine texture, hardened or compacted layers and low hydraulic conductivity. When these soils are subjected to large volumes and rates of rainfall the rate of infiltration will be exceeded and excess water will flow downslope on the soil surface.

The texture, permeability and presence of impeding layers are some of the main determinants of soil erosion. Wischmeier, Johnson and Cross (1971) compiled a soil erodibility nomograph from soil analytical data (**Figure 15**). The nomograph uses the following parameters that are regarded as having a major effect on soil erodibility:

- The mass percentage of the fraction between 0.1 and 0.002 mm (very fine sand plus silt) of the topsoil.
- The mass percentage of the fraction between 0.1 and 2.0 mm diameter of the topsoil.
- Organic matter content of the topsoil. This “content” is obtained by multiplying the organic carbon content (in g/100 g soil – Walkley Black method) by a factor of 1.724.
- A numerical index of soil structure.
- A numerical index of the soil permeability of the soil profile. The least permeable horizon is regarded as horizon that governs permeability.

Box 1 describes the procedure to use the nomograph.

As part of a different study 45 soil samples were collected from 19 points on the HHGD. The samples were described in terms of soil form and analysed with respect to texture (6 fractions) and organic carbon content of the A-horizons (data not presented here but available upon request). The erodibility index and maximum stable slope were calculated for each horizon (according to the method discussed above) in both an unsaturated and saturated soil matrix (data not presented here but available upon request).

The erosion risk is based on the product of the slope (in percentage) and the K-value of erodibility (determined from the Wischmeier, Johnson and Cross (1971) nomograph). This product should not exceed a value of 2.0 in which case soil erosion becomes a major concern. The K-value allows for a “hard” rainfall event but is actually based on scheduled irrigation that allows for infiltration and percolation rates and so-called “normal” rainfall intensity. Soil erosion potential increases with an increase in the very fine sand plus silt fraction, a decrease in the organic matter content, an increase in the structure index and a decrease in permeability. Water quality is assumed not to be a problem for the purposes of the erosion hazard calculations.

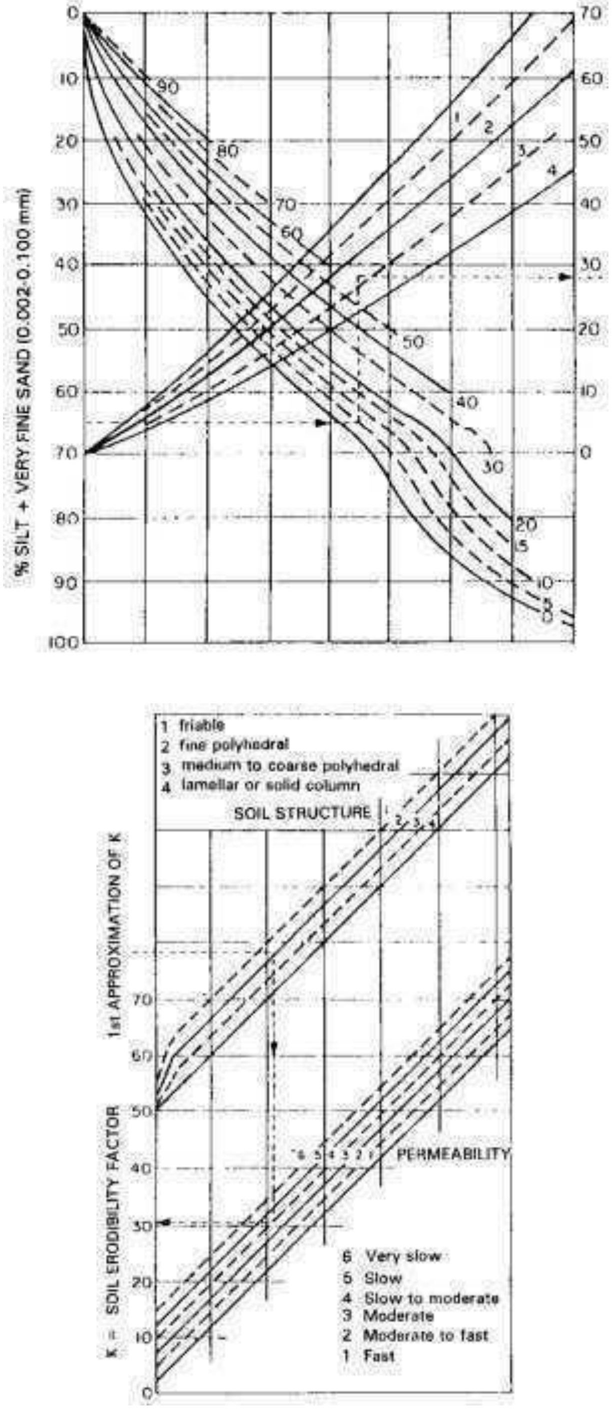

Figure 15 The nomograph by Wischmeier, Johnson and Cross (1971) that allows a quick assessment of the K factor of soil erodibility

Box 1: Using the nomograph by Wischmeier, Johnson and Cross (1971)

In examining the analysis of appropriate surface samples, enter on the left of the graph and plot the percentage of silt (0.002 to 0.1 mm), then of sand (0.10 to 2 mm), then of organic matter, structure and permeability in the direction indicated by the arrows. Interpolate between the drawn curves if necessary. The broken arrowed line indicates the procedure for a sample having 65% silt + very fine sand, 5% sand, 2.8% organic matter, 2 of structure and 4 of permeability. Erodibility factor K = 0,31.

Note: The erodibility factor increase due to saturation was also calculated. These results indicated an increase in erodibility of a factor predominantly between 3 and 4 for saturated soil conditions.

5.10 DETAILED SOIL CHARACTERISTICS – SUMMARISING CONCLUSIONS

The following general conclusions can be made regarding the soil characteristics of the HHGD (and the catchment):

1. The site (and catchment) is dominated by shallow to moderately deep sandy soils with deep soils occurring in the drainage features only;
2. The soils are dominantly coarse sandy in texture;
3. On the bulk of the site the soils are underlain by a hard plinthic layer (ferricrete) that acts as an aquaclude under natural conditions;
4. The bulk of the water movement on the site occurs within 50 cm of the soil surface on top of the ferricrete layer in the absence of human impacts;
5. Wetland delineation is a challenging exercise on the HHGD; and
6. The soils of the HHGD, as those of the site, are highly erodible, especially when saturated with water.

5.11 RECOMMENDED ASSESSMENT APPROACH – HYDROPEDOLOGY INVESTIGATION

5.11.1 Hydropedology Background

The identification and delineation of wetlands rest on several parameters that include topographic, vegetation and soil indicators. Apart from the inherent flaws in the wetland delineation process, as discussed earlier in this report, the concept of wetland delineation implies an emphasis on the wetlands themselves and very little consideration of the processes driving the functioning and presence of the wetlands. One discipline that encompasses a number of tools to elucidate landscape hydrological processes is “hydropedology” (Lin, 2012). The crux of the understanding of hydropedology lies in the fact that pedology is the description and classification of soil on the basis of morphology that is the result of soil and landscape hydrological, physical and chemical processes. But, the soils of which the morphology are described, also take part in and intimately influence the hydrology of the landscape. Soil is therefore both an indicator as well as a participator in the processes that require elucidation.

Wetlands are merely those areas in a landscape where the morphological indicators point to prolonged or intensive saturation near the surface to influence the distribution of wetland vegetation. Wetlands therefore form part of a larger hydrological entity that they cannot be separated from.

5.11.2 Hydropedology – Proposed Approach

In order to provide detailed pedohydrological information both detailed soil surveys and hydrological investigations are needed. In practice these intensive surveys are expensive and very seldom conducted. However, with the understanding of soil morphology, pedology and basic soil physics parameters as well as the collection and interpretation of existing soil survey information, assessments at different levels of detail and confidence can be conducted. In this sense four levels of investigation are proposed namely:

1. Level 1 Assessment: This level includes the collection and generation of all applicable remote sensing, topographic and land type parameters to provide a “desktop” product. This level of investigation rests on adequate experience in conducting such information collection and interpretation exercises and will provide a broad overview of dominant hydropedological parameters of a site. Within this context the presence, distribution and functioning of wetlands will be better understood than without such information.
2. Level 2 Assessment: This level of assessment will make use of the data generated during the Level 1 assessment and will include a reconnaissance soil and site survey to verify the information as well as elucidate many of the unknowns identified during the Level 1 assessment.
3. Level 3 Assessment: This level of assessment will build on the Level 1 and 2 assessments and will consist of a detailed soil survey with sampling and analysis of representative soils. The parameters to be analysed include soil physical, chemical and mineralogical parameters that elucidate and confirm the morphological parameters identified during the field survey.
4. Level 4 Assessment: This level of assessment will make use of the data generated during the previous three levels and will include the installation of adequate monitoring equipment and measurement of soil and landscape hydrological parameters for an adequate time period. The data generated can be used for the building of detailed hydrological models (in conjunction with groundwater and surface hydrologists) for the detailed water management on specific sites.

For most wetland delineation exercises a Level 2 or Level 3 assessment should be adequate. For this investigation a Level 2 assessment was conducted with a reconnaissance soils survey and field work. Analysis of soils was not conducted but data from other sites with highly similar soils was also used to illustrate the challenges faced on the site and in the broader area.

The process of the hydropedology assessment entails the aspects listed in the methodology description below. These items also correspond with the proposed PES assessment methodology discussed in section 4.4.4. The results of the assessment will therefore be structured under the headings as provided below.

6. METHOD OF SITE INVESTIGATION

6.1 WETLAND CONTEXT DETERMINATION

For the purposes of the wetland assessment the context of the specific wetland was determined. This was done through the thorough consideration of the geological, topographical, climatic, hydropedological and catchment context of the site. In this sense the relative contribution of water flow from the catchment upstream was compared to the contribution from the slopes on the specific site. The motivation being that the larger the contribution of the catchment upstream the smaller the impacts of the proposed developments on the site would be in terms of modification of the wetland. The elements of context are described in more detail below.

6.2. AERIAL PHOTOGRAPH INTERPRETATION

An aerial photograph interpretation exercise was conducted through the use of Google Earth images and historical aerial photographs of the site. This data was used to obtain an indication of the extent of the wetlands on the site as well as to provide an indication of the artificial modifiers evident on the site and in the catchment.

6.3 TERRAIN UNIT INDICATOR

Detailed contours of the site (filtered to 5 m intervals for the purpose of map production) were used to provide an indication of drainage depressions and drainage lines. From this data the terrain unit indicator was deduced.

6.4 SOIL FORM AND SOIL WETNESS INDICATORS

The soil form and wetness indicators were assessed on the site through a dedicated soil survey within the context of the description of the HHGD as provided in sections 5.5 to 5.7. During the soil survey areas of significance were identified and soil auger profile description activities conducted for the specific areas.

Historical impacts were identified as the impacts on the soils are very distinct. Soil characteristics could therefore be used to provide a good indication of the historical impacts on the grounds of a forensic approach. In areas where soil impacts are limited the standard approach in terms of identification of soil form and soil wetness indicators was used.

6.5 VEGETATION INDICATOR

Due to the extent of the historical impacts as well as the timing of the investigation a dedicated vegetation survey for the purpose of wetland delineation was not conducted. Relevant vegetation parameters were noted and these are addressed in the report where applicable.

6.6 ARTIFICIAL MODIFIERS

Artificial modifiers of the landscape and wetland area were identified during the different components of the investigation and are addressed in the context of the wetland management plan.

7. SITE SURVEY RESULTS AND DISCUSSION

7.1 WETLAND CONTEXT

The land type, topography and geological setting of the site have been elucidated in section 2 of this document. The main wetland feature on the site is limited to a drainage channel and associated wetland area that runs from east to west immediately north of the N14 highway. The areas surrounding the wetland have been impacted significantly through a range of human activities in the form of residential developments, road infrastructure, dumping of rubble and alteration of the flow regime of the wetland/watercourse. Land use changes on the site may impact on the water quantity and quality in the form of sediment generation and erosion of the stream banks.

7.2 AERIAL PHOTOGRAPH INTERPRETATION

The aerial photograph interpretation was conducted in two stages namely 1) the interpretation of historical aerial photographs indicating the specific wetland conditions and changes and 2) the Google Earth images indicating specific activities and changes on the site.

7.2.1 Historical Aerial Photographs

The historical data collected for the site include aerial photographs of 1958, 1964, 1968 and 1976 (**Figure 16**). The images from 1958 and 1964 indicate a drainage depression that is fed from land that was used for crop production. This is consistent with the land type data for the site that indicates the uppermost part of the landscape consisting of an Ab land type – indicative of well-drained and potentially deep soils. In the 1968 image a new dam is evident at the confluence of the stream under investigation and the stream that joins from the southeast. In the 1976 image the construction activities associated with and the alignment of the N14 (R28) highway are evident. This impact changed the characteristics of the landscape in the form of altered surface hydrology and storm water runoff intensity. It is important to note that prior to the impacts indicated in the 1976 image the drainage feature did not show any signs of significant erosion or colonisation by permanent wetland plants.

7.2.2 Recent Google Earth Images

The Google Earth images of the site were used to identify specific impacts and their timing in high resolution. **Figure 17** indicates the overall land use changes from 2005 to 2013. The changes were predominantly the intensification of residential developments surrounding the site. At this stage (2005) most of the road infrastructure around the site had been established and the specific storm water dynamics altered significantly when compared from the images before 1980 (**Figure 16**). **Figures 18** to **21** indicate the specific wetland area and the residential development north of the site from 2005 to 2013. The rubble that is evident on the image in **Figure 22** is also evident on images from 2005, indicating that the rubble dumping is not a recent development. In **Figure 23** a highly altered drainage feature is evident when compared to the images from the '50s and '60s. This aspect is addressed in more detail later in the report with respects to the functional and ecological assessment of the wetland.

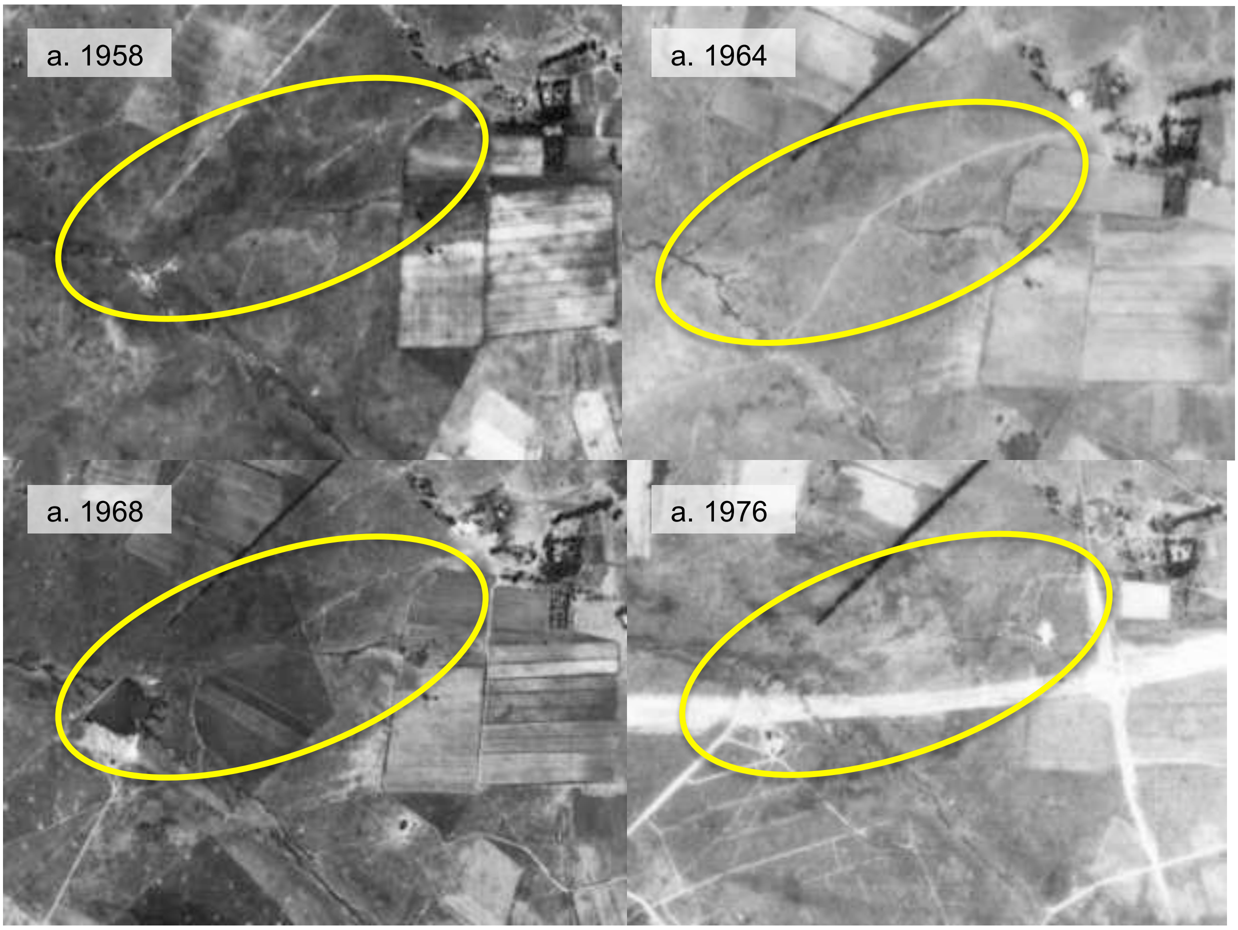

Figure 16 Collage of aerial photographs from 1958 to 1976 at intervals for the investigation site

Figure 17 Google Earth images from 2005/01/03 (top) and 2013/10/29 (bottom) indicating land use changes on and around the site over a decade

Figure 18 Google Earth image (2005/01/03) indicating the wetland area under investigation

Figure 19 Google Earth image (2008/09/07) indicating the wetland area under investigation with newly developed residential infrastructure to the north

Figure 20 Google Earth image (2012/07/03) indicating the wetland area under investigation

Figure 21 Google Earth image (2013/10/18) indicating the wetland area under investigation

Figure 22 Google Earth image (2014/04/05) indicating the eastern section of the site with rubble dumped across the drainage feature

Figure 23 Google Earth image (2014/04/05) indicating the western section of the site with a highly altered stream flow regime

7.3 TERRAIN UNIT INDICATOR

From the contour data a topographic wetness index (TWI) (**Figure 24**) was generated for the site.

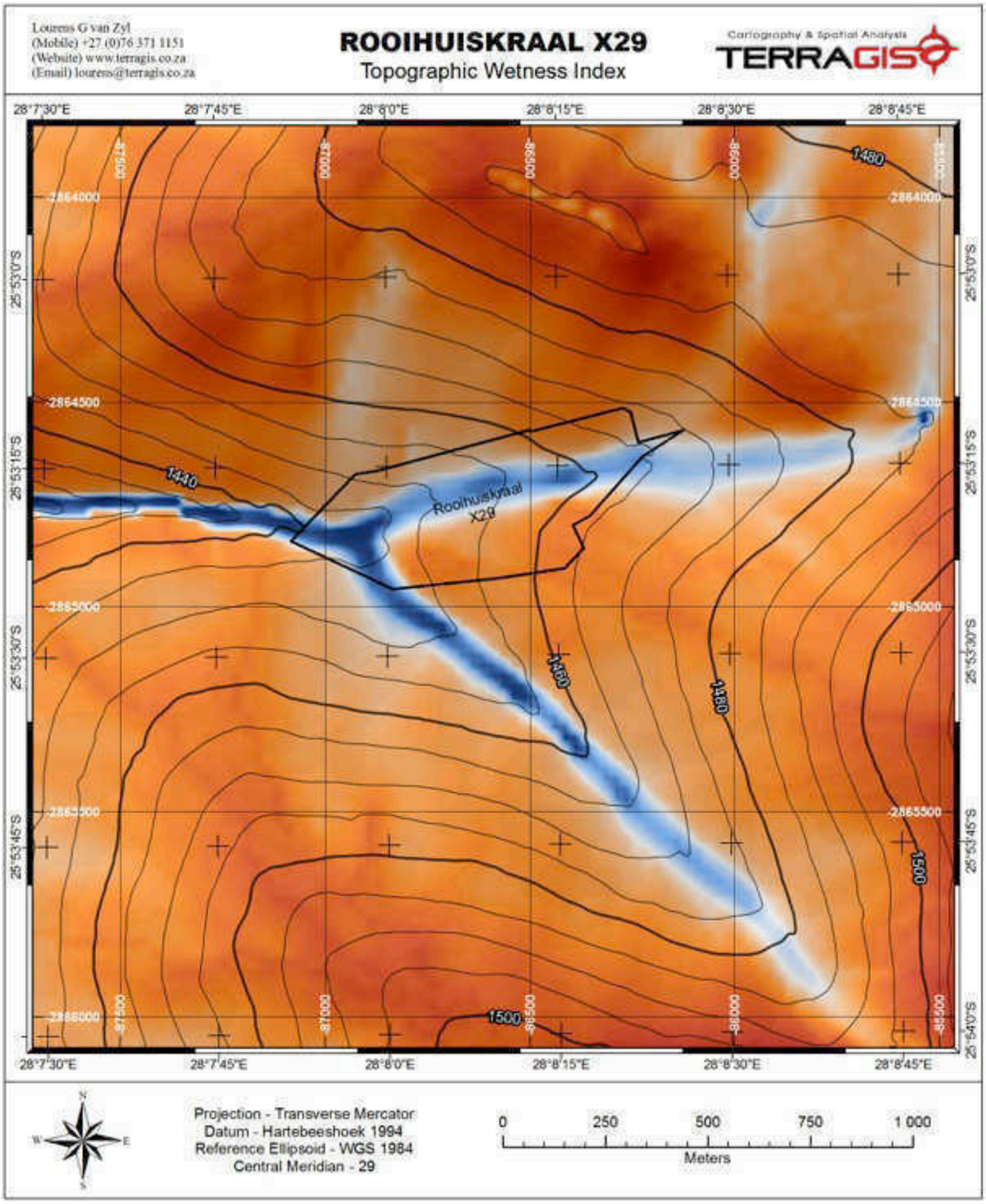

Figure 24 Topographic wetness index (TWI) of the survey site

From extensive experience on the field of hydropedology it is evident that the TWI provides a very accurate indication of water flow paths and areas of water accumulation that are often correlated with wetlands. This is a function of the topography of the site and ties in with the dominant water flow regime in the soils and the landscape (refer to previous section where the concept of these flows was elucidated). Areas in blue indicate concentration of water in flow paths with lighter shades of blue indicating areas of regular water flows in the soils and on the surface of the wetland / terrestrial zone interface.

From the terrain unit indicator it is evident that two distinct drainage features meet at the western edge of the site. The one form the southeast has been impacted by the development of the N14 highway and the feature on the investigation site has been influenced by the construction of Rooihuiskraal Road upslope from the site. Although not clearly evident from the TWI these roads have had a marked influence on the wetland in the form of altered storm water runoff spikes and volumes.

7.4 SOIL FORM AND SOIL WETNESS INDICATORS (AND VEGETATION)

A dedicated field verification exercise was conducted through the auguring of the soils within the wetland feature. The soils found on the site conform to the description provided in section 5.5 to 5.7 and will therefore not be described in further detail. Suffice to say that the soils indicate a large degree of alteration due to the historical human activities and associated erosion of the drainage feature (Figures 25 to 27).

Figure 25 Alteration of the drainage feature through road development, storm water infrastructure and alien vegetation establishment

Figure 26 Alteration of the land due to human activities

Figure 27 Alteration of the soils due to human activities in the form of excavations and historical agricultural activities

7.5 ARTIFICIAL MODIFIERS

Some of the physical historical artificial modifiers on the site were addressed in the sections above. The driver of most of the modifications is the altered hydrology of and runoff from the urban structures in the catchment area (**Figure 28**). Large sections of the site suffer from rubble dumping (**Figures 28** to **34**). **Figure 35** provides a view of the survey site from Rooihuiskraal Road.

Figure 27 Alteration of the drainage channel through erosion and human activities

Figure 28 Dumping of building rubble on the site

Figure 29 Human impacts and dumping of building rubble on the site

Figure 30 Man-made dam on the site due to dumping of building rubble in the drainage feature downslope

Figure 31 Dumped dolomite rock within the original drainage feature

Figure 32 Dumped animal carcases on the site near the drainage feature

Figure 33 Dumped rubble within and on the edge of the original drainage feature

Figure 34 Dumped rubble within and on the edge of the original drainage feature as well as numerous syringe trees

Figure 35 View from Roohuiskraal Road towards the site in the west indicating a range of human alteration of the drainage feature – including dumped rubble in the distance

8. WETLAND ASSESSMENT

8.1 PROPOSED DELINEATION AND BUFFER

Due to the highly impacted nature of the wetland on the site, taking into account all the historical modifiers, a wetland delineation exercise would mean very little. The result of a delineation exercise would invariably be limited to the areas that currently exhibit wetland character in the form of vegetation and would not serve any purpose in informing the management and rehabilitation of the wetland. A delineation outcome is therefore only provided as an indication of the current extent of the wetland (**Figure 36**). Similarly, due to the significant impacts a buffer is a meaningless property. This is especially relevant in the context of the altered hydrology, continued human impacts in the form of dumping of rubbish, uncontrolled human movement and highly altered storm water dynamics. Rather, it is strongly advised that the wetland area be managed in terms of future human impacts and that it be rehabilitated regarding foreign materials (rubbish) and hydrological functioning. In the sense of the latter the main aspects that have to be addressed are sediment generation and erosion.

Figure 36 Proposed wetland delineation for the survey site

8.2 WETLAND CLASSIFICATION / TYPES

Based on the information generated in this document the wetland area is classified as a highly altered valley bottom wetland system with a potential hillslope seep (also altered) feeding the wetland from the east.

8.3 WETLAND FUNCTIONALITY

The functionality of the wetland system has been highly compromised through human activities, building and urban infrastructure development within the catchment, destruction of wetland and drainage systems feeding into the drainage feature. The functionality of the wetland is therefore limited to channelling of water. Due to the extensive impacts the wetland does not have a water cleaning function. In addition, due to the highly erosive nature of the soils on the HHGD the wetland also does not have a flood attenuation function. In the event that the rubble is removed the erosive pressures will increase and care should be taken with the rehabilitation efforts to ensure no additional erosion of the drainage channel.

8.4 PRESENT ECOLOGICAL STATUS (PES) DETERMINATION

Hydrological Criteria:

- Flow modification: Large modification due to urban infrastructure in the catchment with significant erosion in the channel and on the banks. Score 1, Confidence 4.
- Permanent inundation: Permanent inundation was not part of the reference state and cannot be included as a new aspect. Inundation does take place in areas but this is due to significant human impacts in the form of alteration and rubble dumping. Score 1, Confidence 4.

Water Quality Criteria

- Water quality modification: Score 1, Confidence 4
- Sediment load modification: Score 1, Confidence 4

Hydraulic / Geomorphic Criteria

- Canalisation: Score 1, Confidence 4
- Topographic Alteration: Score 1, Confidence 4

Biological Criteria

- Terrestrial encroachment: Score 1, Confidence 3
- Indigenous vegetation removal: Score 1 (for most of the site), Confidence 4
- Invasive plant encroachment: Score 1 (for most of the site), Confidence 4
- Alien fauna: Score 2, Confidence 3
- Overutilisation of biota: Score 1, Confidence 4

Score

PES category F

From the data generated as well as the extent of the identified alterations the conclusion is that the wetland system on the site has a PES rating of an F. The potential for improvement is significant if storm water management is done correctly and if the rubble is removed from the drainage feature.

9. CONCLUSIONS AND RECOMMENDATIONS

A wetland investigation and soil survey yielded that:

1. The wetland area and its catchment have been altered significantly through historical human activities. These activities include urban infrastructure development, storm water alteration and increase, dumping of rubble and general degradation of the drainage feature through foot and vehicle traffic.
2. Significant amounts of building rubble and excavated geological materials have been dumped within the drainage feature. This has led to the establishment of a man-made dam upslope from the rubble dumping area. This dam is not natural and has changed the hydrological functioning of the drainage feature. The future use of this dam can include its upgrading to serve as a storm water attenuation and erosion mitigation structure.
3. From the field survey it is clear that hazardous materials in the form of animal carcases are being dumped within close proximity to the drainage feature. This aspects

compromises the water quality of the feature significantly and should be addressed as a matter of urgency to prevent infection and pollution of downstream water sources.

4. Storm water is released onto the site from a range of surrounding developments and roads. The increase in storm water will have a negative impact on the integrity of the remaining area of the drainage feature. It is therefore imperative that these water inputs be addressed through adequate storm water management on the site. This can be attained through the rehabilitation of the drainage feature but then with inclusion of a number of storm water attenuation structures.
5. A 30 m buffer is not advised for the wetland on the site. Rather, it is proposed that a dedicated rehabilitation effort be undertaken for the drainage feature and that this effort includes adequate storm water management within the drainage feature as well as on the edges. In order for the site owner/developer to pay for these aspects, that will benefit the state and the downstream land owners and water users, it is proposed that the mitigation and rehabilitation measures be included into the site layout and design for the site. This is to be done in a manner that benefits both the developer and the downstream water users and landowners. To emphasize, the main aspects to be addressed related to storm water mitigation and erosion prevention.

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Appendix G10

Wetland Specialist's input on wetland buffer and stormwater design

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Dear Ms Agenbacht

ROOIHUISKRAAL EXT. 29 WETLAND BUFFER AND STORM WATER DESIGN

The Rooihuiskraal Ext. 29 site has been the subject of a number of wetland investigations that include a wetland report by Scientific Aquatic Services (SAS) dated March 2009 and a hydropedology based wetland investigation by Terra Soil Science (TSS) dated 28 September 2014. The findings of both investigations indicate a severely degraded wetland / watercourse with the SAS report providing a delineation outcome and a proposed 15 m buffer. The TSS report emphasises the management of water in the landscape and states that a 30 m buffer is not advised and post development management of water and wetland rehabilitation should be focussed on.

Subsequent to the above reports a township layout plan has been drawn up with a dedicated storm water management approach. The township layout uses the 15 m buffer advised by SAS in conjunction with dedicated storm water management and mitigation through controlled release from the built-up areas into the wetland.

After thorough consideration of all the challenges and characteristics of the site I support the current layout and storm water management approach with the 15 m buffer as proposed by SAS.

Regards

DR. J.H. VAN DER WAALS
Pr.Sci.Nat.

Appendix G11

Traffic Impact Study

Dhubecon
CONSULTING ENGINEERS

ROOIHUISKRAAL NOORD EXTENSION 29

(Proposed Residential Township situated on a Part of the Remainder of Portion 9 and a Part of Portion 145 of the Farm Brakfontein 399-JR)

TRAFFIC IMPACT ASSESSMENT

June 2014

Document Verification

Project Description:	**Rooihuiskraal Noord Extension 29**
Document Description:	**Traffic Impact Assessment**
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Revision 1			
Revision 2			

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Drawings

Annexures

1. Introduction

Dhubecon Consulting Engineers (Pty) Ltd have been appointed to undertake this Traffic Impact Assessment to form part of an application for the proposed township called Rooihuiskraal Noord Extension 29, which is situated on a Part of the Remainder of Portion 9 and a Part of Portion 145 of the Farm Brakfontein 399-JR. **Figures 1** and **2** show the location of the subject site.

A previous traffic impact study was done by ITS Engineers in March 2007 for the proposed township, which was for the development of 453 residential units. The current proposal is also for residential land use but for a total of only 337 units instead, which equates to a density of 100 units per hectare. The proposal also includes the possible development of place of child care on one of the erven.

This study investigates/reviews the anticipated impact of the additional traffic to be generated by the proposed development on the immediate surrounding road network and determines whether it is necessary to implement any road and/or intersection improvements to mitigate the anticipated traffic impact. Traffic counts had been undertaken at the key intersections in the study area in order to quantify and assess the traffic flow operations. The study also provides comments with respect to the site access and non-motorised and public transport.

2. Site Location & Surrounding Road Network

2.1 SITE LOCATION

As shown in **Figures 1** and **2**, the subject site is located approximately 200m south from the intersection between Capensis Avenue and Kraalnaboom Avenue in Rooihuiskraal Noord, Centurion. The site is also situated directly to the north of the N14 freeway (Road P158/2). The only access to the site is via Kraalnaboom Avenue, which is a short collector road originating at its intersection with Capensis Avenue and terminating approximate 200m to the north of the proposed township's boundary.

2.2 EXISTING ROAD NETWORK

The following existing roads are relevant to the study area:

Kraalnaboom Avenue: Kraalnaboom Avenue is a short 2-lane Class 4b collector road which is running in a north-south direction and is situated to the north of the subject site. The road originates at its intersection with Capensis Avenue and terminates on the northern boundary of the site. The road is only about 200m in length and currently provides access to only four residential security complexes. The current traffic volumes on Kraalnaboom Avenue are low about 135 and 110 vph (total both directions) during the weekday AM and PM peak hours.

Capensis Avenue: This road is also classified as a Class 4b collector road, comprising of 2 traffic lanes. Capensis Avenue originates at its T-intersection with Lenchen Avenue, running in a southern and then western direction where it terminates approximately 1.5km from its origin. The road currently serves as a collector road for a number of residential security complexes. The current traffic volumes along Capensis Street in the vicinity of the site are approximately 340 and 330 vph (total both directions) during the weekday AM and PM peak hours.

Lenchen Avenue: Lenchen Avenue is an existing east/west Class 3 arterial road which forms a signalised T-intersection with Rooihuiskraal Road. The road originates at this T-intersection with Rooihuiskraal Road and terminates approximately 1.5km to the west. The road is currently a 2 lane single carriageway road, but with its 32m wide road reserve, it has the potential to be widened substantially to a 4-lane dual carriageway in the future. Near its intersection with Capensis Avenue, the current traffic volumes on Lenchen Avenue are about 950 vph (total both directions) during both the AM and PM peak hours.

Rooihuiskraal Road (M37): This is another Class 3 municipal arterial road located further to the east of the site, which comprises a 4-lane dual carriageway road with additional left- and right-turning lanes at its intersections. The traffic volumes along Rooihuiskraal Road near its intersection with Lenchen Avenue are approximately 2240 and 2480 vph (total both directions) during the weekday AM and PM peak hours respectively.

2.3 PLANNED FUTURE ROAD NETWORK

2.3.1 Planned Provincial Road Network

An extract of the Gauteng Strategic Road Network of March 2007 is shown in **Figure 3**, which apart from the existing N14 Freeway (Road P158/2) running past the southern boundary of the site, indicates no planned future K-routes in the vicinity of the site.

With reference to the town planner's proposed township layout plan, attached as **Annexure A**, it can be noted that provision has been made for a 20m building line on the southern boundary of the site adjacent to the N14 freeway.

2.3.2 Planned Municipal Road Master Plan

An extract of CTMM's local road master plan of 2013 is shown in **Figure 4**. From this road master plan, the following can be noted:

- **Capensis Avenue:** Future planning for this road is for it to be extended to the west, where it will further provide access to other potential developments and again linking up with Lenchen Avenue to the north. An additional link will also be constructed between Capensis Avenue and Apiesdoring Drive to the West.
- **Lenchen Avenue:** Future planning for Lenchen Avenue includes the extension of the road where it currently terminates to the west, linking Lenchen Avenue with Ruimte Road to the west.

Important to note is that the development of Rooihuiskraal Noord Extensions 45 to 49 and Heuweloord Extensions 22 to 23 are planned to start in the near future, which will include the construction of these abovementioned extensions of Capensis and Lenchen Avenue. Due to this, it has been deemed more relevant to consider these extensions completed when determining the expected trip distribution discussed in Section 4.4.

It can also be noted that the proposed extension of Kraalnaboom Avenue, as indicated on the town planner's proposed township layout plan in **Annexure A**, to provide access to small number of erven in the township, also ties in with CTMM's Road Master Plan.

3. Proposed Development & Site Access

3.1 PROPOSED DEVELOPMENT

The subject site is situated on a Part of the Remainder of Portion 9 and a Part of Portion 145 of the Farm Brakfontein 399-JR, Rooihuiskraal Noord with its location indicated in **Figure 1**. The site as a whole is approximately 18ha in size.

A new residential township, to be known as Rooihuiskraal Noord Extension 29, is proposed on the subject site. With reference to the proposed township layout in **Annexure A**, the development will be a residential development consisting of Erven 1-4 with provision for a crèche/place of child care on part of Erf 1. Erven 5 and 6 are allocated for public open space due to the large portion of wetlands on the site. Due to the 1:100 year flood zones, the public open space will account for almost 78% of the total site area.

A density of 100 units per hectare is proposed for erven 1 to 4, which equates to a maximum development extent of 337 residential units. A summary of the development is tabulated in **Table 1.**

Table 1: Development Extent of Proposed Rooihuiskraal Noord Extension 29

Erf	Land Area	Residential	Other	Land Zoning
Erf 1	1.43 ha (7.9%)	143 units	Crèche / Place of Child Care	Special
Erven 2	0.37 ha (2.0%)	37 units	-	Residential 3
Erf 3	0.39 ha (2.2%)	39 units	-	Residential 3
Erf 4	1.18 ha (6.6%)	118 units	-	Residential 3
Erven 5-6	14.05 ha (78.0%)	-	Public Open Space	Public Open Space
Street	0.6 ha (3.3%)	-	Public Street	-
TOTAL	**18.02 ha**	**337 units**		

3.2 PROPOSED SITE ACCESS & ACCESS INTERSECTION

Access to the site itself will be provided via Kraalnaboom Avenue. To provide access to the erven on which the residential units are proposed, i.e. erven 1 to 4, the extension of Kraalnaboom Avenue will be required as shown in **Figure 2** and in the township layout in **Annexure A.** It also implies that the road will have to cross the wetland by means of a bridge structure.

Given the low order status and the very limited usage this proposed extension of Kraalnaboom Avenue will have, only giving access to the residential erven on the subject site, the need for a stacking distance investigation becomes irrelevant, especially if access to the erven is provided by only one access point. More details regarding stacking distances and the number of in- and outbound lanes at the access/accesses will be dealt with during the development of the Site Development Plan.

4. Traffic Flows & Development Trip Generation

4.1 EXISTING TRAFFIC FLOWS & OPERATION

In order to determine the expected traffic impact of the proposed development onto the nearby roads network, traffic counts were undertaken by Dhubecon Consulting Engineers (Pty) Ltd during the critical weekday AM and PM peak periods at the following key intersections:

- Lenchen Avenue / Rooihuiskraal Road (13 May 2014);
- Capensis Avenue / Kraalnaboom Avenue (16 and 21 January 2014); and
- Lenchen Avenue / Capensis Avenue (7 May 2013)

The existing weekday morning (AM) and afternoon (PM) peak hour traffic volumes at the abovementioned key intersections are summarised in **Figure 5.** The respective peak hours occurred at 06:30-07:30 and 17:00-18:00.

4.2 TRAFFIC GROWTH & "OTHER DEVELOPMENT" GENERATIONS

The total future 2019 background traffic presented in this document, and as summarised in **Figure 6**, comprises two main components, namely the traffic growth and the estimated traffic generations of other nearby approved developments that still need to realise.

The *Manual for Traffic Impact Studies (1995)* suggests that for developments which generate more than 150 peak hour trips, it is necessary to take into account traffic growth and/or the potential traffic generations of other nearby approved developments that still need to realise. The "other developments" is often referred to as latent rights.

4.2.1 Traffic growth

In terms of traffic growth and given the extent of the proposed development and the surrounding road network, it was decided to use a 5-year base horizon. In order to make provision for both an increase in background traffic due to normal traffic growth as well as other developments not accounted for, it was assumed that the existing background traffic will increase at a rate of **3.0% per annum** over the next 5 years to future 2019.

4.2.2 Trips Generations from "Other Developments" (Latent Rights)

For the "Other Developments" in this case, a number of another townships located in relatively close proximity of the subject had been taken into account. These are:

- **Rooihuiskraal Noord Ext 40-42:** These three townships are located directly to the northeast of the site and will gain access from the future Nentabos Street, which will run on a portion of the proposed Rooihuiskraal Noord Extension 29 northern boundary as indicated in **Annexure A**. These residential townships are approximately 3.65ha in extent and a maximum density of 100 units/ha is proposed. For the purposes of this study a trip rate of 0,65 trips/unit had been used, which equates to an estimated peak hour traffic generation of approximately 235 vph in the AM and PM peaks.
- **Heuweloord Extensions 22 to 23 and Rooihuiskraal Noord Extensions 45 to 49**: These townships are situated roughly 1.5km to the west of the subject site and will jointly comprise of approximately 3415 residential units, of which about 40% would be retirement centre units and the balance comprising a combination of 'Residential 2' and 'Residential 3' units. The maximum densities proposed are 30-40 units/ha for the 'Residential 2' and 120units/ha for the 'Residential 3' units. The townships also make provision for two schools. The traffic projections for these

townships had been retrieved from the approved Traffic Impact Assessment (dated August 2013), which had been prepared by Dhubecon Consulting Engineers. Several road and intersection upgrades had been proposed in that TIA, some of which also overlaps with the upgrades proposed for this development as discussed in Section 6.

The traffic generations of these 'other developments' or latent rights are included in the future 2019 base traffic flows, shown in attached **Figure 6**.

4.3 DEVELOPMENT TRIP GENERATION

In order to determine the expected trip generation of the proposed development, the latest and most relevant guideline, entitled *TMH 17 Volume 1, South African Trip Data Manual (Version 1, September 2012*) had been used, which have been based on a more comprehensive data base and which makes provision for the different types of residential developments, as well different income levels of developments, vehicle ownership and availability of public transport services.

The *Trip Data Manual* suggests a base trip rate of 0.75 trips per unit for 'multi-level townhouses' and a base trip rate of 0.65 trips per unit for 'Apartments and Flats'. Given the proposed density of 100 units per hectare, which will most probably result in 3 storey buildings which relate more to apartments, a base trip rate of **0.65 trips per unit** had been used for the AM and PM peak hours. **Table 2** below summarises the total estimated AM and PM peak traffic generations for the proposed development, using the recommended directional splits (IN:OUT) as per the *Trip Data Manual* of 25:75 and 70:30 for the AM and PM peaks respectively.

Table 2: Estimated Development Trips

Peak	Development Trips (vph)		
	IN	OUT	TOTAL
Weekday AM Peak hr	55	165	220
Weekday PM Peak hr	155	65	220

With regards to the proposed crèche/ place of child care as mentioned in Section 4.1, the worst case scenario has been assumed which is the construction of only residential units. Such facilities tend to generate only local traffic whereas residential units will have a bigger impact on the surrounding road network.

4.4 TRIP DISTRIBUTION & ASSIGNMENT

Assumptions on the expected trip distribution were based on the location of the proposed site access in relation with the surrounding road network, existing traffic volumes and patterns in the study area, the type of development in relation to employment as well as our knowledge of the area.

The expected development trip distribution of the proposed development is shown in **Figure 7**. Using the expected trip distribution, the estimated development trips through the study area are shown in **Figure 8**.

4.5 ASSESSMENT TRAFFIC FLOWS WITH DEVELOPMENT

Figure 9 shows the total 2014 peak traffic flows with the estimated traffic generations of the proposed development as a whole, which is the summation of **Figures 5** and **8**.

Figure 10 shows the total future 2019 base traffic with "Latent Rights" and the estimated traffic generations of the proposed development as a whole, which is the summation of **Figures 6** and **8**.

These **Figures 9** and **10** have been used for assessing the traffic impact of the proposed development onto the surrounding road network, as covered in the following Section 5.

5. Traffic Impact & Capacity Analyses

In order to determine and quantify the traffic impact of the proposed development, *SIDRA INTERSECTION 5.1* traffic engineering software had been used to undertake capacity analyses at the various key intersections.

With reference to the analyses of various scenarios, this section comments on the current traffic operations without the additional traffic as well as the likely traffic flow conditions with the additional traffic. Where necessary and feasible, intersection improvements have identified that would mitigate the likely traffic impact and/or improve current traffic flow conditions.

The intersection capacity analyses were done for the weekday AM- and PM peak hours at the following key intersections, and by applying optimised traffic signal settings and phasing:

- Capensis Avenue / Kraalnaboom Avenue;
- Lenchen Avenue / Capensis Avenue; and
- Lenchen Avenue / Rooihuiskraal Road.

The following scenarios were analysed, namely:

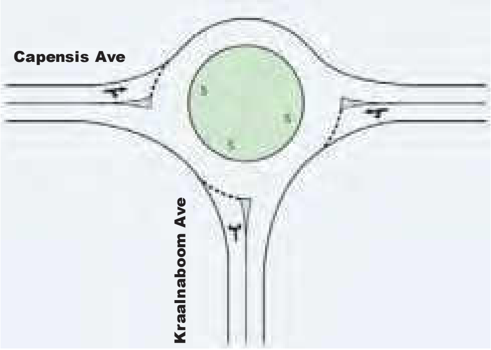
- **Scenario 1:** Existing 2014 weekday AM and PM peak hour traffic flows without the proposed development (as per **Figure 5**);
- **Scenario 2:** Future 2019 base weekday AM and PM peak hour traffic flows without the proposed development (as per **Figure 6**), which also includes the latent rights;
- **Scenario 3:** Existing 2014 weekday AM and PM peak hour traffic flows PLUS proposed full development trips (as per **Figure 9**);
- **Scenario 4:** Future 2019 base weekday AM and PM peak hour traffic flows PLUS the proposed full development trips (as per **Figure 10**), which also includes the latent rights.

Results of the SIDRA capacity analyses at the various intersections are discussed in the following sub sections, with the details of the outputs enclosed in **Annexures B1 to B3**.

5.1 CAPENSIS AVENUE / KRAALNABOOM AVENUE INTERSECTION

Proposed Geometry & Control

- T-intersection
- Mini traffic circle
- One approach lane on all approaches
- Inscribed (outside) diameter approx. 20m
- See **Drawing No 0213/CL/01**



Analysis Results & Conclusion	Intersection: **Capensis Avenue / Kraalnaboom Avenue**				
Detailed Results: **Annexures B1.1 to B1.9**					

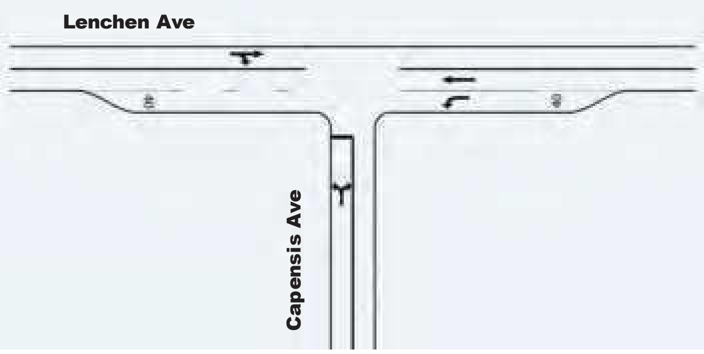
Scenario	**Status / Upgrade**	**Peak**	**On Stop approach or Overall Overall**			**Comments**
			LOS	**Delay(s)**	**v/c$_{max}$**	
Scenario 1	Existing geometry (Stop approach on Kraalnaboom)	AM	B	13	0.18	Good operating conditions, even on the stop approach (Kraalnaboom Avenue)
Scenario 2	Existing geometry	AM	F	>100	1.82	Substantial impact by latent rights and traffic growth – upgrade required
Scenario 2	Upgrade	AM	B	11	0.65	With the proposed upgrade, acceptable conditions are achieved
Scenario 3	Existing geometry	AM	B	15	0.44	Minor development impact; Acceptable conditions
Scenario 4	Upgrade	AM	B	14	0.78	With the proposed upgrade good overall operating conditions are expected, even for this worst case scenario
Scenario 1	Existing geometry	PM	B	13	0.05	Good operating conditions, even on the stop approach (Kraalnaboom Avenue)
Scenario 2	Existing geometry	PM	E	59	0.65	Impact by latent rights and traffic growth -, Although much worse LOS and delay on stop approach, operating conditions are still relatively acceptable
Scenario 3	Existing geometry	PM	B	15	0.18	Minor development impact; Acceptable conditions
Scenario 4	Upgrade	PM	A	9	0.65	Even better conditions than the AM scenario

Conclusion:	Good current operating conditions, but once the extension of Lenchen and Capensis Avenue is completed, the expected through traffic on Capensis will result in conditions requiring an upgrade.
Upgrade Required:	Yes, upgrade shown in **Drawing No 0213/CL/01**
Upgrade Responsibility	Seen as this is the access intersection to Rooihuiskraal Noord Ext 29 and 40-42, with unacceptable stop approach conditions in the future, the required upgrade will be for the account of these developers (bulk contributions to be utilised for upgrade)

5.2 LENCHEN AVENUE / CAPENSIS AVENUE INTERSECTION

Existing Geometry & Control

- 3-legged intersection
- Lenchen Ave and Capensis Ave both single carriageways
- Priority stop controlled
- Southern approach(Capensis Ave) – one approach lane shared for left- and right-turning movements
- Western approach (Lenchen Ave) – Single approach lane shared for through and right-turn movements
- Eastern approach (Lenchen Ave) – two approach lanes, including a dedicated left-turn lane



Analysis Results & Conclusion Intersection: **Lenchen Avenue / Capensis Avenue**

Detailed Results: **Annexures B2.1 to B2.8**

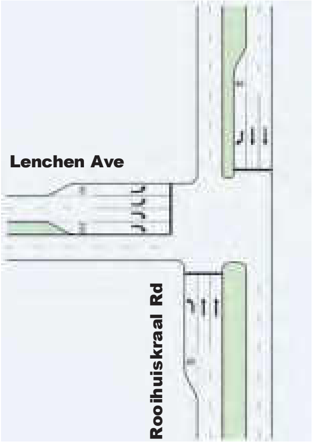
Scenario	**Status / Upgrade**	**Peak**	**On Stop approach or Overall**			**Comments**
			LOS	**Delay(s)**	**v/c_{max}**	
Scenario 1	Existing geometry	AM	E	36	0.77	Acceptable operating conditions
Scenario 2	Upgrade – As proposed by others	AM	C	25	0.76	With the proposed upgrades by other developments, good overall operating conditions are expected
Scenario 3	Existing geometry	AM	F	>100	1.04	Impact by development traffic with existing geometry and control – upgrade required
Scenario 4	Upgrade – As proposed by others	AM	C	29	0.84	Good operating conditions expected with the proposed upgrade by others, even for this worst case scenario
Scenario 1	Existing geometry	PM	C	23	0.26	Good operating conditions, even on the stop approach (Capensis Avenue)
Scenario 2	Upgrade – As proposed by others	PM	B	17	1.00	Good overall operating conditions are expected; Only the left-turn lane on Lenchen Ave at capacity
Scenario 3	Existing geometry	PM	D	30	0.44	Acceptable operating conditions with existing geometry and control, even with development traffic added
Scenario 4	Upgrade – As proposed by others	PM	B	17	1.00	Same result as Scenario 2 PM – minimal difference due to development traffic

Conclusion:	Currently operating at acceptable conditions, but not much more spare capacity available.
Upgrade Required:	Yes, upgrade required as per others - see **Drawing No 0213/CL/02**
Upgrade Responsibility	Costs to be shared by developers of Rooihuiskraal Noord Ext 29 and that of Rooihuiskraal Noord Ext 45-49

5.3 LENCHEN AVENUE / ROOIHUISKRAAL ROAD INTERSECTION

Existing Geometry & Control

- 3-legged intersection
- Lenchen Ave and Rooihuiskraal Rd both dual carriageways
- Signalised with protected right-turn phasing
- Northern and Southern approaches (Rooihuiskraal Rd) – three approach lanes, including dedicated left- and right-turn lanes
- Western approach (Lenchen Ave) – Four approach lanes comprising two left- and two right-turn lanes



Analysis Results & Conclusion	Intersection: **Lenchen Avenue / Rooihuiskraal Road**					
Detailed Results: **Annexures B3.1 to B3.8**						
Scenario	**Status / Upgrade**	**Peak**	**Overall**			**Comments**
			LOS	**Delay(s)**	**v/c_{max}**	
Scenario 1	Existing geometry	AM	B	18	0.60	Good current overall operating conditions with adequate spare capacity
Scenario 2	Upgrade – As proposed by others	AM	C	27	0.83	With the proposed upgrades by other developments, good overall operating conditions are expected
Scenario 3	Existing geometry	AM	B	19	0.61	Acceptable operating conditions with existing geometry and control, even with development traffic added
Scenario 4	Upgrade (others)	AM	C	29	0.78	With the proposed upgrade good overall operating conditions are expected, even for this worst case scenario
Scenario 1	Existing geometry	PM	B	19	0.95	Good current overall operating condition, only turning lanes on Rooihuiskraal Road at 95% capacity
Scenario 2	Upgrade – As proposed by others	PM	C	24	1.00	Good overall operating conditions are expected; Only the right-turn lane on Rooihuiskraal Rd at capacity
Scenario 3	Existing geometry	PM	B	18	1.00	Acceptable operating conditions with existing geometry and control, only the right-turn lane on Rooihuiskraal Rd at capacity
Scenario 4	Upgrade (others)	PM	C	29	1.00	Acceptable operating conditions expected, only the left-turn lane on Rooihuiskraal Rd at capacity

Conclusion:	Currently operating at acceptable conditions, but the increase in traffic due to the latent rights will result in congested turning lanes on Rooihuiskraal Road.
Upgrade Required:	Yes, upgrade required as per others - see **Drawing No 0213/CL/03**
Upgrade Responsibility	Developers of Heuweloord Ext 22-23 and Rooihuiskraal Noord Ext 45-49

6. Road and/or Intersection Upgrades

Based on the estimated additional traffic generations of the proposed development and its projected distribution onto the surrounding road network during the weekday AM and PM peak hours, the capacity analyses in Section 5 as well as site observations during the peaks, the following intersection upgrades are proposed (see also **Drawings No 0213/CL/01-03**):

- **<u>Capensis Ave / Kraalnaboom Ave Intersection:</u> (Drawing No 0213/CL/01)**
  - Upgrading of the existing priority stop controlled T-intersection to a new traffic circle to provide the necessary flow capacity. An inscribed diameter (i.e. outside diameter) of approximately 20m is proposed with one circulating traffic lane.
- **<u>Lenchen Ave / Capensis Ave Intersection:</u> (Drawing No 0213/CL/02 – As per upgrades identified in the TIA for Heuweloord Ext 22-23 and Rooihuiskraal Noord Ext 45-49)**
  - Upgrading from stop control to signalisation;
  - Additional through lane on the Lenchen Avenue western approach;
  - Additional right-turn lane on the Capensis Avenue approach.
- **<u>Extension of Kraalnaboom Avenue:</u>**
  - Extension of Kraalnaboom Avenue form where it currently terminates up to the boundaries of the newly proposed erven as indicated in the township layout plan in **Annexure A**.

The first two intersection upgrades on Capensis Avenue overlaps with the upgrades also required by other township. It is therefore recommended that the costs of the upgrades be shared with the respective other developments, namely:

- The costs of the Capensis / Kraalnaboom upgrade should be shared with Rooihuiskraal Noord Extensions 40-42;
- The costs of the Lenchen / Capensis should be shared with the developer of Rooihuiskraal Noord Extensions 45-49

In the event of bulk engineering contributions payable with respect to roads and stormwater, it is recommended that the contributions be off-set against the proposed roads and intersection upgrades for the proposed development.

Another future intersection upgrade (by other developments) in the study is that of the Lenchen Avenue / Rooihuiskraal Road Intersection as shown in Drawing No 0213/CL/03. With future traffic growth and other latent rights still to realise, it is expected that this intersection will become under pressure and an upgrade will be required in the future. Such an upgrade had already been proposed in the TIA for Heuweloord Extensions 22-23 and Rooihuiskraal Noord Extensions 45-49. It had been assumed that the future upgrade to that intersection will be undertaken by Rooihuiskraal Noord Extensions 45-49, which will also have the most significant traffic impact.

7. Non-Motorised & Public Transport

7.1 AVAILABILITY OF SERVICES & FACILITIES

Due to Lenchen and Capensis Avenue currently terminating to the east, and the access to the subject site situated off a cul-de-sac, the site is currently not located near any public transport routes. The closest public transport routes are on Rooihuiskraal Road, approximately 1.2km from the site.

Once future links for Capensis Avenue and Lenchen Avenue have been constructed to the east, these two roads will be integrated into a larger road network connecting Rooihuiskraal Noord to the suburbs directly to the east. Lenchen Avenue will also provide access between Rooihuiskraal Road and Ruimte Road, both arterial roads being excessively utilised by public transport. This will most likely result in the forming of new routes closer to the site, making the site more accessible for pedestrians making use of public transport.

7.2 PUBLIC TRANSPORT DEMAND

For this proposed development, which will cater for the medium income, it is expected that the majority of residents will make use of private vehicle transport. There will however be employees, such as domestic workers, that will make use public transport in the form of minibus taxis.

If it is assumed that 60% of the households would employ a domestic worker for one day per week, it equates to an average of about 40 public transport users per day, which is the equivalent of about 4 full minibus taxis.

7.3 PROPOSED FACILITIES

In order to make provision for users of public transport generated by the proposed development, it is recommended that a paved sidewalk of 1.5m wide to be constructed along one side of the required Kraalnaboom Avenue extension.

More details of the above would be submitted as part of the Site Development Plans and/or detail designs of the external roads.

8. Summary, Conclusions & Recommendations

Based on the content of this document, the following key conclusions and recommendations are relevant:

1. This Traffic Impact Assessment had been prepared to form part of a township application for Rooihuiskraal Noord Extension 29, which is situated on a Part of the Remainder of Portion 9 and a Part of Portion 145 of the Farm Brakfontein 399-JR. A residential development is proposed comprising a maximum of 337 units/apartments at a density of 100 units/ha. **Figures 1** and **2** show the location of the subject site. Due to flood lines only about 22% of the property can be developed.
2. A previous traffic impact study was done for the same site by ITS Engineers in March 2007, which was then for the development of 453 residential units. The current proposal is for only 337 units. The proposal also includes the possible development of place of child care on part of one of the erven.
3. **ACCESS:** Access to the site itself will be provided via Kraalnaboom Avenue. To provide access to the erven on which the residential units are proposed, an extension of Kraalnaboom Avenue will be required as shown in **Figure 2** and in the township layout in **Annexure A.** The proposed extension of the road will also have to cross the wetland by means of a bridge structure.
4. Given the low order status and the very limited usage this proposed extension of Kraalnaboom Avenue will have and that it will only provide access to the residential erven on the subject site, the need for stacking distance investigation becomes irrelevant, especially if access to the erven is provided by only one access point. More detail regarding the actual site access and its stacking distance, and the number of in- and outbound lanes at the access/accesses will be provided as part of the Site Development Plan.
5. **TRIP GENERATION:** It is estimated that the proposed township as a whole will generate approximately 220vph (total IN plus OUT) during both the weekday AM and PM peak hours. **Figure 8** shows the estimated development trips of the development as a whole in the study area.
6. This study also takes account of the traffic generations of other townships/developments in the area. The estimated traffic generations of those future developments had been incorporated in the projected future 2019 base traffic flows.
7. **ROAD & INTERSECTION UPGRADES:** Based on the estimated additional traffic generations of the proposed development as a whole and its projected distribution onto the surrounding road network during the peak hours, the latent rights in the area, the capacity analyses in Section 5 as well as site our observations, the following road/intersection upgrades are proposed:
    - **Capensis Ave / Kraalnaboom Ave Intersection: (Drawing No 0213/CL/01)**
        - Upgrading of the existing priority stop controlled T-intersection to a new traffic circle to provide the necessary flow capacity. An inscribed diameter (i.e. outside diameter) of approximately 20m is proposed with one circulating traffic lane.
        - Since this proposed upgrade overlaps with the upgrades also required by other township, it is recommended that the costs of the upgrade be shared with the developers of Rooihuiskraal Noord Extensions 40-42.

- **<u>Lenchen Ave / Capensis Ave Intersection:</u> (Drawing No 0213/CL/02)**
  - Upgrading from stop control to signalisation;
  - Additional through lane on the Lenchen Avenue western approach;
  - Additional right-turn lane on the Capensis Avenue approach.
  - Since this proposed upgrade overlaps with the upgrades also required by other townships, it is recommended that the costs of the upgrade be shared with the developer of Rooihuiskraal Noord Extensions 45-49.

- **<u>Extension of Kraalnaboom Avenue:</u>**
  - Extension of Kraalnaboom Avenue form where it currently terminates up to the boundaries of the newly proposed erven as indicated in the township layout plan in **Annexure A**.

8. In the event of bulk engineering contributions payable with respect to roads and stormwater, it is recommended that the contributions be off-set against the proposed roads and intersection upgrades for the proposed development, especially for the new traffic circle proposed at the Capensis Avenue and Kraalnaboom Avenue intersection.

9. **NON-MOTORISED & PUBLIC TRANSPORT:** Since the proposed development will cater for the medium income market, it is expected that the majority of residents will make use of private vehicle transport. There will however be employees, such as domestic workers, that will make use of public transport in the form of minibus taxis and therefore it would be necessary to at least cater for pedestrians. In this case it is recommended that a paved sidewalk of 1.5m wide be constructed along one side of the required Kraalnaboom Avenue extension.

From a traffic engineering perspective, the proposed Rooihuiskraal Noord Extension 29 is supported provided that the proposed external road/intersection upgrades and public transport facilities are implemented to the relevant design standards of the City of Tshwane Metropolitan Municipality.

Figures

Dhubecon
CONSULTING ENGINEERS

Project Name	Rooihuiskraal Noord Ext 29	Proj Ref. P0213
Description	**Locality Plan**	Figure **1**

Dhubecon
CONSULTING ENGINEERS

Client	Notes

Project Name	Rooihuiskraal Noord Ext 29	Proj Ref. P0213
Description	**Site Aerial View & Key Plan**	Figure **2**

Dhubecon
CONSULTING ENGINEERS

Client

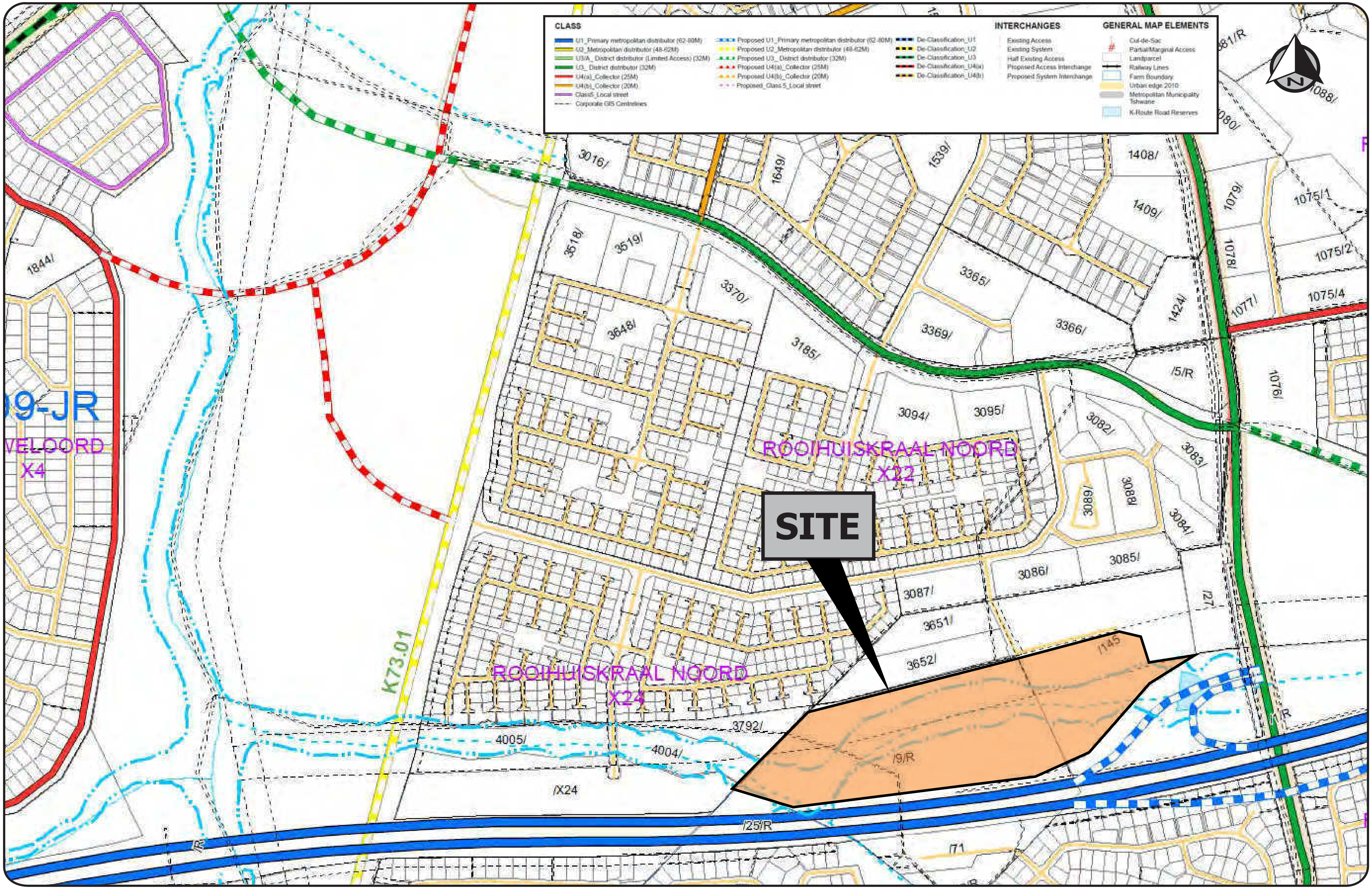
Notes

Project Name
Rooihuiskraal Noord Ext 29

Proj Ref.
P0213

Description
Extract of Gautrans' Strategic Road Network (2007)

Figure
3



Dhubecon
CONSULTING ENGINEERS

Client

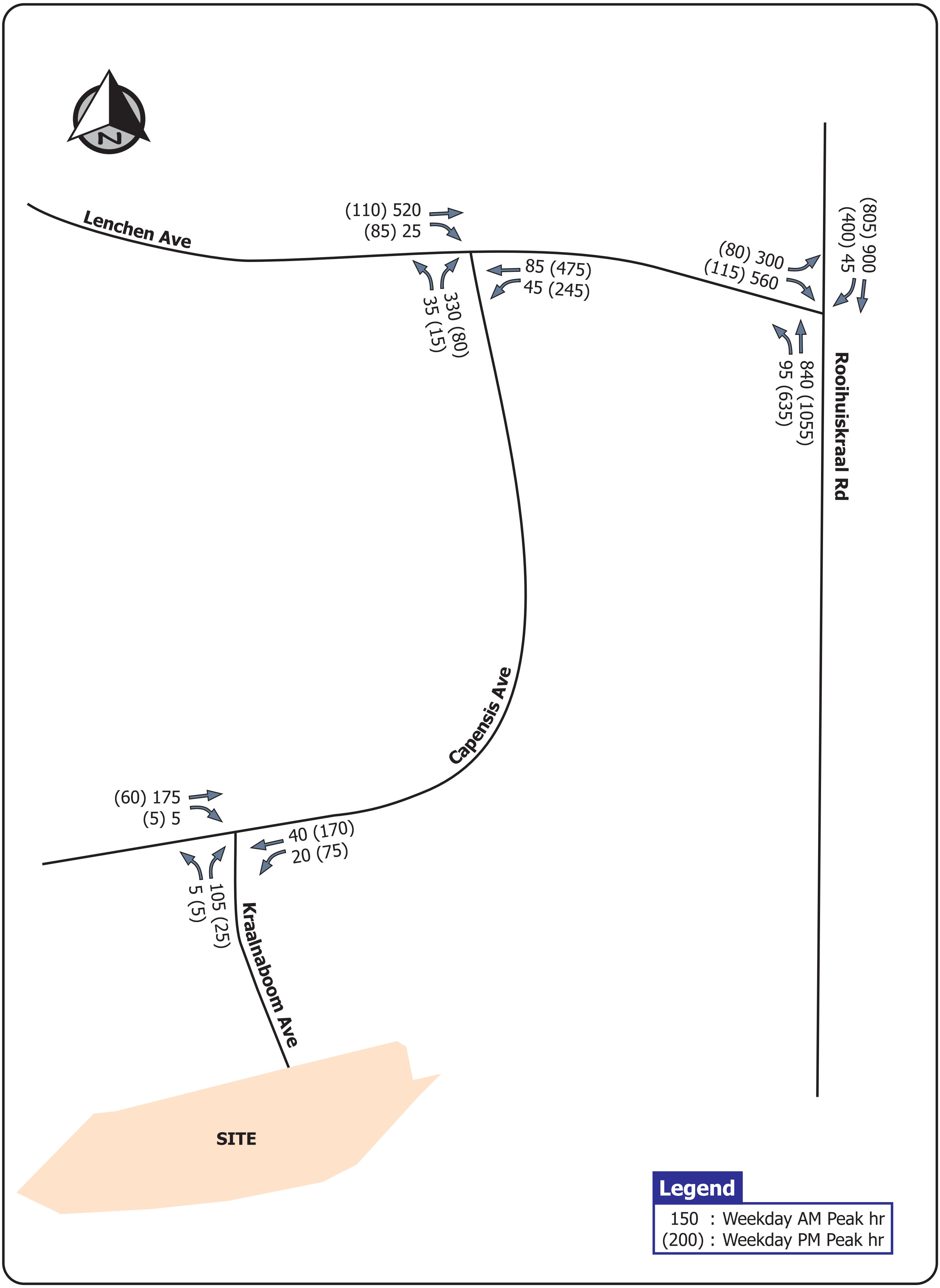
Notes

Project Name
Rooihuiskraal Noord Ext 29

Proj Ref.
P0213

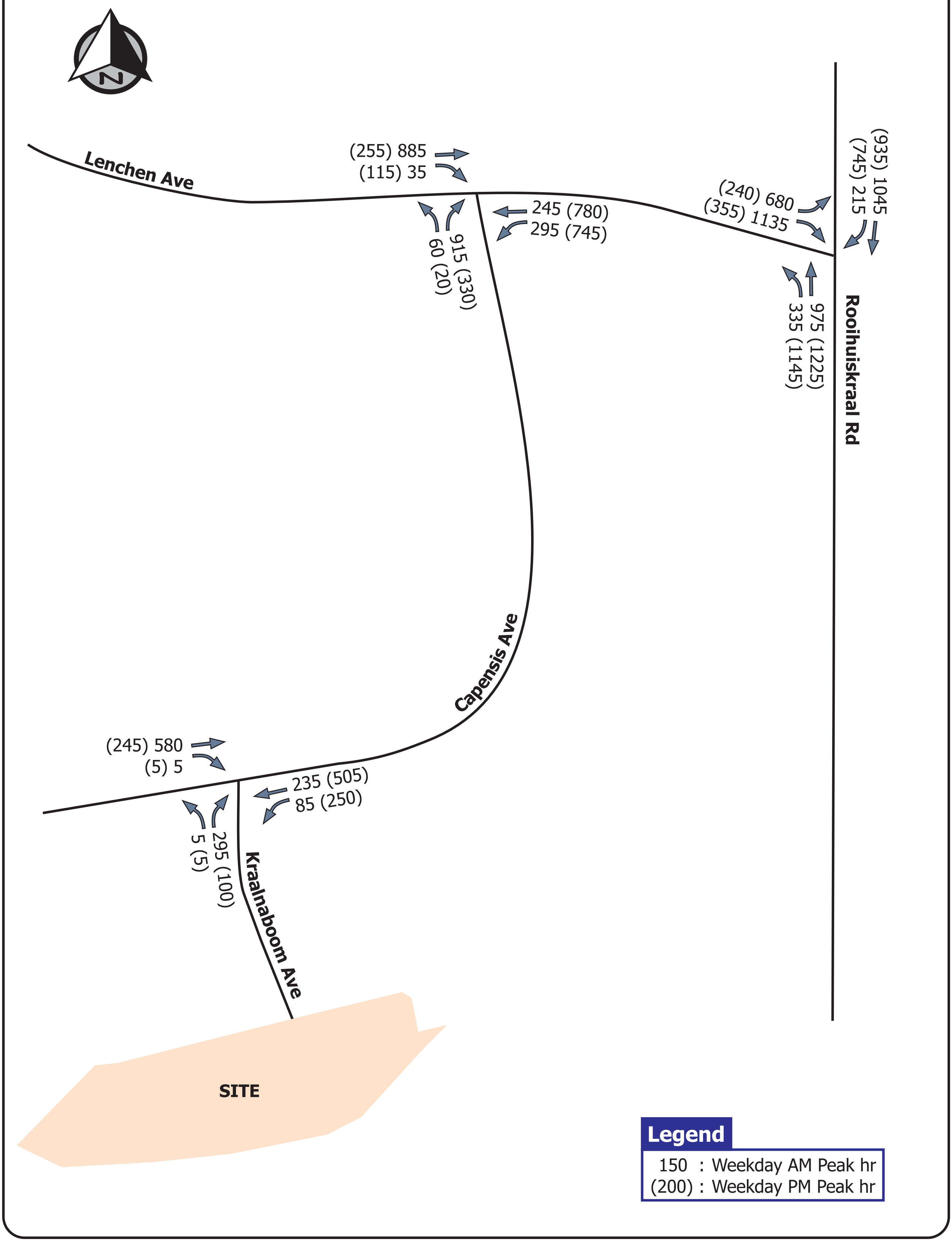
Description
Extract of CTMM's Roads Master Plan (2013)

Figure
4



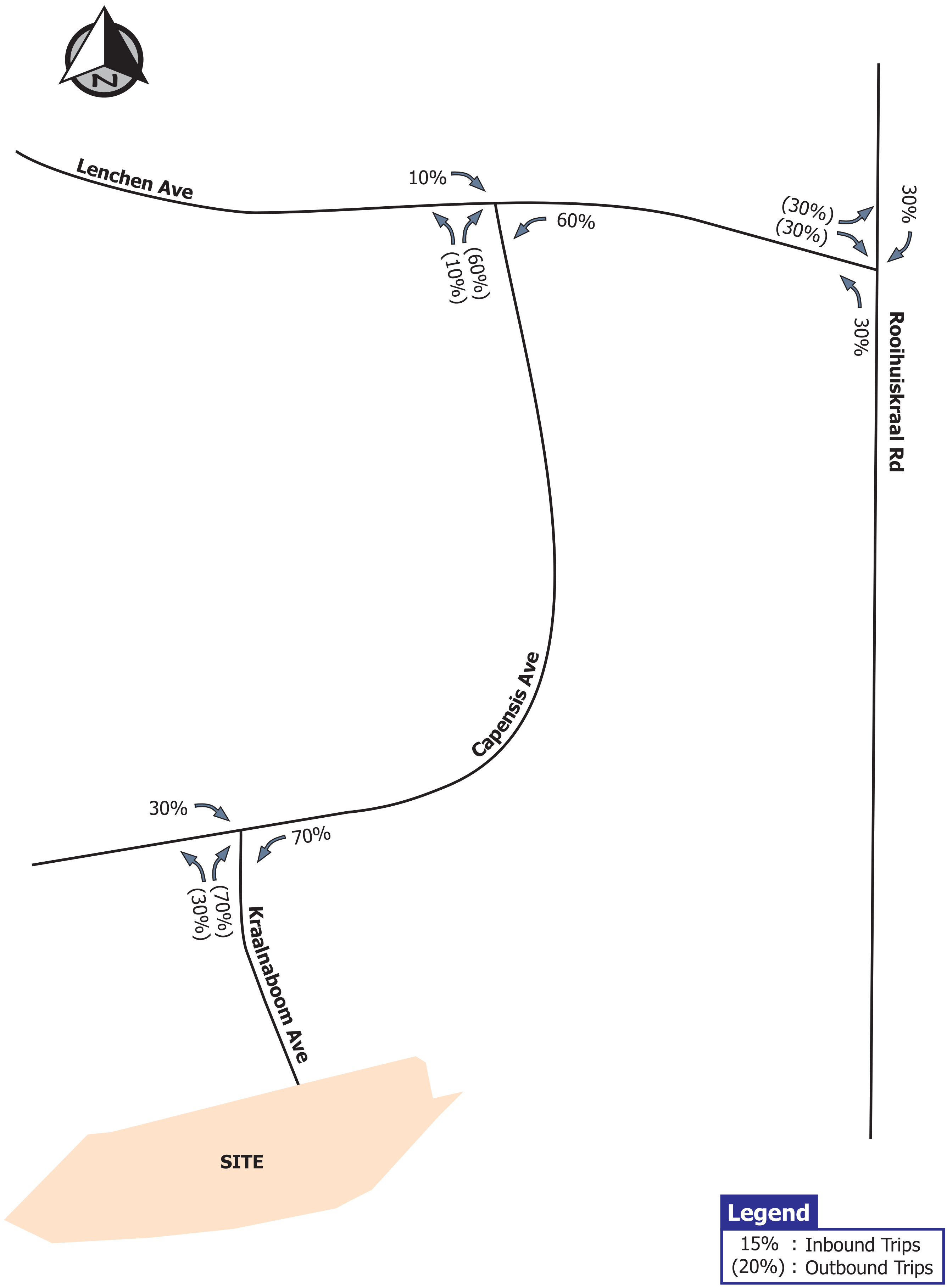
Dhubecon
CONSULTING ENGINEERS

Project Name	Rooihuiskraal Noord Ext 29	Proj Ref.	P0213
Description	**Existing 2014 Peak Hour Traffic Volumes**	Figure	**5**



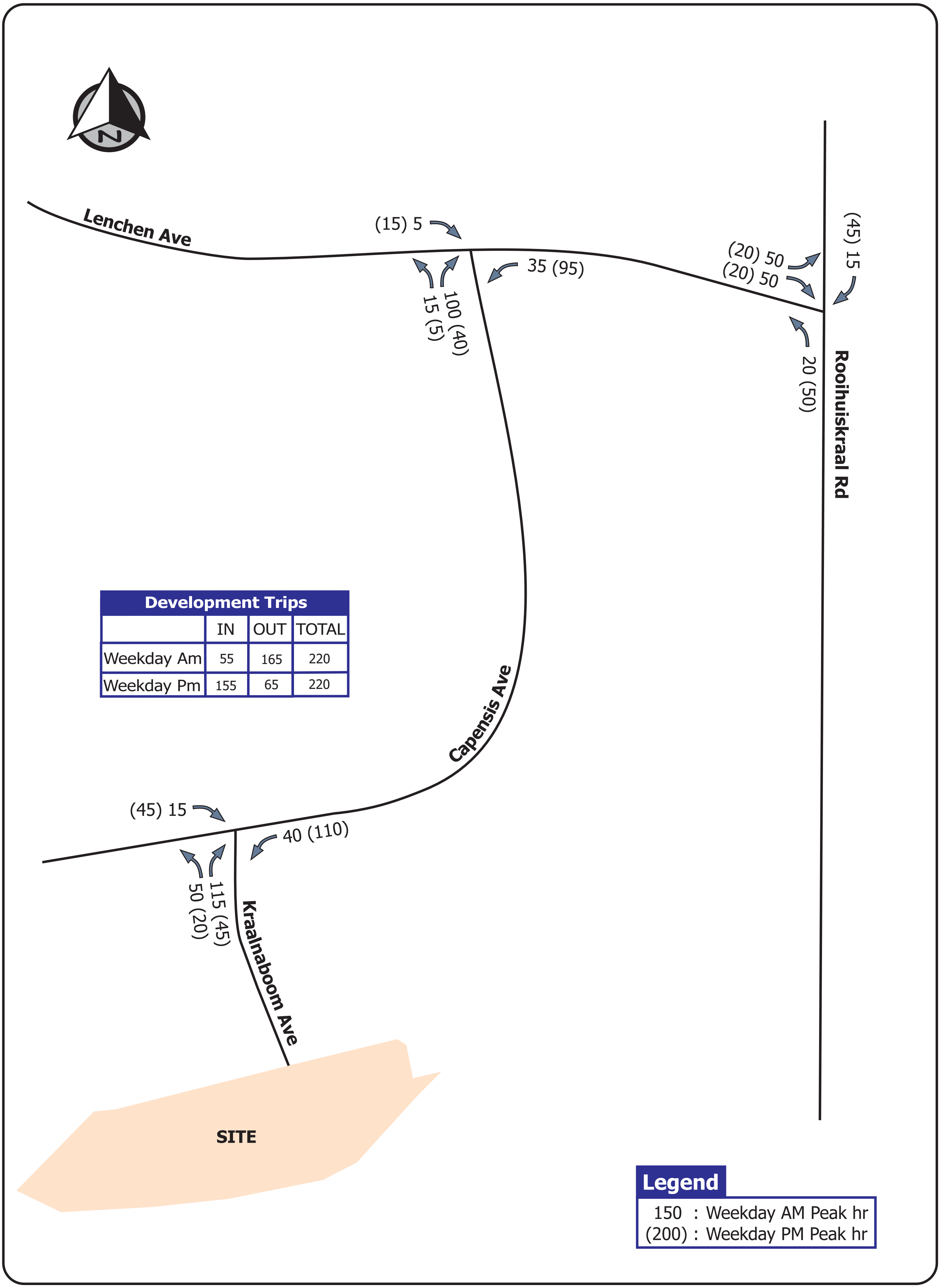
Dhubecon
CONSULTING ENGINEERS

Project Name Rooihuiskraal Noord Ext 29	Proj Ref. P0213
Description **Future 2019 Base Peak Hour Traffic Volumes (Incl. Latent Rights)**	Figure **6**



Dhubecon
CONSULTING ENGINEERS

Project Name	Rooihuiskraal Noord Ext 29	Proj Ref. P0213
Description	**Expected Trip Distribution**	Figure **7**



Development Trips

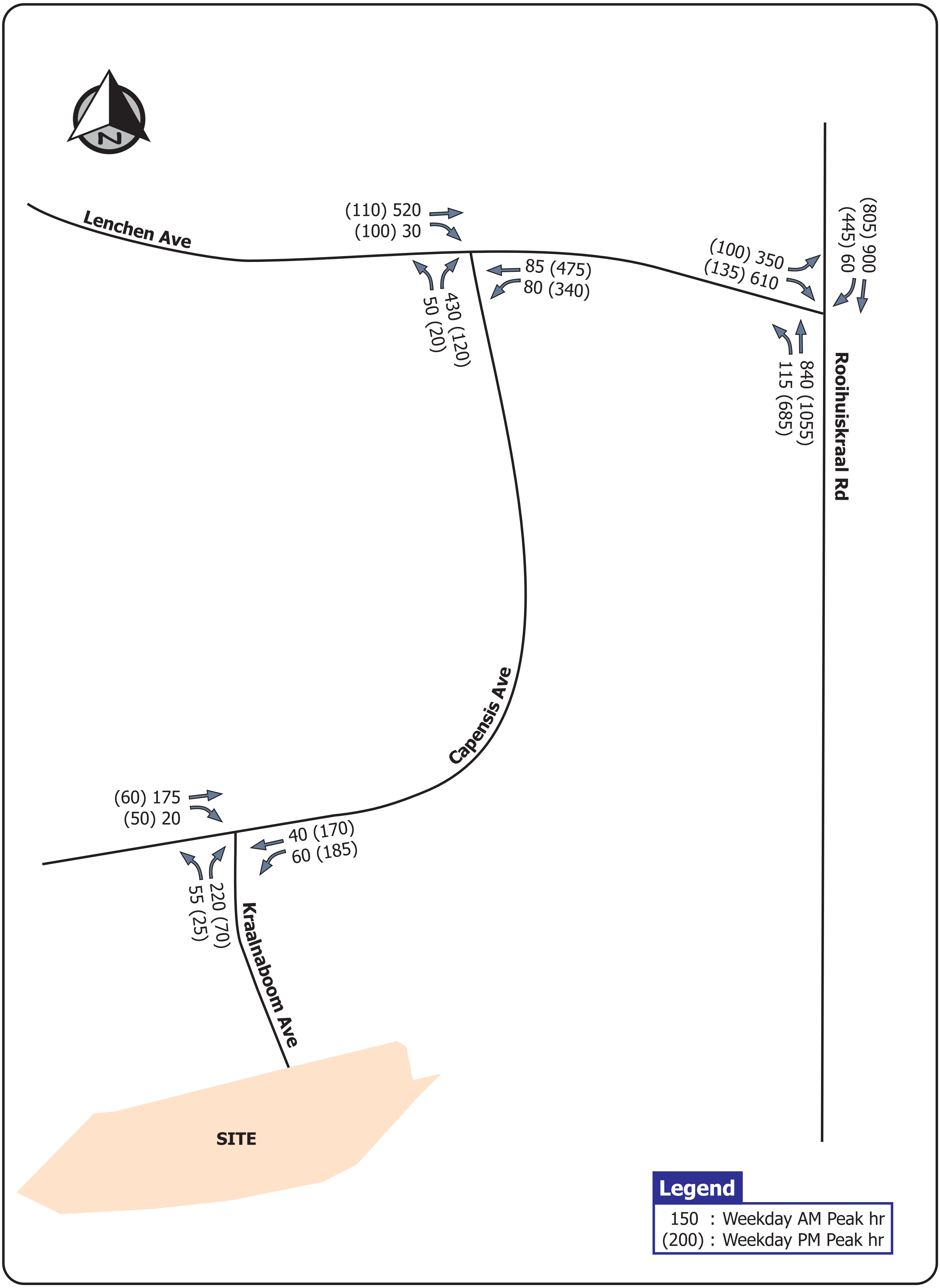
	IN	OUT	TOTAL
Weekday Am	55	165	220
Weekday Pm	155	65	220

Legend

150 : Weekday AM Peak hr
(200) : Weekday PM Peak hr

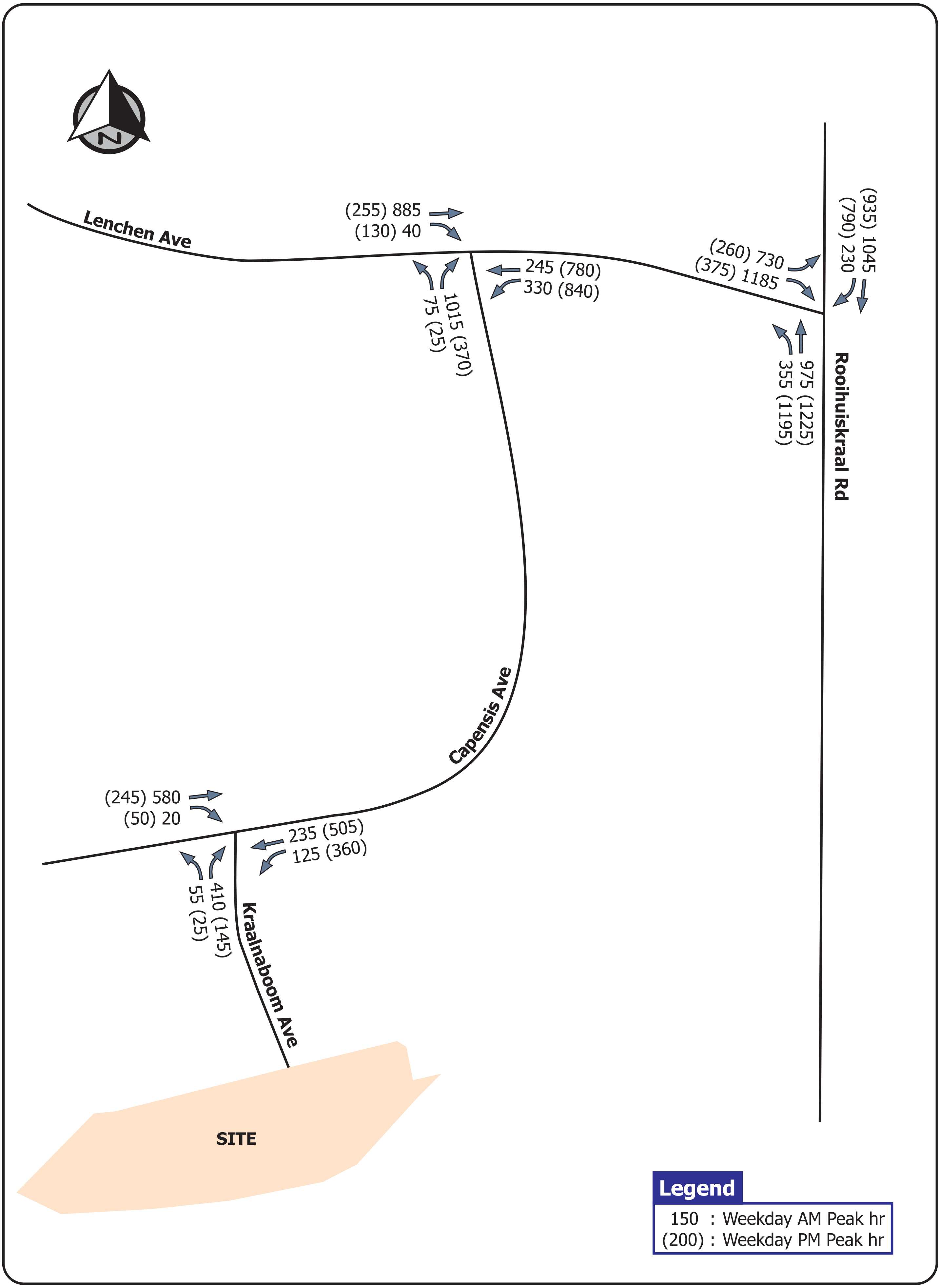
Dhubecon
CONSULTING ENGINEERS

Project Name	Rooihuiskraal Noord Ext 29	Proj Ref. P0213
Description	**Estimated Development Trips**	Figure **8**



Dhubecon
CONSULTING ENGINEERS

Project Name	Rooihuiskraal Noord Ext 29	Proj Ref. P0213
Description	**Existing 2014 Peak Hour Traffic PLUS Total Development Trips**	Figure **9**



Dhubecon
CONSULTING ENGINEERS

Project Name
Rooihuiskraal Noord Ext 29

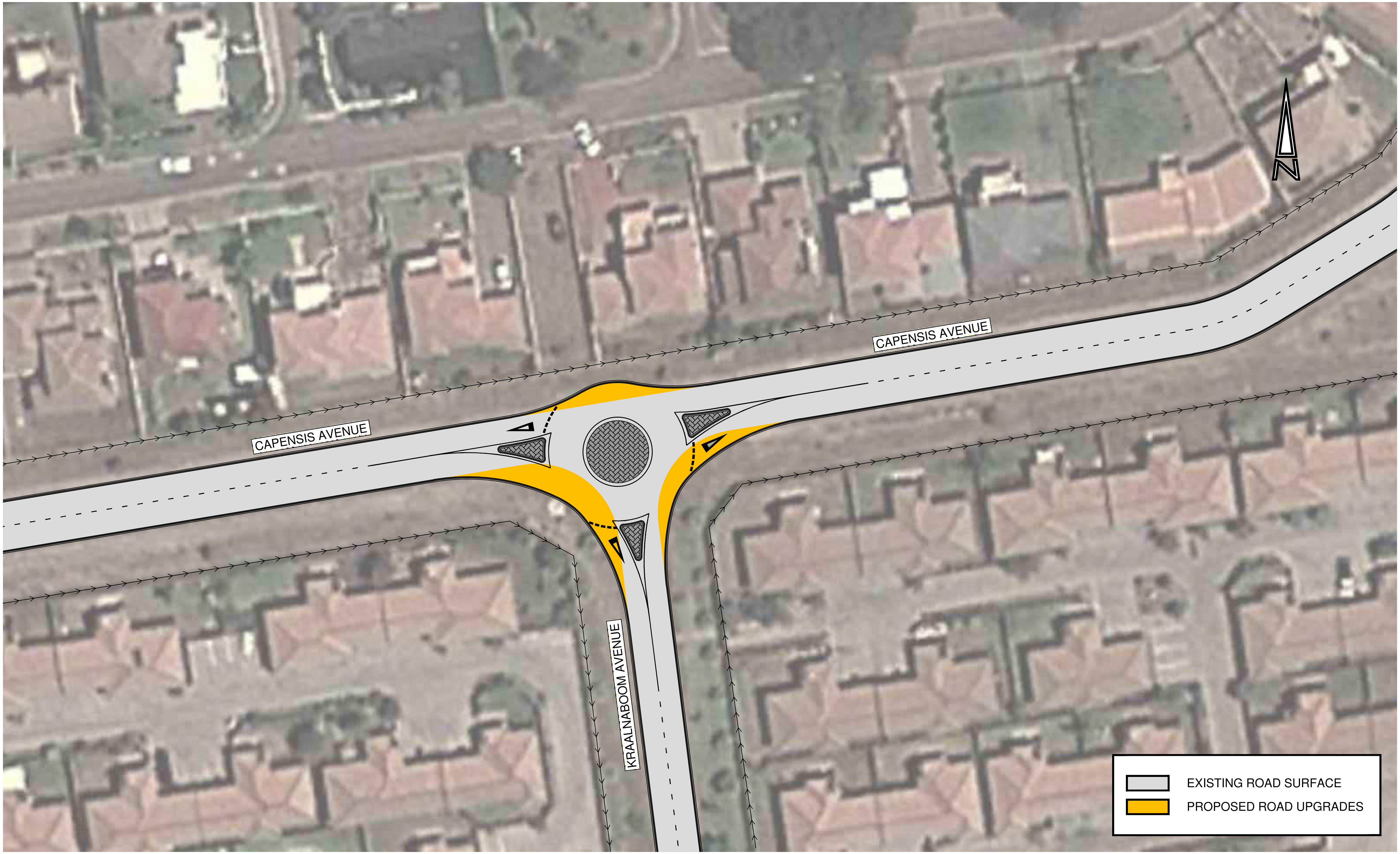
Proj Ref.
P0213

Description
Future 2019 Base Peak Hour with “Latent Rights” PLUS Total Development Trips

Figure
10

Drawings

Drawing No 0213/CL/01	Proposed Road Upgrades – Capensis Avenue & Kraalnaboom Avenue Intersection
Drawing No 0213/CL/02	Proposed Road Upgrades – Lenchen Avenue & Capensis Avenue Intersection
Drawing No 0213/CL/03	Proposed Road Upgrades – Lenchen Avenue & Rooihuiskraal Road Intersection



REV	DATE	BY	DESCRIPTION	CHK	APD

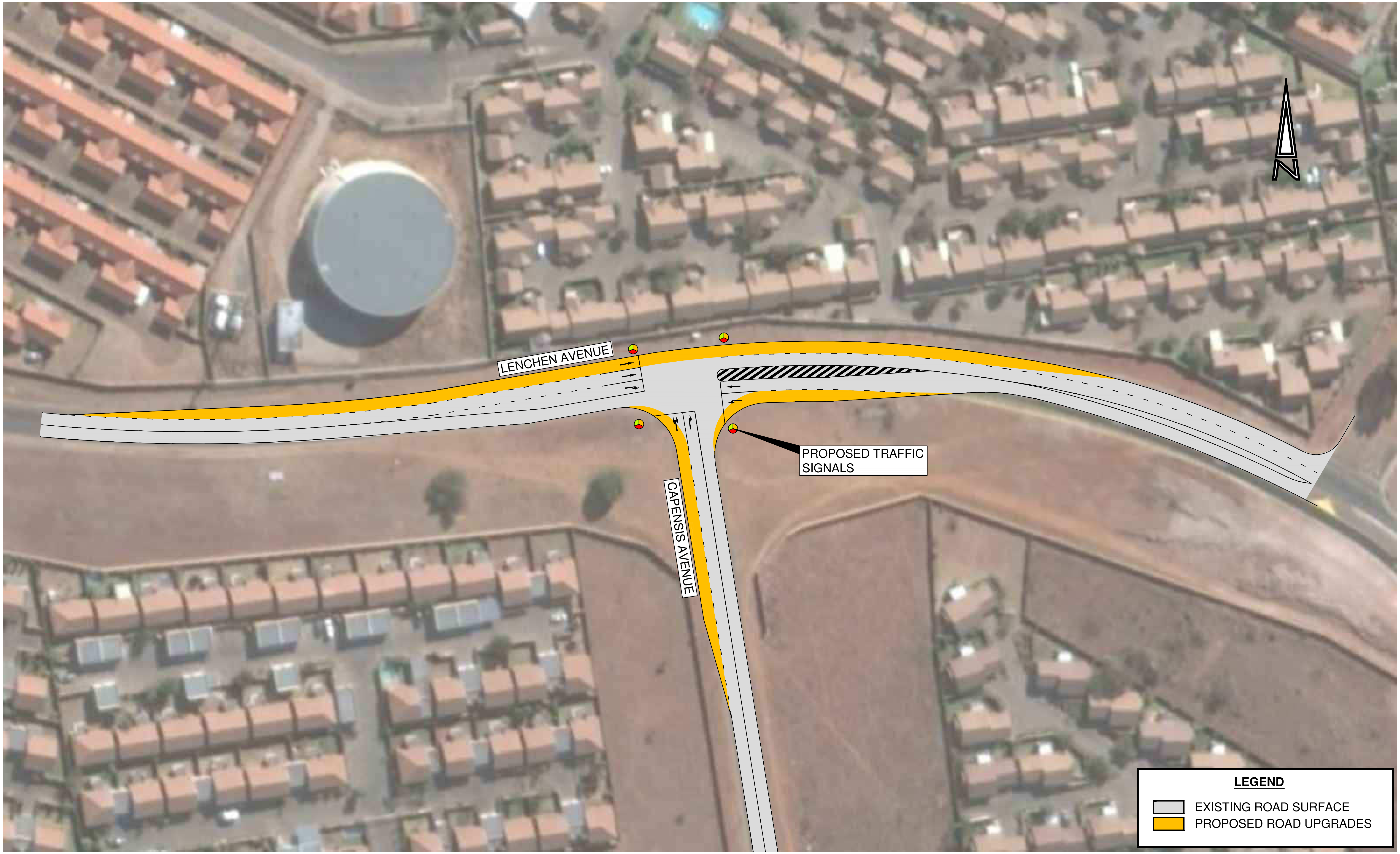
DRAWING STATUS:
TRAFFIC IMPACT ASSESSMENT

Dhubecon Consulting Engineers
2nd Floor, Soetdoring Building
Soetdoring Office Park
Cnr Lupin & Protea
Doringkloof, Centurion
Tel 012 667 5531

PROJECT:
ROOIHUISKRAAL NOORD EXTENSION 29

TITLE:
PROPOSED INTESECTION UPGRADE :
CAPENSIS AVENUE & KRAALNABOOM AVENUE

SCALE : 1:500
CHECKED: D HUNDERMARK
APPROVED: D HUNDERMARK
DESIGN: -
DRAWN: HW BASSON
DATE: 2014/05/28
PROJECT No: P02013
DRAWING No: 0213/CL/01
REV: -



REV	DATE	BY	DESCRIPTION	CHK	APD
-	2013 07 02	HB	INITIAL ISSUE	DH	DH

DRAWING STATUS:
TRAFFIC IMPACT ASSESSMENT

Dhubecon Consulting Engineers
2nd Floor, Soetdoring Building
Soetdoring Office Park
Cnr Lupin & Protea
Doringkloof, Centurion
Tel 012 667 5531

Dhubecon
CONSULTING ENGINEERS

PROJECT:
ROOIHUISKRAAL NOORD EXTENSION 29

TITLE:
PROPOSED INTERSECTION UPGRADE:
LENCHEN AVENUE & CAPENSIS AVENUE

SCALE : 1:1000	CHECKED: D HUNDERMARK	APPROVED: D HUNDERMARK
DESIGN: -	DRAWN: HW BASSON	DATE: 2014/06/02
PROJECT No: P0213	DRAWING No: 0213/CL/02	REV: -

LEGEND

▭	EXISTING ROAD SURFACE
🟩	PROPOSED ROAD UPGRADES BY OTHERS

-	2013 07 02	HB	INITIAL ISSUE	DH	DH
REV	DATE	BY	DESCRIPTION	CHK	APD

DRAWING STATUS:
TRAFFIC IMPACT ASSESSMENT

Dhubecon Consulting Engineers
2nd Floor, Soetdoring Building
Soetdoring Office Park
Cnr Lupin & Protea
Doringkloof, Centurion
Tel 012 667 5531

PROJECT:
ROOIHUISKRAAL NOORD EXTENSION 29

TITLE:
PROPOSED INTERSECTION UPGRADE:
LENCHEN AVENUE & ROOIHUISKRAAL ROAD

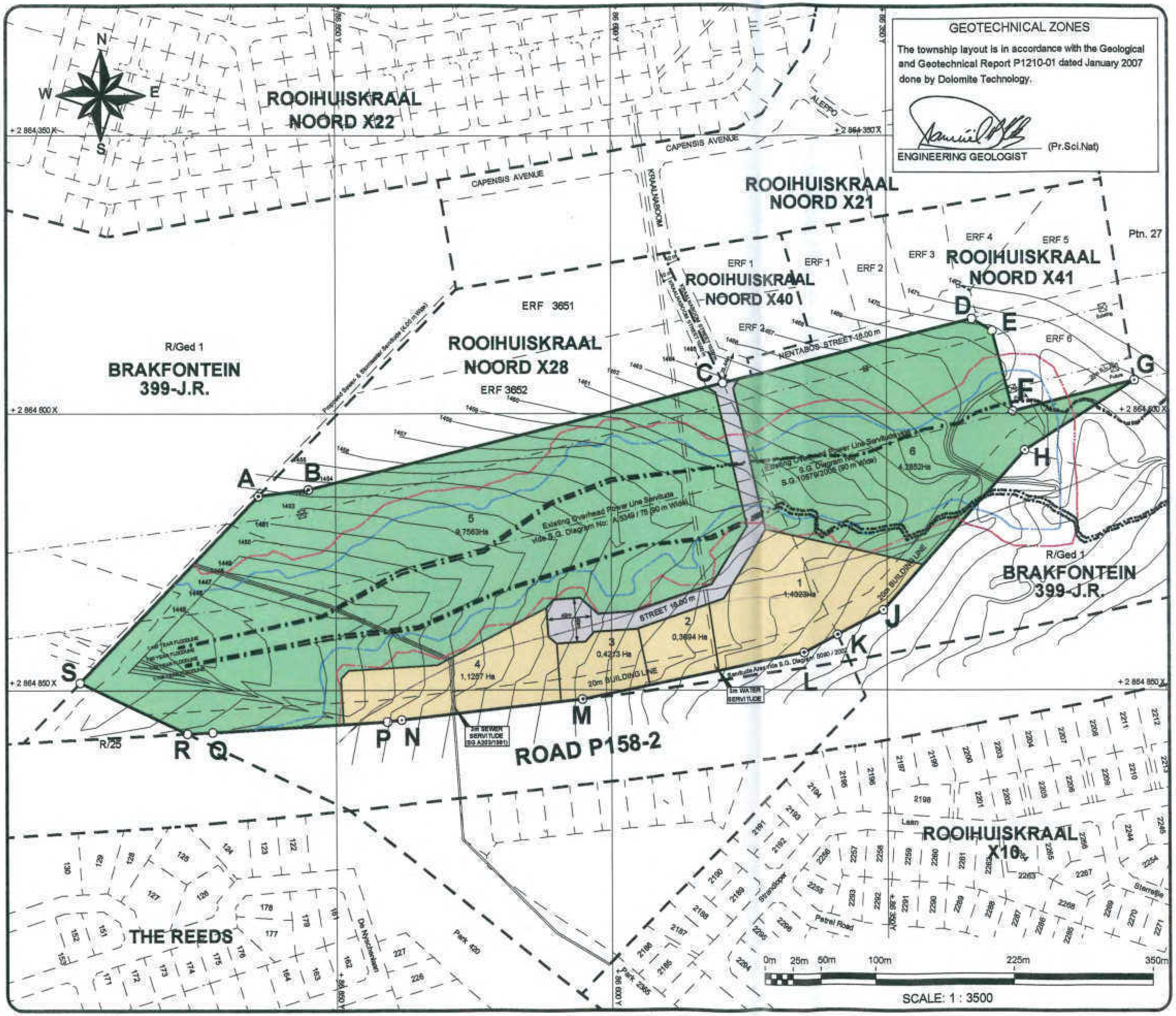
SCALE : 1:1000	CHECKED: D HUNDERMARK	APPROVED: D HUNDERMARK
DESIGN: -	DRAWN: HW BASSON	DATE: 2014/06/02
PROJECT No: P0213	DRAWING No: 0213/CL/03	REV: -

Annexures

Annexure A	Town Planner's Proposed Township Layout Plan
Annexure B	Relevant outputs of the SIDRA intersection capacity analyses

Annexure A

Town Planner’s Proposed Township Layout Plan



SCALE: 1 : 3500

GEOTECHNICAL ZONES

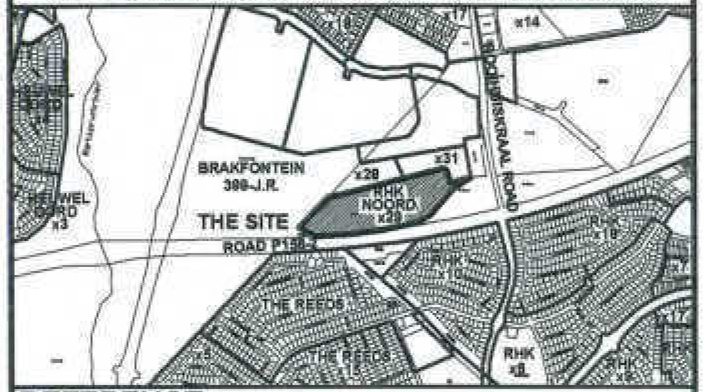
The township layout is in accordance with the Geological and Geotechnical Report P1210-01 dated January 2007 done by Dolomite Technology.

ENGINEERING GEOLOGIST (Pr.Sci.Nat)

PROPOSED TOWNSHIP

ROOIHUISKRAAL NOORD EXT.29

SITUATED ON PART OF RE OF PTN.9 AND A PART OF PORTION 145 OF THE FARM BRAKFONTEIN 399-JR



REFERENCE:

USES	ERF NO.	AMOUNT	AREA (m²)	%
RESIDENTIAL 3	ERVEN 1-4	4	33487m²	18,58%
PUBLIC OPEN SPACE	ERVEN 5-6	2	140415m²	77,92%
STREET			6298m²	3,49%
TOTAL		6	180200m²	100%

Min. Gradient of Streets:	1 : 45
Max. Gradient of Streets:	1 : 17
Total length of Streets:	350m
Date:	Last Amendment: DECEMBER 2012

NOTES:

1.) The figure A to S, A denotes the township boundary.

2.) All measurements are approximate.

3.) The figure — denotes a wetland.

4.) The line — represents the wetland buffer.

FLOOD LINE:

In terms of the Regulations of Article 144 (Act 36 of 1998), is hereby stated that this township is affected by a floodline with an expected frequency of ~~one every~~ 50 years and one every 100 years in the public stream.

PR. ING. 970122

CONTOURS:

The contours on this plan are in accordance with Regulation 18 (1)(a)(1) of the Townplanning- and Townships Ordinance, Ord. 15 of 1986.

The contours on this plan were obtained from Jack Marczak.

LOCAL AUTHORITY'S NUMBER: RHKNX29/05

PLAN NUMBER: D1212 / 09

LOCAL AUTHORITY: CITY OF TSHWANE

Plandev House
Highveld Office Park
Charles de Gaulle Crescent
Highveld
CENTURION
✉ 7710, Centurion, 0046
Tel: (012) 665-2330/1/2
Fax: (012) 665-2333
e-mail: plandev@iafrica.com

PLANDEV

Stads- en Streekbeplanners
Town- and Regional Planners

SCALE: 1 : 3500

DATE: MAY 2014

Annexure B

Relevant outputs of the SIDRA intersection capacity analyses

B1 – Capensis Avenue / Kraalnaboom Avenue;

B2 – Lenchen Avenue / Capensis Avenue;

B3 – Lenchen Avenue / Rooihuiskraal Road;

Annexure B1.1

SIDRA Output: Capensis Avenue / Kraalnaboom Avenue (Priority Stop Controlled)

Existing 2014 Weekday AM Peak Hour traffic flows (without development)

Two-Way Stop

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue Vehicles	85% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Kraalnaboom											
1	L	5	0.0	0.180	13.3	LOS B	0.6	3.8	0.41	0.71	44.5
3	R	111	0.0	0.180	13.1	LOS B	0.6	3.8	0.41	0.92	44.7
Approach		116	0.0	0.180	13.1	LOS B	0.6	3.8	0.41	0.91	44.6
East: Capensis											
4	L	21	0.0	0.033	8.2	LOS A	0.0	0.0	0.00	0.89	49.0
5	T	42	0.0	0.033	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		63	0.0	0.033	2.7	NA	0.0	0.0	0.00	0.30	55.8
West: Capensis											
11	T	184	0.0	0.098	0.2	LOS A	0.4	3.0	0.18	0.00	56.6
12	R	5	0.0	0.098	8.7	LOS A	0.4	3.0	0.18	1.04	48.9
Approach		189	0.0	0.098	0.5	NA	0.4	3.0	0.18	0.03	56.3
All Vehicles		368	0.0	0.180	4.8	NA	0.6	3.8	0.22	0.35	52.0

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B1.2

SIDRA Output: Capensis Avenue / Kraalnaboom Avenue (Priority Stop Controlled)

Existing 2014 Weekday PM Peak Hour traffic flows (without development)

Two-Way Stop

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Kraalnaboom											
1	L	5	0.0	0.050	13.4	LOS B	0.1	1.0	0.44	0.79	44.5
3	R	26	0.0	0.050	13.2	LOS B	0.1	1.0	0.44	0.89	44.7
Approach		32	0.0	0.050	13.2	LOS B	0.1	1.0	0.44	0.88	44.7
East: Capensis											
4	L	79	0.0	0.134	8.2	LOS A	0.0	0.0	0.00	0.91	49.0
5	T	179	0.0	0.134	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		258	0.0	0.134	2.5	NA	0.0	0.0	0.00	0.28	56.1
West: Capensis											
11	T	63	0.0	0.037	1.1	LOS A	0.2	1.2	0.38	0.00	53.0
12	R	5	0.0	0.037	9.5	LOS A	0.2	1.2	0.38	0.93	49.0
Approach		68	0.0	0.037	1.7	NA	0.2	1.2	0.38	0.07	52.7
All Vehicles		358	0.0	0.134	3.3	NA	0.2	1.2	0.11	0.29	54.2

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B1.3

SIDRA Output: Capensis Avenue / Kraalnaboom Avenue (Priority Stop Controlled)

Future 2019 Base Weekday AM Peak Hour traffic flows with Latent Rights (WITHOUT Development)

Two-Way Stop

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Kraalnaboom											
1	L	5	0.0	1.815	782.3	LOS F	71.2	497.5	1.00	6.41	2.7
3	R	311	0.0	1.815	782.1	LOS F	71.2	497.5	1.00	4.92	2.6
Approach		316	0.0	1.815	782.1	LOS F	71.2	497.5	1.00	4.95	2.6
East: Capensis											
4	L	89	0.0	0.175	8.2	LOS A	0.0	0.0	0.00	0.93	49.0
5	T	247	0.0	0.175	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		337	0.0	0.175	2.2	NA	0.0	0.0	0.00	0.25	56.6
West: Capensis											
11	T	611	0.0	0.318	2.2	LOS A	2.3	15.8	0.60	0.00	50.0
12	R	5	0.0	0.318	10.7	LOS B	2.3	15.8	0.60	0.98	49.3
Approach		616	0.0	0.318	2.3	NA	2.3	15.8	0.60	0.01	50.0
All Vehicles		1268	0.0	1.815	196.4	NA	71.2	497.5	0.54	1.30	9.3

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B1.4

SIDRA Output: Capensis Avenue / Kraalnaboom Avenue (UPGRADE - Roundabout)

Future 2019 Base Weekday AM Peak Hour traffic flows with Latent Rights (WITHOUT Development) – With Proposed Upgrade

Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue Vehicles	85% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Kraalnaboom											
1	L	5	0.0	0.318	10.6	LOS B	1.4	9.5	0.49	0.72	46.3
3	R	311	0.0	0.318	12.4	LOS B	1.4	9.5	0.49	0.74	44.8
Approach		316	0.0	0.318	12.4	LOS B	1.4	9.5	0.49	0.74	44.8
East: Capensis											
4	L	89	0.0	0.212	8.8	LOS A	1.1	7.4	0.06	0.74	48.1
5	T	247	0.0	0.212	7.5	LOS A	1.1	7.4	0.06	0.59	49.4
Approach		337	0.0	0.212	7.8	LOS A	1.1	7.4	0.06	0.63	49.1
West: Capensis											
11	T	611	0.0	0.653	12.0	LOS B	5.0	34.8	0.78	0.83	45.0
12	R	5	0.0	0.653	15.2	LOS B	5.0	34.8	0.78	0.88	43.1
Approach		616	0.0	0.653	12.0	LOS B	5.0	34.8	0.78	0.83	45.0
All Vehicles		1268	0.0	0.653	11.0	LOS B	5.0	34.8	0.52	0.75	46.0

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B1.5

SIDRA Output: Capensis Avenue / Kraalnaboom Avenue (Priority Stop Controlled)

Future 2019 Base Weekday PM Peak Hour traffic flows with Latent Rights (WITHOUT Development)

Two-Way Stop

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Kraalnaboom											
1	L	5	0.0	0.651	48.2	LOS E	2.3	16.2	0.92	1.21	26.2
3	R	105	0.0	0.651	48.0	LOS E	2.3	16.2	0.92	1.17	26.3
Approach		111	0.0	0.651	48.0	LOS E	2.3	16.2	0.92	1.17	26.3
East: Capensis											
4	L	263	0.0	0.414	8.2	LOS A	0.0	0.0	0.00	0.89	49.0
5	T	532	0.0	0.414	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		795	0.0	0.414	2.7	NA	0.0	0.0	0.00	0.30	55.8
West: Capensis											
11	T	258	0.0	0.143	6.9	LOS A	1.5	10.2	0.76	0.00	47.4
12	R	5	0.0	0.143	15.3	LOS C	1.5	10.2	0.76	1.05	45.2
Approach		263	0.0	0.143	7.1	NA	1.5	10.2	0.76	0.02	47.4
All Vehicles		1168	0.0	0.651	8.0	NA	2.3	16.2	0.26	0.32	48.7

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B1.6

SIDRA Output: Capensis Avenue / Kraalnaboom Avenue (Priority Stop Controlled)

Existing 2014 Weekday AM Peak Hour traffic flows (PLUS Development)

Two-Way Stop

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Kraalnaboom											
1	L	58	0.0	0.436	15.1	LOS C	2.1	14.6	0.45	0.77	43.0
3	R	232	0.0	0.436	14.9	LOS B	2.1	14.6	0.45	1.01	43.2
Approach		289	0.0	0.436	15.0	LOS B	2.1	14.6	0.45	0.96	43.1
East: Capensis											
4	L	63	0.0	0.056	8.2	LOS A	0.0	0.0	0.00	0.79	49.0
5	T	42	0.0	0.056	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		105	0.0	0.056	4.9	NA	0.0	0.0	0.00	0.47	52.9
West: Capensis											
11	T	184	0.0	0.111	0.4	LOS A	0.5	3.4	0.24	0.00	55.3
12	R	21	0.0	0.111	8.9	LOS A	0.5	3.4	0.24	0.96	48.8
Approach		205	0.0	0.111	1.3	NA	0.5	3.4	0.24	0.10	54.6
All Vehicles		600	0.0	0.436	8.5	NA	2.1	14.6	0.30	0.58	48.2

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B1.7

SIDRA Output: Capensis Avenue / Kraalnaboom Avenue (Priority Stop Controlled)

Existing 2014 Weekday PM Peak Hour traffic flows (PLUS Development)

Two-Way Stop

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Kraalnaboom											
1	L	26	0.0	0.177	14.9	LOS B	0.5	3.6	0.54	0.83	43.3
3	R	74	0.0	0.177	14.7	LOS B	0.5	3.6	0.54	0.98	43.5
Approach		100	0.0	0.177	14.8	LOS B	0.5	3.6	0.54	0.94	43.4
East: Capensis											
4	L	195	0.0	0.197	8.2	LOS A	0.0	0.0	0.00	0.81	49.0
5	T	179	0.0	0.197	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		374	0.0	0.197	4.3	NA	0.0	0.0	0.00	0.42	53.7
West: Capensis											
11	T	63	0.0	0.087	1.8	LOS A	0.3	2.4	0.44	0.00	51.0
12	R	53	0.0	0.087	10.3	LOS B	0.3	2.4	0.44	0.84	47.8
Approach		116	0.0	0.087	5.7	NA	0.3	2.4	0.44	0.38	49.5
All Vehicles		589	0.0	0.197	6.3	NA	0.5	3.6	0.18	0.50	50.8

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B1.8

SIDRA Output: Capensis Avenue / Kraalnaboom Avenue (UPGRADE - Roundabout)

Future 2019 Base Weekday AM Peak Hour traffic flows with Latent Rights (PLUS Development) – With Proposed Upgrade

Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Kraalnaboom											
1	L	58	0.0	0.480	10.9	LOS B	2.5	16.9	0.57	0.73	46.0
3	R	432	0.0	0.480	12.7	LOS B	2.5	16.9	0.57	0.75	44.5
Approach		489	0.0	0.480	12.5	LOS B	2.5	16.9	0.57	0.75	44.7
East: Capensis											
4	L	132	0.0	0.261	8.9	LOS A	1.4	9.8	0.14	0.69	47.8
5	T	247	0.0	0.261	7.6	LOS A	1.4	9.8	0.14	0.57	49.0
Approach		379	0.0	0.261	8.0	LOS A	1.4	9.8	0.14	0.61	48.6
West: Capensis											
11	T	611	0.0	0.775	17.5	LOS B	7.9	55.4	0.96	1.08	40.4
12	R	21	0.0	0.775	20.7	LOS C	7.9	55.4	0.96	1.09	39.0
Approach		632	0.0	0.775	17.6	LOS B	7.9	55.4	0.96	1.08	40.3
All Vehicles		1500	0.0	0.775	13.5	LOS B	7.9	55.4	0.63	0.85	43.6

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B1.9

SIDRA Output: Capensis Avenue / Kraalnaboom Avenue (UPGRADE - Roundabout)

Future 2019 Base Weekday PM Peak Hour traffic flows with Latent Rights (PLUS Development) – With Proposed Upgrade

Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue Vehicles	85% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Kraalnaboom											
1	L	26	0.0	0.239	12.5	LOS B	1.0	6.9	0.67	0.82	44.5
3	R	153	0.0	0.239	14.4	LOS B	1.0	6.9	0.67	0.83	43.1
Approach		179	0.0	0.239	14.1	LOS B	1.0	6.9	0.67	0.83	43.3
East: Capensis											
4	L	379	0.0	0.646	9.3	LOS A	5.3	37.0	0.37	0.64	47.2
5	T	532	0.0	0.646	8.0	LOS A	5.3	37.0	0.37	0.54	47.8
Approach		911	0.0	0.646	8.6	LOS A	5.3	37.0	0.37	0.58	47.5
West: Capensis											
11	T	258	0.0	0.285	8.5	LOS A	1.3	9.4	0.42	0.62	47.6
12	R	53	0.0	0.285	11.6	LOS B	1.3	9.4	0.42	0.75	45.8
Approach		311	0.0	0.285	9.0	LOS A	1.3	9.4	0.42	0.64	47.3
All Vehicles		1400	0.0	0.646	9.4	LOS A	5.3	37.0	0.42	0.63	46.9

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B2.1

SIDRA Output: Lenchen Avenue / Capensis Avenue (Priority Stop Controlled)

Existing 2014 Weekday AM Peak Hour traffic flows (without development)

Two-Way Stop

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Capensis											
1	L	37	0.0	0.765	36.3	LOS E	8.1	48.8	0.83	1.17	30.6
3	R	347	0.0	0.765	36.2	LOS E	8.1	48.8	0.83	1.42	30.7
Approach		384	0.0	0.765	36.3	LOS E	8.1	48.8	0.83	1.40	30.7
East: Lenchen											
4	L	47	0.0	0.026	8.2	LOS A	0.0	0.0	0.00	0.67	49.0
5	T	89	0.0	0.046	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		137	0.0	0.046	2.8	NA	0.0	0.0	0.00	0.23	55.7
West: Lenchen											
11	T	547	0.0	0.302	1.1	LOS A	2.3	13.8	0.44	0.00	52.2
12	R	26	0.0	0.302	9.4	LOS A	2.3	13.8	0.44	0.87	49.2
Approach		574	0.0	0.302	1.5	NA	2.3	13.8	0.44	0.04	52.0
All Vehicles		1095	0.0	0.765	13.9	NA	8.1	48.8	0.52	0.54	42.1

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B2.2

SIDRA Output: Lenchen Avenue / Capensis Avenue (Priority Stop Controlled)

Existing 2014 Weekday PM Peak Hour traffic flows (without development)

Two-Way Stop

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Capensis											
1	L	16	0.0	0.260	23.2	LOS C	1.0	6.0	0.79	1.02	37.5
3	R	84	0.0	0.260	23.2	LOS C	1.0	6.0	0.79	1.02	37.6
Approach		100	0.0	0.260	23.2	LOS C	1.0	6.0	0.79	1.02	37.6
East: Lenchen											
4	L	258	0.0	0.139	8.2	LOS A	0.0	0.0	0.00	0.67	49.0
5	T	500	0.0	0.256	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		758	0.0	0.256	2.8	NA	0.0	0.0	0.00	0.23	55.7
West: Lenchen											
11	T	116	0.0	0.243	9.6	LOS A	1.7	10.1	0.83	0.00	43.1
12	R	89	0.0	0.243	17.9	LOS C	1.7	10.1	0.83	1.01	41.7
Approach		205	0.0	0.243	13.2	NA	1.7	10.1	0.83	0.44	42.5
All Vehicles		1063	0.0	0.260	6.7	NA	1.7	10.1	0.23	0.34	50.4

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B2.3

SIDRA Output: Lenchen Avenue / Capensis Avenue (Signalised)

Future 2019 Base Weekday AM Peak Hour traffic flows with Latent Rights (WITHOUT Development)

Signals - Fixed Time Cycle Time = 90 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Capensis											
1	L	63	0.0	0.755	37.8	LOS D	18.6	111.4	0.95	0.88	29.3
3	R	963	0.0	0.755	37.9	LOS D	18.6	111.4	0.95	0.88	29.3
Approach		1026	0.0	0.755	37.9	LOS D	18.6	111.4	0.95	0.88	29.3
East: Lenchen											
4	L	311	0.0	0.750	28.1	LOS C	8.0	47.9	0.70	0.84	33.8
5	T	258	0.0	0.238	12.5	LOS B	5.5	32.8	0.58	0.49	42.9
Approach		568	0.0	0.750	21.0	LOS C	8.0	47.9	0.65	0.68	37.4
West: Lenchen											
11	T	932	0.0	0.431	14.1	LOS B	11.2	67.1	0.66	0.58	41.3
12	R	37	0.0	0.113	24.7	LOS C	0.9	5.3	0.62	0.73	35.7
Approach		968	0.0	0.431	14.5	LOS B	11.2	67.1	0.66	0.59	41.1
All Vehicles		2563	0.0	0.755	25.3	LOS C	18.6	111.4	0.77	0.73	34.7

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B2.4

SIDRA Output: Lenchen Avenue / Capensis Avenue (Signalised)

Future 2019 Base Weekday PM Peak Hour traffic flows with Latent Rights (WITHOUT Development)

Signals - Fixed Time Cycle Time = 65 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Capensis											
1	L	21	0.0	0.867	47.2	LOS D	6.2	37.0	1.00	1.00	26.0
3	R	347	0.0	0.867	47.3	LOS D	6.2	37.0	1.00	1.00	26.0
Approach		368	0.0	0.867	47.3	LOS D	6.2	37.0	1.00	1.00	26.0
East: Lenchen											
4	L	738	0.0	1.000	17.7	LOS B	9.7	58.4	1.00	0.89	40.3
5	T	868	0.0	0.594	5.1	LOS A	12.4	74.2	0.55	0.50	50.1
Approach		1605	0.0	1.000	10.9	LOS B	12.4	74.2	0.75	0.68	45.1
West: Lenchen											
11	T	268	0.0	0.092	3.1	LOS A	1.2	7.0	0.33	0.27	53.6
12	R	121	0.0	0.681	27.1	LOS C	3.3	19.7	0.79	0.91	34.3
Approach		389	0.0	0.681	10.6	LOS B	3.3	19.7	0.47	0.47	45.7
All Vehicles		2363	0.0	1.000	16.5	LOS B	12.4	74.2	0.75	0.69	40.5

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B2.5

SIDRA Output: Lenchen Avenue / Capensis Avenue (Priority Stop Controlled)

Existing 2014 Weekday AM Peak Hour traffic flows (PLUS Development)

Two-Way Stop

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue Vehicles	85% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Capensis											
1	L	53	0.0	1.043	113.9	LOS F	31.7	189.9	1.00	2.73	14.7
3	R	453	0.0	1.043	113.8	LOS F	31.7	189.9	1.00	2.68	14.7
Approach		505	0.0	1.043	113.8	LOS F	31.7	189.9	1.00	2.68	14.7
East: Lenchen											
4	L	84	0.0	0.045	8.2	LOS A	0.0	0.0	0.00	0.67	49.0
5	T	89	0.0	0.046	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		174	0.0	0.046	4.0	NA	0.0	0.0	0.00	0.32	54.1
West: Lenchen											
11	T	547	0.0	0.308	1.5	LOS A	2.4	14.6	0.51	0.00	51.2
12	R	32	0.0	0.308	9.8	LOS A	2.4	14.6	0.51	0.86	49.2
Approach		579	0.0	0.308	1.9	NA	2.4	14.6	0.51	0.05	51.1
All Vehicles		1258	0.0	1.043	47.1	NA	31.7	189.9	0.63	1.14	25.7

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B2.6

SIDRA Output: Lenchen Avenue / Capensis Avenue (Priority Stop Controlled)

Existing 2014 Weekday PM Peak Hour traffic flows (PLUS Development)

Two-Way Stop

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue Vehicles	85% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Capensis											
1	L	21	0.0	0.435	29.8	LOS D	2.0	12.0	0.85	1.11	33.7
3	R	126	0.0	0.435	29.7	LOS D	2.0	12.0	0.85	1.10	33.8
Approach		147	0.0	0.435	29.7	LOS D	2.0	12.0	0.85	1.10	33.8
East: Lenchen											
4	L	358	0.0	0.193	8.2	LOS A	0.0	0.0	0.00	0.67	49.0
5	T	500	0.0	0.256	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		858	0.0	0.256	3.4	NA	0.0	0.0	0.00	0.28	54.8
West: Lenchen											
11	T	116	0.0	0.316	13.1	LOS B	2.3	13.7	0.94	0.00	39.7
12	R	105	0.0	0.316	21.4	LOS C	2.3	13.7	0.94	1.05	39.1
Approach		221	0.0	0.316	17.0	NA	2.3	13.7	0.94	0.50	39.4
All Vehicles		1226	0.0	0.435	9.0	NA	2.3	13.7	0.27	0.42	47.9

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B2.7

SIDRA Output: Lenchen Avenue / Capensis Avenue (UPGRADE - Signalised)

Future 2019 Base Weekday AM Peak Hour traffic flows with Latent Rights (PLUS Development) – With Proposed Upgrade

Signals - Fixed Time Cycle Time = 90 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Capensis											
1	L	79	0.0	0.844	43.9	LOS D	23.5	141.3	0.99	0.94	27.1
3	R	1068	0.0	0.844	44.0	LOS D	23.5	141.3	0.99	0.94	27.1
Approach		1147	0.0	0.844	44.0	LOS D	23.5	141.3	0.99	0.94	27.1
East: Lenchen											
4	L	347	0.0	0.840	33.7	LOS C	9.7	58.4	0.81	0.88	31.1
5	T	258	0.0	0.238	12.5	LOS B	5.5	32.8	0.58	0.49	42.9
Approach		605	0.0	0.840	24.7	LOS C	9.7	58.4	0.71	0.71	35.2
West: Lenchen											
11	T	932	0.0	0.431	14.1	LOS B	11.2	67.1	0.66	0.58	41.3
12	R	42	0.0	0.133	25.6	LOS C	1.0	6.2	0.64	0.74	35.2
Approach		974	0.0	0.431	14.6	LOS B	11.2	67.1	0.66	0.59	41.0
All Vehicles		2726	0.0	0.844	29.2	LOS C	23.5	141.3	0.81	0.76	32.8

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B2.8

SIDRA Output: Lenchen Avenue / Capensis Avenue (UPGRADE - Signalised)

Future 2019 Base Weekday PM Peak Hour traffic flows with Latent Rights (PLUS Development) – With Proposed Upgrade

Signals - Fixed Time Cycle Time = 60 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Capensis											
1	L	26	0.0	0.903	47.5	LOS D	6.8	40.9	1.00	1.07	25.9
3	R	389	0.0	0.903	47.6	LOS D	6.8	40.9	1.00	1.07	25.9
Approach		416	0.0	0.903	47.6	LOS D	6.8	40.9	1.00	1.07	25.9
East: Lenchen											
4	L	736	0.0	1.000	17.7	LOS B	9.7	58.4	1.00	0.89	40.3
5	T	969	0.0	0.690	6.1	LOS A	15.2	91.4	0.65	0.59	48.2
Approach		1705	0.0	1.000	11.1	LOS B	15.2	91.4	0.80	0.72	44.5
West: Lenchen											
11	T	268	0.0	0.095	3.4	LOS A	1.2	7.1	0.36	0.29	53.2
12	R	137	0.0	0.735	31.5	LOS C	3.9	23.5	0.87	0.96	32.1
Approach		405	0.0	0.735	12.9	LOS B	3.9	23.5	0.53	0.52	43.5
All Vehicles		2526	0.0	1.000	17.4	LOS B	15.2	91.4	0.79	0.75	39.7

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B3.1

SIDRA Output: Lenchen Avenue / Rooihuiskraal Road (Signalised)

Existing 2014 Weekday AM Peak Hour traffic flows (without development)

Signals - Fixed Time Cycle Time = 60 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Rooihuiskraal											
1	L	100	0.0	0.165	21.9	LOS C	1.8	10.6	0.70	0.75	37.4
2	T	884	0.0	0.582	16.8	LOS B	9.5	57.0	0.86	0.74	38.8
Approach		984	0.0	0.582	17.3	LOS B	9.5	57.0	0.84	0.74	38.7
North: Rooihuiskraal											
8	T	947	0.0	0.416	8.5	LOS A	7.3	43.6	0.62	0.55	46.3
9	R	47	0.0	0.124	17.3	LOS B	0.6	3.7	0.75	0.72	40.7
Approach		995	0.0	0.416	8.9	LOS A	7.3	43.6	0.63	0.55	46.0
West: Lenchen											
10	L	316	0.0	0.320	28.5	LOS C	3.5	20.8	0.86	0.79	33.6
12	R	589	0.0	0.598	30.0	LOS C	7.1	42.4	0.93	0.82	33.0
Approach		905	0.0	0.598	29.5	LOS C	7.1	42.4	0.91	0.81	33.2
All Vehicles		2884	0.0	0.598	18.2	LOS B	9.5	57.0	0.79	0.70	38.8

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B3.2

SIDRA Output: Lenchen Avenue / Rooihuiskraal Road (Signalised)

Existing 2014 Weekday PM Peak Hour traffic flows (without development)

Signals - Fixed Time Cycle Time = 60 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Rooihuiskraal											
1	L	668	0.0	0.945	25.2	LOS C	14.6	87.7	0.91	0.89	35.4
2	T	1111	0.0	0.536	11.1	LOS B	10.0	60.1	0.73	0.64	43.6
Approach		1779	0.0	0.945	16.4	LOS B	14.6	87.7	0.80	0.74	40.1
North: Rooihuiskraal											
8	T	847	0.0	0.292	3.6	LOS A	4.2	25.0	0.40	0.35	52.7
9	R	421	0.0	0.949	50.9	LOS D	13.7	82.1	1.00	1.19	25.1
Approach		1268	0.0	0.949	19.3	LOS B	13.7	82.1	0.60	0.63	38.6
West: Lenchen											
10	L	84	0.0	0.213	36.7	LOS D	1.1	6.5	0.95	0.73	29.8
12	R	121	0.0	0.307	36.9	LOS D	1.6	9.5	0.96	0.74	29.9
Approach		205	0.0	0.307	36.8	LOS D	1.6	9.5	0.96	0.74	29.8
All Vehicles		3253	0.0	0.949	18.8	LOS B	14.6	87.7	0.73	0.70	38.7

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B3.3

SIDRA Output: Lenchen Avenue / Rooihuiskraal Road (Signalised)

Future 2019 Base Weekday AM Peak Hour traffic flows with Latent Rights (WITHOUT Development) – With Proposed Upgrade

Signals - Fixed Time Cycle Time = 70 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Rooihuiskraal											
1	L	353	0.0	0.706	32.3	LOS C	9.7	58.4	0.91	0.86	31.7
2	T	1026	0.0	0.826	29.9	LOS C	16.7	99.9	0.99	0.98	31.3
Approach		1379	0.0	0.826	30.5	LOS C	16.7	99.9	0.97	0.95	31.4
North: Rooihuiskraal											
8	T	1100	0.0	0.581	15.2	LOS B	12.5	75.0	0.79	0.70	40.1
9	R	226	0.0	0.785	29.1	LOS C	5.1	30.7	1.00	0.89	33.4
Approach		1326	0.0	0.785	17.6	LOS B	12.5	75.0	0.83	0.73	38.8
West: Lenchen											
10	L	716	0.0	0.592	26.8	LOS C	10.8	65.0	0.83	0.82	34.5
12	R	1195	0.0	0.815	33.8	LOS C	18.6	111.7	0.97	0.94	31.2
Approach		1911	0.0	0.815	31.2	LOS C	18.6	111.7	0.91	0.90	32.3
All Vehicles		4616	0.0	0.826	27.1	LOS C	18.6	111.7	0.91	0.86	33.6

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B3.4

SIDRA Output: Lenchen Avenue / Rooihuiskraal Road (Signalised)

Future 2019 Base Weekday PM Peak Hour traffic flows with Latent Rights (WITHOUT Development) – With Proposed Upgrade

Signals - Fixed Time Cycle Time = 100 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Rooihuiskraal											
1	L	677	0.0	1.000	24.7	LOS C	14.6	87.7	1.00	0.90	35.7
2	T	1818	0.0	0.665	10.4	LOS B	23.6	141.6	0.65	0.60	43.7
Approach		2495	0.0	1.000	14.3	LOS B	23.6	141.6	0.74	0.68	41.2
North: Rooihuiskraal											
8	T	1451	0.0	0.456	4.0	LOS A	10.8	64.6	0.37	0.34	51.8
9	R	318	0.0	1.003	97.5	LOS F	21.8	131.0	1.00	1.25	16.4
Approach		1768	0.0	1.003	20.8	LOS C	21.8	131.0	0.48	0.50	37.3
West: Lenchen											
10	L	253	0.0	0.640	57.6	LOS E	5.6	33.7	1.00	0.81	23.2
12	R	374	0.0	0.947	76.7	LOS E	10.3	61.9	1.00	1.09	19.4
Approach		626	0.0	0.947	69.0	LOS E	10.3	61.9	1.00	0.98	20.7
All Vehicles		4889	0.0	1.003	23.6	LOS C	23.6	141.6	0.68	0.65	35.4

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B3.5

SIDRA Output: Lenchen Avenue / Rooihuiskraal Road (Signalised)

Existing 2014 Weekday AM Peak Hour traffic flows (PLUS Development)

Signals - Fixed Time Cycle Time = 60 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Rooihuiskraal											
1	L	121	0.0	0.204	22.9	LOS C	2.2	13.3	0.73	0.76	36.8
2	T	884	0.0	0.610	17.7	LOS B	9.8	58.6	0.88	0.76	38.2
Approach		1005	0.0	0.610	18.3	LOS B	9.8	58.6	0.86	0.76	38.0
North: Rooihuiskraal											
8	T	947	0.0	0.429	9.2	LOS A	7.5	45.2	0.65	0.57	45.6
9	R	63	0.0	0.169	18.0	LOS B	0.9	5.1	0.78	0.73	40.2
Approach		1011	0.0	0.429	9.7	LOS A	7.5	45.2	0.66	0.58	45.3
West: Lenchen											
10	L	368	0.0	0.370	27.9	LOS C	4.3	25.6	0.85	0.79	33.9
12	R	642	0.0	0.610	29.3	LOS C	7.6	45.7	0.93	0.83	33.3
Approach		1011	0.0	0.610	28.8	LOS C	7.6	45.7	0.90	0.82	33.5
All Vehicles		3026	0.0	0.610	18.9	LOS B	9.8	58.6	0.81	0.72	38.3

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B3.6

SIDRA Output: Lenchen Avenue / Rooihuiskraal Road (Signalised)

Existing 2014 Weekday PM Peak Hour traffic flows (PLUS Development)

Signals - Fixed Time Cycle Time = 120 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Rooihuiskraal											
1	L	721	0.0	0.997	23.3	LOS C	14.6	87.7	1.00	0.90	36.5
2	T	1111	0.0	0.357	5.4	LOS A	9.7	58.1	0.37	0.33	50.7
Approach		1832	0.0	0.997	12.4	LOS B	14.6	87.7	0.62	0.56	44.0
North: Rooihuiskraal											
8	T	890	0.0	0.253	1.8	LOS A	4.3	26.0	0.21	0.18	56.0
9	R	426	0.0	1.000	40.4	LOS F	21.9	131.5	1.00	1.00	28.5
Approach		1316	0.0	1.000	14.3	LOS B	21.9	131.5	0.46	0.45	42.7
West: Lenchen											
10	L	105	0.0	0.534	72.4	LOS E	2.9	17.3	1.00	0.75	20.0
12	R	142	0.0	0.720	74.3	LOS E	4.0	24.1	1.00	0.82	19.8
Approach		247	0.0	0.720	73.5	LOS E	4.0	24.1	1.00	0.79	19.9
All Vehicles		3395	0.0	1.000	17.6	LOS B	21.9	131.5	0.59	0.53	40.0

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B3.7

SIDRA Output: Lenchen Avenue / Rooihuiskraal Road (Signalised)

Future 2019 Base Weekday AM Peak Hour traffic flows with Latent Rights (PLUS Development) – With Proposed Upgrade

Signals - Fixed Time Cycle Time = 90 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue Vehicles	85% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Rooihuiskraal											
1	L	374	0.0	0.293	8.5	LOS A	2.1	12.5	0.19	0.64	48.6
2	T	1026	0.0	0.777	32.6	LOS C	19.3	115.9	0.97	0.89	30.1
Approach		1400	0.0	0.777	26.2	LOS C	19.3	115.9	0.76	0.83	33.6
North: Rooihuiskraal											
8	T	1100	0.0	0.598	20.9	LOS C	16.5	98.9	0.82	0.73	36.2
9	R	242	0.0	0.770	56.9	LOS E	5.2	31.0	1.00	0.88	23.5
Approach		1342	0.0	0.770	27.4	LOS C	16.5	98.9	0.85	0.75	33.0
West: Lenchen											
10	L	768	0.0	0.587	28.0	LOS C	15.4	92.1	0.77	0.82	33.9
12	R	1247	0.0	0.787	32.7	LOS C	24.2	145.3	0.89	0.89	31.7
Approach		2016	0.0	0.787	30.9	LOS C	24.2	145.3	0.84	0.86	32.5
All Vehicles		4758	0.0	0.787	28.5	LOS C	24.2	145.3	0.82	0.82	32.9

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

Annexure B3.8

SIDRA Output: Lenchen Avenue / Rooihuiskraal Road (Signalised)

Future 2019 Base Weekday PM Peak Hour traffic flows with Latent Rights (PLUS Development) – With Proposed Upgrade

Signals - Fixed Time Cycle Time = 90 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	85% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Rooihuiskraal											
1	L	897	0.0	1.000	16.2	LOS B	14.6	87.7	0.64	0.86	41.7
2	T	1650	0.0	0.842	27.2	LOS C	31.6	189.3	0.95	0.92	32.3
Approach		2547	0.0	1.000	23.3	LOS C	31.6	189.3	0.84	0.90	35.1
North: Rooihuiskraal											
8	T	984	0.0	0.312	4.0	LOS A	6.3	37.9	0.36	0.32	52.4
9	R	832	0.0	0.971	54.1	LOS D	21.9	131.5	1.00	0.95	24.2
Approach		1816	0.0	0.971	27.0	LOS C	21.9	131.5	0.65	0.61	34.1
West: Lenchen											
10	L	274	0.0	0.554	49.9	LOS D	5.3	31.7	0.99	0.79	25.2
12	R	395	0.0	0.799	54.6	LOS D	8.3	50.1	1.00	0.92	24.1
Approach		668	0.0	0.799	52.7	LOS D	8.3	50.1	0.99	0.87	24.5
All Vehicles		5032	0.0	1.000	28.5	LOS C	31.6	189.3	0.79	0.79	32.9

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
HCM Delay Model used. Geometric Delay not included.

CITY OF
TSHWANE
IGNITING EXCELLENCE

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Dhubecon Consulting Engineers
Private Bag X 1028
LYTTELTON
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Attention: Desmund Hundermark

31 July 2014

Sir

TOWNSHIP ESTABLISHMENT: TRAFFIC IMPACT STUDY: ROOIHUISKRAAL NOORD EXTENSION 29

The Traffic Impact Study (report number P0213) compiled by Messrs Dhubecon Consulting Engineers dated June 2014 has reference.

1. TRAFFIC ENGINEERING AND OPERATIONS (LAND-USE & TRAFFIC IMPACT STUDIES) - Gerrit Oosthuizen – 012 358 3288

1.1 This applicant must comply with the access arrangements, parking demand and road upgrades as have been stated in the impact study. All road improvements as have been stated in this impact study must be in place before this Section will approve the issuing of the Section 101 certificate and or a Section 82 certificate or before the rights being promulgated, if approved.

1.2 This traffic impact study only evaluates the traffic operations and does evaluate neither the access positions nor the geometric designs. The approval of the Traffic Impact Study also does not imply that the alignment of any of the proposed roads is approved; therefore the applicant must comply with the following:

1.2.1 The recommendations made in this impact study must be included in a detailed Services Report, or amended Services Report, compiled by a Professional Civil Engineer, and submitted to this Division's Centurion offices for approval. The applicant must then enter into agreement with the Municipality for the required road works before the rights will be promulgated, if approved.

1.2.2 This Services Agreement requires that the applicant furnish the Municipality with a guarantee, to the satisfaction of the Head Legal and Secretarial Services and the Chief Financial Officer, for the total value of the road upgrades, which guarantee must remain in force until the works have been completed.

1.2.3 The Developer must take note that due to budget and financial constraints the CoT will not contribute towards the road upgrades. All road upgrades as stated in this traffic Impact study will therefore be for the cost of the applicant.

1.3 Conclusion and Recommendation:

The following conclusions and recommendations are for this Section in order, on condition that all geometrical design standards for roads can be met:

Based on the content of this document, the following key conclusions and recommendations are relevant:

1.3.1 This Traffic Impact Assessment had been prepared to form part of a township application for Rooihuiskraal Noord Extension 29, which is situated on a Part of the Remainder of Portion 9 and a Part of Portion 145 of the Farm Brakfontein 399-JR. A residential development is proposed comprising a maximum of 337 units/apartments at a density of 100 units/ha. Figures 1 and 2 show the location of the subject site. Due to flood lines only about 22% of the property can be developed.

1.3.2 A previous traffic impact study was done for the same site by ITS Engineers in March 2007, which was then for the development of 453 residential units. The current proposal is for only 337 units. The proposal also includes the possible development of place of child care on part of one of the erven.

1.3.3 Access:
Access to the site itself will be provided via Kraalnaboom Avenue. To provide access to the erven on which the residential units are proposed, an extension of Kraalnaboom Avenue will be required as shown in Figure 2 and in the township layout in Annexure A. The proposed extension of the road will also have to cross the wetland by means of a bridge structure.

1.3.4 Given the low order status and the very limited usage this proposed extension of Kraalnaboom Avenue will have and that it will only provide access to the residential erven on the subject site, the need for stacking distance investigation becomes irrelevant, especially if access to the erven is provided by only one access point. More detail regarding the actual site access and its stacking distance, and the number of in- and outbound lanes at the access/accesses will be provided as part of the Site Development Plan.

1.3.5 Trip Generation:
It is estimated that the proposed township as a whole will generate approximately 220vph (total IN plus OUT) during both the weekday AM and PM peak hours. Figure 8 shows the estimated development trips of the development as a whole in the study area.

1.3.6 This study also takes account of the traffic generations of other townships/developments in the area. The estimated traffic generations of those future developments had been incorporated in the projected future 2019 base traffic flows.

1.3.7 Road & Intersection Upgrades:
Based on the estimated additional traffic generations of the proposed development as a whole and its projected distribution onto the surrounding road network during the peak hours, the latent rights in the area, the capacity analyses in Section 5 as well as site our observations, the following road/intersection upgrades are proposed:

a) Capensis Ave / Kraalnaboom Ave Intersection: (Drawing No 0213/CL/01)
  - Upgrading of the existing priority stop controlled T-intersection to a new traffic circle to provide the necessary flow capacity. An inscribed diameter (i.e. outside diameter) of approximately 20m is proposed with one circulating traffic lane.
  - Since this proposed upgrade overlaps with the upgrades also required by other township, it is recommended that the costs of the upgrade be shared with the developers of Rooihuiskraal Noord Extensions 40-42.

b) Lenchen Ave / Capensis Ave Intersection: (Drawing No 0213/CL/02)
  - Upgrading from stop control to signalisation;
  - Additional through lane on the Lenchen Avenue western approach;
  - Additional right-turn lane on the Capensis Avenue approach.
  - Since this proposed upgrade overlaps with the upgrades also required by other townships, it is recommended that the costs of the upgrade be shared with the developer of Rooihuiskraal Noord Extensions 45-49.

c) Extension of Kraalnaboom Avenue:
  - Extension of Kraalnaboom Avenue form where it currently terminates up to the boundaries of the newly proposed erven as indicated in the township layout plan in Annexure A.

1.3.8 In the event of bulk engineering contributions payable with respect to roads and stormwater, it is recommended that the contributions be off-set against the proposed roads and intersection upgrades for the proposed development, especially for the new traffic circle proposed at the Capensis Avenue and Kraalnaboom Avenue intersection.

1.3.9 Non-Motorised & Public Transport:
- Since the proposed development will cater for the medium income market, it is expected that the majority of residents will make use of private vehicle transport. There will however be employees, such as domestic workers, that will make use of public transport in the form of minibus taxis and therefore it would be necessary to at least cater for pedestrians. In this case it is recommended that a paved sidewalk of 1.5m wide be constructed along one side of the required Kraalnaboom Avenue extension.
- From a traffic engineering perspective, the proposed Rooihuiskraal Noord Extension 29 is supported provided that the proposed external road/intersection upgrades and public transport facilities are implemented to the relevant design standards of the City of Tshwane Metropolitan Municipality.

1.4 The following general comments apply:

a) This support concerns the traffic impact analysis only. It does not imply that access and/or geometric designs for the intersection have been approved nor does this letter imply any conditions relating to the change in land-use process.

b) Access points and road upgrading of the road infrastructure will only be valid if all the geometric requirements that might be required by the Executive Director: Transportation Planning Division can be met. The planning design and construction of the access and road infrastructure shall be done in accordance with the latest specifications and no work inside the road reserve may be done before the written permission of this Division has been obtained.

c) The above mentioned design plans must be submitted to this Division for approval.

d) It is a requirement of CoT that surfaced pedestrian walkways of minimum 2.0 metres wide and a cycle path 3.5 metres wide, if space is available for the cycle path, be provided along the full length of the roadway bordering the property of the proposed developments. Details to be submitted to the CoT Roads and Stormwater Division for approval and the provision of a way leave prior to construction of these walkways. The walkways should be taken into consideration in the planning and design of the access to the development as well as the design of the road infrastructure.

e) The applicant will be responsible to obtain any additional road reserve that might be required for the provision of new roads or any additional lanes, applicable on this development.

f) Design and construction of traffic signals must be discussed with Mr.Chris Strydom of this Division.

g) Intersection capacity analysis results must be reported for all individual movements and not as averages. The reporting of average intersection capacity performance figures does not provide an accurate basis for evaluation. This is also in accordance with Section 3.3.2 of the *South African Traffic Impact and Site Traffic Assessment Standards and Requirements Manual* (TMH 16, Volume 2, Version 1.0, August 2012) as published by the Committee of Transport Officials (COTO). In future, please note the difference between reporting analysis results per movement and per approach.

2. COMMENTS BY DIVISION: ENVIRONMENTAL MANAGEMENT- Deputy Manager: Urban Forestry, Nursery and Training- Bertie Dry – 012 358 8813:

2.1 This application can only be supported by the Environmental Management Division (Urban Forestry) subject to the following conditions:

a) The proposed development may have no adverse impact on any existing street tree or result in the removal of any street tree. Should any form of road upgrading or road reserve upgrading or new entrances be contemplated, such upgrading must take existing street trees into consideration and integrate such trees within the overall planning solution.

The removal of street trees on account of such upgrading will not be supported and could result in the Division requesting an Environmental Impact Assessment. However, if any work needs to be done on the road reserve, the trees need to be protected in such a way as to ensure their survival. This includes clean cuts of branches and roots, and the treatment of said branches and roots with a tree seal and commercially available fungicide.

b) In order to prevent damage to trees, where heavy mechanical equipment, (eg TLB, graders) are to be used. The Urban Forestry Sub-section needs to be contacted beforehand, so that the necessary pruning actions can be carried out.

c) When working around individual trees, (above or below ground) all equipment and machinery used by the applicant or contractor must be cleaned or treated with a commercially available fungicide to prevent the spreading of disease from one tree to the next. This action must be carried out consequently between each new tree.

d) When planting trees on road reserves, the guidelines as laid down by the Environmental Management division must be adhered to at all times. These guidelines relate to the tree species used and, the planting distances,

e) Where the formalization of parking areas and/or road reserves are proposed, special care should be taken to ensure the provisioning of proper planting holes. A space of 2 x 2m is in this regard required around trees. The 4m^2 may not be subjected to compacting and any other ancillary negative development impacts.

f) No trees on the road reserve may be damaged or removed.

3. COMMENTS BY SUB-SECTION: INTEGRATED ROAD PLANNING -

(Ben Molleman - 012 358 3292)

3.1 On the traffic impact study prepared by Dhubecon Consulting Engineers dated June 2014; this section has the following comments which must be adhered to before final evaluation of the report can be considered:

3.1.1 The development rights will be limited to a maximum of 337 residential units.

3.1.2 The proposed upgrading of the Capensis Avenue/Kraalnaboom Avenue intersection (Drawing 0213/CL/01 of the study report) and the proposed upgrading and signalisation of the Lenchen Avenue/Capensis Avenue intersection (Drawing 0213/CL/02 of the study report) is a requirement for the implementation of the proposed development. Such upgrades can be offset against bulk contributions payable to the City of Tshwane (CoT) for roads and stormwater by the proposed development.

3.1.3 Written approval for this traffic impact study must be obtained from the Gauteng Department of Public Transport, Roads and Works (GAUTRANS).

3.1.4 All parking requirements of the proposed development must be accommodated on site in accordance with the City of Tshwane Town Planning Scheme of 2008. No parking in any road reserves will be allowed.

3.1.5 The provision of public transport and non-motorised transport facilities and infrastructure must be discussed and agreed with the Integrated Planning and Infrastructure Division of the Transport Department of the CoT.

3.1.6 All internal road works, provision of sidewalks and provision of on-site parking as well as any costs associated with the proposed access to the site will all be for the account of the developer.

3.1.7 Before any construction work of whatever nature will be allowed, the following is to be obtained by the Developer:

a) Way-leave approval from the metropolitan (CoT) and provincial (GAUTRANS) roads authority for work within the relevant road reserves.

b) For roads under the jurisdiction of the CoT, all detail design of all geometric aspects related to the access arrangements and external road improvements must be according to approved UTG and CoT standards. Approval of such detail designs must be obtained in writing from the CoT before construction can commence.

c) For roads under the jurisdiction of GAUTRANS, all detail design of all geometric aspects related to the access arrangements and external road improvements must be according to approved GAUTRANS standards. Approval of such detail designs must be obtained in writing from GAUTRANS before construction can commence.

Yours faithfully

For: ACTING EXECUTIVE DIRECTOR: TRANSPORTATION PLANNING DIVISION
RKW-TE-TIS-ROOIHUISKRAAL NOORD X 29-JULY 2014

Appendix G12

Engineering Geological and Geotechnical Report

ENGINEERING GEOLOGICAL AND GEOTECHNICAL REPORT FOR TOWNSHIP PLANNING PURPOSES FOR ROOIHUISKRAAL NORTH, EXTENSIONS 28, 29 AND 31, TSHWANE METROPOLITAN MUNICIPALITY, GAUTENG

CONSULTANT:

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D G Purnell
Engineering Geologist

CLIENT:

Johan Lewis

Report No.: **P1210-01**
Project No.: **1210-06P**

JANUARY 2007

DOLOMITE

TECHNOLOGY

Title :	***Engineering geological and geotechnical report for township planning purposes for Rooihuiskraal North, Extensions 28, 29 and 31, Tshwane Metropolitan Municipality***

Prepared by : *Dolomite Technology (Pty) Ltd*
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Client : *Johan Lewis*

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Keywords : *Geotechnical, engineering geological; foundations; potentially collapsible; granite*

Project No. : *1210-06*

Report No. : *P1210-01*

Project Team : *D G Purnell Pr Sci Nat*

Date : *January 2007*

Compiled by : *D G Purnell*

Approved for Dolomite Technology (Pty) Ltd

....

D G Purnell Pr Sci Nat

ENGINEERING GEOLOGICAL AND GEOTECHNICAL REPORT FOR TOWNSHIP PLANNING PURPOSES FOR ROOIHUISKRAAL NORTH, EXTENSIONS 28, 29 AND 31, TSHWANE METROPOLITAN MUNICIPALITY

EXECUTIVE SUMMARY

- *Johan Lewis appointed Dolomite Technology (Pty) Ltd verbally to undertake an engineering geological and geotechnical investigation for township planning purposes for Rooihuiskraal North Extensions 28, 29 and 31, Gauteng.*

- *The site is suitable for development as a township, providing the recommendations given in the report are followed. According to the classification of the NHBRC*[10.11] *the entire site can be classified as a H/C1 site. It should be noted that the scope of work for this investigation includes the classification of the site for purposes of township establishment; according to the Guidelines for Urban Engineering Geological Investigations* ***(see Section 11.11)*** *this investigation is classified as an Urban Development investigation. It does* ***not*** *include the NHBRC requirement for classification or certification of* ***individual stands.***

- *It should be noted that a non-perennial water course crosses the south-western part of the site, draining in a westerly direction. It is recommended that the Client should appoint a professional engineer to certify the flood lines. No permanent structures should be erected below the flood lines.*

- *The majority of the site is underlain by loose or potentially collapsible sands to depths of up to 0,6 m, and locally to 1,4 m. The implications and recommended treatment of the material and design of the structures are discussed in* ***Sections 8.5 to 8.7.***

- *As discussed in* ***Section 8.3****, problems due to heaving of the materials are not anticipated. However, as discussed in* ***Section 8.3****, a medium active layer occurs locally at depth, which could result in a heave of probably less than 6 mm. This should be borne in mind in the design of any structures to be constructed in the area.*

- *It should be noted that, although the recommendations given in* ***Sections 8.5*** *and* ***8.6*** *will reduce the likelihood of cracking of the structures founded in the upper 2,5 m of the soil profile, it is possible that minor cracking of structures founded above this depth could still occur.*

- *Seepage of groundwater into excavations can be anticipated. Therefore provision should be made for the removal of groundwater from excavations.*

- *Problems due to excavatibility of the materials are generally not anticipated to at least 2,0 m depth, providing a machine equivalent to a Komatsu WB93R back actor is used, although it should be noted that ferricrete hardpan can occur locally at shallower depths, which will probably require the use of power tools and possibly explosives for excavation.*

- *The sides of excavations will tend to be unstable, and should either be shored or else battered back.*

- *pH and conductivity tests carried out on representative samples of the materials underlying the site indicate that they are alkaline and that they are corrosive. Therefore underground services should be treated so as not be prone to alkaline or corrosive attack.*

- *As regards the suitability of the materials on site for founding conditions for roads, reference should be made to the laboratory test results in* ***Appendix A*** *and the summary of the results in* ***Table 1****. These results indicate that the subgrade conditions for roads are fair to reasonably good. In general the GMs are at least 0,75 and the PIs range from 5 to 14. The construction of reasonably economical paved roads is therefore possible. The in situ material should be compacted by means of a heavy vibrator roller prior to the placement of fill and/or pavement layers.*

ENGINEERING GEOLOGICAL AND GEOTECHNICAL REPORT FOR TOWNSHIP PLANNING PURPOSES FOR ROOIHUISKRAAL NORTH, EXTENSIONS 28, 29 AND 31, TSHWANE METROPOLITAN MUNICIPALITY

1. INTRODUCTION AND TERMS OF REFERENCE

1.1 Johan Lewis appointed Dolomite Technology (Pty) Ltd verbally to undertake an engineering geological and geotechnical investigation for township planning purposes for Rooihuiskraal North Extensions 28, 29 and 31, Gauteng.

2. PURPOSE OF THE INVESTIGATION

2.1 To determine the geological origin of the material on site.
2.2 To determine the engineering properties of the different material layers.
2.3 To give recommendations regarding the founding of proposed structures.

3. THE SITE

The site is in the order of 21 ha in area, being situated on portions of Remainder 1 of the farm Brakfontein 399-JR, approximately 16 km to the south-southwest of the Tshwane CBD, as shown on the **Locality Plan number 1210-06/01,** in **Appendix C.**

The site is bordered to the north by Rooihuiskraal North Extension 21, to the west and east by undeveloped portions of Remainder 1 of the farm Brakfontein 399-JR, and to the south by a proposed servitude for a new overhead power line route (to the south of which lies the N14 national road to Krugersdorp).

Townhouses are in the process of being constructed in Rooihuiskraal North Extension 28, in the north-west of the site. Some builders rubble has been dumped in Rooihuiskraal North Extension 31, particularly in the south of that area. An existing overhead power line crosses the southern part of the site in a west-southwest to east-northeast direction. This line is to be re-routed: the proposed new route for the overhead power lines is to be situated immediately to the south of the proposed township.

Apart from the townhouses in the north-west of the site, and the overhead power lines in the south, there are no structures on the site. There are no trees on the site. The site is covered with veld grass.

A non-perennial west-southwestward draining water course is situated to the south of the site, encroaching onto the site in the south-western corner of the site. The site drains steadily to the south, towards the water course.

4. GEOLOGY

According to the 1:50 000 scale Lyttelton geological map the site is underlain at depth by Archaean Granite of the Halfway House Granite Suite. The area is **not** underlain by dolomite.

5. CLIMATE

Rooihuiskraal Extensions 28, 29 and 31 lie in the Highveld climatic region of South Africa, the climate being described as warm termperate with summer rainfall.

The average daily maximum temperature is in order 28° C in January and 18° C in July. The rainy season is from October to April with an average rainfall in the order of 740 mm. Thornthwaite's classification indicates sub-humid, warm conditions with deficient moisture in all seasons. The Weinert N-value of the region is about 2,4 which indicates that predominantly chemical weathering of the underlying bedrock has taken plase.

6. METHOD OF INVESTIGATION

Eleven test pits were dug in a grid pattern on the site by means of a Komatsu WB93R back actor hired from Potlaki Plant Hire. The spacing of the test pits was in the order of 150 m. The test pits were dug to refusal or else to approximately 2,5 m depth and were fully profiled by an engineering geologist according to the standard method of Jennings et al. Section 11.2.

The bearing capacity of each layer was estimated, and disturbed samples of representative materials were taken in order to determine their physical properties by means of laboratory testing.

The material properties are summarized in **Table 1**, and the hand-held GPS co-ordinates of the test pits are provided in **Table 2** (at the back of the report after **Section 11).** The laboratory test results, test pit profiles, and the **site plan** with test pit positions **number P1210-06/02** are included in the **Appendices** to this report.

7. GENERALISED SOIL PROFILE

The site is underlain at depth by granite bedrock. In the majority of the site a Komatsu WB93R back actor was able to excavate to the weathered granite bedrock. In localized areas of the site a ferricrete hardpan layer has formed at a shallower level than the granite bedrock; in such areas the ferricrete hardpan caused refusal of the back actor.

Therefore the site is underlain by two distinct soil profiles, these being:

- where ferricrete hardpan has not developed and weathered granite bedrock is reached; and
- where ferricrete hardpan occurs.

7.1 Areas where granite bedrock is reached

0,0 – 0.4 m Dry to slightly moist, grey, apparently dense in profile but potentially collapsible, medium grained silty SAND with sub-angular quartzite pebbles up to 30 mm diameter between 0,3 and 0,4 m depth, plus occasional sub-rounded quartzite boulders up to 0,3 m diameter.
Transported.
P=30 kPa
Heave class = Low

0,4 – 0,7 m	Slightly moist to moist, grey blotched yellow-orange mottled black, very dense, partly cemented, medium grained sandy GRAVEL; angular iron concretions up to 20 mm diameter. Pedogenic. P=400 kPa Heave class = Low
0,7 – 1,6 m	Slightly moist, becoming very moist with depth, yellow-orange blotched light grey, very dense, medium grained silty SAND. Residual granite. P=300 kPa Heave class = Low
1,6 – 2,4 m	EITHER: Very moist, reddish-orange dense to very dense, medium grained silty SAND. Residual granite. P=150 to 200 kPa Heave class = Low OR: Very moist, yellow-orange blotched light grey, dense to very dense, medium grained silty SAND. Residual granite. P=200 kPa Heave class = Medium
2,4 – 2,45 m	Reddish-orange blotched grey, highly weathered, medium grained, very soft to soft ROCK; granite. P=600 kPa.

Where P= estimated bearing capacity of the layer, taking into account the soil structure and the possibility of future inundation.

In areas where weathered granite bedrock was encountered, refusal of a Komatsu WB93R back actor occurred on soft granite rock at an average depth of 2,45 m.

7.2 Areas where ferricrete hardpan occurred

0,0 – 0,5 m	Slightly moist, olive, apparently dense in profile but potentially collapsible, medium grained clayey SAND. Transported. P=30 kPa. Heave class = Low
0,5 – 0,55 m	Yellow-orange mottled black, cemented, ferricrete HARDPAN. Pedogenic. P=450 kPa.

In areas where ferricrete hardpan was encountered, refusal of a Komatsu WB93R back actor occurred on ferricrete hardpan at an average depth of 0,55 m beneath the natural ground surface.

7.3 General

Groundwater seepage occurred in 5 of the 11 test pits dug on the site, at an average depth of 0,9 m.

8. DISCUSSION

As discussed in **Section 7,** there are two generalized soil profiles underlying the site, one in areas where weathered granite bedrock can be reached, and the other where ferricrete hardpan is encountered at shallower depths. These generalized soil profiles are described in detail in **Section 7.** Summaries of the generalized soil profiles are as follows:

8.1 Areas where weathered granite bedrock is reached:

Soil type	**Depth (m)**	**Origin**	**Estimated bearing capacity (kPa)**	**Heave classification**
Grey, potentially collapsible, silty sand.	0,0 – 0,4	Transported	30	Low
Grey, very dense, sandy gravel	0,4 – 0,7	Pedogenic	400	Low
Yellow-orange, very dense, silty sand.	0,7 – 1,6	Residual granite	300	Low
EITHER: Reddish-orange, dense to very dense, silty sand	1,6 – 2,4	Residual granite	150 to 200	Low
OR: Yellow-orange, dense to very dense, silty sand	1,6 – 2,4	Residual granite	200	Medium
Reddish-orange, very soft to soft rock	2,4 – 2,45	Granite	600	

8.2 Areas where ferricrete hardpan occurred:

Soil type	**Depth (m)**	**Origin**	**Estimated bearing capacity (kPa)**	**Heave classification**
Olive, potentially collapsible, clayey sand	0,0 – 0,5	Transported	30	Low
Yellow-orange, ferricrete hardpan	0,5 – 0,55	Pedogenic	450	

8.3 As can be seen from the tables above, the majority of the materials encountered on the site had a low heave classification. However, it should be noted that a layer of residual granite, in the form of a silty sand, which occurred between approximately 1,6 m and 2,4 m depth, had a medium active heave classification. If the moisture content of this medium active layer was to increase from a dry to a wet condition, the maximum possible heave to be anticipated at the present ground surface would be in the order of 11 mm. However, it should be noted that the moisture content of the layer at the time of the investigation (December 2006) was very moist. Also, the layer occurs at a depth in the order of 1,5 m – beneath such a depth the moisture content of the soil profile characteristically remains reasonably constant. Therefore, providing measures are taken to maintain a reasonably constant moisture content of this layer, the maximum probable heave to be anticipated to be caused at the present ground surface by this layer should be less than 6 mm, such a heave would not normally require expensive precautionary measures to be taken in the design and construction of conventional non-sensitive structures. Nevertheless, it should be borne in mind during the design of any structures to be constructed in the area.

8.4 It should also be noted that the uppermost layer of the natural soil profile is generally a potentially collapsible clayey sand layer in the order of 0,5 m in thickness. This layer is generally immediately underlain by either a cemented ferricrete hardpan, or else by a dense to very dense, partly cemented layer with an estimated bearing capacity of at least 150 kPa. Therefore, in general it would be recommended that proposed structures should be founded upon the material underlying the potentially collapsible sand at a depth of at least 0,5 m beneath the present ground surface, with a maximum allowable bearing pressure of 150 kPa.

8.5 However, it must also be noted that in test pits number 4 and 11 the potentially collapsible transported sand layer is underlain to a depth in the order of 1,4 m by a potentially collapsible residual granite layer in the form of a clayey sand. It is possible that this potentially collapsible residual granite layer could occur locally in other parts of the site. If structures are founded upon this layer, settlement could take place, if the materials are inundated with water. Such settlement could result in cracking of the structures. To minimize the possibility of settlement of the structures it is recommended that the floors of foundation excavations should be compacted by a hand-operated vibratory roller or else by a machine equivalent to a Wacker Rammer (a mechanized tamping device); a test section should firstly be compacted under the supervision of the Engineer in order to determine the optimum number of roller passes. The structures can then be constructed by conventional means.

8.6 Additional precautionary measures that can be employed are the provision of expansion joints in the walls of the structures, a concrete walkway 1,0 m in width around the perimeter of each structure, and the shaping of the walkway and the ground surface in the vicinity of the structures so as to drain water away from each structure so that no ponding of surface water can take place in the vicinity of the structures.

8.7 It should be noted that the measured described in **Section 8.5** and **8.6** will minimize the possibility of cracks developing due to heaving or settlement of the ground, but that slight cracking of structures founded in the upper 2,5 m of the soil profile may still occur.

8.8 Proposed road routes should be compacted prior to the placement of fill by means of a heavy vibratory roller of at least 13 tonne static mass.

9. ZONING AS REGARDS TOWNSHIP DEVELOPMENT

According to the classification of the NHBRC, the site can be classified as Site Class H/C1. The site is **not underlain by dolomite.**

Using the classification proposed by Partridge et all [119] (see **Table 9.1** below), the site can be classified as 1A/2B/1C/2D/1F/1I.

TABLE 9.1 : 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 totaling 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 compressibility expected.	High soil-heave compressibility expected.
D	High 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^{s} within 50 years.	Mining-induced seismic activity more than 100 cm/s^{s}.	Natural seismic activity more than 100 sm/s^{s}.
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 localized occurrences of the constraint may arise.

10. CONCLUSIONS AND RECOMMENDATIONS

10.1 The site is suitable for development as a township, providing the recommendations given in the report are followed. According to the classification of the NHBRC [10.11] the entire site can be classified as a H/C1 site. It should be noted that the scope of work for this investigation includes the classification of the site for purposes of township establishment; according to the Guidelines for Urban Engineering Geological Investigations **(see Section 11.11)** this investigation is classified as an Urban Development investigation. It does **not** include the NHBRC requirement for classification or certification of **individual stands.**

10.2 It should be noted that a non-perennial water course crosses the south-western part of the site, draining in a westerly direction. It is recommended that the Client should appoint a professional engineer to certify the flood lines. No permanent structures should be erected below the flood lines.

10.3 The majority of the site is underlain by loose or potentially collapsible sands to depths of up to 0,6 m, and locally to 1,4 m. The implications and recommended treatment of the material and design of the structures are discussed in **Sections 8.5 to 8.7.**

10.4 As discussed in **Section 8.3**, problems due to heaving of the materials are not anticipated. However, as discussed in **Section 8.3**, a medium active layer occurs locally at depth, which could result in a heave of probably less than 6 mm. This should be borne in mind in the design of any structures to be constructed in the area.

10.5 It should be noted that, although the recommendations given in **Sections 8.5** and **8.6** will reduce the likelihood of cracking of the structures founded in the upper 2,5 m of the soil profile, it is possible that minor cracking of structures founded above this depth could still occur.

10.6 Seepage of groundwater into excavations can be anticipated. Therefore provision should be made for the removal of groundwater from excavations.

10.7 Problems due to excavatibility of the materials are generally not anticipated to at least 2,0 m depth, providing a machine equivalent to a Komatsu WB93R back actor is used, although it should be noted that ferricrete hardpan can occur locally at shallower depths, which will probably require the use of power tools and possibly explosives for excavation.

10.8 The sides of excavations will tend to be unstable, and should either be shored or else battered back.

10.9 pH and conductivity tests carried out on representative samples of the materials underlying the site indicate that they are alkaline and that they are corrosive. Therefore underground services should be treated so as not be prone to alkaline or corrosive attack.

10.10 As regards the suitability of the materials on site for founding conditions for roads, reference should be made to the laboratory test results in **Appendix A** and the summary of the results in **Table 1**. These results indicate that the subgrade conditions for roads are fair to reasonably good. In general the GMs are at least 0,75 and the PIs range from 5 to 14. The construction of reasonably economical paved roads is therefore possible. The in situ material should be compacted by means of a heavy vibrator roller prior to the placement of fill and/or pavement layers.

11. REFERENCES

11.1 Geological map

Number and title:	2528CC Lyttelton
Scale:	1:50 000
Date of publication:	1973
Source:	Government Printer

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11.10 National Home Builders Registration Council (1999). ***Home builders manual Parts 1 and 2.*** Revision no.1 February 1999.

11.11 SAIEG/SAICE (1996). ***Guidelines for Urban Engineering Geological Investigations.***

APPENDIX A

LABORATORY TEST RESULTS

MATROLAB GROUP (PTY.) LTD.
- CIVIL ENGINEERING SERVICES -

416 RUSTIC AVENUE SILVERTONDALE
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TEST RESULTS

DOLOMITE TECHNOLOGY (PTY) LTD
P.O. BOX 15147
LYTTELTON
0140
Attention: Mr Dave Purnell

Project Rooihuiskraal North 20+29+31

Your Ref

Our Ref 0/PL/35326

Date Reported 11.12.2006

AGGREGATE REPORT (TMH1:A20, A21T)

LAB NR	TP	DEPTH mm	DESCRIPTION	pH	Conductivity @ (S/m)
A9043 (RS1)	7	0-500	Olive Clayey Sand	7.60	0.0236
A9044 (RS2)	7	500-900	Grey Sandy Gravel	7.67	0.00699
A9045 (RS3)	7	900-2300	Yellow Orange Silty Sand	8.22	0.00909
A9049 (RS7)	10	0-800	Dk Grey Clayey Sand	7.84	0.0834
A9050 (RS8)	10	800-1400	Grey Silty Sand	8.06	0.0232
A9050 (RS9)	10	1400-2000	Lt Grey Sandy Clay	8.29	0.0696

Remarks :

Form: C1 Program ver 2.4

for MATROLAB GROUP (PTY) LTD.

1210

MATROLAB (EDMS.)BPK. (PTY.)LTD.
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AANDAG :
ATTENTION : Mr Dave Purnell

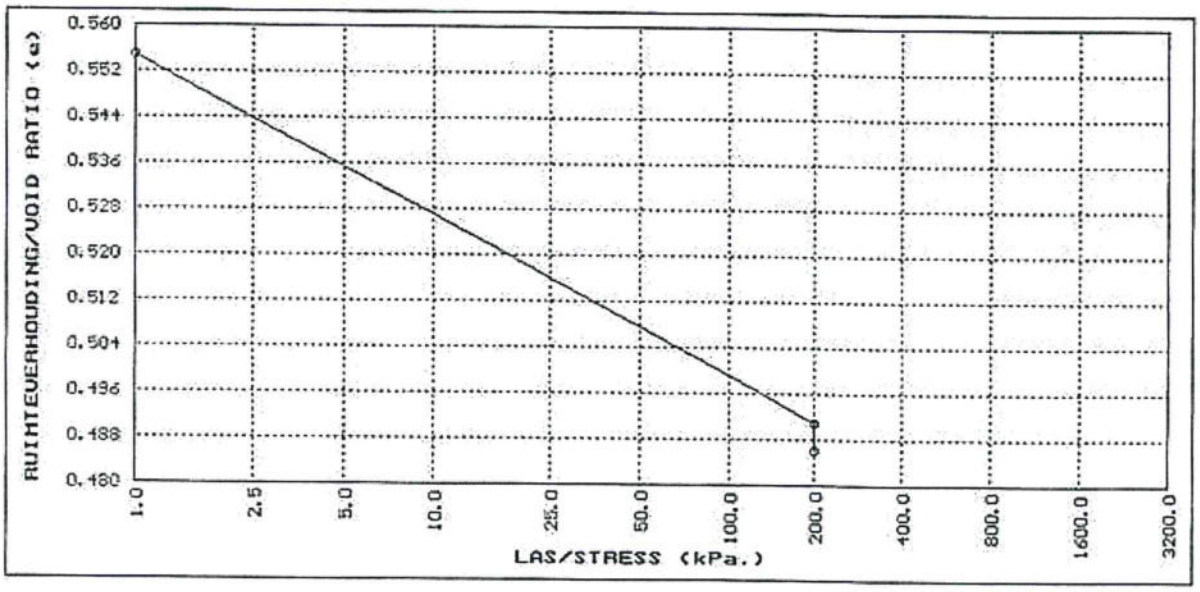
PROJEK :
PROJECT : ROOIHUISKRAAL 20,29+31
U VERW. :
YOUR REF. :
ONS VERW. :
OUR REF. : 0/PL/35326
DATUM GERAPPORTEER :
DATE REPORTED : 14/12/2006

SWIGPOTENSIAAL / COLLAPSE POTENTIAL (TMH6 : ST10)

MONSTER/SAMPLE NO: A9052(RS10) GAT/HOLE NO: 12 DIEPTE/DEPTH(mm): 1100
BESKRYWING/DESCRIPTION: ORANGE BROWN CLAYEY SAND

RELATIEWE DIGTHEID/RELATIVE DENSITY	2.620
DROE DIGTHEID / DRY DENSITY (kg/m³)	1685
VOGINHOUD VOOR TOETS/MOISTURE CONTENT BEFORE TEST (%)	6.2
VOGINHOUD NA TOETS/MOISTURE CONTENT AFTER TEST (%)	15.2
AANVANLIKE RUIMTEVERHOUDING/INITIAL VOID RATIO	0.555
SWIGPOTENSIAAL/COLLAPSE POTENTIAL (%)	0.32
SAAMDRUKBAARHEID/COMPRESSIBILITY (%)	4.12

STRESS (kPa.)	1	200	200												
VOID RATIO (e)	0.555	0.491	0.486												



OPMERKINGS/REMARKS:

VORM/FORM: ST10

Program ver 9.5

nms/for Matrolab (Edms.)Bpk./(Pty.)Ltd.

MATROLAB GROUP (PTY.) LTD.
- CIVIL ENGINEERING SERVICES -
Reg.No.: 2003/029180/07 - VAT. Reg.No.: 4040210587
a SANAS Accredited Testing Laboratory, No. T0025
418 RUSTIC AVE, SILVERTONDALE
P.O. BOX 912387 SILVERTON 0127
Tel. : 012-804 2050
Fax : 012-804 9555
Email: bennievn@matrolab.co.za

TEST RESULTS

DOLOMITE TECHNOLOGY (PTY) LTD
P.O. BOX 15147
LYTTELTON
0140
Attention: Mr Dave Purnell

Project : Rooihuiskraal North X28+29+31

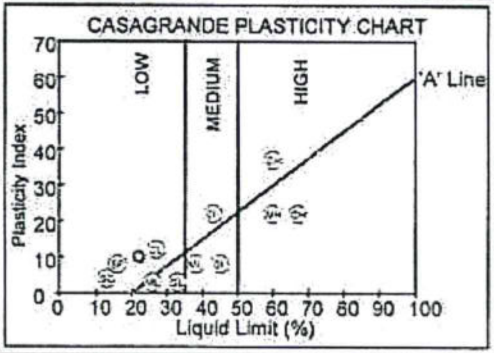
Your Ref :
Our Ref : 0/PL/35326
Date Reported : 13.12.2006

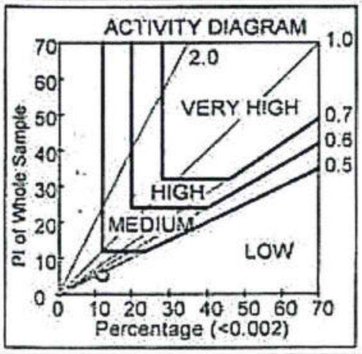
FOUNDATION INDICATOR (ASTM: D422)

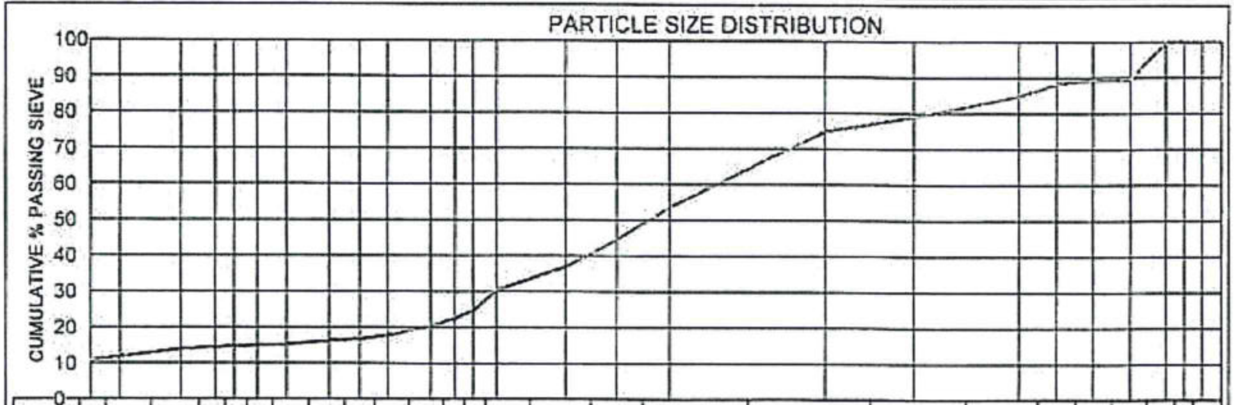
Sample No. : : 9043
Hole No. : : 7 RS1
Depth (mm) : : 0-500
Liquid Limit (%) : 22
Plasticity Index : 10
Linear Shrinkage (%) : 5.5
PI of Whole Sample : 5
P.R.A. Classification : A-2-4(0)
Unified Soil Classificatior. SC
Activity : 0.42
Heave Classification : LOW
Grading Modulus : 1.41
Percentage (<0.002) : 12.0
Moisture Content (%) : 11.5

Material Description : Olive Clayey Silty Gravelly Sand

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	14.5	8.1	52.3	25.2	SILTY SAND
Astm	14.5	15.9	48.6	21.1	SILTY SAND
British Standard	11.9	12.9	50.0	25.2	SILTY SAND







Sieve Size (mm)	0.0015	0.0020	0.0036	0.0050	0.0060	0.0075	0.0100	0.0150	0.0200	0.0260	0.0400	0.0500	0.0600	0.0750	0.1500	0.2500	0.4250	2.0000	4.7500	13.200	19.000	26.500	37.500	53.000	63.000	75.000
% Pass. Sieve	11	12	14	14	15	15	15	16	17	18	20	23	25	30	37	44	53	75	79	85	88	89	89	100	100	100

JENN CLAY | SILT | SAND | GRAVEL
ASTM CLAY | SILT | FINE SAND | MEDIUM SAND | COARSE SAND | GRAVEL
BS CLAY | FINE SILT | MEDIUM SILT | COARSE SILT | FINE SAND | MEDIUM SAND | COARSE SAND | FINE GRAVEL | MEDIUM GRAVEL | COARSE GRAVEL

Remarks :

FORM: A6

Program ver 2.6 (17.08.2006)

for MATROLAB GROUP (PTY) LTD.

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TEST RESULTS

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LYTTELTON
0140
Attention: Mr Dave Purnell

Project : Rooihuiskraal North X28+29+31

Your Ref :
Our Ref : 0/PL/35326
Date Reported : 13.12.2006

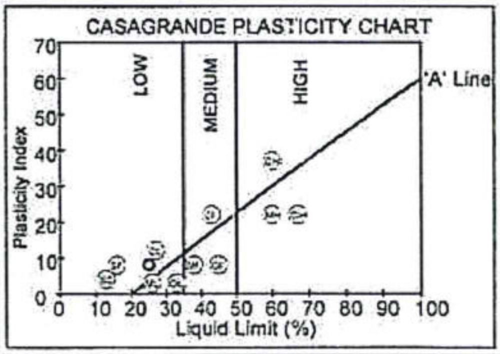
FOUNDATION INDICATOR (ASTM: D422)

Sample No. :	: 9044
Hole No. :	: 7 RS2
Depth (mm) :	: 500-900
Liquid Limit (%)	: 25
Plasticity Index	: 8
Linear Shrinkage (%)	: 4.0
PI of Whole Sample	: 1
P R.A. Classification	: A-2-4(0)
Unified Soil Classificatior	GW-GC
Activity	: 0.35
Heave Classification	: LOW
Grading Modulus	: 2.43
Percentage (<0.002)	: 3.0
Moisture Content (%)	: 8.8

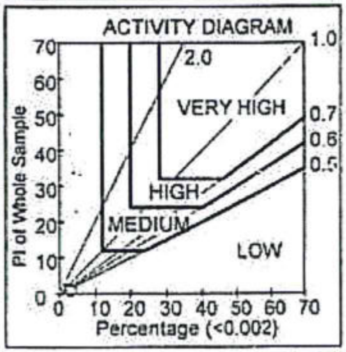
Material Description : Grey Sandy Gravel

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	3.7	3.4	21.9	71.0	SILTY SAND
Astm	3.7	6.6	28.8	60.9	SILTY SAND
British Standard	2.9	5.0	21.2	71.0	SILTY SAND

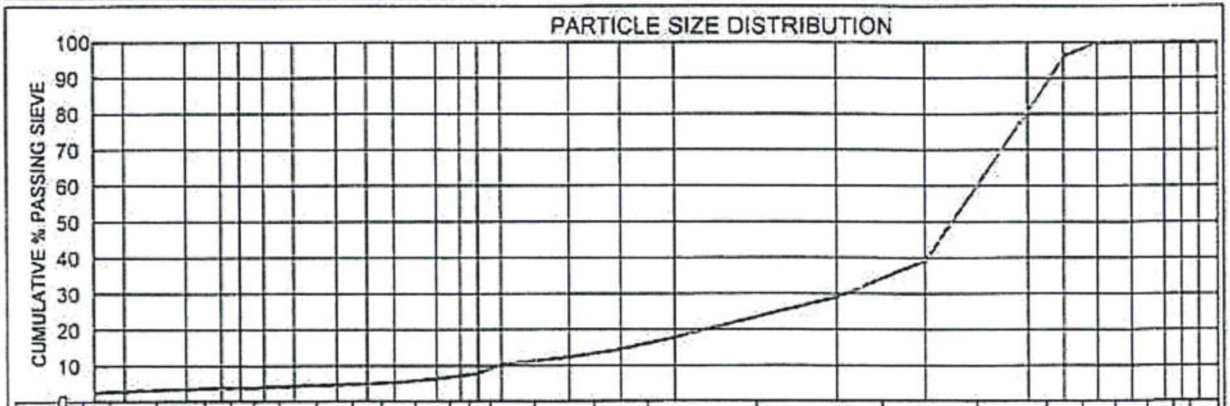
CASAGRANDE PLASTICITY CHART



ACTIVITY DIAGRAM



PARTICLE SIZE DISTRIBUTION



Sieve Size (mm)	0.0015	0.0020	0.0036	0.0050	0.0060	0.0075	0.0100	0.0150	0.0200	0.0260	0.0400	0.0500	0.0600	0.0750	0.1500	0.2500	0.4250	2.0000	4.7500	13.200	19.000	26.500	37.500	53.000	63.000	75.000
% Pass. Sieve	3	3	4	4	4	4	4	5	5	5	6	7	8	10	12	14	18	29	39	80	96	100	100	100	100	100

JENN CLAY | SILT | SAND | GRAVEL

ASTM CLAY | SILT | FINE SAND | MEDIUM SAND | COARSE SAND | GRAVEL

BS CLAY | FINE SILT | MEDIUM SILT | COARSE SILT | FINE SAND | MEDIUM SAND | COARSE SAND | FINE GRAVEL | MEDIUM GRAVEL | COARSE GRAVEL

Remarks :

for MATROLAB GROUP (PTY) LTD.

FORM: A6

Program ver 2.6 (17.08.2006)

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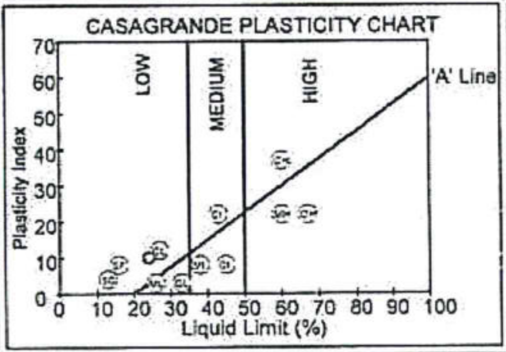
Your Ref :
Our Ref : 0/PL/35326
Date Reported : 13.12.2006

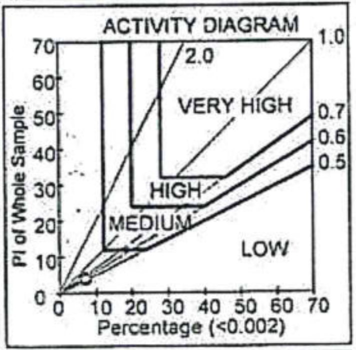
FOUNDATION INDICATOR (ASTM: D422)

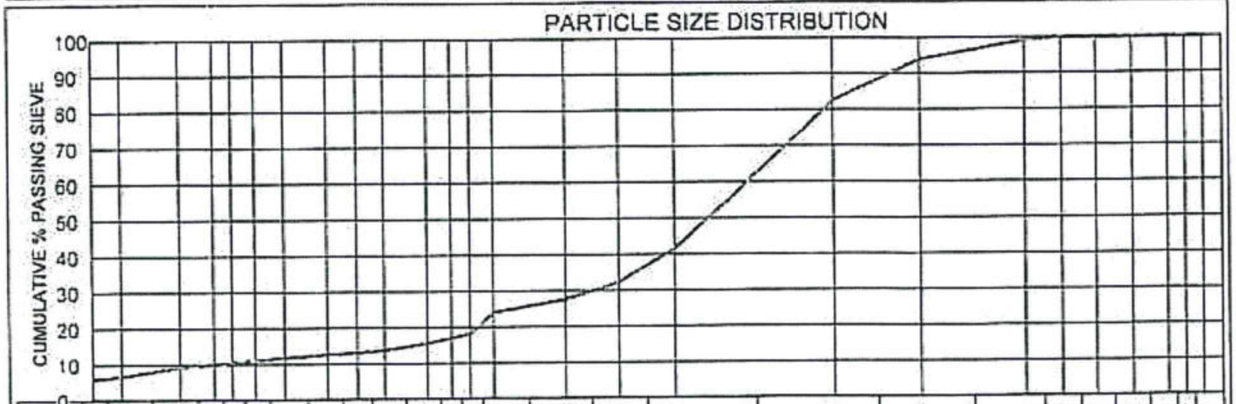
Sample No. :	: 9045
Hole No. :	: 7 RS3
Depth (mm) :	: 900-2300
Liquid Limit (%)	: 24
Plasticity Index	: 10
Linear Shrinkage (%)	: 5.5
PI of Whole Sample	: 4
P.R.A. Classification	: A-2-4(0)
Unified Soil Classification	SC
Activity	: 0.60
Heave Classification	: LOW
Grading Modulus	: 1.52
Percentage (<0.002)	: 7.0
Moisture Content (%)	: 8.3

Material Description : Yellow Orange Silty Sand

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	10.0	7.0	65.6	17.4	SILTY SAND
Astm	10.0	14.1	69.9	6.1	SILTY SAND
British Standard	6.7	11.7	64.2	17.4	SILTY SAND







Sieve Size (mm)	% Pass. Sieve
0.0015	6
0.0020	7
0.0036	9
0.0050	10
0.0060	10
0.0075	11
0.0100	12
0.0150	13
0.0200	13
0.0260	14
0.0400	16
0.0500	17
0.0600	18
0.0750	24
0.1500	28
0.2500	32
0.4250	42
2.0000	83
4.7500	94
13.200	99
19.000	100
26.500	100
37.500	100
53.000	100
63.000	100
75.000	100

JENN: CLAY | SILT | SAND | GRAVEL

ASTM: CLAY | SILT | FINE SAND | MEDIUM SAND | COARSE SAND | GRAVEL

BS: CLAY | FINE SILT | MEDIUM SILT | COARSE SILT | FINE SAND | MEDIUM SAND | COARSE SAND | FINE GRAVEL | MEDIUM GRAVEL | COARSE GRAVEL

Remarks :

FORM: A6

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TEST RESULTS

DOLOMITE TECHNOLOGY (PTY) LTD
P.O. BOX 15147
LYTTELTON
0140
Attention: Mr Dave Purnell

Project : Rooihuiskraal North X28+29+31

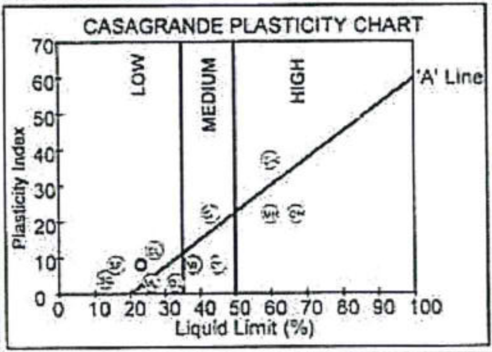
Your Ref :
Our Ref : 0/PL/35326
Date Reported : 13.12.2006

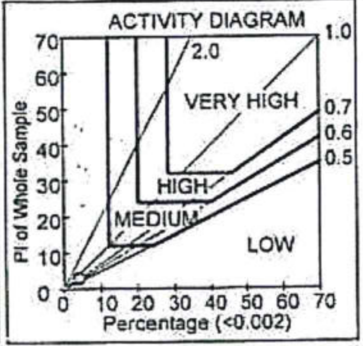
FOUNDATION INDICATOR (ASTM: D422)

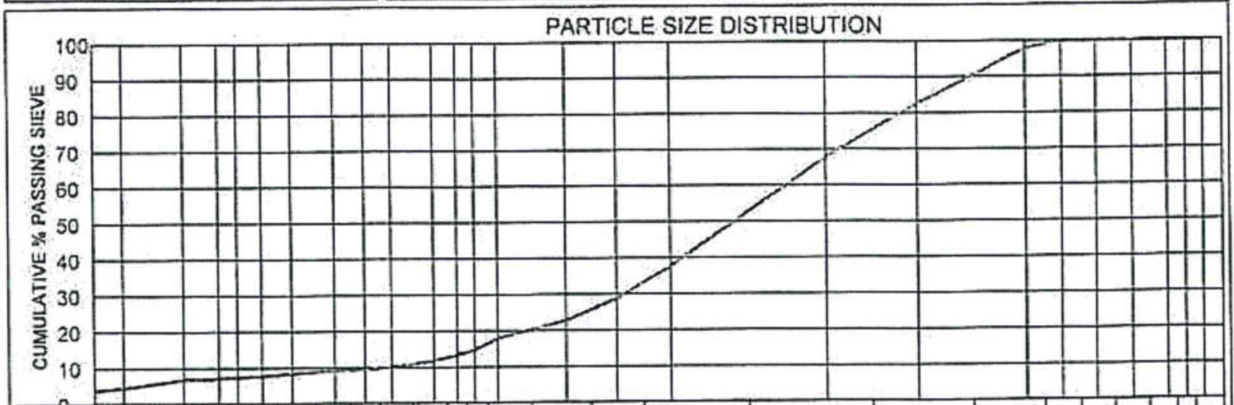
Sample No. : : 9046
Hole No. : : 5 RS4
Depth (mm) : : 150-600
Liquid Limit (%) : 23
Plasticity Index : 8
Linear Shrinkage (%) : 4.0
PI of Whole Sample : 3
P.R.A. Classification : A-2-4(0)
Unified Soil Classification: SC
Activity : 0.67
Heave Classification : LOW
Grading Modulus : 1.77
Percentage (<0.002) : 4.0
Moisture Content (%) : 9.9

Material Description : Grey Silty Gravelly Sand

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	7.1	6.3	54.4	32.2	SAND
Astm	7.1	10.8	64.7	17.4	SILTY SAND
British Standard	4.5	10.5	52.8	32.2	SILTY SAND







Sieve Size (mm)	% Pass. Sieve
0.0015	4
0.0020	4
0.0036	7
0.0050	7
0.0060	7
0.0075	8
0.0100	8
0.0150	9
0.0200	10
0.0260	10
0.0400	12
0.0500	13
0.0600	15
0.0750	18
0.1500	23
0.2500	29
0.4250	37
2.0000	68
4.7500	83
13.200	98
19.000	100
26.500	100
37.500	100
53.000	100
63.000	100
75.000	100

JENN CLAY | SILT | SAND | GRAVEL
ASTM CLAY | SILT | FINE SAND | MEDIUM SAND | COARSE SAND | GRAVEL
BS CLAY | FINE SILT | MEDIUM SILT | COARSE SILT | FINE SAND | MEDIUM SAND | COARSE SAND | FINE GRAVEL | MEDIUM GRAVEL | COARSE GRAVEL

Remarks :

FORM: A6

Program ver 2.6 (17.08.2006)

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TEST RESULTS

DOLOMITE TECHNOLOGY (PTY) LTD
P.O. BOX 15147
LYTTELTON
0140
Attention: Mr Dave Purnell

Project : Rooihuiskraal North X28+29+31

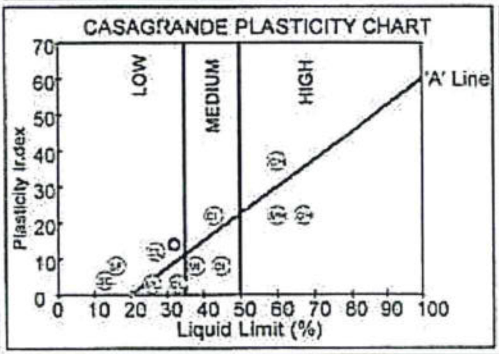
Your Ref :
Our Ref : 0/PL/35326
Date Reported : 13.12.2006

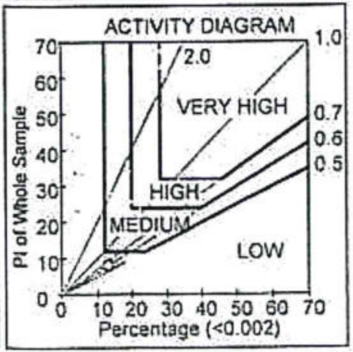
FOUNDATION INDICATOR (ASTM: D422)

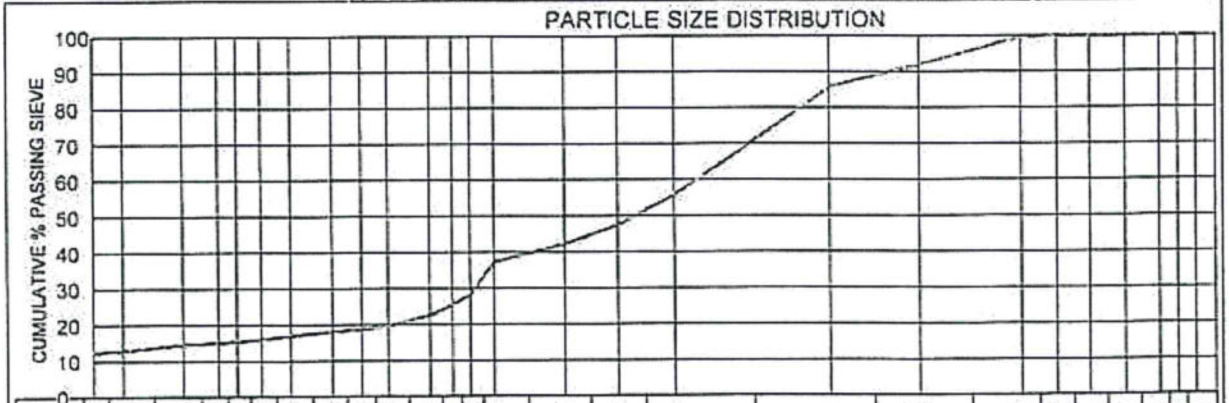
Sample No. :	9047
Hole No. :	5 RS5
Depth (mm) :	600-1400
Liquid Limit (%)	32
Plasticity Index	14
Linear Shrinkage (%)	7.0
PI of Whole Sample	8
P.R.A. Classification	A-6(1)
Unified Soil Classification	SC
Activity	0.62
Heave Classification	LOW
Grading Modulus	1.21
Percentage (<0.002)	13.0
Moisture Content (%)	13.5

Material Description : Yellow Orange Clayey Silty Sand

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	15.1	10.4	60.3	14.3	SILTY SAND
Astm	15.1	22.1	54.8	8.0	SILTY SAND
British Standard	12.9	15.4	57.4	14.3	SILTY SAND







Sieve Size (mm)	% Pass. Sieve
0.0015	12
0.0020	13
0.0036	15
0.0050	15
0.0060	15
0.0075	16
0.0100	17
0.0150	18
0.0200	19
0.0260	20
0.0400	23
0.0500	25
0.0600	29
0.0750	37
0.1500	42
0.2500	47
0.4250	58
2.0000	86
4.7500	92
13.200	99
19.000	100
26.500	100
37.500	100
53.000	100
63.000	100
75.000	100

JENN CLAY | SILT | SAND | GRAVEL

ASTM CLAY | SILT | FINE SAND | MEDIUM SAND | COARSE SAND | GRAVEL

BS CLAY | FINE SILT | MEDIUM SILT | COARSE SILT | FINE SAND | MEDIUM SAND | COARSE SAND | FINE GRAVEL | MEDIUM GRAVEL | COARSE GRAVEL

Remarks :

for MATROLAB GROUP (PTY) LTD.

FORM: A6

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TEST RESULTS

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Attention: Mr Dave Purnell

Project : Roolhuiskraal North X28+29+31

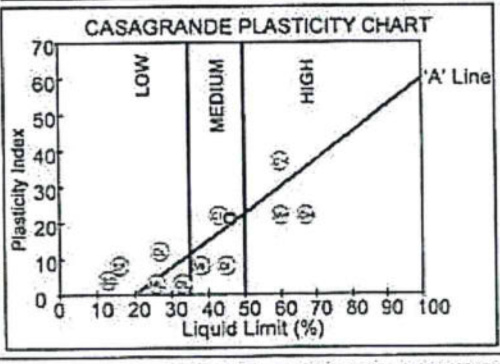
Your Ref :
Our Ref : 0/PL/35326
Date Reported : 13.12.2006

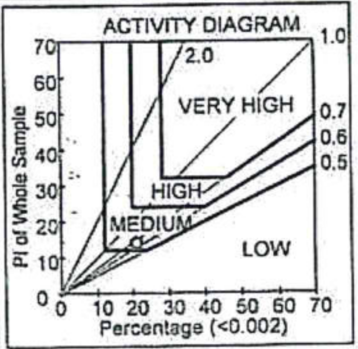
FOUNDATION INDICATOR (ASTM: D422)

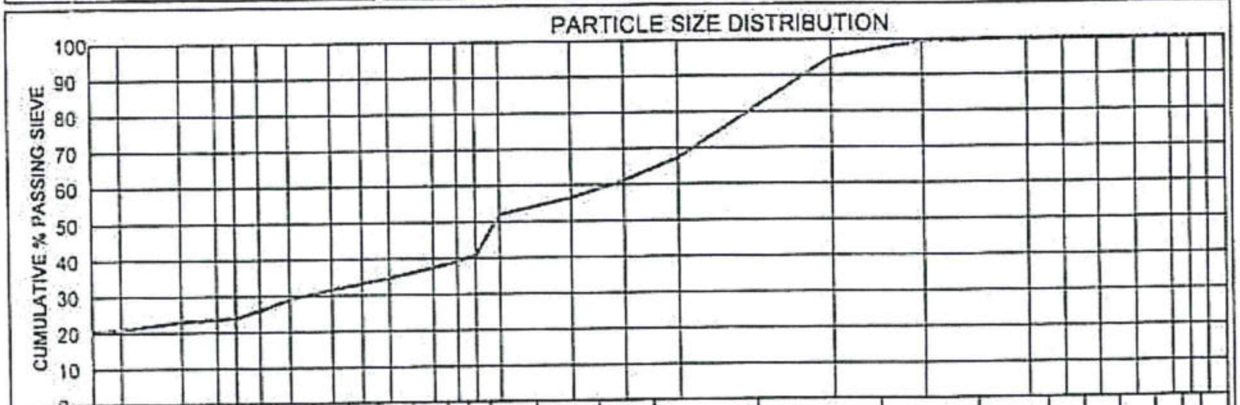
Sample No. :	: 9048
Hole No. :	: 5 RS6
Depth (mm) :	: 1400-2300
Liquid Limit (%)	: 46
Plasticity Index	: 21
Linear Shrinkage (%)	: 11.0
PI of Whole Sample	: 14
P.R.A. Classification	: A-7-6(8)
Unified Soil Classification	: CL
Activity	: 0.67
Heave Classification	: MEDIUM
Grading Modulus	: 0.86
Percentage (<0.002)	: 21.0
Moisture Content (%)	: 22.7

Material Description : Rd Or Clayey Silty Sand

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	23.6	15.6	55.9	5.0	CLAYEY SAND
Astm	23.6	28.4	47.5	0.5	CLAYEY SAND
British Standard	20.9	20.0	54.1	5.0	CLAYEY SAND







Sieve Size (mm)	0.0015	0.0020	0.0036	0.0050	0.0060	0.0075	0.0100	0.0150	0.0200	0.0260	0.0400	0.0500	0.0600	0.0750	0.1500	0.2500	0.4250		2.0000	4.7500	13.200	19.000	26.500	37.500	53.000	63.000	75.000
% Pass. Sieve	20	21	23	24	24	26	29	32	33	35	37	39	41	52	56	61	67		95	99	100	100	100	100	100	100	100

JENN CLAY | SILT | SAND | GRAVEL

ASTM CLAY | SILT | FINE SAND | MEDIUM SAND | COARSE SAND | GRAVEL

BS CLAY | FINE SILT | MEDIUM SILT | COARSE SILT | FINE SAND | MEDIUM SAND | COARSE SAND | FINE GRAVEL | MEDIUM GRAVEL | COARSE GRAVEL

Remarks :

for MATROLAB GROUP (PTY) LTD.

FORM: A6

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Attention: Mr Dave Purnell

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Your Ref :
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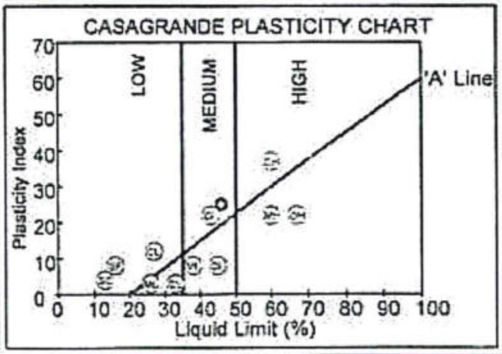
Date Reported : 13.12.2006

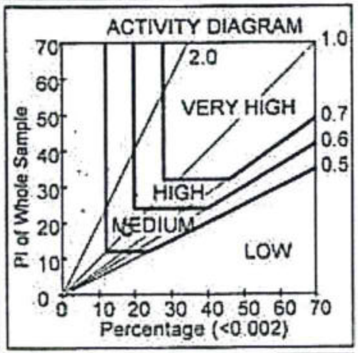
FOUNDATION INDICATOR (ASTM: D422)

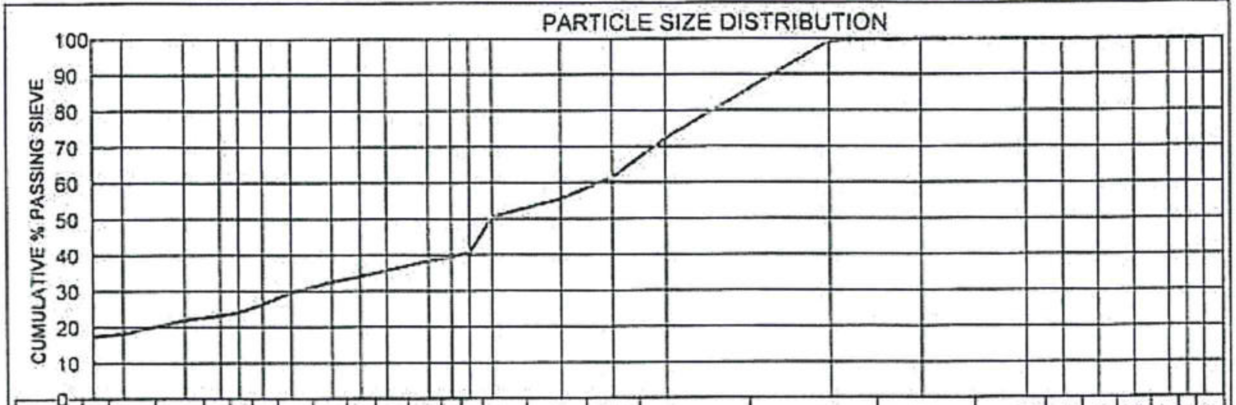
Sample No. :	: 9049
Hole No. :	: 10 RS7
Depth (mm) :	: 0-800
Liquid Limit (%)	: 46
Plasticity Index	: 25
Linear Shrinkage (%)	: 12.0
PI of Whole Sample	: 18
P.R.A. Classification	: A-7-6(9)
Unified Soil Classificatior	CL
Activity	: 0.99
Heave Classification	: MEDIUM
Grading Modulus	: 0.78
Percentage (<0.002)	: 18.0
Moisture Content (%)	: 24.7

Material Description : Dk Gr Clayey Silty Sand

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	23.2	16.3	59.8	0.7	CLAYEY SAND
Astm	23.2	27.3	49.3	0.2	CLAYEY SAND
British Standard	18.1	22.6	58.6	0.7	SILTY SAND







Sieve Size (mm)	% Pass. Sieve
0.0015	17
0.0020	18
0.0036	22
0.0050	23
0.0060	24
0.0075	26
0.0100	30
0.0150	33
0.0200	34
0.0260	36
0.0400	38
0.0500	40
0.0600	41
0.0750	50
0.1500	56
0.2500	61
0.4250	72
2.0000	99
4.7500	100
13.200	100
19.000	100
26.500	100
37.500	100
53.000	100
63.000	100
75.000	100

JENN	CLAY	SILT	SAND	GRAVEL					
ASTM	CLAY	SILT	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL			
BS	CLAY	FINE SILT	MEDIUM SILT	COARSE SILT	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	MEDIUM GRAVEL	COARSE GRAVEL

Remarks :

FORM: A6

Program ver 2.6 (17.08.2006)

for MATROLAB GROUP (PTY) LTD.

MATROLAB GROUP (PTY.) LTD.

- CIVIL ENGINEERING SERVICES -

Reg.No.: 2003/029180/07 - VAT. Reg.No.: 4040210587

a SANAS Accredited Testing Laboratory, No. T0025

418 RUSTIC AVE, SILVERTONDALE
P.O. BOX 912387 SILVERTON 0127

Tel. : 012-804 2050
Fax : 012-804 9555
Email: bennievn@matrolab.co.za

TEST RESULTS

DOLOMITE TECHNOLOGY (PTY) LTD
P.O. BOX 15147
LYTTELTON
0140
Attention: Mr Dave Purnell

Project : Rooihuiskraal North X28+29+31

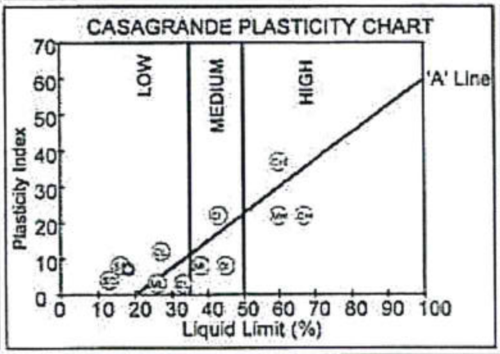
Your Ref :
Our Ref : 0/PL/35326
Date Reported : 13.12.2006

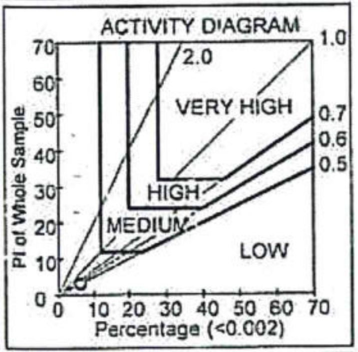
FOUNDATION INDICATOR (ASTM: D422)

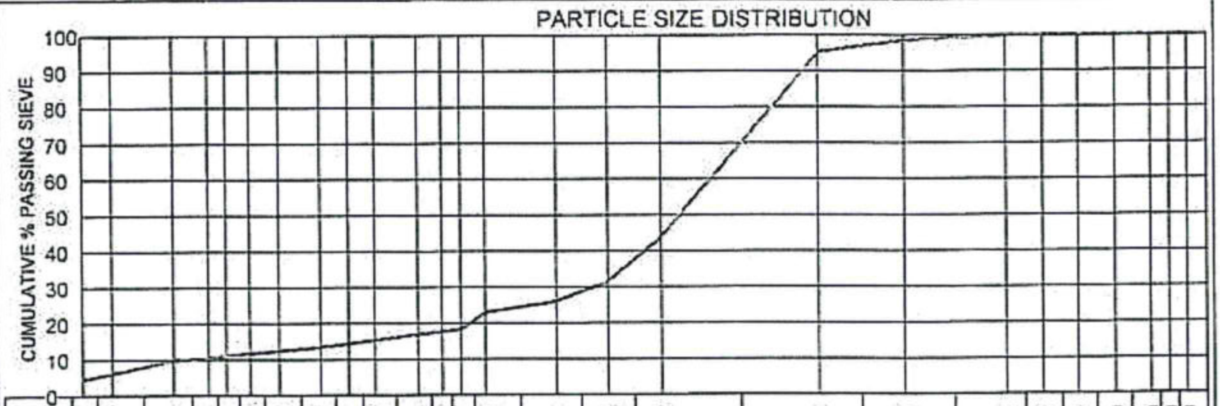
Sample No. :	9050
Hole No. :	10 RS8
Depth (mm) :	800-1400
Liquid Limit (%)	18
Plasticity Index	7
Linear Shrinkage (%)	4.0
PI of Whole Sample	3
P.R.A. Classification	A-2-4(0)
Unified Soil Classification	SM-SC
Activity	0.49
Heave Classification	LOW
Grading Modulus	1.38
Percentage (<0.002)	6.0
Moisture Content (%)	16.8

Material Description : Grey Clayey Silty Sand

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	10.5	7.1	77.5	4.8	SAND
Astm	10.5	12.5	75.6	1.5	SILTY SAND
British Standard	6.2	12.2	76.8	4.8	SAND







Sieve Size (mm)	% Pass. Sieve
0.0015	5
0.0020	6
0.0036	10
0.0050	11
0.0060	11
0.0075	12
0.0100	12
0.0150	13
0.0200	14
0.0280	15
0.0400	17
0.0500	18
0.0600	18
0.0750	23
0.1500	26
0.2500	31
0.4250	44
2.0000	95
4.7500	99
13.200	100
19.000	100
26.500	100
37.500	100
53.000	100
63.000	100
75.000	100

JENN CLAY | SILT | SAND | GRAVEL

ASTM CLAY | SILT | FINE SAND | MEDIUM SAND | COARSE SAND | GRAVEL

BS CLAY | FINE SILT | MEDIUM SILT | COARSE SILT | FINE SAND | MEDIUM SAND | COARSE SAND | FINE GRAVEL | MEDIUM GRAVEL | COARSE GRAVEL

Remarks :

FORM: A6

Program ver 2.6 (17.08.2006)

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TEST RESULTS

DOLOMITE TECHNOLOGY (PTY) LTD
P.O. BOX 15147
LYTTELTON
0140
Attention: Mr Dave Purnell

Project : Rooihuiskraal North X28+29+31

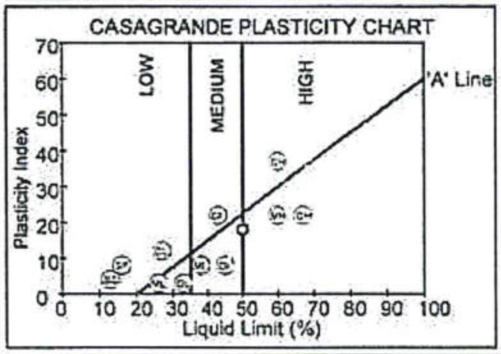
Your Ref :
Our Ref : 0/PL/35326
Date Reported : 13.12.2006

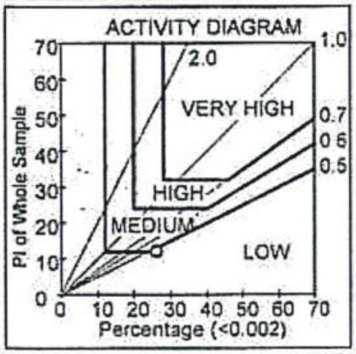
FOUNDATION INDICATOR (ASTM: D422)

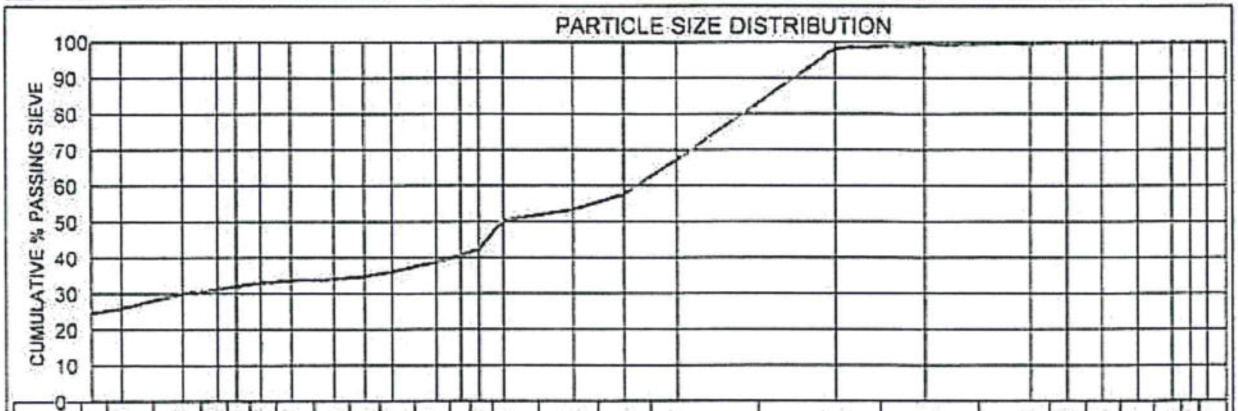
Sample No. : 9051
Hole No. : 10 RS9
Depth (mm) : 1400-2000
Liquid Limit (%) : 50
Plasticity Index : 18
Linear Shrinkage (%) : 9.0
PI of Whole Sample : 12
P.R.A. Classification : A-7-5(7)
Unified Soil Classification: OH
Activity : 0.46
Heave Classification : LOW
Grading Modulus : 0.84
Percentage (<0.002) : 26.0
Moisture Content (%) : 19.2

Material Description : Lt Grey Silty Clayey Sand

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	31.2	9.4	57.7	1.7	SANDY CLAY
Astm	31.2	19.2	48.8	0.8	SANDY CLAY
British Standard	25.9	16.5	55.9	1.7	CLAYEY SAND







Sieve Size (mm)	0.0015	0.0020	0.0036	0.0050	0.0060	0.0075	0.0100	0.0150	0.0200	0.0280	0.0400	0.0500	0.0600	0.0750
% Pass. Sieve	25	26	30	31	32	33	34	34	35	36	39	41	42	50

Sieve Size (mm)	0.1500	0.2500	0.4250	2.0000	4.7500	13.200	19.000	26.500	37.500	53.000	63.000	75.000
% Pass. Sieve	53	58	67	98	99	100	100	100	100	100	100	100

JENN CLAY	SILT	SAND	GRAVEL

ASTM CLAY	SILT	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL

BS CLAY	FINE SILT	MEDIUM SILT	COARSE SILT	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	MEDIUM GRAVEL	COARSE GRAVEL

Remarks :

FORM: A6

Program ver 2.6 (17.08.2006)

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TEST RESULTS

DOLOMITE TECHNOLOGY (PTY) LTD
P.O. BOX 15147
LYTTELTON
0140
Attention: Mr Dave Purnell

Project : Rooihuiskraal North X28+29+31

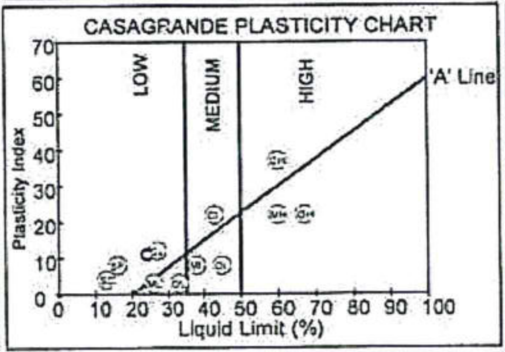
Your Ref :
Our Ref : 0/PL/35326
Date Reported : 13.12.2006

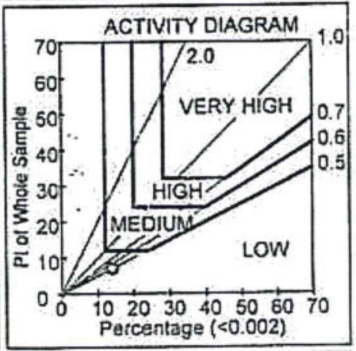
FOUNDATION INDICATOR (ASTM: D422)

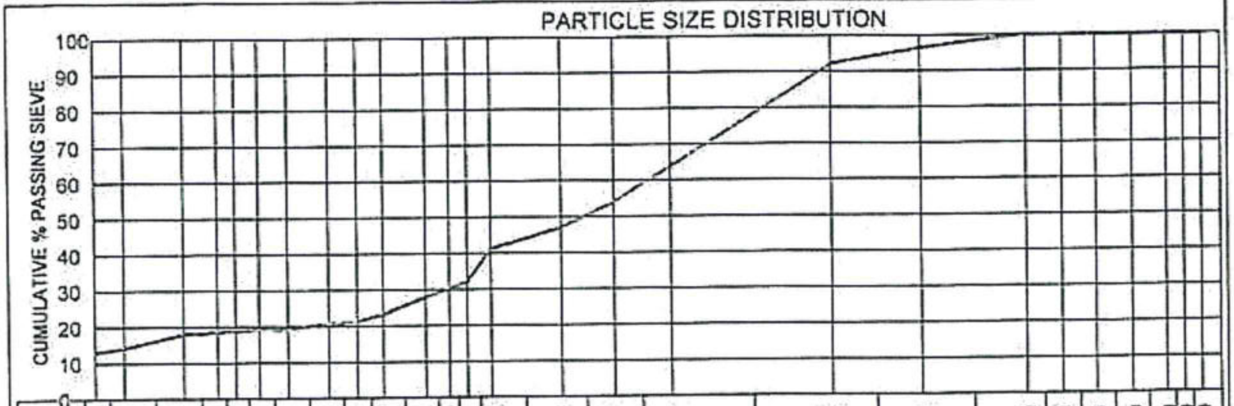
Sample No. :	: 9052
Hole No. :	: 12 RS10
Depth (mm) :	: 700-1300
Liquid Limit (%)	: 24
Plasticity Index	: 11
Linear Shrinkage (%)	: 6.0
PI of Whole Sample	: 7
P.R.A. Classification	: A-6(1)
Unified Soil Classification	SC
Activity	: 0.50
Heave Classification	: LOW
Grading Modulus	: 1.03
Percentage (<0,002)	: 14.0
Moisture Content (%)	: 6.1

Material Description : Or Br Clayey Silty Sand

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	18.5	11.5	62.1	7.8	CLAYEY SAND
Astm	18.5	22.6	55.3	3.6	SILTY SAND
British Standard	14.1	18.1	60.0	7.8	SILTY SAND







Sieve Size (mm)	0.0015	0.0020	0.0036	0.0050	0.0060	0.0075	0.0100	0.0150	0.0200	0.0260	0.0400	0.0500	0.0600	0.0750	0.1500	0.2500	0.4250	2.0000	4.7500	13.200	19.000	26.500	37.500	53.000	63.000	75.000
% Pass. Sieve	13	14	18	19	19	19	19	21	21	23	28	30	32	41	47	54	64	92	96	100	100	100	100	100	100	100

JENN CLAY	SILT	SAND	GRAVEL

ASTM CLAY	SILT	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL

BS CLAY	FINE SILT	MEDIUM SILT	COARSE SILT	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	MEDIUM GRAVEL	COARSE GRAVEL

Remarks :

for MATROLAB GROUP (PTY) LTD.

FORM: A6

Program ver 2,6 (17.08.2006)

MATROLAB GROUP (PTY.) LTD.
- CIVIL ENGINEERING SERVICES -
Reg.No.: 2003/029180/07 - VAT. Reg.No.: 4040210587
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TEST RESULTS

DOLOMITE TECHNOLOGY (PTY) LTD
P.O. BOX 15147
LYTTELTON
0140
Attention: Mr Dave Purnell

Project : Rooihuiskraal North X28+29+31

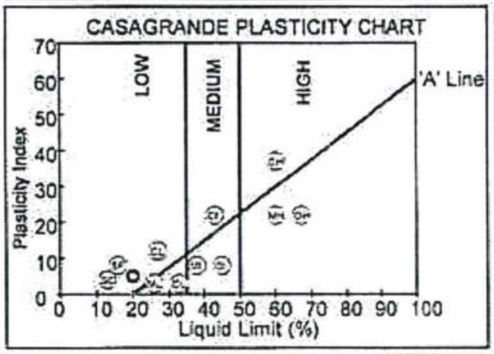
Your Ref :
Our Ref : 0/PL/35326
Date Reported : 13.12.2006

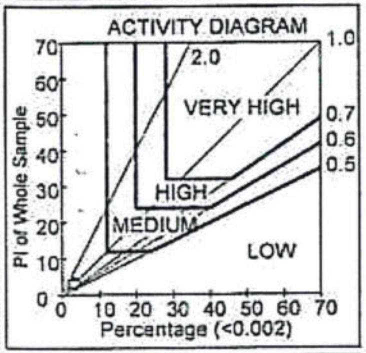
FOUNDATION INDICATOR (ASTM: D422)

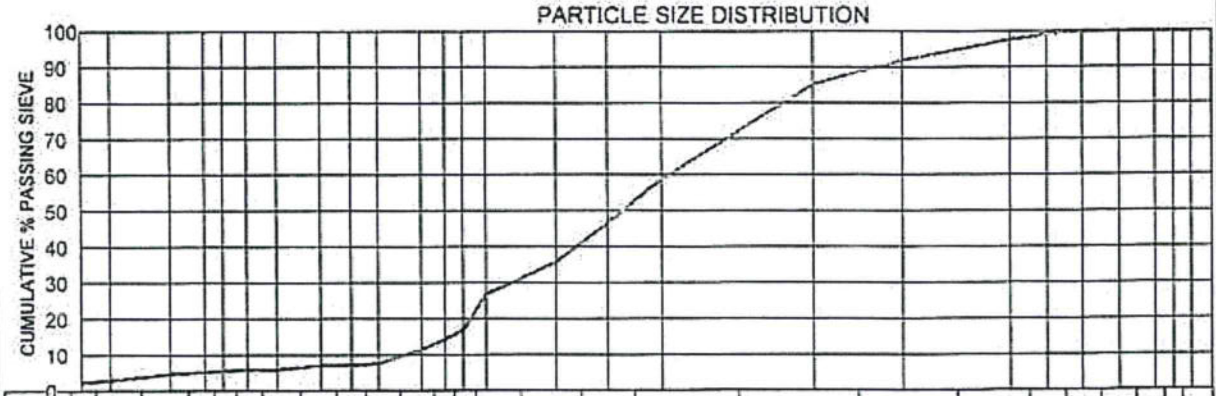
Sample No. : : 9053
Hole No. : : 4 RS11
Depth (mm) : : 0-500
Liquid Limit (%) : 20
Plasticity Index : 5
Linear Shrinkage (%) : 3.0
PI of Whole Sample : 3
P.R.A. Classification : A-2-4(0)
Unified Soil Classificatior: SM-SC
Activity : 1.04
Heave Classification LOW
Grading Modulus : 1.29
Percentage (<0.002) : 3.0
Moisture Content (%) : 3.4

Material Description : Grey Silty Sand

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	5.2	9.0	71.0	14.8	SAND
Astm	5.2	21.5	65.1	8.1	SILTY SAND
British Standard	2.9	14.1	68.2	14.8	SAND







Sieve Size (mm)	0.0015	0.0020	0.0036	0.0050	0.0060	0.0075	0.0100	0.0150	0.0200	0.0260	0.0400	0.0500	0.0600	0.0750	0.1500	0.2500	0.4250	2.0000	4.7500	13.200	19.000	26.500	37.500	53.000	63.000	75.000
% Pass. Sieve	2	3	5	5	6	6	6	7	7	8	11	14	17	27	36	46	59	85	92	98	99	100	100	100	100	100

JENN CLAY | SILT | SAND | GRAVEL

ASTM CLAY | SILT | FINE SAND | MEDIUM SAND | COARSE SAND | GRAVEL

BS CLAY | FINE SILT | MEDIUM SILT | COARSE SILT | FINE SAND | MEDIUM SAND | COARSE SAND | FINE GRAVEL | MEDIUM GRAVEL | COARSE GRAVEL

Remarks :

FORM: A6

Program ver 2.6 (17.08.2006)

for MATROLAB GROUP (PTY) LTD.

APPENDIX B

SOIL PROFILES

TABLE 2: ROOIHUISKRAAL NORTH X28, 29 AND 31 – HAND-HELD GPS CO-ORDINATES OF TEST PIT POSITIONS

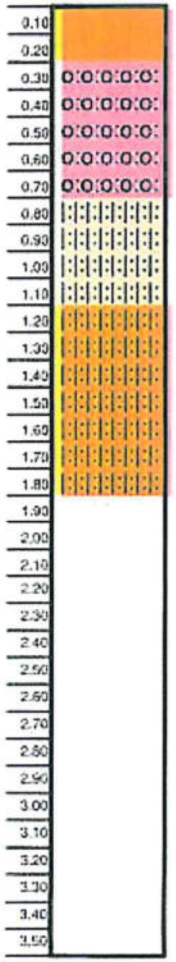
TEST PIT NR	X CO-ORDINATE	Y CO-ORDINATE
1	2864509,86	86739,53
2	2864470,67	86536,05
3	2864440,84	86348,41
4	2864412,16	86172,40
5	2864632,04	86844,09
6	2864599,39	8665032
7	2864534,78	86447,12
8	2864490,91	86165,60
9	2864764,76	86984,53
10	2864726,93	86735,90
11	2864643,25	86504,93
12	2864566,65	86325,91

Project no: 1210B-09
Logged by: SP Kok
Date excavatei 2010-02-08
Date profiled: 2010-02-08

Client: Lezmin 1066 CC
Contractor: WCS
Operator: Pieter
Machine: Case 580 Super R

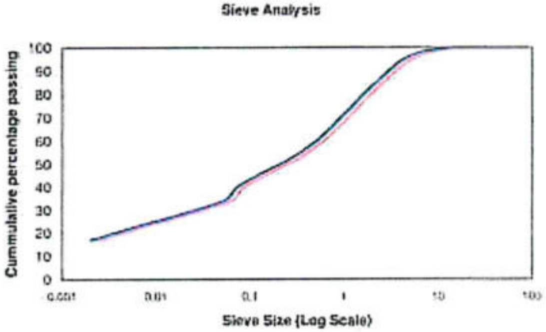
TP NO: A

Geo Buro



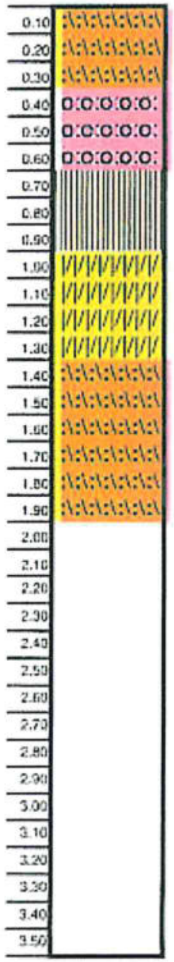
		Sample	Unified
0.00 0.20	Moist, light brown, very loose voided fine sand with quartz gravel and abundant fine roots; Colluvium.		
0.70	Very moist, grey brown, very loose boided, silty sand with abundant fine quartz gravel. Poorly developed pebblemarker.		
1.10	Moist, yellow brown and grwy white with abundant black blotches, firm to stiff, intact sandy clay/sandy silt; Residual granite.	●	SC Low Heave
1.80	Moist, grey white and yellow brown, medium dense, relict jointed clayey sand; Residual granite.		

NOTES:
1 Gradual refusal.
2 No water.
3 Sample taken at TPA/0,9m



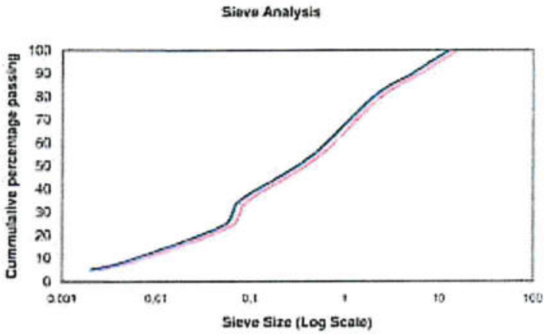
Geo Buro

Project no:	1210B-09	Client:	Lezmin 1066 CC	**TP NO:** B
Logged by:	SP Kok	Contractor:	WCS	
Date excavate	2010-02-08	Operator:	Pieter	
Date profiled:	2010-02-08	Machine:	Case 580 Super R	



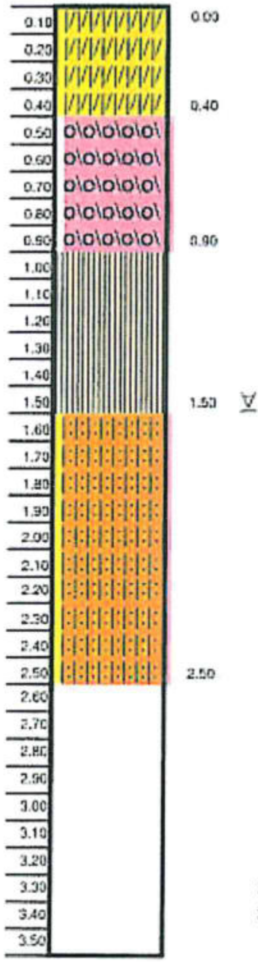
			Sample	Unified
0.00		Moist, grey brown, very loose, voided silty sand with abundant fine roots; Colluvium.		
0.30		Abundant medium to fine sub rounded, unweathered, quarz gravel, matrix support in a matrix of very moist, light gbrown silty sand; Pebblemarker. Overall concistency = loose with occassional ferricrete nodules.		
0.60		Moist, orange and light grey with black blotches, soft, shattered clay; Residual granite.		
0.80	∇	Wet, light grey with abundant fine black blotches, soft clayey silt; Residual granite.	●	SC-SM Low heave
1.30		Wet, orange brown, loose to medium dense, intact silty clayey sand; Residual granite.		
1.90				

NOTES:
1 Gradual refusal on dense residual granite
2 Water seepage at 1.1m
3 Sample taken at TPB/1,2m



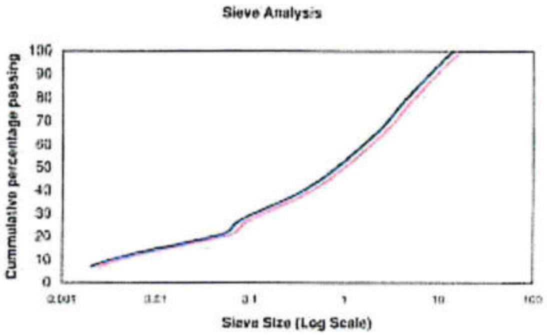
Geo Buro

Project no:	12108-09	Client:	Lezmin 1066 CC	**TP NO:** D
Logged by:	SP Kok	Contractor:	WCS	
Date excavate:	2010-02-08	Operator:	Pieter	
Date profiled:	2010-02-08	Machine:	Case 580 Super R	



	Sample	Unified
Moist, black, soft, intact clayey silt; Colluvium.		
Moist, dark brown to black, soft voided silty clay; Colluvium with fine ferricrete nodules and quartz gravel. Pebblemarker?	●	SC Low heave
Wet, light grey with orange brown mottling, very soft, slickensided clay; Residual.		
Wet, orange brown to greenish brown, firm, relict jointed sandy clay; Residual.		

NOTES:
1 No refusal.
2 Water seepage at 1,5m
3 Sample taken at TPD/0,8m

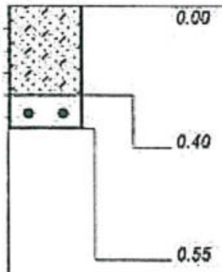


ROOIHUISKRAAL NORTH X28, 29 AND 31

HOLE No: TP 2
Sheet 1 of 1

JOB NUMBER: 1210-06

Scale 1:30



Slightly moist, olive, apparently dense in profile but potentially collapsible, medium grained clayey SAND.
Transported.
P=30 kPa.

Yellow-orange, mottled black, cemented, ferricrete HARDPAN.
Pedogenic.
P=450 kPa.

NOTES

1) No groundwater seepage.

2) Limit of reach of backactor at 0.55 m.

CONTRACTOR: POTLAKI
MACHINE: KOMATSU WB93R
DRILLED BY:
PROFILED BY: D G PURNELL
TYPE SET BY: K STEWART
SETUP FILE: STANDARD.SET

INCLINATION:
DIAM:
DATE: 2006-12-04
DATE: 2006-12-04
DATE: 29/01/07 11:13
TEXT: ..X28_29~1\1_2_3_~1.TXT

ELEVATION:
X-COORD:
Y-COORD:

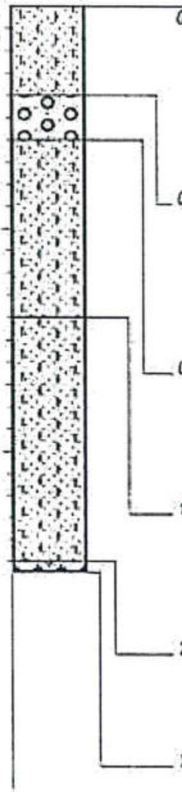
HOLE No: TP 2

ROOIHUISKRAAL NORTH X28, 29 AND 31

HOLE No: TP 3
Sheet 1 of 1

JOB NUMBER: 1210-06

Scale 1:30



0.00	Dry to slightly moist, grey, apparently dense in profile but potentially collapsible, medium grained silty SAND with sub-angular quartzite pebbles up to 30 mm diameter between 0,3 m and 0,4 m depth, plus occasional sub-rounded quartzite boulders up to 0,3 m diameter. Transported. P=30 kPa.
0.40	Slightly moist, grey blotched yellow orange mottled black, very dense, partly cemented, very dense, medium grained sandy GRAVEL, angular iron concretions up to 20 mm diameter. Pedogenic. P=400 kPa.
0.60	Slightly moist becoming moist with depth, yellow-orange blotched light grey, very dense, medium grained, silty SAND. Residual granite. P=300 kPa.
1.40	Very moist, yellow-orange blotched light grey, dense to very dense, medium grained silty SAND. Residual granite. P=200 kPa.
2.50	Reddish-orange blotched grey, highly weathered, medium grained, very soft to soft ROCK, granite. P=600 kPa.
2.55	

NOTES

1) No groundwater seepage.

2) Backactor refusal on soft granite rock at 2.55 m.

CONTRACTOR : POTLAKI
MACHINE : KOMATSU WB93R
DRILLED BY :
PROFILED BY : D G PURNELL

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

INCLINATION :
DIAM :
DATE : 2006-12-04
DATE : 2006-12-04

DATE : 29/01/07 11:13
TEXT : ..X28_29~1\1_2_3_~1.TXT

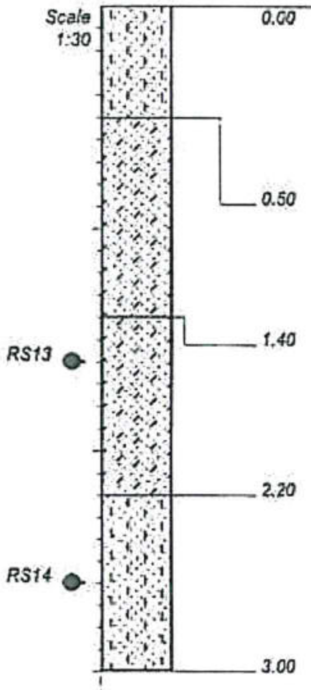
ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP 3

ROOIHUISKRAAL NORTH X28, 29 AND 31

HOLE No: TP 4
Sheet 1 of 1

JOB NUMBER: 1210-06



Dry to slightly moist, grey, apparently dense in profile but potentially collapsible, medium grained silty SAND with sub-angular quartzite pebbles up to 30 mm diameter between 0,4 m and 0,5 m depth, plus occasional sub-rounded quartzite boulders up to 0,3 m diameter.
Transported.
P=30 kPa.

Moist, dark red blotched light grey, dense with abundant potentially collapsible zones, medium grained clayey SAND.
Residual granite.
P=40 kPa.

Moist to very moist, dark reddish-orange mottled light grey, dense to very dense, medium grained clayey SAND rich in mica.
Residual granite.
P=150 kPa.

Very moist, reddish-orange, dense, medium grained silty SAND.
Residual granite.
P=150 kPa.

NOTES

1) No groundwater seepage.

2) Limit of reach of backactor at 3.0 m.

3) Disturbed samples taken; RS13 at 1,6 m and RS14 at 2,6 m.

CONTRACTOR : POTLAKI
MACHINE : KOMATSU WB93R
DRILLED BY :
PROFILED BY : D G PURNELL

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

INCLINATION :
DIAM :
DATE : 2006-12-04
DATE : 2006-12-04

DATE : 29/01/07 11:13
TEXT : ..X28_29~1\1_2_3_~1.TXT

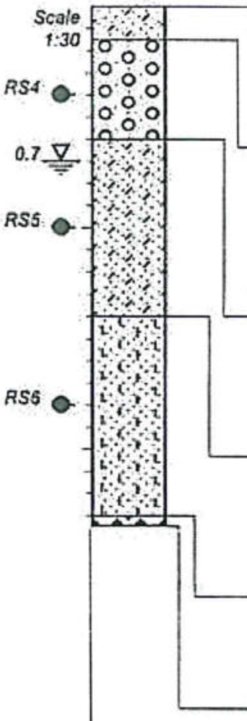
ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP 4

ROOIHUISKRAAL NORTH X28, 29 AND 31

HOLE No: TP 5
Sheet 1 of 1

JOB NUMBER: 1210-06



0.00

Slightly moist, grey, apparently dense in profile but potentially collapsible, medium grained clayey SAND.
Transported.
P=30 kPa.

0.15

Moist, grey blotched yellow orange mottled black, very dense, partly cemented, very dense, medium grained sandy GRAVEL, angular iron concretions up to 20 mm diameter.
Pedogenic.
P=400 kPa.

0.60

Moist to very moist, yellow-orange blotched light grey, very dense, medium grained, clayey SAND.
Residual granite.
P=350 kPa.

1.40

Very moist, reddish-orange streaked light grey, dense to very dense, medium grained silty SAND.
Residual granite.
P=200 kPa.

2.30

Reddish-orange blotched grey, highly weathered, medium grained, very soft to soft ROCK, granite.
P=600 kPa.

2.35

NOTES

1) Perched groundwater table at 0,7 m, slight localised seepage.

2) Backactor refusal on soft granite rock at 2,35 m.

3) Disturbed samples taken, RS4 at 0,4 m, RS5 at 1,0 m and RS6 at 1,8 m.

CONTRACTOR: POTLAKI
MACHINE: KOMATSU WB93R
DRILLED BY:
PROFILED BY: D G PURNELL

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

INCLINATION:
DIAM:
DATE: 2006-12-04
DATE: 2006-12-04

DATE: 29/01/07 11:13
TEXT: ..X28_29~1\1_2_3_~1.TXT

ELEVATION:
X-COORD:
Y-COORD:

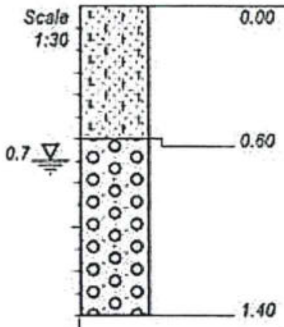
HOLE No: TP 5

HOLE No: TP 6
Sheet 1 of 1

ROOIHUISKRAAL NORTH X28, 29 AND 31

JOB NUMBER: 1210-06

Scale 1:30



Very moist to wet, grey, loose to very loose, fine to medium grained silty SAND.
Transported.
P=25 kPa.

Very moist, dark yellow-orange blotched light grey mottled black, very dense, cemented, medium grained sandy GRAVEL, iron concretions up to 20 mm diameter (almost a hardpan).
Pedogenic.
P=450 kPa.

NOTES

1) Perched groundwater table at 0,7 m, slight localised seepage.

2) Backactor refusal on ferricrete hardpan at 1,4 m.

CONTRACTOR : POTLAKI
MACHINE : KOMATSU WB93R
DRILLED BY :
PROFILED BY : D G PURNELL
TYPE SET BY : K STEWART
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 2006-12-04
DATE : 2006-12-04
DATE : 29/01/07 11:13
TEXT : ..X28_29~1\1_2_3_~1.TXT

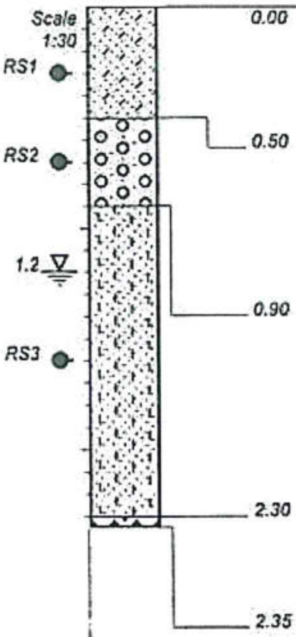
ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP 6

ROOIHUISKRAAL NORTH X28, 29 AND 31

HOLE No: TP 7
Sheet 1 of 1

JOB NUMBER: 1210-06



0.00

Very moist, olive, apparently medium dense in profile but potentially collapsible, medium grained clayey SAND.
Transported.
P=30 kPa.

0.50

Very moist, grey, blotched yellow orange mottled black, very dense, partly cemented, very dense, medium grained sandy GRAVEL, angular iron concretions up to 20 mm diameter.
Pedogenic.
P=400 kPa.

0.90

Very moist, yellow-orange blotched light grey, very dense, medium grained, silty SAND.
Residual granite.
P=300 kPa.

2.30

Reddish-orange blotched grey, highly weathered, medium grained, very soft to soft ROCK, granite.
P=600 kPa.

2.35

NOTES

1) Perched groundwater table at 1,2 m, slight localised seepage.

2) Backactor refusal on soft granite rock at 2,35 m.

3) Disturbed samples taken; RS1 at 0,3 m, RS2 at 0,7 m and RS3 at 1,6 m.

CONTRACTOR: POTLAKI
MACHINE: KOMATSU WB93R
DRILLED BY:
PROFILED BY: D G PURNELL

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

INCLINATION:
DIAM:
DATE: 2006-12-04
DATE: 2006-12-04

DATE: 29/01/07 11:13
TEXT: ..X28_29~1\1_2_3_~1.TXT

ELEVATION:
X-COORD:
Y-COORD:

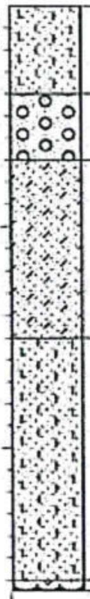
HOLE No: TP 7

HOLE No: TP 8
Sheet 1 of 1

ROOIHUISKRAAL NORTH X28, 29 AND 31

JOB NUMBER: 1210-06

Scale
1:30



0.00

Dry to slightly moist, grey, apparently dense in profile but potentially collapsible, medium grained silty SAND with sub-angular quartzite pebbles up to 30 mm diameter between 0,3 m and 0,4 m depth, plus occasional sub-rounded quartzite boulders up to 0,3 m diameter.
Transported.
P=30 kPa.

0.40

Slightly moist, grey, blotched yellow orange mottled black, dense, partly cemented in places, very dense, medium grained sandy GRAVEL, angular iron concretions up to 20 mm diameter.
Pedogenic.
P=150 kPa.

0.70

Moist, yellow-orange blotched light grey, very dense, medium grained clayey SAND.
Residual granite.
P=200 kPa.

1.50

Very moist, reddish-orange, very dense, medium grained silty SAND with a very soft zone 1,0 m in diameter.
Residual granite.
P=200 kPa.

2.60

Reddish-orange blotched grey, highly weathered, medium grained, very soft to soft ROCK, granite.
P=600 kPa.

2.65

NOTES

1) No groundwater seepage.

2) Backactor refusal on soft granite rock at 2,65 m.

CONTRACTOR: POTLAKI
MACHINE: KOMATSU WB93R
DRILLED BY:
PROFILED BY: D G PURNELL
TYPE SET BY: K STEWART
SETUP FILE: STANDARD.SET

INCLINATION:
DIAM:
DATE: 2006-12-04
DATE: 2006-12-04
DATE: 29/01/07 11:13
TEXT: ..X28_29~1\1_2_3_~1.TXT

ELEVATION:
X-COORD:
Y-COORD:

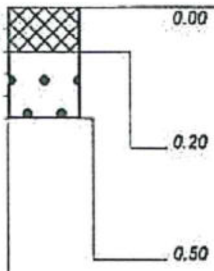
HOLE No: TP 8

ROOIHUISKRAAL NORTH X28, 29 AND 31

HOLE No: TP 9
Sheet 1 of 1

JOB NUMBER: 1210-06

Scale
1:30



Slightly moist, grey, dense, fine grained sandy gravel, sub-angular quartz pebbles up to 6 m diameter.
FILL.
Imported.

Yellow-orange, mottled black, cemented, ferricrete HARDPAN.
Pedogenic.
P=450 kPa.

NOTES

1) No groundwater seepage.

2) Backactor refusal on ferricrete hardpan at 0,5 m.

CONTRACTOR : POTLAKI
MACHINE : KOMATSU WB93R
DRILLED BY :
PROFILED BY : D G PURNELL
TYPE SET BY : K STEWART
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 2006-12-04
DATE : 2006-12-04
DATE : 29/01/07 11:13
TEXT : ..X28_29-1\1_2_3_-1.TXT

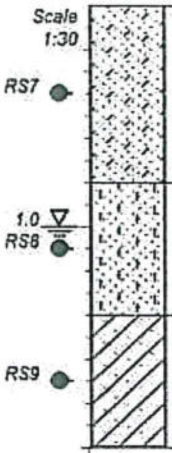
ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP 9

ROOIHUISKRAAL NORTH X28, 29 AND 31

HOLE No: TP 10
Sheet 1 of 1

JOB NUMBER: 1210-06



0.00	Very moist to wet, dark grey-black, soft to firm, medium grained clayey SAND. Transported. P=20 kPa.
0.80	Wet, grey, very loose, medium grained silty SAND. Transported. P=20 kPa.
1.40	Very moist, light grey mottled yellow-orange, firm to stiff, sandy CLAY. Transported. P=80 kPa.
2.00	

NOTES

1) Perched groundwater table at 1,0 m, slight localised seepage.

2) Instructed backactor to stop digging at 2.0 m.

3) Did not enter test pit, sides were unstable.

4) Disturbed samples taken, RS7 at 0,4 m, RS8 at 1,1 m and RS9 at 1,7 m.

CONTRACTOR : POTLAKI
MACHINE : KOMATSU WB93R
DRILLED BY :
PROFILED BY : D G PURNELL
TYPE SET BY : K STEWART
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 2006-12-04
DATE : 2006-12-04
DATE : 29/01/07 11:12
TEXT : ..X28_29~1\1_2_3_-1.TXT

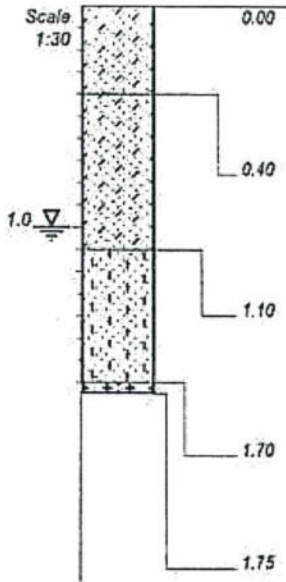
ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP 10

ROOIHUISKRAAL NORTH X28, 29 AND 31

HOLE No: TP 11
Sheet 1 of 1

JOB NUMBER: 1210-06



Very moist, grey, apparently dense in profile but potentially collapsible, medium grained clayey SAND with occasional sub-angular quartz pebbles at 0,4 m depth becoming the PEBBLE MARKER.
Transported.
P=30 kPa.

Very moist to wet, yellow-orange blotched light grey, dense with abundant potentially collapsible zones, medium grained clayey SAND.
Residual granite.
P=40 kPa.

Very moist to wet, yellow-orange blotched light grey, very dense, medium grained, silty SAND.
Residual granite.
P=300 kPa.

Reddish-orange blotched grey, highly weathered, medium grained, very soft to soft ROCK, granite.
P=600 kPa.

NOTES

1) Perched groundwater table at 1,0 m, slight localised seepage.

2) Backactor refusal on soft granite rock at 1,75 m.

CONTRACTOR : POTLAKI
MACHINE : KOMATSU WB93R
DRILLED BY :
PROFILED BY : D G PURNELL
TYPE SET BY : K STEWART
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 2006-12-04
DATE : 2006-12-04
DATE : 29/01/07 11:12
TEXT : ..X28_29~1\1_2_3_~1.TXT

ELEVATION :
X-COORD :
Y-COORD :

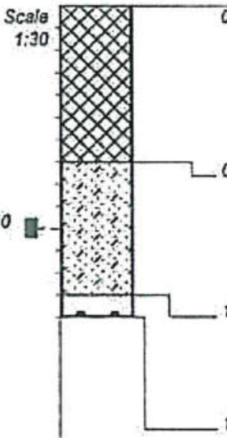
HOLE No: TP 11

ROOIHUISKRAAL NORTH X28, 29 AND 31

HOLE No: TP 12
Sheet 1 of 1

JOB NUMBER: 1210-06

Scale
1:30



0.00	Slightly moist, brown, medium dense, medium grained silty sand with builders rubble, household refuse and angular dolomite boulders up to 1,0 m diameter. FILL. Imported.
0.70	Slightly moist, brown becoming orange brown with depth, apparently dense in profile but potentially collapsible, medium grained clayey SAND. Transported. P=30 kPa.
1.30	Yellow-orange, mottled black, cemented, ferricrete HARDPAN. Pedogenic. P=450 kPa.
1.40	

NOTES

1) No groundwater seepage.

2) Backactor refusal on ferricrete hardpan at 1,4 m.

3) Undisturbed sample taken. RS10 at 1,0 m.

CONTRACTOR: POTLAKI
MACHINE: KOMATSU WB93R
DRILLED BY:
PROFILED BY: D G PURNELL

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

INCLINATION:
DIAM:
DATE: 2006-12-04
DATE: 2006-12-04

DATE: 29/01/07 11:13
TEXT: ..X28_29~1\1_2_3_~1.TXT

ELEVATION:
X-COORD:
Y-COORD:

HOLE No: TP 12

MATROLAB GROUP (PTY.) LTD.
- CIVIL ENGINEERING SERVICES -
Reg.No.: 2003/029180/07 - VAT. Reg.No.: 4040210587

a SANAS Accredited Testing Laboratory, No. T0025

418 RUSTIC AVE, SILVERTONDALE
P.O. BOX 912387 SILVERTON 0127

Tel. : 012-804 2050
Fax : 012-804 9555
Email: bennievn@matrolab.co.za

TEST RESULTS

DOLOMITE TECHNOLOGY (PTY) LTD
P.O. BOX 15147
LYTTELTON
0140
Attention: Mr Dave Purnell

Project : Rooihuiskraal North X28+29+31

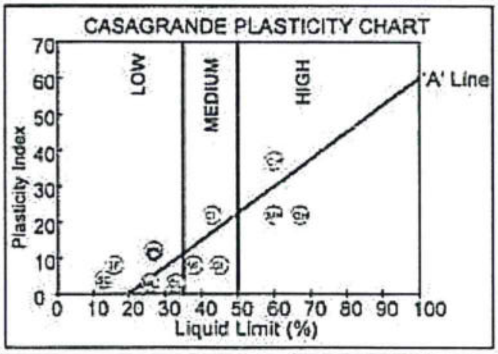
Your Ref :
Our Ref : 0/PL/35326
Date Reported : 13.12.2006

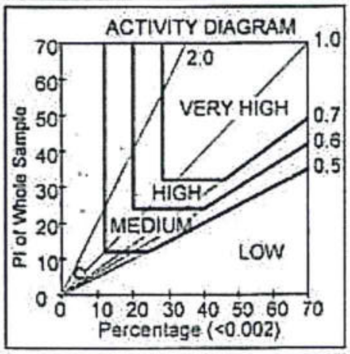
FOUNDATION INDICATOR (ASTM: D422)

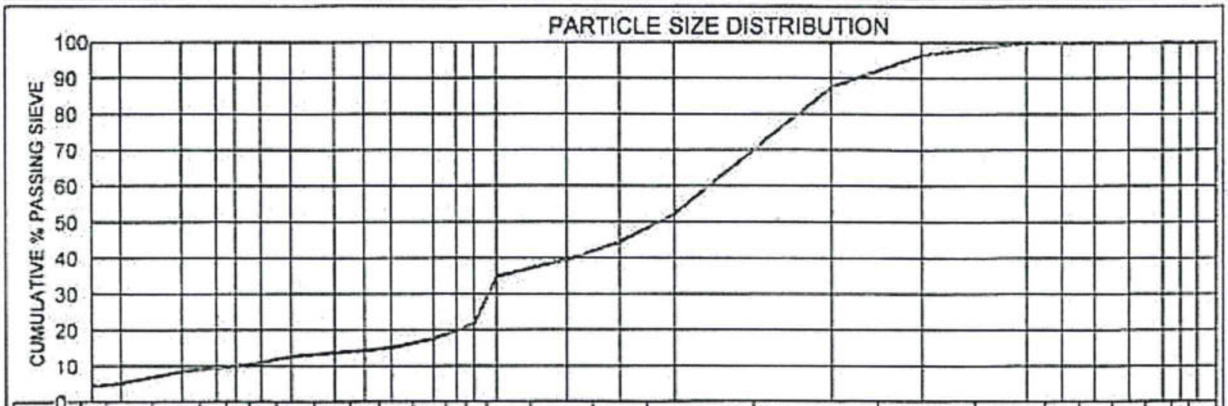
Sample No. : : 9056
Hole No. : : 4 RS12
Depth (mm) : : 500-1400
Liquid Limit (%) : 27
Plasticity Index : 11
Linear Shrinkage (%) : 6.0
PI of Whole Sample : 6
P.R.A. Classification : A-2-6(0)
Unified Soil Classificatior: SC
Activity : 1.16
Heave Classification : LOW
Grading Modulus : 1.26
Percentage (<0.002) : 5.0
Moisture Content (%) : 10.1

Material Description : Dk Red Silty Sand

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	9.4	10.4	67.7	12.5	SILTY SAND
Astm	9.4	25.4	61.7	3.6	SILTY SAND
British Standard	5.2	16.7	65.6	12.5	SILTY SAND







Sieve Size (mm)	0.0015	0.0020	0.0036	0.0050	0.0060	0.0075	0.0100	0.0150	0.0200	0.0280	0.0400	0.0500	0.0600	0.0750	0.1500	0.2500	0.4250	2.0000	4.7500	13.200	19.000	26.500	37.500	53.000	63.000	75.000
% Pass. Sieve	4	5	8	9	10	11	13	14	14	15	18	20	22	35	40	44	52	87	96	100	100	100	100	100	100	100

JENN CLAY | SILT | SAND | GRAVEL

ASTM CLAY | SILT | FINE SAND | MEDIUM SAND | COARSE SAND | GRAVEL

BS CLAY | FINE SILT | MEDIUM SILT | COARSE SILT | FINE SAND | MEDIUM SAND | COARSE SAND | FINE GRAVEL | MEDIUM GRAVEL | COARSE GRAVEL

Remarks :

FORM: A6

Program ver 2.6 (17.08.2006)

for MATROLAB GROUP (PTY) LTD.

MATROLAB GROUP (PTY.) LTD.
- CIVIL ENGINEERING SERVICES -
Reg.No.: 2003/029180/07 - VAT. Reg.No.: 4040210587

a SANAS Accredited Testing Laboratory, No. T0025

418 RUSTIC AVE. SILVERTONDALE
P.O. BOX 912387 SILVERTON 0127

Tel. : 012-804 2050
Fax : 012-804 9555
Email: bennievn@matrolab.co.za

TEST RESULTS

DOLOMITE TECHNOLOGY (PTY) LTD
P.O. BOX 15147
LYTTELTON
0140
Attention: Mr Dave Purnell

Project : Rooihuiskraal North X28+29+31

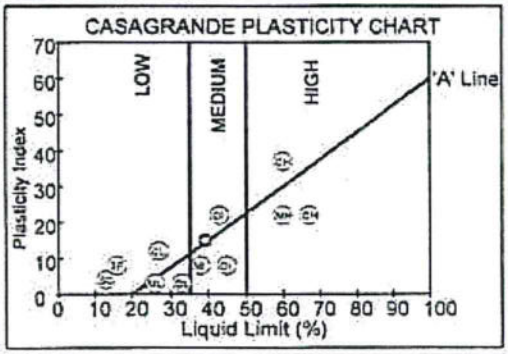
Your Ref :
Our Ref : 0/PL/35326
Date Reported : 13.12.2006

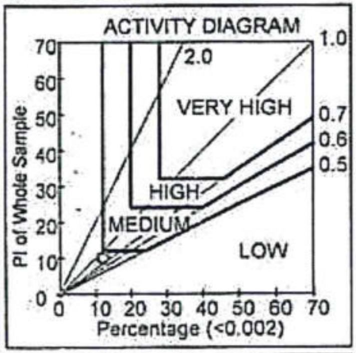
FOUNDATION INDICATOR (ASTM: D422)

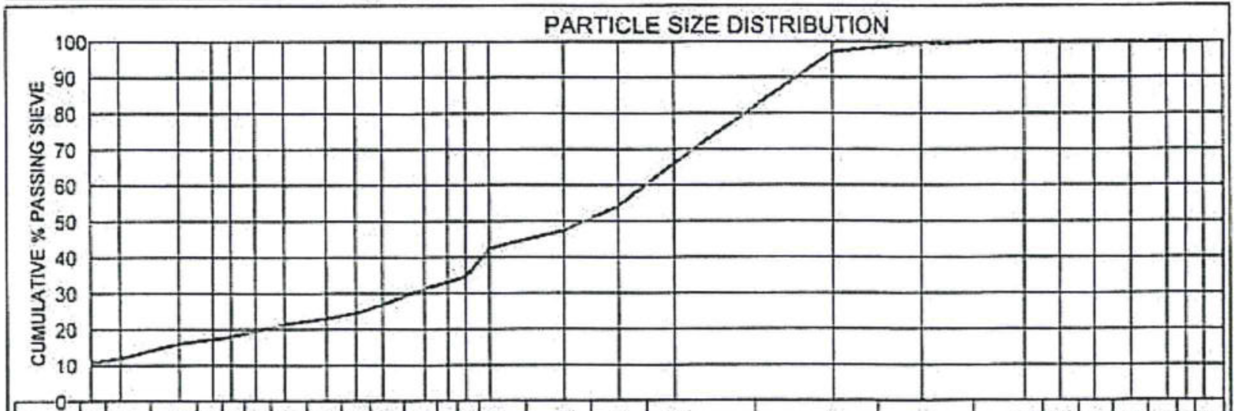
Sample No. :	: 9057
Hole No. :	: 4 RS13
Depth (mm) :	: 1400-2200
Liquid Limit (%)	: 39
Plasticity Index	: 15
Linear Shrinkage (%)	: 7.5
PI of Whole Sample	: 10
P.R.A. Classification	: A-6(3)
Unified Soil Classificatior:	SC
Activity	: 0.84
Heave Classification	: LOW
Grading Modulus	: 0.94
Percentage (<0.002)	: 12.0
Moisture Content (%)	: 17.6

Material Description : Dk Rd Or Clayey Silty Sand

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	17.2	15.8	64.1	2.9	SILTY SAND
Astm	17.2	25.2	57.1	0.5	SILTY SAND
British Standard	12.0	22.8	62.4	2.9	SILTY SAND







Sieve Size (mm)	% Pass. Sieve
0.0015	11
0.0020	12
0.0036	16
0.0050	17
0.0060	18
0.0075	19
0.0100	21
0.0150	23
0.0200	24
0.0260	27
0.0400	31
0.0500	33
0.0600	35
0.0750	42
0.1500	47
0.2500	54
0.4250	66
2.0000	97
4.7500	100
13.200	100
19.000	100
26.500	100
37.500	100
53.000	100
63.000	100
75.000	100

JENN CLAY | SILT | SAND | GRAVEL

ASTM CLAY | SILT | FINE SAND | MEDIUM SAND | COARSE SAND | GRAVEL

BS CLAY | FINE SILT | MEDIUM SILT | COARSE SILT | FINE SAND | MEDIUM SAND | COARSE SAND | FINE GRAVEL | MEDIUM GRAVEL | COARSE GRAVEL

Remarks :

FORM: A6

Program ver 2.6 (17.08.2006)

for MATROLAB GROUP (PTY) LTD.

MATROLAB GROUP (PTY.) LTD.

- CIVIL ENGINEERING SERVICES -

Reg.No.: 2003/029180/07 - VAT. Reg.No.: 4040210587

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TEST RESULTS

DOLOMITE TECHNOLOGY (PTY) LTD
P.O. BOX 15147
LYTTELTON
0140
Attention: Mr Dave Purnell

Project : Rooihuiskraal North X28+29+31

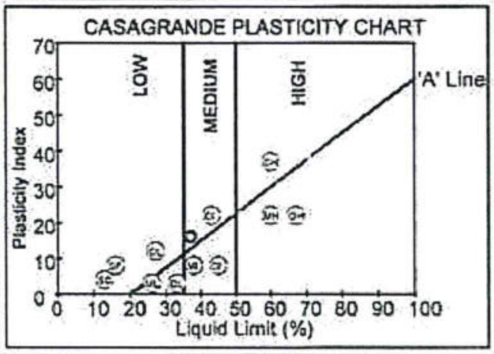
Your Ref :
Our Ref : 0/PL/35326
Date Reported : 13.12.2006

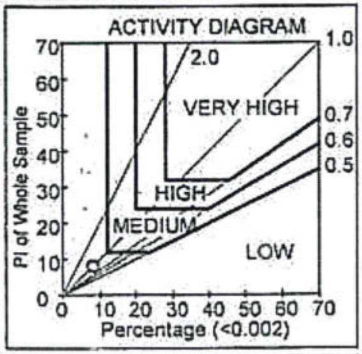
FOUNDATION INDICATOR (ASTM: D422)

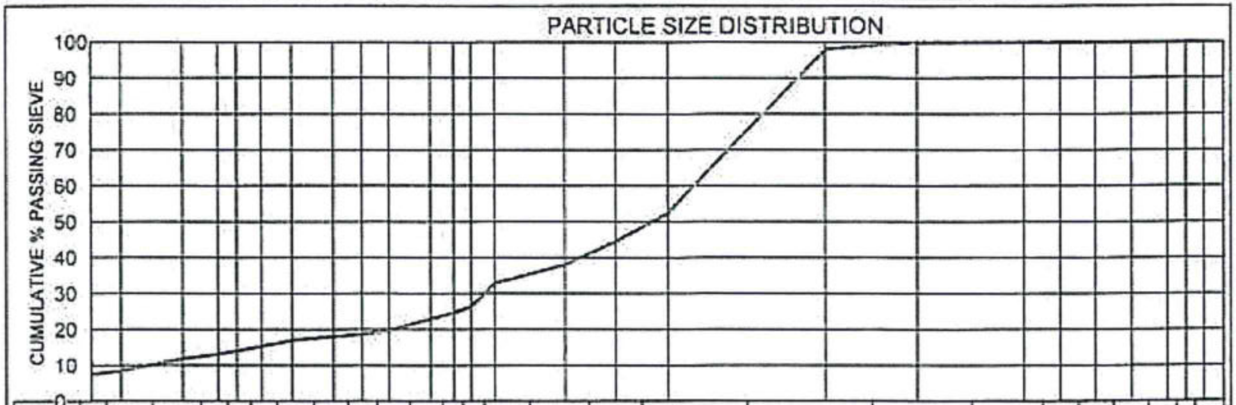
Sample No. :	: 9058
Hole No. :	: 4 RS14
Depth (mm) :	: 2200-3000
Liquid Limit (%)	: 37
Plasticity Index	: 16
Linear Shrinkage (%)	: 7.5
PI of Whole Sample	: 8
P.R.A. Classification	: A-2-6(1)
Unified Soil Classification	: SC
Activity	: 0.95
Heave Classification	: LOW
Grading Modulus	: 1.17
Percentage (<0.002)	: 8.0
Moisture Content (%)	: 10.0

Material Description : Red orange Clayey Silty Sand

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	13.1	11.5	73.2	2.1	SILTY SAND
Astm	13.1	19.7	67.1	0.1	SILTY SAND
British Standard	8.4	18.0	71.5	2.1	SILTY SAND







Sieve Size (mm)	% Pass. Sieve
0.0015	7
0.0020	8
0.0036	12
0.0050	13
0.0060	14
0.0075	15
0.0100	17
0.0150	18
0.0200	19
0.0280	20
0.0400	23
0.0500	25
0.0600	26
0.0750	33
0.1500	38
0.2500	44
0.4250	52
2.0000	98
4.7500	100
13.200	100
19.000	100
26.500	100
37.500	100
53.000	100
63.000	100
75.000	100

JENN CLAY | SILT | SAND | GRAVEL

ASTM CLAY | SILT | FINE SAND | MEDIUM SAND | COARSE SAND | GRAVEL

BS CLAY | FINE SILT | MEDIUM SILT | COARSE SILT | FINE SAND | MEDIUM SAND | COARSE SAND | FINE GRAVEL | MEDIUM GRAVEL | COARSE GRAVEL

Remarks :

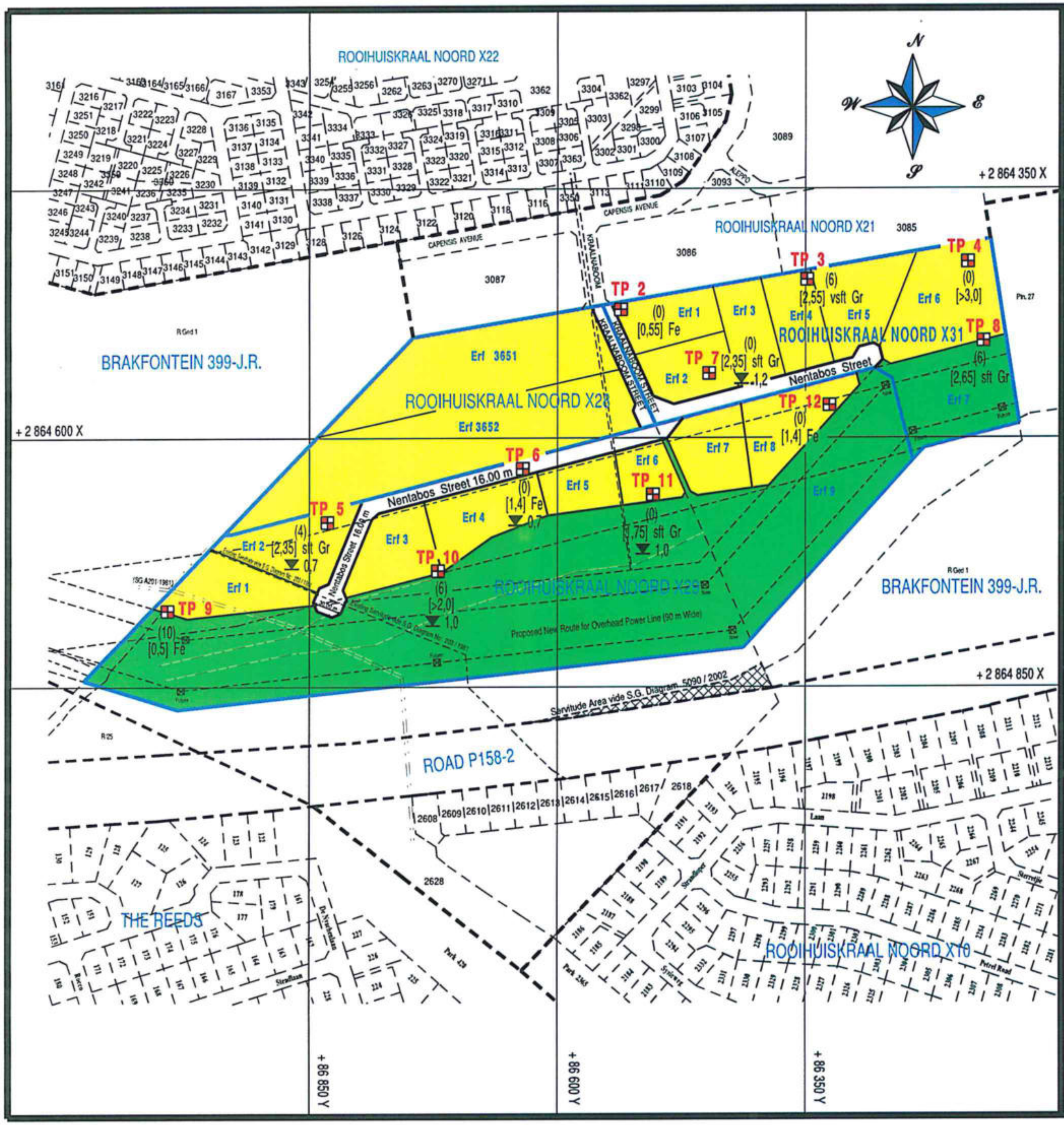
FORM: A6

Program ver 2.6 (17.08.2006)

for MATROLAB GROUP (PTY) LTD.

APPENDIX C

PLANS



TEST PIT POSITIONS MAP

ROOIHUISKRAAL NOORD EXTENSIONS 29 AND 30

Legend:

TP 4 ⊞	Test Pit Position
(6)	Maximum possible heave at present ground surface (mm)
[2,5]	Refusal depth of Komatsu WB93R Backactor (m)
vsft	Very Soft
sft	Soft
Gr	Granite
Fe	Ferricrete Hardpan

PLAN NUMBER:	D1210 / 02
COMPILE BY:	S.P. KOK
LOCAL AUTHORITY:	CITY OF TSWANE

Dolomite Technology Pty (Ltd)
Reg. No: 2002 / 030518 / 07
95 Shepstone Avenue
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DOLOMITE TECHNOLOGY

SCALE: 1 : 2 500

DATE: JANUARY 2007

LOCALITY PLAN

ROOIHUISKRAAL NOORD EXTENSIONS 29 AND 31

Legend:

▨ The Application Site

PLAN NUMBER:	D1210 / 01
COMPILED BY:	S.P. KOK
LOCAL AUTHORITY:	CITY OF TSHWANE

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DOLOMITE TECHNOLOGY

SCALE: 1 : 30 000

DATE: JANUARY 2007

ENGINEERING GEOLOGICAL AND GEOTECHNICAL REPORT FOR TOWNSHIP PLANNING PURPOSES FOR ROOIHUISKRAAL NORTH EXTENSIONS 29 AND 31, TSHWANE METROPOLITAN MUNICIPALITY, GAUTENG

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Report no: K1210-02
Project no: 1210-GB

February 2010

S P KOK Pr Sci Nat
Engineering geologist
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ROOIHUISKRAAL NORTH EXTENSIONS 29 AND 31: GEOTECHNICAL INVESTIGATION

Title: ENGINEERING GEOLOGICAL AND GEOTECHNICAL REPORT FOR TOWNSHIP PLANNING PURPOSES FOR ROOIHUISKRAAL NORTH EXTENSIONS 29 AND 31, TSHWANE METROPOLITAN MUNICIPALITY, GAUTENG

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Project no: 1210-GB

Report no: K1210-02

Project Team:
S P Kok
A Michel
Mrs W Labuschagne

Date: February 2010

Approved for Geo Buro Geotechnical Surveys

Table of contents

APPENDICES

1. Introduction

Johan Lewis appointed Dolomite Technology (Pty) Ltd verbally to undertake an engineering geological and geotechnical investigation for township planning purposes for Rooihuiskraal North Extensions 29 and 31, Gauteng. In 2010 Geo Buro was appointed by Lezmin 1066 CC to update the existing geotechnical report.

2. Purpose of the investigation

- Update existing report.
- To determine the geological origin of the material on site.
- To determine the engineering properties of the different material layers.
- To give recommendations regarding the founding of proposed structures.

3. The site

The site is in the order of 21 ha in area, being situated on portions of Remainder 1 of the farm Brakfontein 399-JR, approximately 16 km to the south-southwest of the Tshwane CBD, as shown on the **Locality Plan number 1210-06/01**, in **Appendix C.**

The site is bordered to the north by Rooihuiskraal North Extension 21, to the west and east by undeveloped portions of Remainder 1 of the farm Brakfontein 399-JR, and to the south by a proposed servitude for a new overhead power line route (to the south of which lies the N14 national road to Krugersdorp).

Townhouses have been constructed in Rooihuiskraal North Extension 28, in the north-west of the site. Some builders rubble has been dumped in Rooihuiskraal North Extension 31, particularly in the south of that area.

Apart from the townhouses in the north-west of the site, and the overhead power lines in the south, there are no structures on the site. There are no trees on the site. The site is covered with veld grass.

A non-perennial west-south-westward draining water course is situated to the south of the site, encroaching onto the site in the south-western corner of the site. The site drains steadily to the south, towards the water course.

4. Geology

According to the 1:50 000 scale Lyttelton geological map the site is underlain at depth by Archaean Granite of the Halfway House Granite Suite (now the Johannesburg granite Dome). The area is **not** underlain by dolomite.

5. Climate

The site lies within the Highveld climatic region, the climate being described as warm temperate with summer rainfall.

The average daily maximum temperature is in the order of 28ºC in January and 18ºC in July. The rainy season is from October to March, with an average rainfall of about 740mm. Thornwaite's classification indicates sub humid, warm conditions with deficient moisture in all seasons.

The Weinert N-value is in the region of 2.4 which indicates that predominantly chemical decomposition of the underlying rock has taken place.

6. Method of investigation

In 2007 eleven test pits were dug in a grid pattern on the site by means of a Komatsu WB93R back actor hired from Potlaki Plant Hire. The spacing of the test pits was in the order of 150 m. Subsequently in 2010 an additional four test pits were excavated, soil profiling done and material samples taken. Due to the presence of rubble, the access to parts of the site is very difficult. The test pits were dug to refusal or else to approximately 2,5 m depth and were fully profiled by an engineering geologist according to the standard method of Jennings et al. Section 11.2.

The bearing capacity of each layer was estimated, and disturbed samples of representative materials were taken in order to determine their physical properties by means of laboratory testing.

The material properties are summarized in **Table 1**, and the hand-held GPS co-ordinates of the test pits are provided in **Table 2** (at the back of the report after **Section 11)**. The laboratory test results, test pit profiles, and the **site plan** with test pit positions **number 1210B-03** are included in the **Appendices** to this report.

7. Generalised soil profile

The site is underlain at depth by granite bedrock. In the majority of the site a Komatsu WB93R back actor or Case 580 Super R was able to excavate to the weathered granite bedrock. In localized areas of the site a ferricrete hardpan layer has formed at a shallower level than the granite bedrock; in such areas the ferricrete hardpan caused refusal of the back actor.

Therefore the site is underlain by two distinct soil profiles, these being:

- where ferricrete hardpan has not developed and weathered granite bedrock is reached; and
- where ferricrete hardpan occurs.

7.1 Areas where granite bedrock is reached

0,0 – 0.4 m	Dry to slightly moist, grey, apparently dense in profile but potentially collapsible, medium grained silty SAND with sub-angular quartzite pebbles up to 30 mm diameter between 0,3 and 0,4 m depth, plus occasional sub-rounded quartzite boulders up to 0,3 m diameter. Transported. P=30 kPa Heave class = Low
0,4 – 0,7 m	Slightly moist to moist, grey blotched yellow-orange mottled black, very dense, partly cemented, medium grained sandy GRAVEL; angular iron concretions up to 20 mm diameter. Pedogenic. P=400 kPa Heave class = Low

0,7 – 1,6 m	Slightly moist, becoming very moist with depth, yellow-orange blotched light grey, very dense, medium grained silty SAND. Residual granite. P=300 kPa Heave class = Low
1,6 – 2,4 m	EITHER: Very moist, reddish-orange dense to very dense, medium grained silty SAND. Residual granite. P=150 to 200 kPa Heave class = Low OR: Very moist, yellow-orange blotched light grey, dense to very dense, medium grained silty SAND. Residual granite. P=200 kPa Heave class = Medium
2,4 – 2,45 m	Reddish-orange blotched grey, highly weathered, medium grained, very soft to soft ROCK; granite. P=600 kPa.

Where P= estimated bearing capacity of the layer, taking into account the soil structure and the possibility of future inundation.

In areas where weathered granite bedrock was encountered, refusal of a Komatsu WB93R or Case 580 Super R back actor occurred on soft granite rock at an average depth of 2,45 m.

7.2 Areas where ferricrete hardpan occurred

0,0 – 0,5 m	Slightly moist, olive, apparently dense in profile but potentially collapsible, medium grained clayey SAND. Transported. P=30 kPa. Heave class = Low
0,5 – 0,55 m	Yellow-orange mottled black, cemented, ferricrete HARDPAN. Pedogenic. P=450 kPa.

In areas where ferricrete hardpan was encountered, refusal of a Komatsu WB93R back actor occurred on ferricrete hardpan at an average depth of 0,55 m beneath the natural ground surface.

7.3 General

Groundwater seepage occurred in 7 of the 15 test pits excavated on this site, at an average depth of 0,9 m.

8. Discussion

As discussed in **Section 7,** there are two generalized soil profiles underlying the site, one in areas where weathered granite bedrock can be reached, and the other where ferricrete hardpan is encountered at shallower depths. These generalized soil profiles are described in detail in **Section 7.** Summaries of the generalized soil profiles are as follows:

8.1 Areas where weathered granite bedrock is reached:

Soil type	**Depth (m)**	**Origin**	**Estimated bearing capacity (kPa)**	**Heave classification**
Grey, potentially collapsible, silty sand.	0,0 – 0,4	Transported	30	Low
Grey, very dense, sandy gravel	0,4 – 0,7	Pedogenic	400	Low
Yellow-orange, very dense, silty sand.	0,7 – 1,6	Residual granite	300	Low
EITHER: Reddish-orange, dense to very dense, silty sand	1,6 – 2,4	Residual granite	150 to 200	Low
OR: Yellow-orange, dense to very dense, silty sand	1,6 – 2,4	Residual granite	200	Medium
Reddish-orange, very soft to soft rock	2,4 – 2,45	Granite	600	

8.2 Areas where ferricrete hardpan occurred:

Soil type	**Depth (m)**	**Origin**	**Estimated bearing capacity (kPa)**	**Heave classification**
Olive, potentially collapsible, clayey sand	0,0 – 0,5	Transported	30	Low
Yellow-orange, ferricrete hardpan	0,5 – 0,55	Pedogenic	450	

8.3 As can be seen from the tables above, the majority of the materials encountered on the site had a low heave classification. However, it should be noted that a layer of residual granite, in the form of a silty sand, which occurred between approximately 1,6 m and 2,4 m depth, had a medium active heave classification. If the moisture content of this medium active layer was to increase from a dry to a wet condition, the maximum possible heave to be anticipated at the present ground surface would be in the order of 11 mm. However, it should be noted that the moisture content of the layer at the time of the investigation (December 2006) was very moist. Also, the layer occurs at a depth in the order of 1,5 m – beneath such a depth the moisture content of the soil profile characteristically remains reasonably constant. Therefore, providing measures are taken to maintain a reasonably constant moisture content of this layer, the maximum probable heave to be anticipated to be caused at the present ground surface by this layer should be less than 6 mm, such a heave would not normally require expensive precautionary measures to be taken in the design and construction of conventional non-sensitive structures. Nevertheless, it should be borne in mind during the design of any structures to be constructed in the area.

8.4 It should also be noted that the uppermost layer of the natural soil profile is generally a potentially collapsible clayey sand layer in the order of 0,5 m in thickness. This layer is generally immediately underlain by either a cemented ferricrete hardpan, or else by a dense to very dense, partly cemented layer with an estimated bearing capacity of at least 150 kPa. Therefore, in general it would be recommended that proposed structures should be founded upon the material underlying the potentially collapsible sand at a depth of at least 0,5 m beneath the present ground surface, with a maximum allowable bearing pressure of 150 kPa.

8.5 However, it must also be noted that in test pits number 4 and 11 the potentially collapsible transported sand layer is underlain to a depth in the order of 1,4 m by a potentially collapsible residual granite layer in the form of a clayey sand. It is possible that this potentially collapsible residual granite layer could occur locally in other parts of the site. If structures are founded upon this layer, settlement could take place, if the materials are inundated with water. Such settlement could result in cracking of the structures. To minimize the possibility of settlement of the structures it is recommended that the floors of foundation excavations should be compacted by a hand-operated vibratory roller or else by a machine equivalent to a Wacker Rammer (a mechanized tamping device); a test section should firstly be compacted under the supervision of the Engineer in order to determine the optimum number of roller passes. The structures can then be constructed by conventional means.

8.6 Additional precautionary measures that can be employed are the provision of expansion joints in the walls of the structures, a concrete walkway 1,0 m in width around the perimeter of each structure, and the shaping of the walkway and the ground surface in the vicinity of the structures so as to drain water away from each structure so that no ponding of surface water can take place in the vicinity of the structures.

8.7 It should be noted that the measured described in **Section 8.5** and **8.6** will minimize the possibility of cracks developing due to heaving or settlement of the ground, but that slight cracking of structures founded in the upper 2,5 m of the soil profile may still occur.

8.8 Proposed road routes should be compacted prior to the placement of fill by means of a heavy vibratory roller of at least 13 tonne static mass.

9. Zonation

According to the classification of the NHBRC, the site can be classified as a NHBRC Site Class **H/C1**. The site is **not underlain by dolomite.**

Using the classification proposed by Partridge et all [19] (see **Table 9.1** below), the site can be classified as 1A/2B/1C/2D/1F/1I.

TABLE 9.1 : 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 total-ing 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 compres-sibility expected.	High soil-heave compres-sibility expected.
D	High compressible soil	Low soil compressibility expected*	Moderate soil compres-sibility 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 than 100 cm/s^2.	Natural seismic activity more than 100 sm/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 localized occurrences of the constraint may arise.