63 Wessel Road, Rivonia, 2128 PO Box 2597, Rivonia, 2128
South Africa **Tel:** +27 (0) 11 803 5726
Fax: +27 (0) 11 803 5745 **Web:** www.gcs-sa.biz

Soil Investigation Greenwich Landfill Site Final Report

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Pedological Investigation

Greenwich Landfill Site

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GLOSSARY OF TERMS AND ACRONYMS

A Horizon	Topmost layer of a soil profile commonly known as the topsoil, usually a darker colour than underlying layers because of the presence of decomposed organic matter
Apedal	Soil without macrostructure
Avalon	Soil form characterised by an Orthic A horizon, a yellow-brown apedal B horizon overlying a soft plinthic B horizon
B Horizon	A mineral subsurface horizon which is a zone of accumulation through illuviation, alteration or weathering
Concretions	Compact masses of mineral matter or small stones found in soils
Dolomite	Sedimentary carbonate rock composed of calcium, magnesium and carbonate chemically combined together
Estcourt	Soil form classified by an Orthic A horizon with an E horizon overlying a prismacutanic B horizon.
Glenrosa	Soil form with an orthic topsoil and a lithocutanic B horizon.
Hutton	Soil form with an orthic topsoil, a red apedal B subsoil overlying an unspecified layer
Inanda	Soil form classified by a Humic A horizon overlying a red apedal B horizon with an unspecified layer below.
Katspruit	Soil form with an orthic topsoil and a gleyed subsoil.
Lithology	Description of a rock's physical characteristics visible at outcrop, in hand or core samples or with low magnification microscopy, such as colour, texture, grain size, or composition
Lithocutanic	B soil horizon underlying a topsoil layer and merges into an underlying weathering parent rock

Magwa	A soil form classified as a Humic A horizon with a yellow-brown apedal B overlying unspecified material.
Mispah	A soil form classified as an Orthic A horizon overlying hard rock.
Orthic	A topsoil horizon that does not qualify as an organic, humic, melanic or vertic topsoil although it may have been darkened by organic matter
Pedogenesis	Process of soil formation as regulated by the effects of place, environment, and history
Pinedene	Soil form characterised by an orthic topsoil a yellow-brown B horizon overlying unspecified material with signs of wetness.
Shortlands	Soil form with an Orthic topsoil overlying a red structured B horizon
Sweetwater	Soil form with a Humic A horizon, neocutanic B horizon overlying unspecified material.

EXECUTIVE SUMMARY

GCS Pty (Ltd) was requested to conduct a soil study for the proposed Greenwich Landfill Site.

The soil assessment forms part of the requirements for an Environmental Impact Assessment (EIA).

Soil Classification

The soil forms identified through augering on the Greenwich site were:

- red well drained: Hutton and Inanda;
- yellow-Brown moderately drained: Pinedene, Avalon, Magwa, Kranskop and Sweetwater;
- drainage impaired soils: Katspruit, Glenrosa and Estcourt; and
- shallow soils: Mispah.

Soil Chemistry

The soils at Greenwich were found to be low in macro cations, with calcium, magnesium and potassium being below the critical levels. The micro cation, iron was high in the A horizon, with aluminium and magnesium being above the critical levels. The anion levels at Greenwich indicated nitrates to be within the critical levels, however, most sulphates were above the critical levels.

Land Capability

Seven land capability classes were identified, namely I, II, III, V, VI, VII AND VIII. The dominant land capability class found in Greenwich is Class I, which is suitable for cultivation. The soils occurring within this land capability class are the Inanda, Hutton and Kranskop.

Land Suitability

Land suitability classification takes into account soil form classification, land capability, soil chemistry, climate of the area and physical characteristics. Therefore, it provides an insightful detail with regards the most appropriate land use. Six land suitability classes were identified, namely I, II, III, VI, VII and VIII. The dominant land suitability class was identified as I, which is suitable for annual cropping.

Risk Assessment

The impact of the proposed landfill activities on the soil were identified for the pre-construction, construction, operational and decommissioning phases. For the construction phase, two impacts pertaining to soil erosion and soil disturbance were identified. For the operational phase, the potential impacts pertaining to soil disturbance, compaction and soil contamination were identified. Finally, the potential impact during the decommissioning phase was identified as ongoing pollution

from the landfill leachate. Mitigation measures for each potential impact identified was discussed (see Section 4.5).

REQUIREMENT	STATUS
1. A specialist report prepared in terms of these Regulations must contain—	
(a) details of—	
(i) the specialist who prepared the report; and	Page i
(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	Appendix H
(b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Appendix G
(c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 2
(cA) an indication of the quality and age of base data used for the specialist report;	Section 3
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 4.5
(d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 3
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 3

REQUIREMENT	STATUS
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternative;	Section 4.5
(g) an identification of any areas to be avoided, including buffers;	N/A
(h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	N/A
(i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 3
(j) a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	Section 4.5
(k) any mitigation measures for inclusion in the EMPr;	Section 4.5
(l) any conditions for inclusion in the environmental authorisation;	N/A
(m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	N/A
(n) a reasoned opinion—	Section 7

REQUIREMENT	STATUS
(i) whether the proposed activity, activities or portions thereof should be authorised;	N/A
(iA) regarding the acceptability of the proposed activity or activities; and	N/A
(ii) if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	N/A
(o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	N/a
(p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	N/a
(q) any other information requested by the competent authority.	N/A
2. Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	N/A

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1 INTRODUCTION

Envitech Solutions (Pty) Ltd commissioned GCS (Pty) Ltd. to undertake a soil investigation of the proposed Greenwich landfill site. The site is situated in quaternary catchment V31K located within the Water Management Area 7 (See

Figure 1-1). The site is located approximately 10km South of the town of Newcastle and is the proposed landfill site for the town.

The soil investigation formed part of the requirements for the Environmental Impact Assessment (EIA).

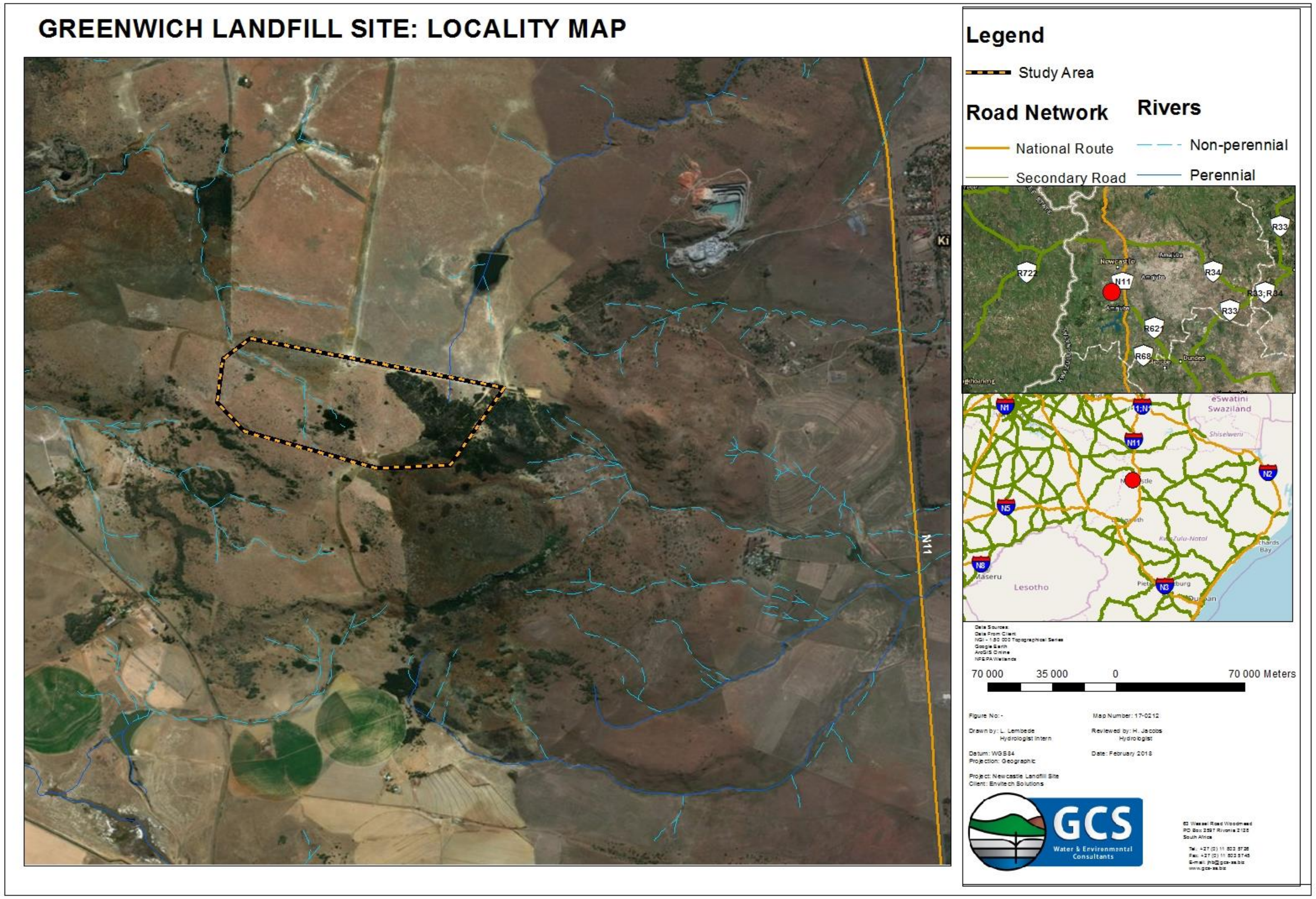


Figure 1-1: Locality of the Greenwich Landfill Site

2 SCOPE OF WORK

1. Desktop Assessment:
    - General project site assessment; and
    - Determination of soil survey and sampling points.
2. Site Visit:
    - Visual site assessment;
    - Soil survey classification and sampling; and
    - Land use assessment.
3. Climate:
    - Determination of the Mean Annual Precipitation (MAP) and Mean Annual Evaporation (MAE) for the site.
4. Soil Laboratory Analysis:
    - Sample testing; and
    - Chemistry interpretation.
5. Land Capability:
    - Determination of soil potential holding other factors constant;
    - Determination of soil potential given other influencing factors.
6. Risk Assessment:
    - Construction Phase;
    - Operation Phase;
    - Closure/Decommissioning Phase; and
7. Reporting:
    - A close-out report detailing all the activities listed above was compiled; and
    - Recommendations were made.

3 METHODOLOGY

3.1 Desktop Assessment

A description of the catchment characteristics that may be affected by the proposed development activity was undertaken using the Google Earth satellite imagery (Google Earth, 2017). Positions of the soil survey and sampling points were also determined using the Google Earth satellite imagery.

The only reliable data available pre-site evaluation was the 1:250,000 scale Land Type maps that are available from the Department of Agriculture.

3.2 Site Visit

The site visit was undertaken on the 29th of January 2018 to physically assess catchment characteristics and to conduct a soil survey and sampling on the Greenwich Site.

3.3 Climate

A meteorological analysis was undertaken within the context of this study in order to better understand the soil environment since climate influences soil formation. The climatic data were obtained from the WR2012 database (WRC, 2015) and evaluated to determine the Mean Annual Precipitation (MAP), Mean Annual Evaporation (MAE) and the Mean Annual Runoff (MAR) for the site. The climate data is useful to indicate the weathering and erosion of soils.

3.4 Soil Survey and Classification

3.4.1 Soil survey

The detailed pedological study of the site was performed based on a grid overlay (150m x 150m) to the area. A total area of 1210 ha was covered in the course of this study. Standard mapping procedures and field equipment were used throughout the survey. Soils were identified from hand augured samples during the site visit. 25 Auger points were laid out in a grid pattern of the site.

3.4.2 Soil classification

The identification and classification of soil profiles were carried out using the TAXONOMIC SOIL CLASSIFICATION SYSTEM (*Mac Vicar et al, 1991*). The TAXONOMIC SOIL CLASSIFICATION SYSTEM is in essence a very simple system that employs two main categories or levels of classes, an upper level or general level containing soil forms, and a lower, more specific level containing soil famalies. Each of the soil Forms in the classification is a class at the upper level, defined by a unique vertical sequence of diagnostic horizons and materials. All Forms are subdivided into two or more families, which have in common the properties of the Form, but are differentiated within the Form on the basis of their defined properties.

In this way, standardised soil identification and communication is allowed by use of the names and numbers given to both Form and Family. The procedure adopted in field when classifying the soil profiles is as follows:

i) Demarcate master horizons
ii) Identify applicable diagnostic horizons by visually noting the physical properties such as:
- Depth
- Texture
- Structure
- Mottling
- Visible pores
- Concretions
- Compaction

iii) Determine from i) and ii) the appropriate Soil Form
iv) Establishing provisionally the most likely Soil Family

Five soil samples, consisting of an A and a B horizon were analysed by an accredited laboratory, UIS Organics Pty (Ltd) (see SANAS certification in Appendix F). These soils were analysed for micro cations, macro cations and anions. Soil chemistry is useful for fertilizer recommendation as well as identification of possible toxic levels of metals in the soil prior to establishment of the landfill site.

3.5 Land Capability and Suitability

3.5.1 Land Capability

Land capability mapping was based on identified soil forms at the site. As mentioned, the soil forms were derived according to the South African Soil Classification Taxonomic System (Soil Classification Working Group, 1991). The land capability mapping involved dividing land into one of eight (8) potential classes of soil capability, whereby Classes I-IV represent arable land and Classes V-VIII represent non-arable land according the guidelines (Appendix C) (Schoeman *et al.*, 2002). The Table for Land Capability can be viewed in Appendix A.

3.5.2 Land Suitability

Soil suitability mapping was determined by taking into account the soil forms, land capability classes, soil chemistry results, the hydrology of the site and the current land use. The process involved allocating terrain factors (such as slope) and soil factors (such as depth, texture, internal drainage and mechanical limitations (which affect soil-water processes) which define soil forms, to an area of land. The soil chemistry, which includes pH, cation and anion concentrations as well as organic carbon and nitrogen compositions, which are affected by the site hydrology, were considered in determining the final suitability of the soil. The suitability guidelines used in this study are presented in Appendix C (Schoeman *et al.*, 2002).

3.6 Environmental Management Plan

The soil assessment forms part of an Environmental Impact Assessment (EIA) required for the development of an Environmental Management Plan (EMP) aimed to fulfil the requirements of the South African National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA), the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) (NEMWA) and the National Water Act, 1998 (Act No. 36 of 1998) (NWA).

3.7 Risk Assessment

Each identified impact was assessed in terms of probability (likelihood of occurring), scale (spatial scale), magnitude (severity) and duration (temporal scale). To enable a scientific approach to the determination of the environmental significance (importance), a numerical value was linked to each rating scale (scaling shown in Appendix D) (rating table shown in Appendix E). The following criteria were applied:

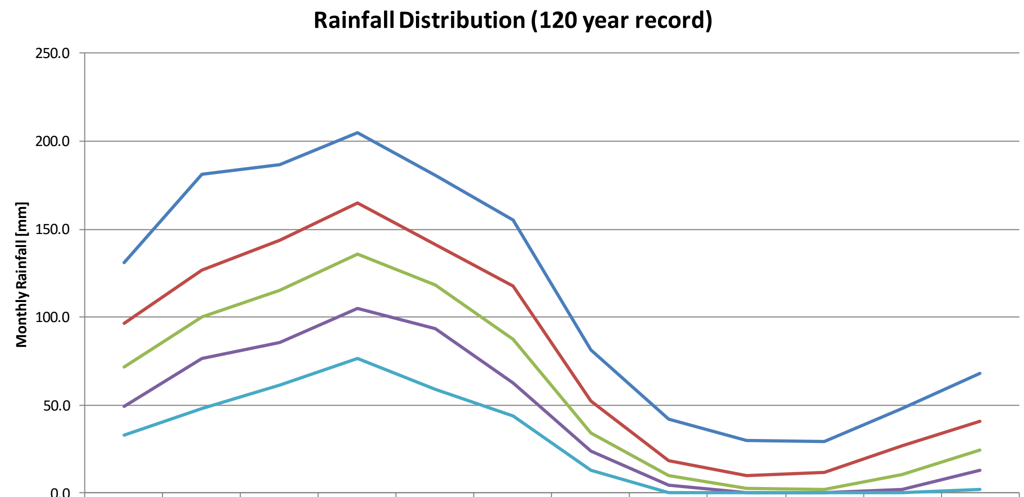
- Occurrence:
  - Probability of occurrence (how likely is it that the impact may occur?); and
  - Duration of occurrence (how long the impact may last?).
- Severity:
  - Magnitude (severity) of impact (will the impact be of high, moderate or low severity); and
  - Scale/extent of impact (will the impact affect the national, regional or local environment, or only that of the site).

4 RESULTS

This section presents findings of the soil assessment processes undertaken throughout this study.

4.1 Climate

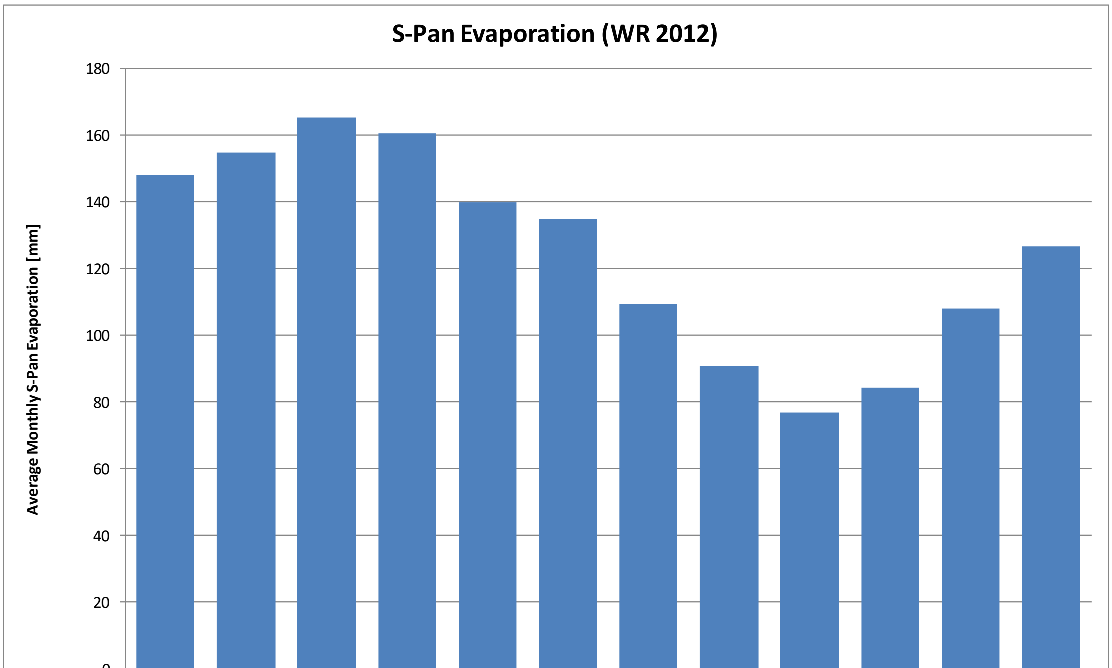
The MAP and MAE for quaternary catchment V31K are 800 mm and 1500 mm, respectively (WRC, 2012). The MAP monthly distribution can be seen in Figure 4-1. The monthly average evaporation for the catchment far exceeds precipitation (See Figure 4-2) and this is typical of semi-arid environments in South Africa. Distinct seasonal rainfall is experienced in this area with the wet season running from October to March, while the dry season starts in the month of April and ends in September. Rainfall seasonality is useful when working soils as this should be undertaken during the dry season to avoid erosion and loss of soil. Wetland and hydromorphic soils are much easier to work with when dry.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
E10	131.0	181.0	186.7	205.2	180.6	155.3	81.6	41.9	30.1	29.1	48.2	68.1
E30	96.7	126.6	143.6	165.2	141.0	117.5	52.3	18.6	9.9	11.8	26.6	40.9
E50	71.9	100.0	115.4	136.1	118.5	87.3	33.9	9.9	2.5	1.8	10.8	24.6
E70	49.2	76.4	85.6	104.9	93.5	62.8	24.1	4.7	0.1	0.1	1.8	13.0
E90	33.0	47.9	61.3	76.8	58.9	43.9	12.9	0.1	0.0	0.0	0.0	1.8

E30 represents a value that is likely to be exceeded in 30% of years, etc.

Figure 4-1: Monthly rainfall distribution for quaternary catchment V31K



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
S-Pan Evap	148	155	165.3	160.7	140.1	134.9	109.3	90.8	77	84.2	108	126.7

Figure 4-2: Monthly evaporation for quaternary catchment V31K.

4.2 Soils Survey and Classification

4.2.1 Identified Soils Forms

The major soil types encountered include:

- red well drained: Hutton and Inanda;
- yellow-Brown moderately drained: Pinedene, Avalon, Magwa, Kranskop and Sweetwater;
- drainage impaired soils: Katspruit, Glenrosa and Estcourt; and
- shallow soils: Mispah

The area covered and the soil form distribution map of the study area are depicted on

Figure 4-4 the survey points surveyed are shown in Figure 4-3.

Table 4-1 details the soil coverage by soil form.

Table 4-1: Soil survey within the Greenwich site

Sample Point	X- Co-ordinate	Y- Co-ordinate	Depth (m)	Horizon	Soil Form	Description
S1	29.93113941	-27.84936984	0.35	A	Pinedene	Orthic
			0.35-0.70	B		Yellow Brown apedal
			>0.70	unspecified		Unspecified Material with signs of wetness
S2	29.9300576	-27.85087263	0.25	A	Avalon	Orthic
			0.25-0.60	B		Yellow-brown apedal
			>0.60	B		Soft plinthic
S3	29.92882921	-27.84916941	0.30	A	Katspruit	Orthic
			>1.5	G		Gleyed horizon with black and red concretions
S4	29.92791584	-27.85064718	0.25	A	Magwa	Humic
			>1.5	B		Yellow brown apedal
S5	29.92826911	-27.85236795	0.15	A	Avalon	Orthic
			0.15-0.6	B		Yellow-brown apedal
			>0.60	B		Soft plinthic
S6	29.92781507	-27.85387909	0.18	A	Hutton	Orthic
			0.18-1.5	B		Red apedal
			>1.5	B		Unspecified
S7	29.92556599	-27.85367887	0.3	A	Inanda	Humic

			0.3-0.8	B		Red apedal
			>0.8	unspecified		unspecified
S8	29.9258482	-27.85159777	0.45	A	Sweetwater	Humic
			>0.45	B		Neocutanic
			>0.45	B		Unspecified
S9	29.92678176	-27.84883582	0.05	A	Kranskop	Humic
			0.05-0.8	B		Yellow-brown apedal
			0.8->1.5	B		Red apedal
S10	29.92429722	-27.84939745	0.1	A	Glenrosa	Orthic
			0.25-0.75	B		Lithocutanic
S11	29.92347	-27.85114411	0.22	A	Magwa	Humic
			0.22-0.8	B		Yellow-brown appedal
			>0.8	B		Unspecified
S12	29.92357677	-27.85305399	0.2	A	Inanda	Humic
			0.2-0.8	B		Red apedal
			>0.8	unspecified		unspecified
S13	29.92097654	-27.85308194	0.1	A	Inanda	Humic
			0.1-0.8	B		Red apedal
			>0.8	unspecified		unspecified

S14	29.92093163	-27.85045058	0.1	A	Inanda	Humic
			0.1-0.8	B		Red apedal
			>0.8	unspecified		unspecified
S15	29.9218979	-27.84795976	0.1	A	Inanda	Humic
			0.1-0.8	B		Red apedal
			>0.8	unspecified		unspecified
S16	29.91915607	-27.84846002	0.1	A	Glenrosa	Orthic
			>0.1	B		Lithocutanic
S17	29.91811625	-27.85006616	0.35	A	Estcourt	Orthic
			0.35-0.55	E		E horizon
			>0.55	B		Prismacutanic
S18	29.91823197	-27.85196749	0.07	A	Mispah	Orthic
			>0.07	B		Hard rock
S19	29.91751307	-27.84709804	0.12	A	Sweetwater	Humic
			0.12-0.22	B		Neocutanic
			>0.22	B		Unspecified
S20	29.91666996	-27.84888168	0.15	A	Avalon	Orthic
			0.15-0.75	B		Yellow-brown apedal
			>0.75	B		Soft plinthic
S21	29.9160308	-27.85053075	0.09	A	Mispah	Orthic
			>0.09	B		Hard rock

S22	29.91434026	-27.85130251	0.15	A	Inanda	Humic
			0.15-1	B		Red apedal
			1->1.5	unspecified		unspecified
S23	29.91320056	-27.84956469	0.22	A	Inanda	Humic
			0.22-1.2	B		Red apedal
			>1.2	unspecified		unspecified
S24	29.91426119	-27.84760076	0.9	A	Inanda	Humic
			0.09-0.35	B		Red apedal
			0.35->1.2	unspecified		unspecified
S25	29.91224545	-27.84727234	0.11	A	Inanda	Humic
			0.11-0.24	B		Red apedal
			0.24>1.3	unspecified		unspecified

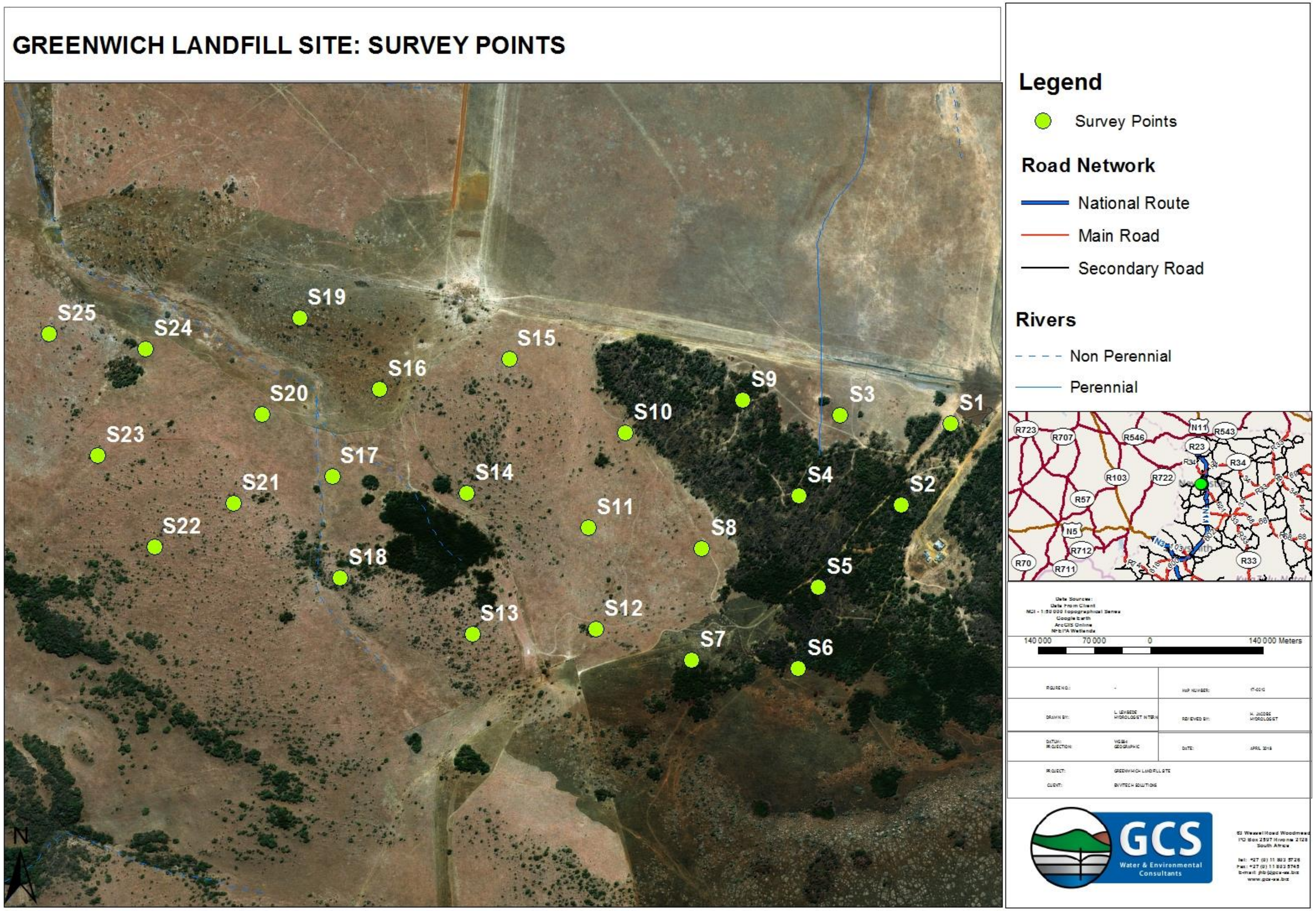


Figure 4-3 Soil Survey points for Greenwich landfill site

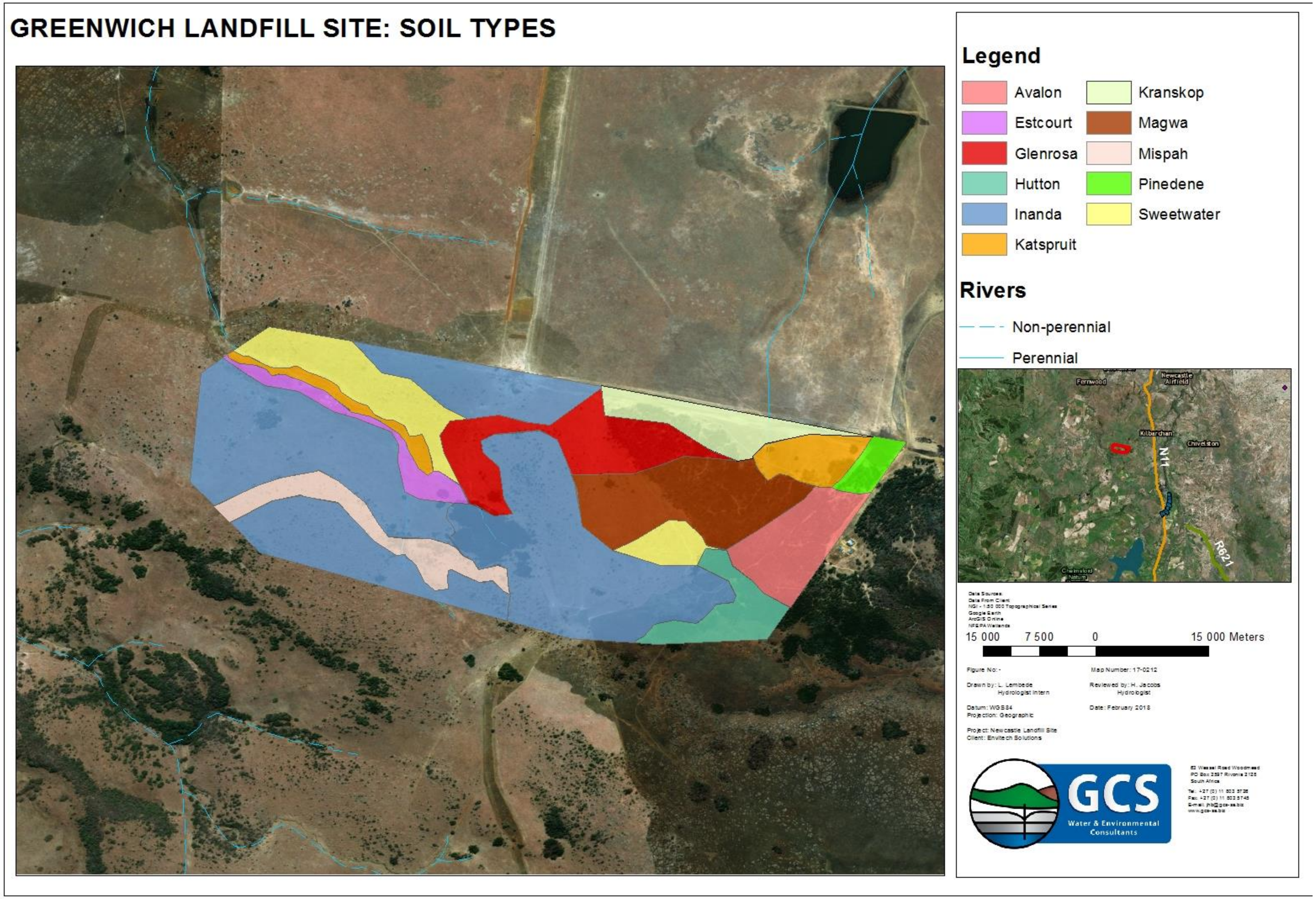


Figure 4-4: Greenwich Soil Map

Katspruit (Ka)

The Katspruit soil forms were found to be associated exclusively with the wetland areas alongside the rivers and around the prominent pan features. The hydromorphic nature of these soils renders them highly susceptible to compaction and erosion.

Re-working of these soils for rehabilitation purposes will need to be undertaken during the dry months of the year, and will require that the structure is broken down if these soils are to be used for topdressing of areas prior to replanting.

Photo 4-1 Katspruit soil form

Avalon (Av)

The Avalon soils mapped were found predominantly on the south-east facing slopes. These soils showed high clay content of non-expansive clays. The effective rooting depths of these soils is greater than 1.5m. These soils are generally found in the mid-slope section and downslope of well drained soils. The yellow-brown B horizon shows limited oxidation of the iron in the soil.

Photo 4-2 Avalon soil form found at the Greenwich site

Magwa

The Magwa soils occur at the lower slopes and are moderately drained, thus the yellow-brown hue. These soils ranged in depth from 80 cm to 1.5m with rooting depth being limited by the unspecified material. Drainage was impaired by the unspecified material.

Photo 4-3 Magwa soil form found at the Greenwich site

Inanda

The Inanda is the most predominant soil found on site, these soils were predominantly clayey loams with moderate drainage in the lateral direction. These soils were limited to depths of less than 0.8m with the unspecified parent material creating an impermeable layer. The steepness of the slope allows good drainage.

Photo 4-4 Inanda soil form found on site

Hutton

The Hutton soils found on site were deep and dark red due to the oxidisation of iron from the doleritic parent material. These soils had good structure with a high clay content and rooting depths of over 1 meter.

Photo 4-5 Hutton soil found on site

Sweetwater (Sr)

The Sweetwater soils found on the Greenwich site were greater than 1m deep, however the neocuntanic horizon in these soils, showed poor structure.

Glenrosa (Gs)

The Glenrosa soil form returned effective rooting depths of between 100 and 400 mm. The major constraint with these soils will be tillage, sub surface drainage and erosion. The restrictive layer associated with these soils is a hard lithocutanic layer in the form of weathered parent material, or rock. The effective soil depth is restricted; resulting in reduced soil volumes and as a result a depletion in the water holding capacity as well as nutrient availability. Geophysical characteristics of these soils include moderate to high clay percentages (20 to 32%), moderate internal drainage and low water holding capabilities.

Photo 4-6 Glenrosa soil form

It is imperative that good management of these soils is implemented, both from the erosion as well as the compaction perspective.

Estcourt (Es)

The Estcourt soil form was found along the side of a river section. This soil returned a shallow effective rooting depth, possibly due to the lack of nutrients in the e horizon or the impermeable nature of the prismacutanic layer.

Mispah (Ms)

Mispah soils by nature are very shallow and found on the crests of hills and rocky outcrops. These soils consist only of an A horizon overlying rock. Due to the shallow nature, these soils are susceptible for erosion.

4.3 Soil Chemistry

A and B horizon samples were collected from the points S6, S7, S17, S23 and S24 and were tested for their chemical properties and the results are indicated in Figure 4-5, Figure 4-6 and Figure 4-7. The soils were analysed by UIS Organics, and analysed for:

- pH,
- EC,
- major cations (Mg, K, Na, Ca, Al and Fe),
- anions (SO4, NO3, PO4 and Cl),
- trace elements (Mn, Cu and Bo)

4.3.1 Macro Cations

The calcium and potassium levels are below the critical levels for plant growth which are expected to be 5 000 mg/kg and 10 000 mg/kg (Bonner and Varner, 1965). The magnesium level is below the critical level of 2 000 mg/kg (Bonner and Varner, 1965). There is evidence of leaching of these nutrients from the A horizon to the B horizon as indicated by higher concentrations of macro-cations in the B horizon than in the A horizon.

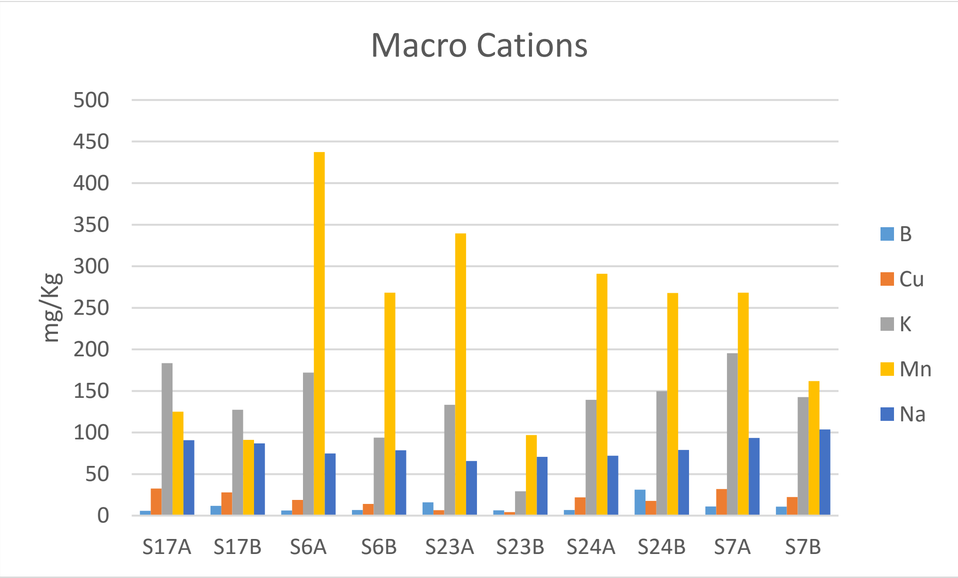


Figure 4-5 Macro-cation chemical analysis for the Greenwich site.

4.3.2 Micro Cations

The concentration of iron (Fe) is quite high. Aluminium concentrations in the A horizons were well above the aluminium toxicity range of 2-3 mg/kg for most plants, with a pH of below 5.5 (Silva, 2012), however this is normal for soils derived from doleritic parent material. pH for the analysed soils ranged between 5.3 and 6.6 on the Greenwich site. pH affects the availability of nutrients as well as the solubility of aluminium and iron, at pH levels of below 5.5 aluminium becomes soluble and leads to aluminium toxicity in plants. Manganese was found to be above the critical level of 50 mg/kg for all the soils analysed.

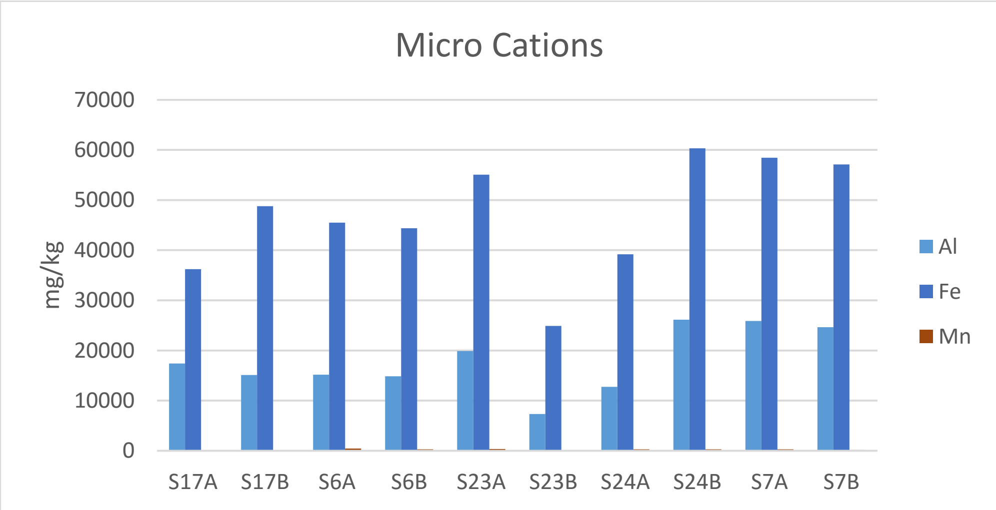


Figure 4-6 Micro-cation nutrient analysis for the Greenwich Site.

4.3.3 Anions

Nitrate levels are all below the optimal level of 20 mg/kg (Harivandi *et al.*, 1992) for all the soils analysed, this indicates low fertility of soils. The sulphates, a nutrient critical for protein synthesis, the critical level for sulphates is 1000 mg/kg (Little and Nair, 2009). The Greenwich soil analyses showed concentrations for sulphate ranging from 140 mg/kg to 6000mg/kg, most of the soils analysed were well above the critical threshold for sulphate.

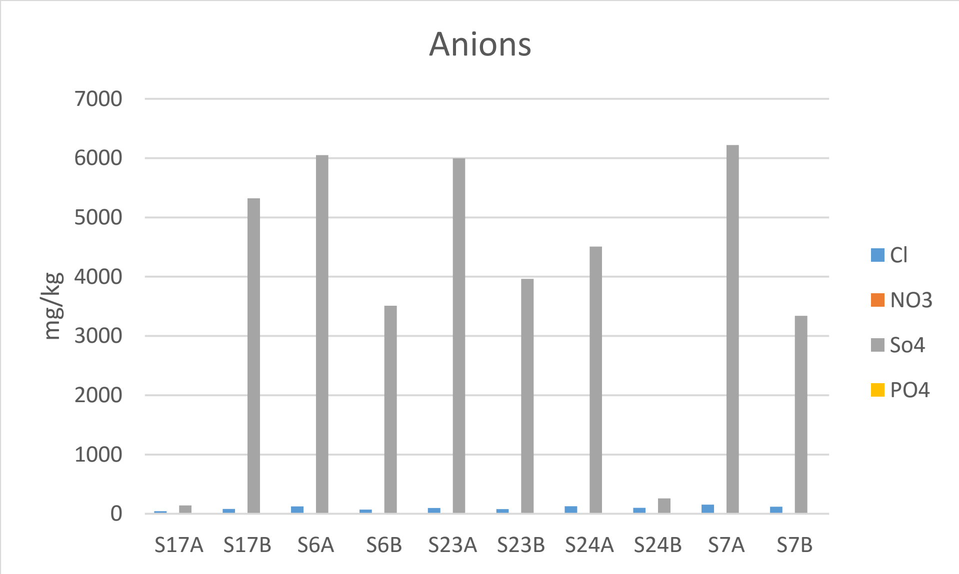


Figure 4-7 Anion analysis for the Greenwich site.

4.4 Land Capability and Suitability

Land capability can be described as '*the fitness of a given tract of land to sustain a defined use; differences in the degree of capability are determined by the present state of associated attributes of the area in question*' (Schoeman *et al.*, 2002). Land capability generally refers to the ability of a soil to sustain productive agriculture (based on the soil forms identified). Land capability is increasingly becoming a valuable tool in land use planning as many users of land have difficulty interpreting and understanding soil information.

4.4.1 Land Capability

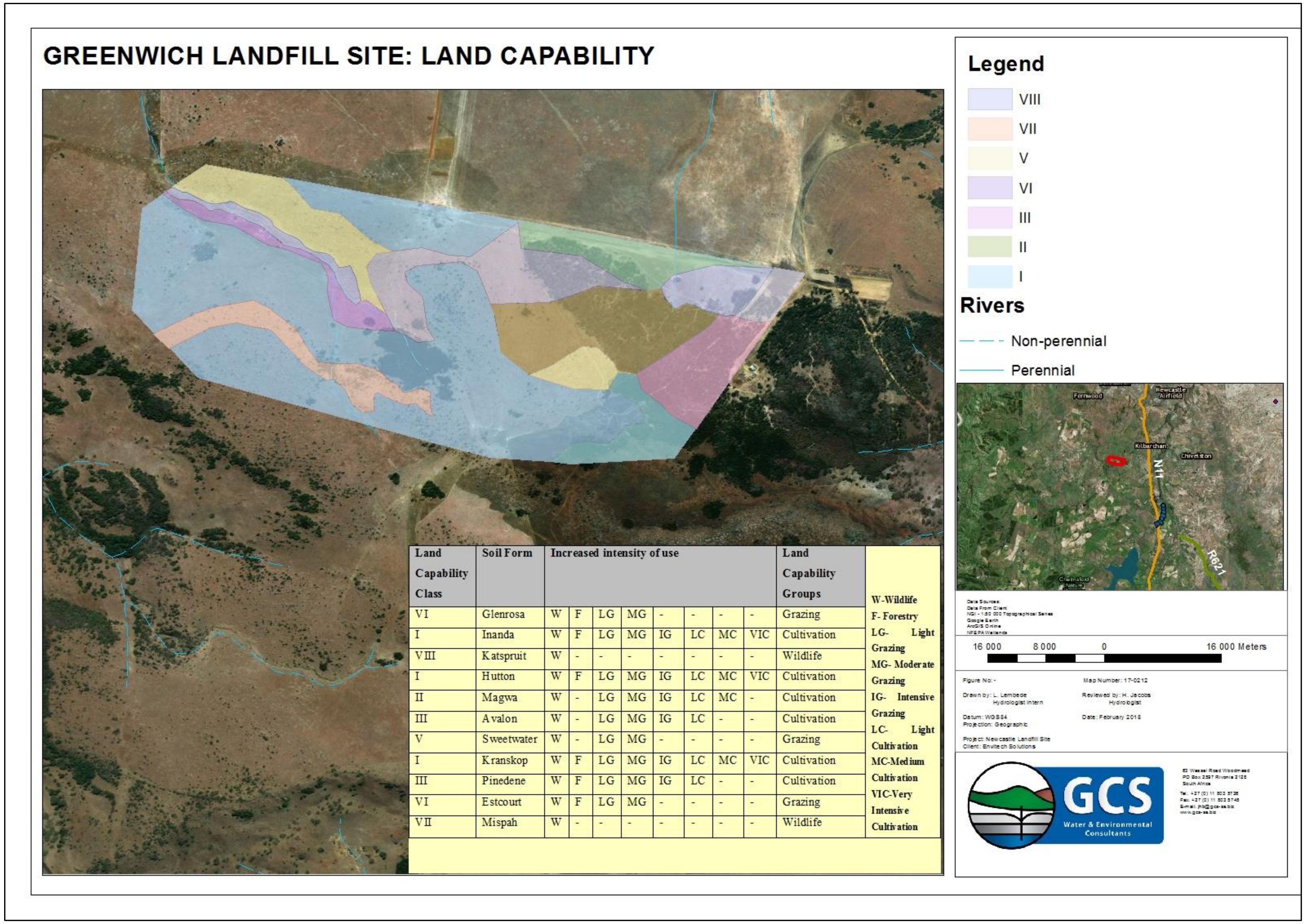
Land capability classes determined by Schoeman *et al.* (2002) were assigned to the study area. The land capability classes for the site can be seen in Table 4-2 and in

Figure 4-8.

Table 4-2 Land Capability at the Greenwich site

Land Capability Class	Soil Form	Increased intensity of use								Land Capability Groups
VI	Glenrosa	W	F	LG	MG	-	-	-	-	Grazing
I	Inanda	W	F	LG	MG	IG	LC	MC	VIC	Cultivation
VIII	Katspruit	W	-	-	-	-	-	-	-	Wildlife
I	Hutton	W	F	LG	MG	IG	LC	MC	VIC	Cultivation
II	Magwa	W	-	LG	MG	IG	LC	MC	-	Cultivation
III	Avalon	W	-	LG	MG	IG	LC	-	-	Cultivation
V	Sweetwater	W	-	LG	MG	-	-	-	-	Grazing
I	Kranskop	W	F	LG	MG	IG	LC	MC	VIC	Cultivation
III	Pinedene	W	F	LG	MG	IG	LC	-	-	Cultivation
VI	Estcourt	W	F	LG	MG	-	-	-	-	Grazing
VII	Mispah	W	-	-	-	-	-	-	-	Wildlife

W-Wildlife
F- Forestry
LG- Light Grazing
MG- Moderate Grazing
IG- Intensive Grazing
LC- Light Cultivation
MC-Medium Cultivation
VIC-Very Intensive Cultivation



Land Capability Class	Soil Form	Increased intensity of use								Land Capability Groups
VI	Glenrosa	W	F	LG	MG	-	-	-	-	Grazing
I	Inanda	W	F	LG	MG	IG	LC	MC	VIC	Cultivation
VIII	Katspruit	W	-	-	-	-	-	-	-	Wildlife
I	Hutton	W	F	LG	MG	IG	LC	MC	VIC	Cultivation
II	Magwa	W	-	LG	MG	IG	LC	MC	-	Cultivation
III	Avalon	W	-	LG	MG	IG	LC	-	-	Cultivation
V	Sweetwater	W	-	LG	MG	-	-	-	-	Grazing
I	Kranskop	W	F	LG	MG	IG	LC	MC	VIC	Cultivation
III	Pinedene	W	F	LG	MG	IG	LC	-	-	Cultivation
VI	Estcourt	W	F	LG	MG	-	-	-	-	Grazing
VII	Mispah	W	-	-	-	-	-	-	-	Wildlife

W-Wildlife
F- Forestry
LG- Light Grazing
MG- Moderate Grazing
IG- Intensive Grazing
LC- Light Cultivation
MC-Medium Cultivation
VIC-Very Intensive Cultivation

Figure 4-8 Greenwich Land capability

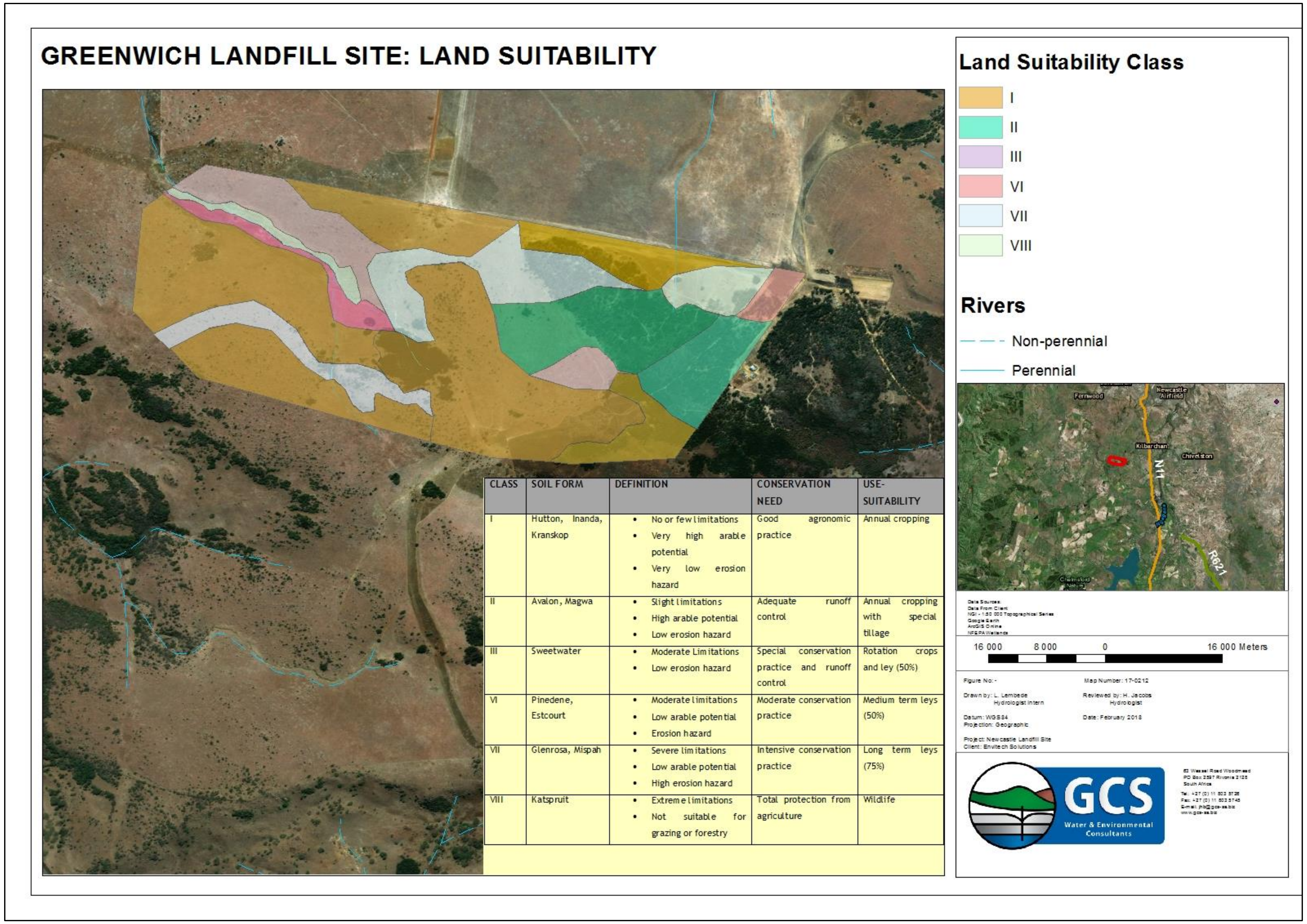
4.4.2 Land Suitability

Having taken into consideration the soil form classification, land capability, soil chemistry, of the area and physical characteristics identified during the site visit, the soils at the Greenwich project site were determined to fall under suitability Classes I, II, III, VI and VIII. Class V the Pinedene and Estcourt soil forms, while the Glenrosa falls within the Suitability Class VII. The Pinedene and the Estcourt soils are limited due to the limited depth and limited aeration in the subsoil. The Hutton, Inanda and Kranskop are capable of intensive agriculture provided good agronomic practices are put in place, this is due to the deep soils, with good drainage and high content. The Avalon and Magwa soils are capable soils for agriculture but require adequate runoff control. The Sweetwater, Pinedene and Estcourt soils are capable of being utilized for but need to be carefully managed due to their erosion potential and lack of drainage. The and Mispah soils can be utilized for light grazing but need to be carefully managed due to the erosion potential of these soils. Katspruit soils are hydromorphic and are only suitable for The determined classes, conservation needs, use suitability and justifications can be seen in Table 4-3 and

Figure 4-9.

Table 4-3 Land suitability at the Greenwich Site

CLASS	SOIL FORM	DEFINITION	CONSERVATION NEED	USE-SUITABILITY
I	Hutton, Inanda, Kranskop	• No or few limitations • Very high arable potential • Very low erosion hazard	Good agronomic practice	Annual cropping
II	Avalon, Magwa	• Slight limitations • High arable potential • Low erosion hazard	Adequate runoff control	Annual cropping with special tillage
III	Sweetwater	• Moderate Limitations • Low erosion hazard	Special conservation practice and runoff control	Rotation crops and ley (50%)
VI	Pinedene, Estcourt	• Moderate limitations • Low arable potential • Erosion hazard	Moderate conservation practice	Medium term leys (50%)
VII	Glenrosa, Mispah	• Severe limitations • Low arable potential • High erosion hazard	Intensive conservation practice	Long term leys (75%)
VIII	Katspruit	• Extreme limitations • Not suitable for grazing or forestry	Total protection from agriculture	Wildlife



CLASS	SOIL FORM	DEFINITION	CONSERVATION NEED	USE-SUITABILITY
I	Hutton, Inanda, Kranskop	• No or few limitations • Very high arable potential • Very low erosion hazard	Good agronomic practice	Annual cropping
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III	Sweetwater	• Moderate Limitations • Low erosion hazard	Special conservation practice and runoff control	Rotation crops and ley (50%)
VI	Pinedene, Estcourt	• Moderate limitations • Low arable potential • Erosion hazard	Moderate conservation practice	Medium term leys (50%)
VII	Glenrosa, Mispah	• Severe limitations • Low arable potential • High erosion hazard	Intensive conservation practice	Long term leys (75%)
VIII	Katspruit	• Extreme limitations • Not suitable for grazing or forestry	Total protection from agriculture	Wildlife

Figure 4-9 Greenwich Land Suitability

4.5 Risk Assessment

The risk assessment was undertaken for the Construction, Operational, Decommissioning and Residual Impact after Closure Phases of the Greenwich Landfill site. Potential impacts on soils expected to arise from activities during these phases of the project are described in the succeeding subsections.

4.5.1 Construction Phase

During the construction phase soils are removed (stripped) from their current area and stored in a "stockpile" for use during the rehabilitation phase.

Impact Assessment

- The impact on the soils stripped during the construction of the landfill and access road areas will be negative in the medium to long term. The moderate to low clay content and low expansiveness of the majority of the soils that are to be affected will make for relative ease of working within a variety of conditions. Areas to be developed on the more clay rich and relatively more sensitive soils will lead to the formation of hard clods on drying and should only be worked in the dry state. These soils are generally moderately susceptible to compaction and erosion, while the more friable sandy loams are less affected than the more clay rich and wet based clay loams.
- Soil erosion is expected to occur due to vegetation removal which exposes the soil to erosion agents which include water and wind.
- Care will need to be taken to keep any wet soils separated from the dry soils, and to keep all stockpiled soils in storage vegetated and protected from erosion.
- The sensitive nature of the soils associated with the drainage lines (if impacted on) will need to be managed exceptionally well. These soils will be stripped in sequence, along with the dry and friable soils, and they will need to be kept separate from one another if rehabilitation is to be executed successfully and cost effectively.
- Soil pollution is expected to occur resulting from spillage, leakage and seepage of oils, grease, fuels and other hydrocarbons by construction vehicles and machinery.

Mitigation

The impacts on the soils may be mitigated with management procedures including:

- Effective soil stripping during the winter months, this will help to maintain the structural integrity of the soils;

- Conduct quick clean-ups when oil spillages occur. Oil recovered from any vehicle or machinery on site should be collected, stored and disposed of by accredited vendors for recycling;
- Restrict vegetation clearance to footprint area;
- Soil replacement and the preparation of a seed bed to facilitate the revegetation program and to limit potential erodibility; and
- Soil amelioration to enhance the agricultural capability of the soils.

Impact Assessment

- The construction of the landfill area, access roads, and offices will require that soils are removed and stockpiled for rehabilitation on closure. Again, it is important that the wet (if impacted) and dry soils are stockpiled separately where these may occur, and that the structural integrity and erosive nature of the wet soils is managed during the stockpiling phase so as to make these soils utilizable on rehabilitation. This action, will have a negative impact on the structure of the disturbed soils in the medium to long term.
- The roads and landfill related infrastructure might cover the complete range of soils mapped. It is important that the wet soils (if impacted upon) that are high in clay are stockpiled separately from the more easily worked dry and friable materials, and that erosion and compaction are managed.

Mitigation

Stockpile soils in heaps no more than 1.5 m high and vegetate for the life of the landfill.

4.5.2 Operational Phase

The Greenwich landfill site will consist of seven cells, operated in a linear landfill system. The current cell will utilise the next linear cell for the daily capping material will be sourced from the adjacent cell.

Impact Assessment

The significance of the impacts on the soils on the site may be differentiated according to the two broad categories of soils, as follows: (refer to soils map **Error! Reference source not found.**)

- The free draining soils (red and yellow-brown sandy loams to sandy clay loams) and;
- The soils associated with a shallow or perched water table (grey and black clay loams and clay rich soils).

Both of these soil categories will be impacted upon, by topsoil handling activities within the landfill, infrastructure (landfill and Offices/workshops). The significance of the impact will, however, differ between the two categories. These two categories should be stockpiled separately.

The free draining soils are susceptible to compaction in their wet state, however, they are generally easily worked and stockpiled. These soils may also be susceptible to wind and water erosion if adequate drainage and vegetation cover is not considered. On this basis, the significance of disturbing these soils will be a negative impact in the medium to long term.

The black and grey coloured gleyed soils are, however, highly susceptible to disturbance. Working of these soils, in the wet state may cause long-term damage to soil structure. On drying, the high clay content will lead to the formation of strong blocky structures (clods) that are difficult to work. These soils are also highly susceptible to erosion and compaction. The significance of the impact will be negative in the medium to long term.

Soil contamination may occur from spillage and leakage of hydrocarbons such as fuels, grease and oils by moving vehicles and machinery during maintenance of the sewer infrastructure, if due care is not exercised.

Mitigation

The impacts on the soils may be mitigated with management procedures including:

- Effective soil stripping during the dry winter months. This will help to maintain the structural integrity of the wet based soils;
- Soil replacement and the preparation of a seed bed to facilitate the revegetation program and to limit potential erosion;
- Soil amelioration to enhance the agricultural capability of the soils;
- Routine maintenance of the sewer infrastructure should be undertaken and adhered to; and
- Conduct quick clean-ups when spillages occur. Oil recovered from any vehicle or machinery on site should be collected, stored and disposed of by accredited vendors for recycling.

Impact assessment

The spillage/leaking of leachate form the waste within the landfill site will pollute the soil.

Mitigation

The pollution of soils from leachate from the landfill is mitigated by correct drainage of leachate from the landfill cells, minimizing leachate by:

- Minimizing infiltration of water
- Ensuring correct lining and capping of cells
- Ensuring leachate system is properly installed and functioning correctly

4.5.3 Decommissioning phase

The decommissioning phase is characterised by the landfill site no longer accepting waste. Although no waste is coming onto the site, the landfill site will still pose risks.

Impact Assessment

After decommissioning the landfill site has the potential to impact soil through the pollution of soils with landfill leachate as the cells continue to breakdown.

Mitigation

The pollution of soils from leachate from the landfill is mitigated by correct drainage of leachate from the landfill cells, minimizing leachate and correct lining and capping of the waste cells. The correct installation of HDPE liner and geotextile weave capping material as well as maintain the drainage within the cells will minimize the impact.

Table 4-4: Significance Assessment

Impact description											
No.	Phases	Activity	Aspect	Impact	Signicance before mitigation		Signicance after mitigation		Mitigation measures	Action plan	Responsible person
1	Construction	Site clearing / preparation	vegetation removal	Soil exposure	-	M	-	M	Limit vegeation clearing	Minimize fottprint of impact	Site manager
2	Construction	Earth Excavation	Soil compaction/exposure	Soil compaction	-	L	-	L	Minimize footprint of area	Limit movement of heavy machinery	Site manager
3	Operation	Hydrocarbon spills	Oil/Diesel spill from machinery	pollution of soil	-	M	-	M	Minimize impact of spill	Ensure quick clean-up of spills	Site manager
4	Operation	Waste site operation	Leaching/overtopping of landfill leachate	Pollution of soil	-	M	-	M	Ensure leachate does not overtop cell or leak through lining	•Ensure correct linging/sealing of waste •Monitoring leachate detction system •Minimize stormwater flowing over cells	Site manager
5	Operation	Earth Excavation	excavation of cover material from adjacent cell	Erosion	-	M	-	M	Minimize erosion and runoff	•Temporary cover of exposed area during rainfall events •Minimize area of exposed soil	Site manager
6	Operation	Earth Excavation	Incorrect storage of soils	Loss of soil	-	L	-	L	Correct storage of soil	Ahere to soil stockpiling recommendations	Site manager
7	Decommisioning and Closure	Waste site operation	Leaching/overtopping of landfill leachate	Pollution of soil	0	M	-	M	Ensure leachate does not overtop cell or leak through lining	•Ensure correct linging/sealing of waste •Monitoring leachate detction system •Minimize stormwater flowing over cells	Site manager

4.6 Environmental Management Plan

4.6.1 Construction and Operational Phase

4.6.1.1 ***Vegetation of the Stockpiles***

OBJECTIVE

To stockpile the soils removed from the construction areas to be disturbed, and to create a feature that emulates the existing landscape as closely as possible and does not adversely impact on the area in general.

ACTION

4.6.1.2 ***Soils***

4.6.1.2.1 Soil handling and removal

The sandy clays and sandy clay loams can be stockpiled and used to create berm structures upslope of the landfill areas and related infrastructure as well as the waste rock facilities, while the upper portion of the subsoil, and overburden material (where removed) can be stored as separate stockpiles close to the areas where they will be required for rehabilitation.

The soil removed from the access roads must be stored as close as possible to the structures and separately managed in stockpiles that can be easily used for rehabilitation of the infrastructure at closure. The soil should be stripped to a depth of approximately 0.6m. The base to the structures to be constructed should be founded on stabilized material, the soil having been stripped to below the topsoil contact.

It will be necessary to differentially strip the topsoil and subsoil horizons, while every endeavour should be made not to disturb or work the soil during the wet summer months due to their susceptibility to compaction.

The cultivated soil should be stripped and stockpiled without the vegetation having been cleared, while the pristine grasslands that have not been cultivated should be fertilized with super phosphate prior to being stripped. This will ensure that the fertilizer is well mixed into the soil during the stripping operation and will reduce the amount of fertilizer required during the rehabilitation program.

4.6.1.2.2 Soil replacement and land preparation

It is proposed that the construction of the berms and soil storage stockpiles is undertaken in a series of 1,5m lifts if the storage facilities are to be higher than 1,5m. The top soil can be utilized to top dress the stockpiles, while the heavier subsoil can best be used to form the base of the stockpile structure. Utilizing the soil in this manner will maximize the beneficial properties of each material, and help to reduce erosion of the stored soil.

It is imperative that the topsoils that are used to cap the stockpile structure are well protected from erosion and compaction. These topsoils must be adequately vegetated as soon after construction as possible and maintained throughout the life of the landfill. It is recommended that the following actions be implemented:

- Strip and stockpile the topsoil from the landfill area and associated infrastructure areas on top of the storage stockpile structure, using the sub soils and overburden (if encountered) from the shaft(s) and deeper foundations as the bulk of the stockpile material. The soil storage facility and berms should comprise a series of 1,5m terraces if the height required is >1,5m. The top soils should then be spread evenly over the top and sides of these structures;
- Disc the area using a large disc harrow;
- Add the fertilizer and manure if required (see fertilizer recommendations). The fertilizer and manure should be added using a standard industrial spreader; and
- Harrow the area again to ensure adequate mixing has occurred. The area can now be seeded with the recommended seed mix.

If the soils are stripped in their dry state it will not be necessary to cultivate the topsoil. However, if the soils are stripped when wet, then ripping and disking of the topsoil is recommended prior to seeding of the soils in order to break up any structure that might have developed.

It is imperative, where possible, that the slopes of the stockpile facility/berm are constructed to 1: 6 or more gentle; this will minimize the chances of erosion of the topsoil. However, prior to the establishment of vegetation, it is recommended that erosion control measures, such as the planting of Vetiver Grass, or the construction of benches and cut-off drains be included in the stockpile/berm design. These actions will limit the potential for uncontrolled run-off and the subsequent erosion of the unconsolidated soils, while the vegetation is establishing itself.

4.6.1.2.3 Fertilizers and soil amendments

For soil amelioration, it is necessary to distinguish between the initial application of fertilizers or soil amendments and maintenance dressings. Basal or initial applications are required to correct disorders that might be present in the in-situ material and raise the fertility status of the soil to a suitable level prior to seeding. The initial application of fertilizer and lime to the disturbed soils is necessary to establish a healthy plant cover as soon as possible. This will prevent erosion. Maintenance dressings are applied for the purpose of keeping up nutrient levels. These applications will be undertaken only if required, and only after additional sample analysis has been undertaken.

Fertilizer

It is recommended that prior to soil stripping, super phosphate fertilizer should be added to the sandy loams and sandy clay loams (yellow-brown and red soils) at a rate of about 200 kg/ha if they have not previously been fertilized or cultivated.

The soils mapped are generally deficient in nitrogen, phosphorus and potassium (NPK). It is therefore recommended that a standard 3:2:1 (25) ratio N:P:K fertilizer be added to the soil before re-vegetation. The fertilizer should be added to the soil in a slow release granular form at a rate of approximately 200 kg/ha.

It will be necessary to re-evaluate the nutrient status of the soils at regular intervals to determine the possibility of needing additional fertilizer applications.

4.6.1.2.4 Maintenance of planted areas

The following maintenance is required:

- The area must be fenced, and all animals kept off the area until the vegetation is self-sustaining;
- Newly seeded/planted areas must be protected against compaction and erosion;
- Traffic should be limited were possible while the vegetation is establishing itself;
- Plants should be watered and weeded regularly;
- Check for pests and diseases at least once every two weeks and treat if necessary;
- Replace unhealthy or dead plant material;
- Fertilise, hydro-seeded and grassed areas with 200 kg/ha ammonium sulphate 4-6 weeks after germination; and
- Repair any damage caused by erosion.

4.6.2 Landfill Area Rehabilitation

OBJECTIVE

To create an indigenous grassland that will stabilize the soils in the short term, and re-create the natural grassland in the long term.

ACTION

4.6.2.1 Soils

Soil handling and removal

The topsoil and sub-soil horizons must be stripped separately since the physical, biological and chemical characteristics of the topsoil are generally more suitable for the germination, survival and growth of vegetation. In addition, the wet based soils must be stripped and stockpiled separately form the dry, more friable sandy loams. The depth-limiting horizon, for most of the soils on the site, is either the saprolitic “C” horizon or rock (R), or the soft plinthic B-horizon closer to the streams. However, in the case of the more clay rich and structured soils associated with the dolerite parent materials, the strong structure associated with the soil “B” horizon is the limiting factor in determining the depth of rooting.

Soil stockpiling will be required for all areas that are to be affected by construction of the landfill, or by the associated infrastructure. All landfill areas will need to be stripped of the valuable topsoil and a proportion of the subsoils in order that there is sufficient soil available at closure to rehabilitate the disturbed areas (roads, landfill, offices etc.), or to top dress the features that will remain permanently in place (waste rock dumps, slimes dams etc.). The footprint of the soils stockpiled must be minimized as far as possible, utilizing as small an area as is practical, without compromising the integrity of the soil stored. The soils will best be stored as berm structures upslope of the land-fill area and for the construction of the dam walls (if suitable) for the storm water control dams. However, excess soil from the subsoil horizons, and the soft saprolitic layer might need to be stockpiled in larger amounts. These soils should then be stockpiled in a series of 1,5m lifts, as terraces to a maximum of 15m.

Vegetation (grass and small shrubs) should not be cleared from the site prior to stripping. The maintenance of the vegetative matter will provide additional organic nutrients to the soil, which will aid the soils during the rehabilitation process, and will help to preserve the soil structure while stockpiled.

It is recommended that 200kg/ha super phosphate fertilizer be added to the soil prior to stripping. This will ensure that the fertilizer is well mixed into the soil during the stripping operations and will reduce the amount of fertilizer that will be needed on rehabilitation.

<u>Soil replacement and land preparation</u>

Soil replacement depths are controlled by the pre-development available/mapped, and all soils should be replaced to as similar a depth as was encountered prior to the construction/earthworks, but at least to a depth that will sustain grazing (400mm).

Stones and boulders, encountered on the site, during the stripping operation should be stockpiled with the overburden, and should be buried as deep in the soft overburden as possible, so that they do not interfere with the preparation of the seedbed during either the stockpiling stage, or the rehabilitation stage.

The action of soil stripping causes the material to expand in volume, a process known as bulking. This is followed by a degree of natural compaction as the material settles after replacement. Induced compaction may lead to the following problems:

- Water logging of materials;
- Prevention of proper root development.

Limiting the access of vehicles onto the rehabilitated land may reduce induced compaction. Vehicles with a low compaction (such as tracked and flotation wheel equipped machinery) should be used in preference to normal wheeled vehicles in the levelling operations. Ripping prior to planting may also alleviate the effects of over-compaction.

The areas rehabilitated will be levelled so as to emulate the pre-earthworks contours, and soils should, ideally, not be placed on slopes with a gradient greater than 6 % to limit the potential for erosion. A shallow slope is preferable to enhance sub-surface drainage. Adequate sub-surface drainage will limit the potential for salinization of the soils and should enhance the agricultural potential of the soils.

In order to further limit erosion, prior to the establishment of vegetation, it is recommended that erosion controls be placed at intervals over the rehabilitated land, using either grass or contour ridges. This should limit the effect of uncontrolled run-off onto the unconsolidated soils.

It is recommended that the soils should be prepared as follows:

- Replace overburden from stockpiles, followed by the sub soils. Spread the soils evenly over the rehab area to achieve pre-earthworks topography;
- In the case of any wet soils (Katspruit) that might have been disturbed, they should be levelled, ripped and diced to break up any induced structure (soil clods). Ripping is only recommended for the wet based and clay rich soils (dark or grey structured soils). A moderately deep rip is recommended as this helps to break up any compacted layers and clods, improves water infiltration and drainage, increases root penetration and aerates the soil.

However, care must be taken not to rip the soils excessively since over-ripping may hasten the oxidation of organic material in the soil and may break down stable soil aggregates;

- Add the soil nutrients. The fertilizer should be added using a standard fertilizer spreader and should be applied in small quantities at regular intervals.
- The area is now ready for seeding.

Fertilizers and soil nutrition

Fertilizer requirements reported herein are based on the sampling of the soils at the time of the baseline survey. These levels will change during the stockpiling period due to a number of physical and chemical processes. The fertilizer requirements should thus be re-evaluated at the time of rehabilitation. It is recommended that a qualified person is employed to establish the lime and fertilizer requirements that will be applied, prior to the starting of the rehabilitation process.

Fertilizer

Application of fertilizers should be carried out in small quantities at regular intervals so as to avoid any contamination of the surface water or groundwater environments.

Analysis of the soils on the site returned deficiencies of nitrogen, phosphorus and potassium. A standard 3:2:1 (25) ratio N:P:K fertilizer should be added to the soil in a slow release granular form at a rate of approximately 200 kg/ha before revegetation (These results must be verified prior to rehabilitation commencing).

It will be necessary to re-evaluate the soil conditions of the site at regular intervals to determine if additional fertilizer applications are required.

Soil Sampling

During the rehabilitation exercise preliminary soil sampling should be carried out to determine the fertilizer requirements. Additional soil sampling should also be carried out annually until the levels of nutrients, specifically phosphorus and potassium, are at the required level (approximately 20 and 120 mg/kg respectively). Once the desired nutritional status has been achieved, it is recommended that the interval between sampling be increased. If growth problems develop, *ad hoc*, sampling should be carried out to determine the problem.

Sampling should always be carried out at the same time of the year and at least six weeks after the last application of fertilizer.

All of the soil samples should be analysed for the following parameters:

- Calcium Mg/Kg;
- Magnesium Mg/Kg;
- Potassium Mg/Kg;
- Sodium Mg/Kg;
- Cation exchange capacity;
- Phosphorus (Bray I);

5 CONCLUSIONS

The conclusions drawn from the soils assessment from the Greenwich Site are presented in the following sub sections.

5.1 Climate

The MAP and MAE for quaternary catchment V31K are 800mm and mm, respectively (WRC, 2012). The monthly average evaporation for the catchment far exceeds precipitation and this is typical of semi-arid environments in South Africa. Distinct seasonal rainfall is experienced in this area with the wet season running from October to March, while the dry season starts in the month of April and ends in September.

5.2 Soil Classification

The dominant soil forms which characterise the project site were identified during the site visit for the proposed Greenwich Site. Eleven soil forms were identified, namely Hutton, Inanda, Pinedene, Avalon, Magwa, Kranskop, Sweetwater, Katspruit, Glenrosa and Estcourt and Mispah. The dominant soil form in the study site was identified as Inanda.

5.3 Land use

The majority land use at the Greenwich site is mixed natural veld, alien invasive vegetation and small-scale subsistence grazing.

5.4 Soil Chemistry

The soils at the Greenwich site were found to be low in macro cations, with calcium, magnesium and potassium being below the critical levels. The micro cation, iron was high in the A horizon, with aluminium and magnesium being above the critical levels. The anion levels at Greenwich indicated nitrates to be within the critical levels, however, most sulphates were above the critical levels. Furthermore, the soils returned a deficiency in the essential NPK elements. It was therefore recommended that the soil be fertilized prior to re-vegetation.

5.5 Risk Assessment

The impact of the proposed landfill activities on the soil are summarized below.

Construction Phase:

Impact: Soil erosion by wind and water due to vegetation removal.

Mitigation: Restrict vegetation clearance.

Impact: Disturbance of soil during construction of access roads and landfill site.

Mitigation: Stockpile soils no more than 1.5m high, vegetate stockpiles to limit erosion and loss of soil.

Operational Phase:

Mitigation: Soil stripping during dry months for hydromorphic soils, soil amelioration.

Impact: Soil erosion

Mitigation: Minimize area of exposed soil from the adjacent cell (soil used for daily capping material of current cell). Use temporary for exposed area during rainfall events.

Impact: Soil pollution of landfill leachate.

Mitigation: Ensure correct lining and capping of cells. Monitor for leachate and mitigate clean-up measures should leachate pollute soil.

Decommissioning phase:

Impact: Pollution of soil from leachate.

Mitigation: Ensure correct lining and capping of cells. Monitor for leachate and mitigate clean-up measures should leachate pollute soil.

6 Recommendations

The soils' agricultural potential is generally high. The implementation of the project should, however, be undertaken with consideration of the following recommendations in order to minimise the impacts that are expected to result from the 3 phases of the project life cycle.

6.1 Construction phase

In order to minimise disturbance of the soil ecosystem, it is recommended that the project proponent should preserve as much natural vegetation as possible through keeping vegetation clearance to the footprint area. Vehicle and heavy machinery traffic should also be restricted to designated access roads. Quick clean-ups of hydrocarbons and other chemical wastes should be undertaken to mitigate impacts of soil pollution during the construction phase.

6.2 Operation phase

Minimizing impacts during the operational phase should include correct management of stored soils, minimizing erosion and excessive compaction. All round site management of erosion as well as keeping compaction of soils to a minimum. Maintaining vegetation on soil storage facilities reduces the risk of erosion.

6.3 Decommissioning phase

In order to mitigate disturbance of soil ecosystem during the closure phase of the project, designated transport routes should be adhered to when transporting removed material from the decommissioned Greenwich landfill site. Care should also be taken not to release any pollutants along the way during transportation of materials. All soils should be returned in the correct horizons and the correct classes. Vegetation removed from the site should be used for rehabilitation.

7 REASONED OPINION AND CONDITIONS

- Given the soil impacts as described in this report, the landfill project can only be viable if the mitigation measures are implemented as prescribed.
- The landfill site should be authorised provided the soil is correctly rehabilitated and the mitigation measures described in the report are correctly implemented.

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9 APPENDICES

Appendix A: Criteria for Pre-landfill Land Capability (Chamber of Mines, 2007)

Criteria for Wetland

- Land with organic soils or supporting hygrophilous vegetation where soil and vegetation processes are water determined.

Criteria for Arable land

- Land, which does not qualify as a wetland.
- The soil is readily permeable to a depth of 750 mm.
- The soil has a pH value of between 4.0 and 8.4.
- The soil has a low salinity and SAR
- The soil has less than 10% (by volume) rocks or pedocrete fragments larger than 100 mm in the upper 750 mm.
- Has a slope (in %) and erodibility factor (K) such that their product is <2.0
- Occurs under a climate of crop yields that are at least equal to the current national average for these crops.

Criteria for Grazing land

- Land, which does not qualify as wetland or arable land.
- Has soil, or soil-like material, permeable to roots of native plants, that is more than 250 mm thick and contains less than 50 % by volume of rocks or pedocrete fragments larger than 100 mm.
- Supports, or is capable of supporting, a stand of native or introduced grass species, or other forage plants utilisable by domesticated livestock or game animals on a commercial basis.

Criteria for Wilderness land

- Land, which does not qualify as wetland, arable land or grazing land.

Appendix B: Land Capability Classes

LAND CAPABILITY CLASS	INCREASED INTENSITY OF USE									LAND CAPABILITY GROUPS	
I	W	F	LG	MG	IG	LC	MC	IC	VIC	Arable land	W - Wildlife
II	W	F	LG	MG	IG	LC	MC	IC	-		F - Forestry
III	W	F	LG	MG	IG	LC	MC	-	-		LG - Light grazing
IV	W	F	LG	MG	IG	LC	-	-	-		MG – Moderate grazing
V	W	-	LG	MG	-	-	-	-	-	Grazing land	IG - Intensive grazing
VI	W	F	LG	MG	-	-	-	-	-		LC - Light cultivation
VII	W	F	LG	-	-	-	-	-	-	Wildlife	MC - Moderate cultivation
VIII	W	-	-	-	-	-	-	-	-		IC - Intensive cultivation VIC - Very intensive cultivation

Appendix C: Land Suitability Classes: Descriptions and suitability

CLASS	DEFINITION	CONSERVATION NEED	USE-SUITABILITY
I	▫ No or few limitations. ▫ Very high arable potential. ▫ Very low erosion hazard.	Good agronomic practice.	Annual cropping.
II	▫ Slight limitations. ▫ High arable potential. ▫ Low erosion hazard.	Adequate run-off control	Annual cropping with special tillage or ley (25 %).
III	▫ Moderate limitations. ▫ Some erosion hazards.	Special conservation practice and tillage methods.	Rotation of crops and ley (50 %).
IV	▫ Severe limitations. ▫ Low arable potential. ▫ High erosion hazard.	Intensive conservation practice.	Long term leys (75 %).
V	▫ Watercourse and land with wetness limitations.	Protection and control of water table	Improved pastures or Wildlife
VI	▫ Limitations preclude cultivation. ▫ Suitable for perennial vegetation.	Protection measures for establishment e.g. Sod-seeding	Veld and/or afforestation
VII	▫ Very severe limitations. ▫ Suitable only for natural vegetation.	Adequate management for natural vegetation.	Natural veld grazing and afforestation.

VIII	▫ Extremely severe limitations. ▫ Not suitable for grazing or afforestation.	Total protection from agriculture.	Wildlife.

Appendix D: Risk Assessment scaling

Status of Impact

+: Positive (A benefit to the receiving environment)

N: Neutral (No cost or benefit to the receiving environment) -: Negative (A cost to the receiving environment)

Magnitude:=M	***Duration:=D***
10: Very high/don't know	5: Permanent
8: High	4: Long-term (ceases with the operational life)
6: Moderate	3: Medium-term (5-15 years)
4: Low	2: Short-term (0-5 years)
2: Minor	1: Immediate
0: Not applicable/none/negligible	0: Not applicable/none/negligible

Scale:=S	***Probability:=P***
5: International	5: Definite/don't know
4: National	4: Highly probable
3: Regional	3: Medium probability
2: Local	2: Low probability
1: Site only	1: Improbable
0: Not applicable/none/negligible	0: Not applicable/none/negligible

Impact significance measured using Significance Points (SP) was calculated for the ranked impacts using the following formula:

SP = (magnitude + duration + scale) x probability

Appendix E: Environmental Risk rating table

SIGNIFICANCE	ENVIRONMENTAL SIGNIFICANCE POINTS	COLOUR CODE
High (positive)	>60	H
Medium (positive)	30 to 60	M
Low (positive)	<30	L
Neutral	0	N
Low (negative)	>-30	L
Medium (negative)	-30 to -60	M
High (negative)	<-60	H

Appendix F: UIS Organics SANAS certificate

sanas
South African National
Accreditation System

CERTIFICATE OF ACCREDITATION

In terms of section 22(2) (b) of the Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act, 2006 (Act 19 of 2006), read with sections 23(1), (2) and (3) of the said Act, I hereby certify that:-

UIS ORGANIC LABORATORY (PTY) LTD
Co. Reg. No.: 2007/001896/07

Facility Accreditation Number: **T0419**

is a South African National Accreditation System accredited Testing laboratory provided that all SANAS conditions and requirements are complied with

This certificate is valid as per the scope as stated in the accompanying schedule of accreditation Annexure "A", bearing the above accreditation number for

CHEMICAL ANALYSIS

The facility is accredited in accordance with the recognised International Standard

ISO/IEC 17025:2005

The accreditation demonstrates technical competency for a defined scope and the operation of a laboratory quality management system

While this certificate remains valid, the Accredited Facility named above is authorised to use the relevant SANAS accreditation symbol to issue facility reports and/or certificates

Mr M Phaloane
Acting Chief Executive Officer

Effective Date: 05 October 2014
Certificate Expires: 04 October 2019

Appendix G:

DECLARATION OF THE SPECIALIST

I, *Haden Jacobs*, declare that –

General declaration:

- 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 48 and is punishable in terms of section 24F of the Act.

GCS Water and Environment (Pty) Ltd