Appendix E2: Soils
SPECIALIST STUDY REPORT
SOILS, LAND CAPABILITY, and LAND USE

INCLUDING

BASELINE DESCRIPTION OF THE ENVIRONMENT;
ENVIRONMENTAL IMPACT ASSESSMENT; and
ENVIRONMENTAL MANAGEMENT PLAN

ALSO INCLUDING INFORMATION ON:

- WETLAND CLASSIFICATION/DELINEATION AND RIPARIAN AREAS,
- And SENSITIVE LANDSCAPES

OF

LEPHALALE COAL AND POWER PROJECT

ON THE ORIGINAL FARMS
HONINGSHADE 427 LQ, BOTMANSDRIFT 423 LQ, GROOTGENOEG 426 LQ,
WELTEVREDEN 482 LQ, PRETORIA 483 LQ, GARIBALDI 480 LQ;
FRANSCHHOEK 207 LQ, SEBRIGHT 205 LQ, STUTGARD 420 LQ, FORFARSHIRE
419 LQ, BILLIARDS 428 LQ, and WELLINGTON 432 LQ

LEPHALALE LOCAL MUNICIPALITY, WATERBERG DISTRICT MUNICIPALITY
LIMPOPO PROVINCE
SOUTH AFRICA

Prepared for
KONGIWE ENVIRONMENTAL (PTY) LTD
and
LEPHALALE COAL MINES (PTY) LTD

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July 2017

Survey Reference: REMS60-LCPP Project-Soils-Specialist Study Report
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EXECUTIVE SUMMARY

INTRODUCTION

Kongiwe Environmental (Pty) Ltd (hereafter referred to as Kongiwe) was appointed by Lephalale Coal Mines (Pty) Limited to undertake the Environmental Impact Assessment (EIA) process in support of the Mining Right Application (MRA) and other Environmental Authorisations required for the proposed mine and IPP. Applications at this stage will be conducted for the mining section only, while applications for the IPP will be done in the future once the design of the IPP has progressed.

Red Earth cc was in turn commissioned by Kongiwe firstly to produce a Scoping Report, and thereafter a Specialist Study Report (current report). The Specialist Study Report incorporates the previous Scoping Report information, together with the Baseline Report, Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) sections for the Soils, Land Capability and Land Use components.

Additional Baseline information presented in this Specialist Study Report includes the following: Wetland Identification/Delineation and Riparian Areas, Parent Material, Sensitive Landscapes, and location of Sites of Cultural and Archaeological Interest.

Numerous written Sections precede the Soils Baseline Sections of the current document, these being outlined in the Table of Contents.

SOILS BASELINE

Survey Methods and Data Collection

An intensive systematic grid soil survey was undertaken, with auger sampling points 300m (one auger per 9.00ha) apart throughout the proposed Operational Area only (2743.59ha), a total of three-hundred-and-twenty-two augers being conducted at pre-determined positions in the survey area as a whole. Seven modal (typical representative) soil auger points were augered, photographed and sampled (for agricultural analysis).

The Soil Map

Soil-mapping units are indicated on Map 2a (Soil Mapping Units), and are summarized in terms of soil form in Table 8.2.2 (Summary of Soil Form).

The different soil types identified were grouped together into soil-mapping units on the basis of soil form, effective rooting depth (ERD) for rehabilitation (stripping depth) and cropping, surface features, and parent material. Each soil-mapping unit has a unique code, which describes these factors.

Soil Types

The soils encountered in the Operational Area were divided into seven broad groups as follows:

- Red apedal soils (Hutton and Lichtenburg forms) [509.64 ha; 18.58 %];
- Yellow-brown apedal soils (Clovelly and Glencoe forms) [882.51 ha; 32.17 %];
- Neocutanic soils (Tukulu form) [11.07 ha; 0.40 %];
- Carbonate soils (Plooysburg, Kimberley and Molopo forms [42.25 ha; 1.54 %]; and Augrabies, Addo, Prieska, Montagu, Brandvlei and Coega forms [119.67 ha; 4.36 %]; Total [161.92 ha; 5.90 %];
- Pedocutanic soils (Swartland, Sepane and Bonheim forms) [492.48 ha; 17.95 %];
- Shallow soils (i.e. lithosols) (Glenrosa, Mispah and Dresden forms) [617.15 ha; 22.49 %];
- Hydromorphic soils (Westleigh and Katspruit forms, the latter form generally occurring in and adjacent to pans [59.43 ha; 2.17 %]; and
- Pans (generally Katspruit form) [4.97 ha; 0.18 %]; Total [64.40 ha; 2.35 %]).
- Total (Soils) [2739.18 ha; 99.84 %].

The district road (3.95 ha; 0.14 %) and three man-made ponds (0.47 ha; 0.02 %) in terrestrial (non-wetland) areas comprise the balance of the Operational Area total survey area (2743.59 ha; 100.00 %); the aforementioned being indicated in Table 8.2.2 (Summary of Soil Form).

Soil Water Table

Map 2a (Soil Mapping Units) normally indicates the distribution of perched soil water-tables (or moisture) in augered depth; making use of the terms ‘moist depth’, ‘moist’, ‘wet’, or ‘very wet’; including the depth at which the moisture associated with a perched water-table commences. Moist soil profiles were not encountered in the current survey area due to both the low effective rainfall in the area, as well as the time of year that the survey was conducted. Furthermore, given the grid espacement utilised, augers were generally not conducted in the currently dry pan areas (that may still be moist).

Soil Analytical Data

Table 8.2.5 (Soil Analytical Data) shows the agricultural analysis analytical data for the seven topsoil (A-horizon) and four subsoil (B-horizon) samples collected from seven modal (typical) soil augers.

The following physical and chemical variables were analysed (or calculated from the data provided): texture seven fractions (also includes clay %), exchangeable cations (emol (+) kg⁻¹ soil and ppm), S-value (emol (+) kg⁻¹ clay), cation exchange capacity (emol (+) kg⁻¹ soil, and clay), base saturation (%), exchangeable sodium percentage (%), electrical conductivity (µS/cm ÷ 10 = mS/m), pH (H₂O), saturation extract soluble cations (emol (+) kg⁻¹ soil), organic carbon (Walkley Black %), phosphorus (Bray 1 ppm), and saturation % (ml of water used to saturate 100g of soil).

Soil Analytical Characteristics and Soil Fertility

The following represent the overall texture range in the Operational Area:

- Yellow-brown apedal, Neocutanic, Shallow, and Carbonate soils (broad soil groups): loamy-sand to sandy-loam textures (clay content approximately 5 - 16%),
- Red apedal soils: sandy-loam to sandy-clay-loam (clay content approximately 10 - 26%),
- Pedocutanic soils: clay to sandy-clay -loam textures (clay content approximately 55 - 30%), and
- Hydromorphic soils: sandy-loam to clay textures (clay content approximately 15 - 55%).
The following points are relevant to soil fertility:

- **pH:**
  An optimum pH is assumed to be between about 6 to 7 (the range in which most nutrients are most available, and the average range preferred by most crops).
  The pH of the analysed topsoil and subsoil (collectively) samples vary as follows:
  - Yellow-brown apedal (Glencoe form) and Shallow (Glenrosa form): 5.53 - 5.89 (medium acid): i.e. slightly too acid;
  - Shallow (Dresden form), Hydromorphic (Westleigh form), Pedocutanic (Swartland form), and Red apedal (Hutton form): 6.02 - 6.37 (slightly acid): i.e. ideal; and
  - Carbonate (Brandvlei form): 8.26 (moderately alkaline): i.e. too alkaline.

- **Electrical Conductivity (EC):**
  The EC of the analysed samples varies from approximately 100-200 for the majority of samples, to up to approximately 500 for the pedocutanic (Swartland form) sample, and up to approximately 900 for the carbonate (Brandvlei form) sample. Thus the majority of the samples are non-saline as per The Chamber of Mines definition, bar the pedocutanic (Swartland form, probably also many of the Sepane forms) and carbonate (Brandvlei form, and probably also many examples of the non-analysed Augrabies, Addo, Prieska, Montagu, and Coega forms) soils which are saline.

- **Exchangeable Sodium Percentage (ESP):**
  The ESP of the analysed samples varies from 0.26 to 1.12 % for the majority of samples, and 2.50 to 6.06 % for the hydromorphic (Westleigh form) topsoil and subsoil samples. Thus all of the soils are non-sodic as per The Chamber of Mines definition.

- **Total Nitrogen (N):**
  Total N of the analysed samples is likely to be low to medium for the majority of analysed samples, and very high for the carbonate (Brandvlei form) sample.

- **Potassium (K), Magnesium (Mg), and Phosphorus (P):**
  In terms of fertility for maize, the optimal levels of nutrients (exchangeable cations) are: K (120 ppm optimal - 100 ppm acceptable), Mg (60 ppm) and P (34 ppm).
  Levels of K for the eleven samples range from 79 (moderately deficient) to 310 (far more than adequate) ppm. Deficiencies (79 - 96 ppm: moderately - very slightly deficient) are present for the following samples: red apedal subsoil, yellow-brown apedal topsoil and subsoil, and shallow (Glenrosa form) topsoil.
  Levels of Mg for the eleven samples range from 55 (very slightly deficient) to 273 (far more than adequate) ppm. Very slight deficiencies (55 - 58 ppm) are present for the following samples: red apedal topsoil, and shallow (Glenrosa form) topsoil.
  Levels of P are seriously deficient (1.04 - 14.29 ppm) for all of the topsoil and subsoil samples.

**Erosion Hazard and Slope**

Erosion slopes were calculated from the Soil Erodibility Nomograph of Wischmeier, Johnson and Cross (1971) [Figure 8.2.7]. The results are presented in Table 8.2.7 (Data Used and Results Obtained from the Soil Erodibility Nomograph).

*In-Situ* (undisturbed) soils:
Slope in the Operational Area varies as follows for natural areas:
- Midslopes (and concave ‘valley-bottom’ areas): almost level (0.5 - 1 degree): vast majority;
- Midslopes (and concave ‘valley-bottom’ areas): very gently sloping (1 - 2 degrees): occasionally; and
- Midslopes (and concave ‘valley-bottom’ areas): gently sloping (2 - 4 degrees): rarely.

The following critical erosion slopes have been selected from our data in Table 8.2.7 to represent the topsoils (A-horizons) of the various broad soil groups that occur in the area:

- Red apedal and Yellow-brown apedal soils (also applicable to Neocutanic soils, and Carbonate [Py, Ky and Mp soil forms only] soils):
  Average 7.0 degrees (12.3 % percentage grade).
- Pedocutanic soils (also applicable to Hydromorphic soils):
  Average 6.2 degrees (10.8 % percentage grade).
- Shallow soils:
  Average 4.8 degrees (8.4 % percentage grade).

Despite the fact that the determined critical erosion slopes are steeper than the prevailing slopes in the area, soil erosion is severe to moderate in the majority of the Operational Area as a result of the degradation/removal of the majority of the grass cover due to overstocking/overgrazing in the past. Unacceptable levels of soil erosion will almost always begin to occur in bare areas (without grass cover).

Critical erosion slopes are next presented for a number of different Rehabilitation Scenarios:

(i) Rehabilitated ‘topsoiled’ areas overlying building rubble, removed features, and opencast areas [not intentionally compacted].
   [i.e. rehabilitated ‘topsoiled’ areas overlying the footprints of all demolished/removed man-made features not included in Point ii)].

This scenario applies to the rehabilitation of the footprints of all of the sites of the demolished/removed/levelled man-made facilities/features upon closure: e.g. infrastructure / buildings, roads, ‘non-waste’ prepared surfaces/piles/banks, excavations; re-graded opencast areas; non-carbonaceous rock dumps that remain in perpetuity; and the sites of removed rock dumps (or piles of material) / removed overburden or underburden ‘waste’ layers / removed ‘topsoil’ stockpiles.

Rehabilitated areas must be re-graded (re-sloped), to ensure that the following recommended calculated slopes are not exceeded:

- Red apedal and Yellow-brown apedal soils: 5.2 degrees (9.2 % percentage grade). Also applicable to the Neocutanic soils, and Carbonate (Py, Ky and Mp soil forms only) soils.
- Pedocutanic soils: 6.2 degrees (10.8 % percentage grade).
- The final selected slope is 5.2 degrees (9.2 % percentage grade) for all ‘topsoil’ types, the soils in the former bullet being preferred.

All of the aforementioned slopes refer to non-vegetated areas, but may be slightly steeper (undetermined) after re-vegetation.

Suitable broad soil groups for rehabilitation ‘topsoiling’ purposes (surface placement) are as follows:
Red apedal (very high suitability), Yellow-brown apedal (high suitability), Neocutanic (high suitability), Carbonate [Py, Ky and Mp soil forms only] (high suitability), and Pedocutanic (moderate-low suitability).

(ii) Rehabilitated ‘topsoiled’ areas overlying a compacted-‘remoulded’ ‘seal’ layer and/or overlying a potentially-polluting rehabilitated feature.
[i.e. the ‘seal’ layer should ideally overlie rehabilitated pollution control/return water/process water dams, evaporation ponds, slurry/tailings dams, and potentially polluting dumps (e.g. carbonaceous discard dumps and ash dumps) at the time that these features become redundant and are rehabilitated. The seal layer should also underlie these features at the time of their construction, and also including the dirty water gullies/drains/canals].

During rehabilitation these feature must be re-graded (re-sloped) before placement of either the compacted -‘remoulded’ soil layer, or the overlying ‘topsoil’ layer to ensure that the following recommended slope is ideally not exceeded:

Pedocutanic (B-horizon) or Hydromorphic (G- or B-horizons) soils: maximum 5.2 degrees (9.2 % percentage grade) [non-vegetated, but slightly steeper (undetermined) after re-vegetation].
Thus, in terms of the overlying non-compacted ‘topsoil’ layer (Red apedal, Yellow-brown apedal, Neocutanic, or Carbonate [Py, Ky and Mp soil forms only], the determined slope would be the same.

The aforementioned slope is impractical since the slope of a ‘topsoiled’ ‘rehabilitated’ potentially polluting carbonaceous discard dump or ash dump cannot easily be reduced to this extent, while that of a ‘rehabilitated’ pollution control/return water/process water dam can be reduced (unless this feature remains functioning in perpetuity).
Thus, given the erodibility of the soils on steeper slopes, the ‘topsoiling’ of some features may not be feasible. In such cases, the feature must be re-vegetated using phytoremediation and ecological restoration principles.

(iii) Opencast Mining Areas.

Two pits are planned to be excavated for the current proposed project. Opencast areas must be re-graded, ‘topsoiled’, and re-vegetated as per Point (i).

Dryland / Irrigated Production Potential

Ranching:

The land in the region is suited to extensive game ranching and eco-tourism, and to a lesser extent extensive cattle ranching. Previous cattle ranching and over-stocking (of grazers) have resulted in the currently degraded eroded land. The farmers should completely discontinue burning for a good number of years, while grazer stocking densities must be kept as absolutely low as possible, to give the land a chance to ‘recover’ somewhat.

Cultivation:

Dryland
Given the low mean annual precipitation (435 mm), the hot climate (average maximum temperatures ranging from 30°C to 36°C), as well as the unpredictable rainfall in the area;
Dryland production is not recommended due to the very low yields obtained as well as the high associated risk.

According to the South African Atlas of Agrohydrology and Climatology (R.E. Schulze et-al, 1997), the generalised dryland yield (dry mass) in the region for maize on arable soils is 2 - 3 tonnes/ha, with an inter-seasonal coefficient of variation of approximately 40 - 50%. The dryland breakeven for maize is considered to be approximately 3 tonnes/ha. Schultz et-al indicates that the area is climatically unsuitable for all other dryland crops.

Irrigated

The irrigation potential in the soil survey area is based on the characteristics (already described) of the soils that occur, and generally varies as follows:

- High: red apedal soils;
- Moderate: yellow-brown apedal, neocutanic, and carbonate (Py, Ky and Mp soil forms only) soils;
- Low: pedocutanic soils (‘red’ colours); and
- Unsuitable: shallow, hydromorphic, pedocutanic (‘bleached’ grey colours), and carbonate (Ag, Ad, Pr, Mu, Br and Cg soil forms) soils.

Despite the arable soils that occur in many areas, such areas will not be able to be commercially cultivated without the provision of irrigation, due to the semi-arid prevailing climate in the area. Furthermore, there is a scarcity of borehole water for irrigation purposes, as well as the potentially saline water quality in some areas. High profit drip irrigated crops such as citrus or vegetables are likely to be feasible, provided that irrigation water is available.

Overburden / Underburden ‘Wastes’ and ‘Non-Wastes’

‘Wastes’ (mining related) do not occur in the current green fields survey area.

The term ‘wastes’ has been selected (by the author for discussion purposes) to refer to mining/processing/industrial/smelting related raw materials and by-products, that may have an inherently high pollution potential under certain circumstances. These may include materials such as discard, ash, potentially polluting carbonaceous spoil rock (particularly that which has been crushed to a fine grade), ore fines, slag, pellets, slurry/tailings, coke/anthracite/coal, and scrap.

The term ‘non-wastes’ has been selected (by the author for discussion purposes) to refer to other (non-mining or -processing, or -industrial, or -smelting related) materials, that have an inherently low pollution potential. These may include materials such as potentially non-polluting deposited rock, rubble, concrete, stone chips, and soil (when mixed with the aforementioned).

Soil Utilization (Stripping) Guide

As the opencast, infrastructure, storage, waste and containment facilities expand, the available ‘topsoil’ reserves must be stripped as per the depths indicated on Map 5 (Soil Utilization [Stripping] Guide), and either utilised to ‘topsoil’ a feature undergoing rehabilitation or stockpiled for later use (rehabilitation purposes).

Table 8.2.11 (Summary of Soil Utilization [Stripping] Guide) is extracted from Map 5, and summarizes the information for the survey area (Operational Area).
Table 8.2.11 shows that 16 389 904m³ of usable (high to low-unsuitable suitability) ‘topsoil’
(suitable A- and B-horizons) is present *in-situ* in the Operational Area.

Suitable broad soil groups for rehabilitation ‘topsoiling’ purposes (surface placement) are as
follows (descending order of suitability) [types i - iii preferred]:

i) Red apedal, very high suitability,
ii) Yellow-brown apedal (and Neocutanic), high suitability,
iii) Carbonate (Py, Ky, and Mp soil forms only), high suitability, and
iv) Pedocutanic (‘red’ colours only), moderate-low suitability.

The following broad soil groups are not recommended for surface placement, but may be
utilised further down in the rehabilitated profile:

v) Carbonate (Ag, Ad, Pr, Mu, Br, Cg soil forms only), very low to unsuitable (saline), and
vi) Shallow, Hydromorphic, and Pedocutanic (‘grey’ colours), very low to unsuitable (Shallow-gravelly/rocky; Hydromorphic and Structured-bleached).

The following broad soil groups are recommended for sealing purposes (compacted-‘re-
moulded’ seal) overlying/underlying a potentially-polluting rehabilitation feature.

vii) Hydromorphic (G- and B-horizons) and Pedocutanic (B-horizon), highly suited to this purpose.

**Rehabilitation ‘Topsoil’ Budget**

The Chamber of Mines specifies that at least the same percentage of arable and grazing land
should exist, as were present before disturbance. Furthermore, Government Notice R537 (of 21
March 1980) requires that all topsoil (as defined) removed must be replaced on the disturbed
sicface during rehabilitation.

Based on the volume (16 389 904m³) of available ‘topsoil’ reflected on Map 5 (Soil Utilization
[Stripping] Guide) and in Table 8.2.11 (Summary of Soil Utilization [Stripping] Guide), then
the following area would be able to be rehabilitated to the post-mining/disturbance arable
capability classes (*albeit* to a lower production potential): Arable (‘topsoiling’ depth: 0.60m) =
2731ha.

However, not all areas will need to be rehabilitated to the arable depth class standard (0.6m), as
determined by the pre-mining/disturbance capability class. Thus, many areas will be ‘topsoiled’
to the grazing (0.25m) or non-grazing (‘wilderness’ 0.15m) depth class standards.

Furthermore, the extent of the impacted (and thus rehabilitated) footprint will obviously occupy
a far lesser extent than the entire Operational Area (2743.59ha). Thus, available ‘topsoil’ is in
more than abundant supply. The Red apedal, Yellow-brown apedal, Neocutanic, and Carbonate
(Py, Ky and Mp soil forms only) broad soil groups are preferred for rehabilitation ‘topsoiling’
purposes, as a surface cover.

The following volumes of suitable ‘topsoil’ material are available for the construction of
compacted-‘re-moulded’ seals in the Operational Area: Pedocutanic (B-horizons): 3 492
439m³, and Hydromorphic (G- and B-horizons): 117 049m³. Thus, material for sealing
purposes is in more than abundant supply.
LAND CAPABILITY BASELINE

Land Capability

Land capability classes were determined using the guidelines outlined in the following document produced by The Chamber of Mines of South Africa / CoalTech: Guidelines for the Rehabilitation of Mined Land (November 2007).

Table 8.3.1b (Summary of Pre-Mining Land Capability) is extracted from Map 3a (Pre-Mining Land Capability), and summarizes the information for the Operational Area.

The pre-mining/disturbance land capability has been divided into eleven classes. In summary, the broad land capability groupings for the Operational Area are as follows:

- **Arable**: 825.10 ha, 30.07% of survey area;
- **Grazing**: 1282.81 ha, 46.76%;
- **Non-Grazing**: 550.71 ha, 20.07%; and
- **Wetland**: 80.55 ha, 9.33%.

- **Man-Made Features**: 4.42 ha, 0.16%.
- **Total Survey Area**: 2743.59 ha, 100%.

Wetland Classification/Delineation and Riparian Areas

The wetland delineation procedure is based on the following document: ‘A Practical Field Procedure for Identification and Delineation of Wetlands and Riparian Areas’, published by the Department of Water Affairs and Forestry (DWAF) [Edition 1, September 2005].

The wetlands (thus also riparian areas) encountered within the Operational Area are indicated on Map 3b (Wetlands) [and Map 3a - Pre-Mining Land Capability] and are summarised in Table 8.3.2b (Summary of Wetlands).

The indicated wetlands include the following:

- **Wetland Permanent**: 13.52 ha, 0.49% Soils; 4.98 ha, 0.18% Pans (25);
- **Wetland Seasonal**: 55.78 ha, 2.03%; and
- **Wetland Temporary**: 6.27 ha, 0.23%.

- **Total Wetlands**: 80.56 ha or 2.94%.

Three man-made ponds occur in terrestrial (non-wetland) areas: 0.47 ha, 0.02%.

Wetlands are also defined as riparian areas.

LAND USE BASELINE

The present land use in the Operational Area is presented on Map 4 (Present Land Use), and summarised in Table 8.4 (Summary of Present Land Use).

The land use both within and immediately adjacent to LCPP is dominated by game ranching/farming and eco-tourism, and to a lesser extent cattle ranching. Occasional lands are
also spread out throughout the area, the aforementioned probably producing dryland hay and other types of livestock feed on a small scale.

Table 8.4 indicates the present land use as follows:

- **Terrestrial Natural:**
  - Bush (Bush/Savannah/Grassland/Bare) : 2575.59 ha, 93.88 %;

- **Terrestrial Farming/Ranching Related Area:**
  - Cp (Cultivated Previously) : 79.67ha, 2.90 %;
  - Orchard (Citrus) : 0.05ha, 0.00 %;
  - Kraal (Cattle Kraal) : 0.23ha, 0.01 %;
  - Farmyard : 3.09ha, 0.11 %;

- **Terrestrial-Other Man-Made:**
  - Pond (Pond and Wall) : 0.47ha, 0.02 %;
  - District Road : 3.95ha, 0.14 %.

- **Wetland Natural:**
  - Wp (Riparian/Wetland Vegetation-Permanent Wetland) : 13.52ha, 0.49 %;
  - Pan (undisturbed) and Pan.W (pan with a man-made wall):
    - Both Permanent Wetlands : 4.98ha, 0.18 %;
  - Ws (Riparian/Wetland Vegetation-Seasonal Wetland) : 55.69ha, 2.03 %;
  - Wt (Riparian/Wetland Vegetation-Temporary Wetland) : 6.27ha, 0.23 %;

- **Wetland in Farming Related Area:**
  - Seasonal Wetland passing through a Farmyard : 0.09ha, 0.00 %.

**Man-Made Features**

The man-made features within the Operational Area are presented on Map 4 (Present Land Use), and summarised on the corresponding summary Tables 8.4 (Summary of Present Land Use).

Table 8.4 indicates the following features:
- District Road (one) : 3.95ha, 0.14 %; and
- Ponds (man-made) (three) : 0.47ha, 0.02 %.

Map 4 also indicates numerous tracks on the various farms, the aforementioned not being divided into polygons and thus having no area.

**Man-Made (Existing) Structures**

The man-made (i.e. existing) structures within the Operational Area are indicated on Map 4 (Present Land Use), and are summarised on the corresponding summary Table 8.4.1 (Summary of Man-Made Structures).

Table 8.4.1 indicates the following human/ranching/farming related structures, as well as the ‘count’ (number of occurrences) in brackets:

Borehole/pump (1), borehole (2), chalet (2), construction (1), dip (2), garage (1), house (11), house & braai (2), IR [i.e. informal house ruins] (3), lounge/kitchen (1), pool (1), reservoir (7), reservoir? (2), residence [i.e. main homestead] (5), rondawel (4), shed (5), silo (2), tank (1), tank[JoJo] (4), tank [JoJo] & solar (1), tower (1), trough (5), trough.F (i.e. trough for feed)] (8),
trough.F (x7) [i.e. trough for feed - 7 troughs spread out in one location] (1), trough.W [i.e. trough for water] (3), U [i.e. undifferentiated/unknown] (16), windmill (3), and workshop (1).

The aforementioned are not divided into polygons and thus have no area.

**Broad Vegetation Communities**

The vegetated areas are presented on Map 4 (Present Land Use), and summarised in Table 8.4.1 (Summary of Present Land Use).

Although degraded or transformed in sections, the vegetated areas include the following:
- Bush (or Savannah) in Terrestrial (non-wetland) areas: 2575.59ha (93.88 % of Operational Area); and
- Wetland/Riparian Vegetation in Wetland areas: 80.47ha (2.93 %); and
- Total Vegetated area: 2656.06ha (96.81 %).

**Human Settlement**

Human settlement is indicated on Map 4 (Present Land Use), and is summarized in Tables 8.4 (Summary of Present Land Use) and 8.4.1 (Summary of Man-Made Structures).

Current human settlement within the Operational area is essentially comprised of the following:
- Residences (i.e. main farmhouse) on each of the farms in the Operational Area (except Garibaldi). Associated structures such as sheds, workshops, garages, rondawels, chalets, windmills, boreholes, reservoirs, and water tanks are present in the immediate vicinity of each of these sites; and
- Houses for guests or labour are frequently present in either the immediate vicinity of the residences, or further away from these main settlement sites.
- Each of the residence or house sites is surrounded by an open area described on Map 4 as a ‘farmyard’.

Previous (but contemporary) settlement sites are described as Informal Ruins (‘IR’) on Map 4. These sites include brick and concrete rubble scattered around the relevant areas.

**Historical Agricultural Production**

Ranching (game and cattle) and farming related activities within the Operational Area are indicated on Map 4 (Present Land Use), and are summarized in Tables 8.4 (Summary of Present Land Use) and 8.4.1 (Summary of Man-Made Structures).

Agriculture:

Previous cultivation was identified at six locations, the aforementioned being comprised of twelve distinct fields in terrestrial areas amounting to 79.67ha (2.90 % of Operational Area). These dryland fields were probably predominantly utilised to produce supplementary feed for livestock in the past. Ranching/farming related features and structures are discussed in Sections 8.4.1 (MAN-MADE FEATURES) and 8.4.5 (EXISTING STRUCTURES). Crop production is discussed in Section 8.2.8 (DRYLAND / IRRIGATED PRODUCTION POTENTIAL).

Grazing and Browsing:
The farms are utilised for game ranching/farming and eco-tourism, and to a lesser extent cattle ranching.

**Evidence of Misuse**

Overgrazing and soil erosion are evident in the vast majority of the surveyed area, the levels of sheet erosion being indicated on Map 2a (Soil Mapping Units). At most sites, soil losses of between approximately 5 - 15cm have occurred throughout approximately 40 - 80% of the surface area, the only relatively non-eroded areas being those underlying low vegetation such as small bushes and trees.

The levels of overgrazing/soil erosion on the various farms generally appear to be as follows (from most to least eroded): Grootgenoeg Ptn.1 (very highly eroded in many sections), Honingshade (highly eroded), Grootgenoeg Ptn. 0 (moderately-highly), Weltevreden Ptn. 0 (moderately-highly), Botmansdrift (moderately), Weltevreden Ptn. 1 (slightly-moderately), and Garibaldi (slightly). The current levels of grass basal cover are closely correlated with the existing levels of soil erosion.

Given the widespread erosion in the area, the farmers should completely discontinue burning for a good number of years, while grazer stocking densities must be kept as absolutely low as possible to give the land a chance to ‘recover’ somewhat. Furthermore, erosion control measures such as the laying out of brush packs along the contour must be implemented.

**SENSITIVE LANDSCAPES**

Sensitive landscapes are discussed from the following perspectives in Section 8.5 (SENSITIVE LANDSCAPES):

i) Natural Wetland Soils
   Ephemeral wetlands soils amount to 80.56ha or 2.94% of the Operational Area (2743.59ha).

ii) Natural Wetland Drainage Features
   A limited number of short disconnected slightly concave ephemeral drainage features exist in the Operational area, these features being occupied by the aforementioned natural wetland soils. Drainage gullies, streams and rivers do not exist in the immediate area.

iii) Wetland/Riparian Vegetation
   The main categories of wetland/riparian vegetation in the Operational Area are described in Section 8.4.2 (BROAD VEGETATION COMMUNITIES).

   The wetland soils / wetland drainage features / wetland-riparian vegetation occurring within the Operational Area are not deemed to represent fatal flaws by the author for the following reasons: ephemeral in nature; dissipate a short distance after they commence; are generally underlain by solid rock or hard plinthite (ferricrete) at approximately 40-70cm below the surface; are not connected to streams and thus do not constitute catchment areas; and are commonly occurring features in the surrounding areas in general. Thus, the loss of these wetland areas due to mining related activities is deemed acceptable by the author.

iv) Erodible Soils
   Despite the determined erosion slopes in Section 8.2.7 (EROSION HAZARD AND SLOPE; In-Situ [Undisturbed] Soils), soil erosion is a major issue in the natural vegetated areas, the
aforementioned due to the generally extremely low grass basal cover as a result of many years of overgrazing, burning, and rain drop splash erosion on a largely bare surface.

The soils in the study area that are likely to be more sensitive to erosion than others include the following:
- pedocutanic soils, due to a slow–moderate subsoil permeability; and
- shallow soils, due to a relatively impermeable (to water) depth limiting horizon within 10 - 30cm below the soil surface, the aforementioned being either hard plinthite (Dresden form) or hard rock (Mispah form).

v) Vegetative Cover
Severe overgrazing and fire over many years are the likely causes of the low grass basal cover and thus severe to moderate levels of sheet erosion that occur throughout the majority of the survey area.

vi) Anthropogenic Moisture
Anthropogenic moisture does not occur in the current green fields site. Measures must be taken to prevent/limit the infiltration of ‘dirty’ water into the soils, and thereafter into the perched soil water-table, perched ‘ground’ water-table and ‘deeper’ groundwater-tables, during the operational and closure phases of the proposed project.

vii) Paleochannels and Naturally Buried Soils
No such soils were encountered.

Provided that the potential future mining /processing/containment procedures are conducted appropriately, then the impact to the soils/land capability/land use will be limited.

SITES OF CULTURAL AND ARCHAEOLOGICAL INTEREST

Sites of archaeological interest were not encountered in the current area. Sites of cultural interest are indicated on Map 4 (Present Land Use), and are summarized in Table 8.4.1 (Summary of Man-made Structures) in Section 8.4.1 (MAN-MADE FEATURES) of the current report. All of these contemporary structures are related to game and cattle ranching, eco-tourism, and farming.

ENVIRONMENTAL IMPACT ASSESSMENT

Chapters 9 (IMPACT AND RISK ASSESSMENT) and 10 (QUANTIFICATION OF IMPACTS) of the current document are relevant and are compliant with the NEMA Regulations (GN R982 of 4 December 2014).

Impact Significance Rating / Management Measures Tables were compiled for all three life cycle phases (Construction, Operational, and Decommissioning and Closure) of the LCPP Project. This was done for the Activities deemed to have a potential impact with reference to the Aspects identified.

The aforementioned Tables include the following information: Activity Area, Activity, Aspect, Impact Category, Type of Impact, Impact Description, Impact Significance Rating before Management (Measures), Mitigation Measures, Time Period for Implementation, and Impact Significance Rating after Management (Measures).
Impact Significance Rating / Management Measures Tables relevant to the Construction Phase are relayed in Table 9.2.2(a), to the Operational Phase in Table 9.2.2(b) and finally to the Decommissioning and Closure Phase in Table 9.2.2(c).

Impacts and Management Measures relevant to the Post-Closure Phase are relayed in Table 9.2.2(d). The aforementioned Table includes the following information: Impact Category, Mitigation Measures, and Time Period for Implementation only. The Mitigation Measures described are equally applicable to all of the previously identified Activity Areas, Activities, and Aspects.

ENVIRONMENTAL MANAGEMENT PLAN

As previously mentioned, Tables 9.2.2(a) [Construction phase], 9.2.2(b) [Operational phase], and 9.2.2(c) [Decommissioning and Closure phase] in Chapter 9 (IMPACT AND RISK ASSESSMENT) of the current document also include the following information: Mitigation Measures, Time Period for Implementation, and Impact Significance Rating after Management Measures. Table 9.2.2(d) [Post-Closure phase] includes the following information: Mitigation Measures, and Time Period for Implementation only.

In addition, Chapters 11 (TECHNICAL DETAILS OF MANAGEMENT MEASURES) and 12 (RELINQUISHMENT CRITERIA) of the current report are also relevant.

Furthermore, Section 8.4.6 (EVIDENCE OF MISUSE; Point a: Agriculture; and Point b: Mining, Processing and Industry) is also relevant and must be referred to.

ENVIRONMENTAL MONITORING PLAN

Chapter 13 (ENVIRONMENTAL MONITORING PLAN) of the current document is relevant.

Monitoring Standards, Monitoring Localities, Monitoring Procedures (frequency, variables to be recorded, monitoring/sampling technique, and sample presentation to the laboratory), Data Capture, and Reporting are discussed.

REASONED OPINION AND RECOMMENDATIONS

Chapter 14 (REASONED OPINION AND RECOMMENDATIONS) of the current document is relevant.

Impact Statement

- The Soils / Land Capability / Land Use Impact Assessment conducted for the LCPP project was informed by a comprehensive, site specific, quantitative and qualitative 300m-grid soil survey, conducted with the aid of an aerial photograph. The aforementioned enabled a reasonably accurate (would have been more detailed had a 150m-grid soil survey been conducted instead) description in support of a fundamental understanding of the attributes of the occurring soils, land capability and land use environments that will be influenced by both the existing and proposed new activities/developments/expansions.

- The project applicant furthermore provided sufficiently detailed information pertaining to the existing and proposed activities, to enable an accurate definition and description of the existing and potential aspects which could cause soils, land capability and land use impacts.
Based on the above, the following Impact Statement is made:

In the context of the situation, the associated impacts are conditionally deemed to be acceptable impacts; provided that the rehabilitation complies with the relinquishment criteria listed in Section 12 (RELINQUISHMENT CRITERIA) and specifically Table 12 (Relinquishment Criteria).

**Recommendations for Approval**

Based on the aforementioned Impact Statement, it is recommended that the New Project Activities/Aspects may proceed subject to the recommendations and conditions stated below.

**Recommendations for Measures and/or Conditions**

The New Project (LCPP Project) may proceed provided that the following recommendations and conditions are met:

- The applicant must take full cognizance of the soils / land capability / land use relinquishment criteria, as detailed in Section 12 (RELINQUISHMENT CRITERIA) and specifically Table 12 (Relinquishment Criteria). These include the Soil Component (Final Slope, Soil Erosion, Soil Depth, Soil Fertility, and Soil Contamination), the Land Capability Component, and the Land Use Component. Given the semi-arid climate, it is imperative that all of the relinquishment criteria are adhered to, and particularly the calculated final slopes, rehabilitation ‘topsoiling’ depth; and re-vegetation that is successful, functional and appropriate.

- The applicant must take full cognizance of the soils / land capability / land use sensitivities of the proposed New Project (LCPP Project) as detailed in Section 8.5 (SENSITIVE LANDSCAPES) into consideration throughout the life of the mine.

- The applicant must further comply with the recommendations for mitigation, management and monitoring as contained in the EMP Chapters 9 to 17 of this report and as stated in the conditional acceptance of the impacts as stated above.

The approval is subject to the development of the proposed ‘New Project Sites’ being sited in accordance with the approximate proposed location of such sites (as provided), and that should these proposed locations be shifted slightly for any reason, that these shifted sites do not intrude outside of the current proposed Operational Area. Any future proposed activities outside of the current proposed Operational Area will require another Baseline/EIA/EMP process to be conducted, together with the associated licences and approvals.

Respectfully submitted,

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Bruce McLeroth

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1. INTRODUCTION

Lephalale Coal Mines (Pty) Ltd (LCM), which is a subsidiary within the Masimong Group Holdings (MGH), proposes to develop a new coal mine and energy project in the Waterberg Coalfield, approximately 22km north-east of the town of Lephalale, Limpopo Province, Republic of South Africa. The project is known as the Lephalale Coal and Power Project (hereafter referred to as LCPP or the Project). The proposed Project is to consist of an open pit coal mine and, at a later stage, an Independent Power Producer (IPP) plant. LCM holds the prospecting rights for 12 farms associated with the Project.

Kongiwe Environmental (Pty) Ltd (Kongiwe) has been appointed by LCM to undertake the Environmental Impact Assessment (EIA) process in support of the Mining Right Application (MRA) and other Environmental Authorisations required for the proposed mine and IPP. Applications at this stage will be conducted for the mining section only, while applications for the IPP will be done in the future once the design of the IPP has progressed.


Red Earth cc was in turn commissioned by Kongiwe to firstly produce a Scoping Report, and thereafter a Specialist Study Report (current report). The Specialist Study Report incorporates the previous Scoping Report information; together with the Baseline Report, Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) sections for the Soils, Land Capability and Land Use components.

Additional Baseline information presented in this Specialist Study Report includes the following: Wetland Identification/Delineation and Riparian Areas, Parent Material, Sensitive Landscapes, and location of Sites of Cultural and Archaeological Interest.

It is herewith confirmed that this Soils / Land Capability / Land Use Specialist Study Report (including a Baseline Description, EIA, and EMP) has been compiled in accordance with, and contains the information as specified in Appendix 6 of the EIA 2014 Regulations.

The following components have therefore been assessed and are included in this report:

- Title page including name of author and contact details;
- Executive Summary detailing the major findings (in Specialist Study Report document only);
- Table of Contents;
- Introduction and project background;
- Specialist details and declaration of independence;
- Relevant legislation; and a statement that the study has addresses the relevant requirements;
- Scope/purpose of work undertaken; and approach and methodology;
- Assumptions, uncertainties, and knowledge gaps; as well as sources of data;
- Project description;
- Site sensitivity related to the activity;
• Areas to be avoided including buffers (i.e. fatal flaw assessment);
• Description of the Baseline Environment;
• Impact/Risk assessment (direct, indirect and cumulative) utilising the prescribed assessment methodology/format;
• Management plan including mitigation measures to deal with both negative and positive risks/impacts;
• Monitoring plan;
• Reasoned opinion and recommendations;
• Notes on the consultation process;
• Checklist of the information requested by the competent authorities; and
• Conclusions and References.

2. DETAILS OF SPECIALIST

This current Soils / Land Capability / Land Use Specialist Study Report has been compiled by an experienced specialist. The following specialist was involved with the investigation and in the compilation of the aforementioned reports:

Specialist:

- Bruce McLeroth

Qualifications and Experience:

- B.Sc. Agriculture (Natal);

- Member of the Soil Science Society of Southern Africa; and

- Years of Experience in the current field: 31 years as follows:
  - 28 years of these in my own business (Red Earth cc from 1989 till present); and
  - 3 years prior to that (Institute for Commercial Forestry Research from 1986-1988).

- A synoptic C.V. of the abovementioned specialist is attached as Appendix IV of the Specialist Study Report. A detailed C.V. can be made available upon request.

Given time constraints due to the immanent commencement of the hunting season, the following persons assisted the author with the soil fieldwork exercise: Diana Rietz (Phd Soil Science), Bonginkosi Vilakazi (M.Sc Soil Science) and Anele Mkila (B.Sc Soil Science).
3. DECLARATION OF INDEPENDANCE

I Bruce Bertram McLeroth as the appointed specialist hereby declare/affirm the correctness of the information provided as part of the application, and 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 am aware that it is an offence in terms of Regulation 48 to provide incorrect or misleading information and that a person convicted of such an offence is liable to the penalties as contemplated in section 49B(2) of the National Environmental Management Act, 1998 (Act No. 107 of 1998).

B.B.McLeroth

Signature of the Specialist

Red Earth cc

Name of Company

30 June 2017

Date
4. RELEVANT LEGISLATION AND GUIDELINES

All relevant Acts, Regulations and Guidelines are routinely considered during the compilation of a Specialist Study Report. The Specialist Report is always compiled in support of an Environmental Authorization Process under the management of an Environmental Assessment Practitioner (EAP).

In support of the abovementioned environmental authorisation applications cognisance was taken of the following Acts, Regulations and Guidelines (among others – refer to Sections 4.1 and 4.2 of the current document) during the compilation of the Soils / Land Capability / Land Use Specialist Study Report.

The following applications will be made to the Department of Mineral Resources (DMR) as the competent authority for the proposed mining project:

- Mining Right Application (MRA) in terms of the Minerals and Petroleum Resource Development Act, 2002 (Act No. 28 of 2002) (MPRDA);
- Application for Environmental Authorisation (EA) for listed activities triggered in Listing Notices GNR 983, 984 and 985 and in accordance with the Environmental Impact Assessment (EIA) Regulations, 2014, promulgated in terms of National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA); and

In addition, the following applications will be made to the relevant competent authorities:

- Atmospheric Emission Licence (AEL) Application, in terms of the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) (NEMQAQA). The Lephalale Local Municipality (LLM) is the competent authority;
- Integrated Water Use Licence (IWUL) Application, in terms of the National Water Act, 1998 (Act No. 36 of 1998), as amended (NWA). The Department of Water and Sanitation (DWS) is the competent authority; and
- Relevant permit applications will also be made in terms of sections 34, 35 and 36 of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA). The South African Heritage Resources Agency (SAHRA) and/or the Limpopo Heritage Resources Authority (LHRA) will be the competent authorities.
# 4.1 ACTS AND REGULATIONS

**Table 4.1: Acts and Regulations**

| Act: Constitution of the Republic of South Africa No. 108 of 1996 (Constitution) |
| Act: Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA) |
| GNR 527 of 23 April 2004 - Mineral and Petroleum Resources Development Regulations |
| Regulations: |
| GNR 704 of 4 June 1999 – Regulations on Use of Water for Mining and Related Activities aimed at the Protection of Water Resources |
| Act: National Environmental Management Act 107 of 1998 (NEMA) |
| Regulations: |
| GNR 807 of 10 October 2012 - Publication of Public Participation Guideline |
| GNR 982 of 08 December 2014 - Environmental Impact Assessment Regulations |
| GNR 983 of 08 December 2014 - Environmental Impact Assessment Regulations - Listing Notice 1 of 2014 |
| GNR 985 of 08 December 2014 - Environmental Impact Assessment Regulations - Listing Notice 3 of 2014 |
| Regulations: |
| GNR 344 of 4 May 2012 – National Waste Management Strategy |
| GNR 921 of 29 November 2013 – List of Waste Management Activities that have, or are likely to have, a Detrimental Effect on the Environment |
| GNR 634 of 23 August 2013 – Waste Classification and Management Regulations |
| GNR 635 of 23 August 2013 – National Norms and Standards for the Assessment of Waste for Landfill Disposal |
| GNR 636 of 23 August 2013 – National Norms and Standards for Disposal of Waste to Landfill |
| GN 926 of 29 November 2013 – National Norms and Standards for the Storage of Waste |
| GN 331 of 2 May 2014 – National Norms and Standards for the Remediation of Contaminated Land and Soil Quality |
| GN 332 of 2 May 2014 – Amendment to the List of Waste Management Activities that have, or are likely to have a Detrimental Effect on the Environment |
| Act: National Heritage Resources Act (Act No. 25 of 1999) (NHRA) |
## 4.2 GUIDELINES

### Table 4.2: Guidelines

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<td>Department of Mineral Resources (DMR) Guideline for Consultation with Communities and Interested and Affected Parties</td>
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<td>DMR Guideline for the Compilation of an Environmental Impact Assessment and an Environmental Management Programme</td>
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<td>Integrated Environmental Management, Information Series 5, Impact Significance</td>
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<td>Guideline 5: Assessment of Alternatives and Impacts</td>
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<td>Guideline 6: Environmental Management Frameworks</td>
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<td>Guideline 7: Detailed Guide to Implementation of the EIA Regulations</td>
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<td>Guideline 9: Need and Desirability in terms of the Environmental Impact Assessment Regulations</td>
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<td>Framework for the Management of Contaminated Land. DEA 2010</td>
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<td>DEA Guideline on Understanding the Definition of Waste.</td>
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5. SCOPE, PURPOSE, APPROACH AND METHODOLOGY

5.1 SCOPE AND PURPOSE OF THE REPORT

Kongiwe Environmental (Pty) Ltd (Kongiwe) has been appointed by LCM to undertake the Environmental Impact Assessment (EIA) process in support of the Mining Right Application (MRA) and other Environmental Authorisations required for the proposed mine and IPP. Applications at this stage will be conducted for the mining section only, while applications for the IPP will be done in the future once the design of the IPP has progressed.

The applications require a Scoping and Environmental Impact Assessment as per Regulation 21 and Regulation 24 of the EIA 2014 Regulations, of the National Environmental Management Act (NEMA).

Red Earth cc was in turn commissioned by Kongiwe firstly to produce a Scoping Report, and thereafter a Specialist Study Report (current report). The Specialist Study Report incorporates the previous Scoping Report information; together with the Baseline Report, Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) sections for the Soils, Land Capability and Land Use components.

5.2 APPROACH, METHODOLOGY AND ACTIONS PERFORMED

The Soils / Land Capability / Land Use investigations conducted entailed both qualitative (mostly) and quantitative (soil analytical data only) site specific investigations using data obtained in the field as well as information documented during previous studies, in accordance with the various guidelines and documents obtained from the regulating authorities. The approach and methodology which was followed during the various investigations is discussed below.

5.2.1 DESKTOP STUDY / REVIEW EXISTING INFORMATION

- Obtain and review the existing soils, land capability, land use and mining related information pertaining to the survey area. This includes published regional information, as well as available reports relevant to LCPP.

- Compile figures (maps) of the regional location/topography, and soils of the Study Area and surrounds. These figures are used as a reference to aid in the description of the regional setting of the Project Area. The figures were compiled as clipped sections or line work extracted from the following published or unpublished maps:
  
  - 1:50 000 Topographical Map Series of South Africa. Published Sheets 2327 BC, 2327 DA, 2327 BD, 2327 DB, and 2328 AC;
  
  - 1:250 000 Land Type Map Series of South Africa. Unpublished 1: 250 000 Sheet 2326 Ellisras; and

- Compile a 1:10 000 base map for fieldwork purposes. This map is based on overlying the available LCPP AutoCAD line work, as well as available Surveyor Generals Office shape file line work on the latest Surveyor Generals Office image or alternatively the Google Maps image; and thereafter establishing sample point positions and references.

- Calculate the farm areas relevant to the Project. The farm areas were calculated from shape file boundaries sourced from the relevant 1:50 000 Topographical maps mentioned in the current chapter. Given that the deeds office title deed boundaries may not necessarily exactly correspond with the published shape file data (from our own experience), the deeds office boundaries should ideally be requested, surveyed in-field, and put into shape file format by the client.

**Table 5.2.1: Farm Names and Areas**

<table>
<thead>
<tr>
<th>Farm Name</th>
<th>Section Within Operational Area (ha)</th>
<th>Section Outside of Operational Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honingshade 427 LQ</td>
<td>636.06</td>
<td>234.02</td>
</tr>
<tr>
<td>Botmansdrift 423 LQ</td>
<td>129.86</td>
<td>720.83</td>
</tr>
<tr>
<td>Grootgenoeg 426 LQ</td>
<td>594.04</td>
<td></td>
</tr>
<tr>
<td>Weltevreden 482 LQ</td>
<td>479.93</td>
<td>429.42</td>
</tr>
<tr>
<td>Pretoria 483 LQ</td>
<td>21.77</td>
<td>1020.15</td>
</tr>
<tr>
<td></td>
<td>141.91</td>
<td></td>
</tr>
<tr>
<td>Garibaldi 480 LQ</td>
<td>212.19</td>
<td>940.12</td>
</tr>
<tr>
<td>Franschhoek 207 LQ</td>
<td>925.79</td>
<td></td>
</tr>
<tr>
<td>Sebright 205 LQ</td>
<td>334.41</td>
<td>173.46</td>
</tr>
<tr>
<td>Stutgard 420 LQ</td>
<td>367.20</td>
<td>173.46</td>
</tr>
<tr>
<td>Forfarshire 419 LQ</td>
<td>869.38</td>
<td>172.63</td>
</tr>
<tr>
<td>Billiards 428 LQ</td>
<td>813.30</td>
<td></td>
</tr>
<tr>
<td>Wellington 432 LQ</td>
<td>1031.90</td>
<td></td>
</tr>
<tr>
<td><strong>Totals (ha)</strong></td>
<td><strong>2874.74</strong></td>
<td><strong>8878.21</strong></td>
</tr>
</tbody>
</table>

Portions of the Farms Wolvendraai 481 LQ, and Goodhope 492 LQ lie outside of the the Scoping Report Project area: 557.45ha
Despite the Operational Area extent indicated in Table 5.2.1 (2874.74ha), the final mapping Shapefiles for the map set indicate the extent to be **2743.59ha**, since the mapping boundaries were digitized according to the farm fence boundaries that are visible on the aerial photograph. Both sets of areas include that portion of the district dirt road that dissects the farms.

### 5.2.2 FIELDWORK AND RESEARCH

A detailed qualitative site-specific fieldwork investigation was undertaken at LCPP between 23 April and 10 May 2017 as part of the Soils / Land Capability / Land Use study, the aforementioned by means of a 300m grid auger soil survey.

Due to the non-polluted (by mining or industry) green fields nature of the Soils / Land Capability / Land Use environments at LCPP, it is not expected that the season / time of the year during which the fieldwork was undertaken will have a significant influence on the outcome of the assessment. Note that in polluted areas (other sites outside of current Project Area), where soil / ‘waste’ / ‘non-waste’ samples are collected during the rainy season, a proportion of the potential pollutants in the 0-2cm sample depth range will have been leached to a lower depth (generally top 30cm or 60cm) in the soil profile to a certain extent. The opposite applies during the dry season, where potential pollutants will have moved closer to the soil surface as a result of capillary action.

The procedure was:

- Write up the Scoping Report before commencement of the soil augering fieldwork exercise.
- Conduct the soil survey fieldwork and describe and classify the soils at each of the pre-determined auger points, as per the procedure outlined in Section 8.2.1 (SURVEY METHODS AND DATA COLLECTION).
- Concurrently with the soil survey fieldwork exercise, also record the land capability and land use at each pre-determined soil auger point. At the same time also record the types of ‘waste’ or ‘non-waste’ (none occur), and the location of sites of cultural and archaeological (none encountered) interest.
- Upon completion of the soil survey fieldwork exercise, auger seven modal (typical representative) soil auger points. Immediately after augering; photograph, sample (for agricultural analysis) and describe each of the modal soil augers, one at a time. A maximum of two samples were collected from each soil augers, these being one each from the topsoil and subsoil. A total of only eleven samples were collected, since three of the profiles did not display a subsoil horizon.
- Submit the agricultural soil samples to the Institute for Soil, Climate and Water for analysis. Analyse the samples for the range of physical and chemical variables as indicated in Table 8.2.5 (Soil Analytical Data). Interpret the resultant data.
- Conduct the mapping of the following maps with reference to the data collected in-field, aerial photographic interpretation, and the contours. Map 1: Soil Sampling Points; Map 2a: Soil Mapping Units; Map 2b: Soil Mapping Units - Image Overlay; Map 3a: Pre-Mining Land Capability; Map 3b: Wetlands; Map 4: Present Land Use; and Map 5: Soil Utilization (Stripping) Guide.
Map 2c: Parent Material; Map 4a: Present Land Use - Man-Made Features Theme; Map 4b: Present Land Use - Broad Vegetation Communities Theme; and Map 5: Sites of Archaeological and Cultural Interest; were not produced since a 300m-grid soil survey was utilised for the fieldwork (instead of the recommended 150m grid soil survey). The collected data were thus insufficient to produce the aforementioned maps.

- Should the proposed Project continue in the future, then all of the mapping products must be updated based on intensifying the soil survey grid intensity to 150m, as specified by the Chamber of Mines.

- Finalise the aforementioned maps into Shape file format.

- Write-up the Specialist Study Report document, which includes the Baseline, EIA, and EMP components.

### 5.2.3 BASELINE DESCRIPTION

Comprehensive Soils, Land Capability, and Land Use Baselines were compiled.

Additional baseline information routinely presented includes the following: location and mapping of ‘Wastes’ / ‘Non-Wastes’ (none present in current green fields Study Area), Wetland Identification/Delineation and Riparian Areas, and Broad Vegetation Communities (Distribution - not species composition – not compiled due to 300m grid utilised). These chapters are routinely included with the Soils, Land Capability and Land Use Baselines respectively.

Further additional information routinely presented includes the following: Sensitive Landscapes, and Sites of Cultural and Archaeological Interest (not compiled due to 300m grid utilised).

The Soils Baseline routinely describes the following aspects:

- soil distribution [homogenous areas of soil] (i.e. soil mapping units map – includes soil form, depth, surface features, parent material, perched soil water-table – not encountered, overburden waste or non-waste depth and type – none encountered; and rarely precipitated sub-surface/surface salts);
- soil frequency (i.e. soil mapping units map – map legend summary, and table in document);
- soil types and suitability for agriculture (i.e. cultivation) and ‘topsoil’ (i.e. rehabilitation ‘topsoiling’ purposes);
- soil water-table (i.e. anthropogenic, semi-permanent, seasonal, and temporary perched water-tables);
- soil analytical data (i.e. chemical and physical data);
- soil analytical characteristics and soil fertility (i.e. how the soil chemical and physical analytical data relates to soil fertility);
- erosion hazard and slope (i.e. how the soil physical analytical data relates to soil erosion, both naturally in-situ, and in two different rehabilitation scenarios [not intentionally compacted underlying material, and compacted -‘remoulded’ ‘seal’] in the post-mining/industrial state);
- dryland and irrigated production potential (i.e. crop range and yields);
• soil utilization (stripping) guide (i.e. distribution) [map], frequency [map legend summary], and volume [map legend summary] of broad soil groups, that must be stripped / stockpiled / and utilised for rehabilitation ‘topsoiling’ purposes [frequently separately from ‘each other’, for the different broad soil groups];

• rehabilitation ‘topsoil’ budget (i.e. comparison of the volume of stockpiled ‘topsoil’, versus that required to rehabilitate [‘topsoil’] the various post-mining / post-industrial landscapes to the arable or grazing or non-grazing capability classes during the operational and closure phases, for two different rehabilitation scenarios [not intentionally compacted underlying material, and compacted - ‘remoulded’ ‘seal’ layer]; and

• ‘waste’ or ‘non-waste’ overburden/underburden – includes distribution/depth/frequency/types of ‘wastes’ or ‘non-wastes’ (i.e. indicated on soil mapping units map, and explanation table in document). This is to inform a potential ‘Wastes’ Baseline of the entire survey area, this being necessary to quantify the state of the property, so that the mine/smelter can make informed decisions regarding the best / safest / most cost effective measures for dealing with the materials. Such material did not occur in the current green fields Study Area.

The Land Capability Baseline describes the following aspects:

• land capability requirements (i.e. the allocation of soils to different land capabilities, based on the various requirements allocated to each land capability class);

• land capability distribution (i.e. land capability and wetland delineation - map); and

• land capability frequency (i.e. land capability and wetland delineation maps - map legend summaries, and tables in document).

The Land Use Baseline describes the following aspects:

• present land use distribution (i.e. present land use map, including vegetated areas);

• present land use frequency (i.e. present land use map - map legend summary, and table in document);

• on the aforementioned map/table, the various structures, features and landscapes will be mapped, classified, quantified, and summarized in detail; and

• the present/past land use will be discussed from the following perspectives: human settlement, historical agricultural production, existing structures, and evidence of misuse from the agricultural perspective in the current area.

Furthermore, additional related information provided includes the following aspects:

• wetland classification/delineation and riparian areas;

• sensitive landscapes; and

• sites of cultural and archaeological (none encountered) interest.

Wetland Classification/Delineation and Riparian Areas describes the following aspects:

• wetland distribution (i.e. included on the land capability and wetland delineation map);

• wetland frequency (i.e. included on the land capability and wetland delineation map - map legend summaries, and tables in document); and

• wetland identification and classification/delineation procedure (i.e. initial identification of wetlands based on the recognition of ‘signs of wetness’ within the top 0.5m of soil depth; and thereafter the wetlands are classified into the semi-permanent/permanent, seasonal and temporary classes).

Sensitive Landscapes describes the following aspects:

• natural wetland soils, natural (wetland) drainage features, wetland/riparian vegetation, erodible soils and vegetative cover, anthropogenic moisture (not encountered), and
paleochannels/naturally buried soils (not encountered). The sensitive landscapes will be identifiable on the following maps (and map legend summaries): pre-mining land capability; and soil mapping units.

Sites of Archaeological and Cultural Interest describes the following aspects:
• location of sites of cultural interest (i.e. present land use map, and table in document). Sites of archaeological interest were not encountered in the current area.

To this end, a 300m-grid auger soil survey was conducted to map, classify, quantify and summarize all of the aforementioned.

5.2.4 IMPACT AND RISK ASSESSMENT

These aspects of the Project are discussed in Sections 9 – 17 of the current document.
6. ASSUMPTIONS, UNCERTAINTIES AND KNOWLEDGE GAPS

6.1 ASSUMPTIONS

Soils study

Due to the qualitative (mostly) / quantitative (soil analytical data only) investigative nature of the assessment very few significant assumptions were made. The vast majority of the information included in the report was either verified during (observed soil variables) or after (estimated soil variables were largely verified by the soil analytical data of the seven modal soil augers) the field investigations.

The volume of available *in-situ* ‘topsoil’ (suitable topsoils and subsoils), calculated for the soil utilization (stripping) guide is precise up till the weathering/hard rock/hardpan carbonate horizon/soft carbonate horizon/soft plinthic horizon/G-horizon, since this figure was calculated using both soil depth and extent (area). Table 8.2.11 (Summary of Soil Utilization [Stripping] Guide) indicates the aforementioned.

‘Topsoil’ stockpiles and ‘waste’ were not encountered in the current green fields survey area.

Further assumptions made relate to the Adequacy of the Predictive Methods utilised.

The predictive methods used throughout the soils, land capability and land use investigations generally adhere to the relevant regulating requirements and are both applicable to and adequate (bar the soil survey grid intensity utilised) for the investigations conducted. These methods include the soil survey intensity (i.e. grid espacement – 150m grid is recommended and appropriate; not 300m-grid), and the recording of observed / estimated data during the fieldwork exercise, as well as the analytical determinations conducted on the modal soil samples collected for agricultural analyses.

Soil survey grid intensity:

The 150m-grid auger observation interval is recommended to be utilised throughout areas where detailed soil information is required (where large amounts of surface disturbance will, or have already occurred). The 150m-grid intensity represents the generally accepted minimum industry standard (also recommended by the Chamber of Mines) that will achieve a high mapping purity, ensuring that the area does not have to be revisited in the future to refine detail.

Given time constraints due to the immanent commencement of the hunting season, the 300m-grid auger intensity (instead of the 150m-grid auger intensity) was utilised in the proposed ‘Operational Area’ (i.e. ‘Footprint’ indicated on Figure 7.1a) for mapping and reporting purposes. Should the proposed Project continue in the future, then the area must be revisited and the sampling intensified. In this event, the first version of the mapping / Specialist Study Report document must then be updated.

Recording of observed and estimated soil variables:
Observed soil variables are recorded accurately in the field (at each auger point / sample position), and include most of those mentioned in Section 8.2.1 (SURVEY METHODS AND DATA COLLECTION). The ‘Recorded soil variables’ are either: ‘Recorded per horizon’ or ‘Recorded per profile’. Exceptions in this list, which are estimated in the field, are recorded below.

Estimated soil variables are recorded approximately in the field (at each auger point / sample position), and include surface features (% of surface cover), topsoil organic carbon (%), clay content (%), sand grade (dominantly fine, medium, or coarse), and cultivation factors (coarse fragments %). The latter four estimates will be adjusted slightly (where necessary), after comparing them with the soil analytical data of the modal soil profiles (topsoils and subsoils) that were collected and analysed.

Soil analytical determinations:

The agricultural soil analyses were conducted at the laboratories of The Institute for Soil, Climate, and Water (ISCW) (Agricultural Research Council) on eleven samples that were collected from eight modal soil augers. The data is likely to be precise given that the laboratory has a long history and professional staff.

**Land Capability (including Wetland Classification / Delineation and Riparian Areas) study**

Due to the qualitative (soil form, effective rooting depth, signs of wetness in the soil profile, and slope) and quantitative (soil analytical data) investigative nature of the assessment, no significant assumptions were made in areas augered or traversed. Furthermore the guidelines governing the classification of land capabilities and wetlands are clearly defined.

Despite the aforementioned, the 300m-grid soil survey was found to be insufficient to map the wetland boundaries and the soil forms occurring therein accurately. Thus, the delineation (boundaries) and classification (permanent, seasonal or temporary) of wetlands that were not augered or traversed were subjective and in many instances based on aerial photograph interpretation.

**Land Use study**

Information recorded in-field was of a qualitative nature. However, due to the quantitative nature of the mapping (utilizing an aerial photograph, from which all of the mapping was conducted, for all of the maps in the set); no significant assumptions will be made during the mapping exercise.

Despite the aforementioned, given the low resolution of the aerial photograph utilised, man-made structures were frequently not clearly visible on the image or alternatively not visible at all. Thus, the positions of many of the man-made structures are approximate only.

The dryland/irrigated agricultural production potential yields are far more subjective, given that yields assume a high level of expertise and management, and furthermore the unpredictable rainfall patterns also play a role. Quoted yields will be as per R.E. Schulze et-al (1997).
6.2 UNCERTAINTIES

The vast majority of the information used/recorded during the various studies was qualitatively/quantitatively obtained, before, during, and after the field work exercise. Information that was collected during the various studies was either verified or quantified during the field investigations conducted on site, or afterwards by soil analysis of modal soil profiles (augers) or comparison with published data for the area.

Mapping uncertainty exists in certain aspects of the mapping (already discussed) given both the utilisation of the 300m-grid intensity auger soil survey conducted (lower mapping purity) as opposed to the recommended 150m-grid survey; as well as due to the resolution of the geo-referenced aerial photograph utilised. The resultant lower mapping purity in certain instances cannot thus be attributed to the specialist, but rather to both the time constraints (and thus broad mapping grid) specified by the client, as well as the non-provision of a high resolution geo-referenced aerial photograph by the client.

6.3 KNOWLEDGE GAPS

Minor knowledge gaps exist in certain aspects of the mapping (already discussed) given both the utilisation of the 300m-grid intensity auger soil survey conducted (lower mapping purity) as opposed to the recommended 150m-grid survey; as well as due to the resolution of the geo-referenced aerial photograph utilised.

Neither the Parent Material map nor the Present Land Use (Broad Vegetation Communities Theme) map were compiled as a result.
7. PROJECT ASPECTS RELEVANT TO SOILS, LAND CAPABILITY AND LAND USE

The current section is comprised of Infrastructure and Layout, Site Sensitivity, a Fatal Flaw Assessment, and Features and Buffers for Avoidance.

7.1 INFRASTRUCTURE AND LAYOUT
(Refer to Figures 7.1a and 7.1b; Map 4; and Tables 8.4 and 8.4.1)

Proposed Infrastructure Layout:

The proposed infrastructure and layout within the proposed ‘Operational Area’ (i.e. ‘Footprint’ indicated on Figure 7.1b) is indicated on Figure 7.1b, these features occupying the majority of this area. The proposed infrastructure will be comprised of the following:

- Opencast pits (two), crushing circuit, wash plant, conveyors;
- Discard dump, Run of Mine stockpiles, ash dump, topsoil stockpiles;
- Water supply network, storm water network, pollution control dams, raw water dam, effluent water, water treatment works;
- Offices, workshops, change house, storehouses, warehouses;
- Internal roads, haul roads, fuel storage facilities; and
- Independent Power Producer station (design and location to be covered by a later Specialist Studies Report document).

A more detailed proposed Infrastructure list is provided in Tables 9.2.2a-c.

Map 4 (Present Land Use) indicates the currently occurring man-made features in the proposed Operational Area (only). The corresponding summary Tables 8.4 (Summary of Present Land Use) and 8.4.1 (Summary of Man-Made Structures) summarises these features.

Adjacent Areas:

The man-made features in the greater Project / Study Area surrounding the proposed Operational Area will not be mapped. Thus, the proposed Operational Area may in the current document be referred to as the survey area.
Figure 7.1(a): Proposed Infrastructure Layout (General)
Figure 7.1(b): Proposed Infrastructure Layout (Operational Area Detail)
7.2 SITE SENSITIVITY

Section 8.5 (SENSITIVE LANDSCAPES) of the current document describes the potentially sensitive landscapes in the survey area.

The sensitive landscapes were grouped according to the following:

i) Natural Wetland Soils.

ii) Natural (Wetland) Drainage Features.

iii) Wetland/Riparian Vegetation. Such vegetation is found in the areas associated with Points i) and ii).

iv) Erodible Soils

v) Vegetative Cover.

vi) Anthropogenic Moisture.

vii) Paleochannels and Naturally Buried Soils.

Future infrastructure and containment facilities must be carefully planned so as not to impact or intrude into sensitive wetland soils / riparian areas.

7.3 FATAL FLAW ASSESSMENT

(Refer to Figure 7.4)

Section 7.4 (FEATURES AND BUFFERS FOR AVOIDANCE) indicates that no fatal flaws were encountered within the LCPP Operational Area. The procedure that was utilised to identify potential fatal flaws is described in the current Section.

The fatal flaw assessment is performed subject to the guidelines contained within the DWAF Waste Management Series’ “Mining Requirements for Waste Disposal by Landfill” document. It is a Minimum Requirement that no landfill site be developed in an area with an inherent Fatal Flaw. The assessment is performed by highlighting any potential fatal flaw from the list provided, which are known to occur within the LCPP Operational and immediate surrounding areas, ending up with a map that indicates areas void of any fatal flaws.

The fatal flaw assessment at LCPP is addressed with reference to the features depicted on Figure 7.4 (Features and Buffers for Avoidance), which incorporates each of the identified requirements for the fatal flaw assessment. This map (Figure 7.4) was compiled based on existing published information (extracted from the published 1:50 000 Topographical maps of the area) as well as information generated during the various field investigations conducted at LCPP.

In a green fields situation (such as the current LCPP Study Area) the map would be used to site activities within these fatal flaw free zones. In a brown fields situation the map would be used to identify activities for which the design criteria should be adapted to engineer for possible fatal flaw related complications.
A number of aspects representing potential fatal flaws (situations which may preclude the development of an environmentally or publicly acceptable waste disposal facility except at excessive cost) were considered during the fatal flaw assessment. The proposed ash dump may be considered as a waste disposal facility.

A number of the potentially fatal flaws may possibly occur more than once in the discussions of the various aspects. The various aspects include the following:

- **3000m from the end of any airport runway or landing strip in the direct line of the flight path and within 500m of an airport or airfield boundary.**  
  *This is because certain waste disposal landfills (typically domestic) may attract birds, creating a danger to aircraft.*

  The closest farm landing strip on the farm Franschoek 207 LQ (within the Project Area) is located approximately 4.5km to the north-east of the northern property corner (farm Botmansdrift 423 LQ) of the Operational Area. The Operational Area is therefore not located in the direct line of approaching or departing aircraft.

- **Areas below the 1 in 50 year flood line.**  
  *These areas are included to protect naturally sensitive areas such as streams, wetlands (wetland soils, vleis and pans), flood plains and riparian vegetation, where development would result in the destruction of the soils/land capability/land use in these areas, while water pollution could [potentially] also result. Furthermore, this is also to prevent the flooding and resultant instability of man-made features.*

  The water courses and ephemeral pans indicated on Figure 7.4 as a solid blue line were extracted from the South African National Biodiversity Institute (SANBI) database (‘wetlands’ layer).

  These solid blue water course lines were also overlaid on top of the dashed blue drainage lines/pan indicated on the combined 1:50 000 Topographical Map Series of South Africa (Sheets 2327 BC, 2327 DA, 2327 BD, 2327 DB, and 2328 AC), to create Figures 7.1a (Proposed Infrastructure Layout [General]) and 8.1.1 (Location and Topography of Study Area).

  The SANBI ‘wetlands’ layer indicates three unnamed non-perennial water courses (short sections only) and sixteen ephemeral pans within the Project Area, outside of the Operational Area. Further wetlands will occur in this area (not indicated by SANBI). The extent of wetlands in the aforementioned area may be inferred from that occurring in the Operational Area (2.94% of area). Although the SANBI ‘wetlands’ layer did not indicate any wetlands within the Operational Area, this is not correct.

  The wetlands identified within the Operational Area during the course of the soil survey (refer to the following bullet: Areas characterized by flat gradients, shallow or emergent groundwater) were added to Figure 7.4.

  The 1: 50 year and 1: 100 year flood lines will be calculated as part of the Surface Water Specialist Study Report. In the absence of delineated flood lines, we delineated only the water courses, pans, and wetlands (without the buffer).

  Figure 7.4 indicates the relevant features as follows:

Outside Operational Area (i.e. Project Area): ‘Water Courses’, and ‘Pans’.

- **Areas in close proximity to significant surface water bodies.**

No major water courses, major water bodies or major dams occur within the Project Area.

Surface water for livestock and human drinking purposes is pumped from boreholes and stored in a limited number of man-made ponds, reservoirs, tanks and troughs. Three man-made ponds have been constructed in terrestrial (non-wetland) areas within the Operational Area, the aforementioned amounting to 0.47ha or 0.02% of the Operational Area. The area of man-made ponds within the Project Area (outside of the Operational Area) is unknown to the author. The ephemeral pans display surface water for short periods after rainfall events.

The Mokolo (AKA Magol) and Lephalale Rivers (tributaries of the Limpopo River), are the closest significant surface water body, flowing in a northerly and north-westerly direction approximately 18.5 km to the west and 18.0 km to the north-east of the LCPP Operational Area respectively.

- **Catchment areas for important water resources.**

Although all sites ultimately fall within a catchment area, the size and sensitivity of the catchment is important, especially if it feeds a water resource.

The Project Area does not produce surface runoff (an endoreic area) due to the semi-arid climatic conditions and shallow topographical gradients. **The limited ephemeral wetlands within the Operational Area dissipate a short distance after they commence and are not connected to streams, and thus do not constitute catchment areas.**

Thus, the size and locality of the LCPP Project Area is not deemed to represent a fatal flaw.

- **Areas characterized by flat gradients, shallow or emergent groundwater**

Such areas are regarded as wetlands (wetland soils, springs and pans).

Wetlands and their associated riparian vegetation areas are normally regarded as especially sensitive landscapes under statutory protection, and as such must not be disturbed, polluted, cultivated or overgrazed without a licence. Such areas have a high significance from a preservation point of view, since they perform important hydrological functions, and are major contributors to the bio-diversity of an area. In wetland areas there would not be a sufficient unsaturated zone separating a waste body and the groundwater.

The DWA interpretation of the NWA is that no mining activities or infrastructural placement may take place within a 500m radius of the boundary of any wetland; unless an authorisation is issued in terms of Sections 21 (c) [Impeding or diverting the flow of a watercourse] and (I) [Altering the bed, banks, course or characteristics of a watercourse] of the NWA.

The SANBI (South African National Biodiversity Institute) ‘wetlands’ layer indicates three unnamed non-perennial water courses (short sections only) and sixteen ephemeral pans within the Project Area, outside of the Operational Area. Further wetlands will occur in this
area (not indicated by SANBI). The extent of wetlands in the aforementioned area may be inferred from that occurring in the Operational Area (2.94% of area). Although the SANBI ‘wetlands’ layer did not indicate any wetlands within the Operational Area, this is not correct.

Within the Operational Area, the soil survey indicated the following: 23 pans (3.96ha, 0.14% of Operational Area); 2 pans further dammed up by a man-made wall (1.02ha, 0.04%); and further wetland areas (permanent 13.52ha, 0.49%; seasonal 55.78ha, 2.03%; and temporary 6.27ha, 0.23%). Thus total wetlands amount to 80.56ha or 2.94% of the Operational Area (2743.59ha).

Any proposed infrastructure in such areas will require a license. It is the opinion of the author that such a license should be granted, given our comments in the following two paragraphs.

The ephemeral wetlands and pans occurring within the Operational Area are not deemed to represent fatal flaws by the author for the following reasons:
- ephemeral in nature; dissipate a short distance after they commence; are generally underlain by solid rock or hard plinthite (ferricrete) at approximately 40-70cm below the surface; are not connected to streams and thus do not constitute catchment areas; and are commonly occurring features in the surrounding areas in general.
- Thus, the loss of these wetland areas due to mining related activities is deemed acceptable by the author.

An ephemeral stream is defined in Appendix III of our report as follows: “A stream or portion of a stream that flows only in direct response to precipitation, and receives little or no water from springs or no long continued supply from snow or other sources, and its channel is at all times above the water table”.

Figure 7.4 indicates the relevant features as follows:
- Outside Operational Area (i.e. Project Area): ‘Water Courses’, and ‘Pans’.

- **Sensitive ecological and/or historical areas.**
  These include areas of ecological significance (increased bio-diversity and nature reserves), and sites of cultural or archaeological interest.

Wetlands and their associated riparian vegetation areas are regarded as especially sensitive landscapes under statutory protection, and are major contributors to the bio-diversity of an area. Thus, such areas must ideally be preserved.

Areas of broader vegetative (and other) diversity are also relevant, such as those that occur on rocky ridges where there is a reduced incidence of fire.

The Study Area is not a formally protected area; the closest major ecologically sensitive area being the D’Nyala Nature Reserve which is located approximately 17.0 km to the south-south-west of the proposed Operational Area. The Hans Strydom Nature Reserve surrounds the Mokolo Dam, approximately 45km to the south of the proposed Operational Area.
Sites of archaeological and cultural significance were searched for during the course of the soil survey fieldwork exercise. However, no archaeological sites were encountered. The existing contemporary man-made structures are presented in Section 8.4.1 (MAN MADE FEATURES) and Table 8.4.1 (Summary of Man-Made Structures) and may have some cultural interest.

Figure 7.4 indicates the relevant features as follows:
Outside Operational Area (i.e. Project Area): ‘Water Courses’, ‘Pans’, and ‘Rocky Soils’.

- **Areas of groundwater recharge on account of topography and/or highly permeable soils.**

Groundwater recharge may be increased in areas of rapid soil permeability, as well as associated with dykes and certain (dykes) rocky soils. Dykes in particular may represent a fatal flaw in terms of groundwater recharge.

Rehabilitated opencast pits / other features (none present in current green fields Study Area) may also represent areas of increased groundwater recharge.

Figure 7.4 indicates only one possible relevant feature as follows:
Outside Operational Area (i.e. Project Area): ‘Rocky Soils’.

- **Areas overlying or adjacent to important or potentially important aquifers.**

This aspect is not applicable to our scope of work.

- **Areas characterized by steep gradients, where stability of slopes could be problematic.**

Steep areas do not occur within the proposed Operational Area. Thus, Figure 7.4 does not presently indicate any relevant features.

- **Areas characterized by shallow bedrock with little soil cover.**

The shallow broad soil group (lithosols - typically 5 - 30cm of soil overlying shattered or weathering rock) is relevant when associated with dykes (or faults). Bio-diversity is usually high in the less rocky sections of such areas, while groundwater recharge may also be raised relative to the surrounds.

The soil survey fieldwork exercise determined that no such soils associated with dykes occur in the proposed Operational Area. The shallow soils associated with mudstone, siltstone, sandstone and ferricrete in the Operational Area are not relevant.

Figure 7.4 indicates only one possible relevant feature (two locations) as follows:
Outside Operational Area (i.e. Project Area): ‘Rocky Soils’.

- **Areas in close proximity to land-uses which are incompatible with land-filling.**

  Community resistance to incompatible land-uses is likely to arise from proposed developments in the vicinity of residential areas, nature reserves and cemeteries.

No major residential areas exist in proximity to the proposed Operational Area.
Thus, Figure 7.4 does not presently indicate any relevant features.

- **Areas where adequate buffer zones are not possible.**
  The DWAF Minimum Requirements for Waste Disposal by Landfill (2nd Edition) indicate that buffer zones are separations between the registered (or proposed) landfill site boundary and any adjacent residential or sensitive development. They are established to ensure that a landfill operation does not have an adverse impact on quality of life and/or public health.

  The buffer zone around LCPP is deemed adequate given that the proposed Operational Area is surrounded by areas of livestock/game farming, as well as limited areas of cultivated land.

- **Areas which, because of title deeds and other constraints, can never be rezoned to permit a waste disposal facility.**
  This aspect is not applicable to our scope of work.

- **Areas immediately upwind of a residential area in the prevailing wind direction(s).**
  This aspect is not applicable to our scope of work, and is dealt with in the Air Quality Specialist Study Report.

- **Areas over which servitudes are held that would prevent the establishment of a waste disposal facility.**
  This aspect is not applicable to our scope of work. The details of all the servitudes (e.g. Eskom Power Lines and District Roads) will be confirmed during the relevant Specialist Study Report.

  Nevertheless, Figure 7.4 indicates one relevant feature as follows:
  Inside Operational Area: ‘Secondary Roads’ (i.e. the District Road).

- **Any area characterized by any factor that would prohibit the development of a landfill except at prohibitive cost.**
  This refers to areas with specific engineering challenges.
  This aspect is not applicable to our scope of work.

- **Areas in conflict with the Local Development Objectives (LDO) process and the Regional Waste Strategy.**
  This aspect is not applicable to our scope of work.
7.4 FEATURES AND BUFFERS FOR AVOIDANCE
(Refer to Figure 7.4)

The features and buffers addressed in Section 7.3 (FATAL FLAW ASSESSMENT) have been used to identify the areas which are normally considered as fatal flaws, and which should therefore be avoided.

Those areas which contain features and buffers which are to be avoided are indicated on Figure 7.4 (Features and Buffers for Avoidance). However, given our comments in Section 7.3, and specifically Bullet: Areas characterised by flat gradients, shallow or emergent groundwater; the wetlands/pans occurring in the Operational Area are not considered by the author to be particularly ecologically sensitive areas, and are thus not considered to be fatal flaws.
Figure 7.4: Features and Buffers for Avoidance
8. BASELINE DESCRIPTION OF THE ENVIRONMENT

The Soils, Land Capability, and Land Use Scoping Report baseline descriptions (and other related studies) were compiled with reference to the available information pertaining to the site (moderate amount of the information). The majority of the information was generated during the field investigations and a small minority after completion of the investigations. The soils/land capability/land use baseline descriptions are further documented in such a manner as to support the information required for the respective applications in terms of the MPRDA, the NEMA, the NEMWA as well as the NWA.

8.1 REGIONAL SETTING

The regional setting is discussed with reference to available published regional information for the survey area. The discussion will deal with the regional location, topography, surface drainage, meteorology, geology/parent material, soils, land capability, and land use; all of which have an influence on the soil/land capability/land use setting of the site.

8.1.1 LOCATION

(Refer to Figure 8.1.1)

Figure 8.1.1 (Location and Topography of Survey Area) indicates the location of the site, the figure having being clipped from the published 1: 50 000 Topographical Map Series of South Africa, compilation of Sheets 2327 BC, 2327 DA, 2327 BD, 2327 DB, and 2328 AC.

The LCPP Project is located in the Waterberg Coalfield, the proposed Operational Area lying approximately 22km north-east of the town of Lephalale (Limpopo Province), and approximately 40km south of the Botswana border.

The centre of the proposed Operational Area lies approximately 12km north of the R518 provincial tar road that links the town of Lephalale with the village of Marken, and approximately 27km east of the R510 provincial tar road that trends to the north-north-west from the town of Lephalale. The Project Area is bisected by a number of district dirt roads.
Figure 8.1.1: Location and Topography of Study Area
8.1.2 TOPOGRAPHY
(Refer to Figure 8.1.1)

The topography is evident in Figure 8.1.1 (Location and Topography of Study Area).

Topographically the Study Area lies within the Ellisras-Limpopo Plain, which is a flat to gently undulating region. The area is part of the broad Limpopo Basin.

The topography in the area is described as being generally that of an almost level (0.5 - 1 degree slope) plain with very gentle undulations and no prominent topographical features. Slope is very gentle (1 - 2 degrees) in other limited areas of the plain.

At least two rocky outcrops exist outside of the proposed Operational Area. Slopes in these areas may exceed 5 degrees (moderate slope is defined as 5 - 10 degrees) in certain sections. One of these outcrops exists in the central section of the farm Wellington 432 LQ, while the other is a small isolated outcrop in the western extent of the farm Garibaldi 480 LQ. There are no natural areas characterized by steep gradients in the proposed Operational Area. A number of concave ‘valley-bottom’ areas associated with wetlands also exist, these areas being almost non-discernible in-field due to the almost level to very gently sloping prevailing slopes.

Altitude within the Project Area varies as follows: 840m (western boundary of Wellington 432 LQ); 865m (north-eastern corner of Franschhoek 207 LQ); 890m (north-western corner of Forfarshire 419 LQ); and 940m (south-eastern corner of Pretoria 483 LQ).

Aspects are generally north-westerly, except on the farm Forfarshire 419 LQ where they are south-easterly.

In summary, after completion of the soil survey exercise, slope in the Operational Area was determined to vary as follows for natural areas:

- Midslopes (and concave ‘valley-bottom’ areas): almost level (0.5 - 1 degree): vast majority;
- Midslopes (and concave ‘valley-bottom’ areas): very gently sloping (1 - 2 degrees): occasionally; and
- Midslopes (and concave ‘valley-bottom’ areas): gently sloping (2 - 4 degrees): rarely.

8.1.3 SURFACE DRAINAGE
(Refer to Figure 8.1.1)

The Ellisras-Limpopo Plain area is part of the broad Limpopo Basin and is drained by several rivers, of varying size, which flow northwards to the Limpopo River. These rivers are, from west to east, the Matlabas, Mokolo, Lephalale, Mogalakwena and Sand Rivers. The current Study Area is bounded by the Mokolo River to the west and the Lephalale River to the east.

The surface drainage in the Study Area is evident in Figure 8.1.1 (Location and Topography of Study Area).

The Mokolo (AKA Magol) and Lephalale Rivers (tributaries of the Limpopo River), are the closest significant surface water body, flowing in a northerly and north-westerly direction.
approximately 18.5 km to the west and 18.0 km to the north-east of the LCPP Operational Area respectively.

The majority of slopes in the Project Area are towards the Mokolo River to the west, with a limited number sloping towards the Lephalale River to the north-east. The majority of the Project Area falls within the A42J quaternary catchment of the Limpopo Water Management Area, the aforementioned draining to the Mokolo River, A42 sub-catchment. A limited section to the north-east of the Project Area drains instead into another catchment to the north-east, also within the Limpopo Water Management Area.

Despite the aforementioned, the Project Area does not produce surface runoff (an endoreic area) on account of the semi-arid climatic conditions and shallow topographic gradients that occur.

The SANBI (South African National Biodiversity Institute) ‘wetlands’ layer indicates three unnamed non-perennial water courses (short sections only) and sixteen ephemeral pans within the Project Area, outside of the Operational Area. Further wetlands will occur in this area (not indicated by SANBI). The extent of wetlands in the aforementioned area may be inferred from that occurring in the Operational Area (2.94% of area). Although the SANBI ‘wetlands’ layer did not indicate any wetlands within the Operational Area, this is not correct.

Within the Operational Area, the soil survey indicated the following: 23 pans (3.96ha, 0.14% of Operational Area); 2 pans further dammed up by a man-made wall (1.02ha, 0.04%); and further wetland areas (permanent 13.52ha, 0.49%; seasonal 55.78ha, 2.03%; and temporary 6.27ha, 0.23%). Thus total wetlands amount to 80.56ha or 2.94% of the Operational Area (2743.59ha).

8.1.4 METEOROLOGY

The climatic information that follows (in quotations) was sourced from Section 1.10 (CLIMATE) of the RSV ENCO Consulting report entitled ‘Lephalale Coal Project, Dedicoal 06860001, Scoping Study Report’, dated May 2014 (Document Number: 06860001A-00-REP-0001).

“The climate is best described as semi-arid with rainfall of between 250mm - 500mm per annum and temperatures reaching up to 40°C. The mean annual rainfall is 435mm, mostly falling during the summer months of October to April with very dry winters extending from May to September, as can be seen in Table 8.1.4”.

Figure 8.1.4: Annual Rainfall (mm)
“Monthly temperatures vary with average maximum temperatures ranging from 30°C to 36°C and minimum temperatures of between 3°C and 7°C. Record highs were measured at 40.7°C in January and lowest of 0.2°C in June”.

“The average humidity recorded is 69% and the minimum and maximum average humidity ranges between 28% and 99% respectively”.

“The average wind speed recorded is 1.4 m/s, with the minimum and maximum wind speed ranging from 0 m/s to 5.2 m/s. Wind direction is predominantly west-south-west”.

8.1.5 GEOLOGY AND PARENT MATERIAL

Geology:

The geological information for the area is described in the following report: RSV Enco Consulting report entitled ‘Fatal Flaw and Screening Assessment - Lephalale Coal Project’, dated February 2014 (Report Reference: RSV2436). The report indicates that Karoo sandstone, siltstone, mudstone, grit, conglomerates, shale and coal exist in the area.

Parent Material:

Parent material is the material from which soil has weathered, which in turn has weathered from the parent rock. Thus, the parent material is usually the rock type that directly underlies the soil profile. Different parent material types, largely by nature of their inherent relative concentrations of cations, lead to the development of differing soil types.

In the case of the current Study Area, the underlying ‘geology’ in the Operational Area frequently consists of the rock types mentioned in the Geology sub-section of the report, while the deep Aeolian sand mantle of the Quaternary System exists to the north-west outside of the Operational Area (within the Project Area) on the farms Forfarshire 419 LQ and Stutgard 420 LQ.

Parent materials encountered (observed) in the proposed Operational Area during the course of the soil survey (in descending order of frequency) include the following: sandstone/grit; ferricrete (secondary - usually overlying sandstone at depth); chert (predominantly chert stone layer mixed with fragments of numerous other parent material types - possibly weathered from conglomerates); calcrete (secondary - probably overlying a base rich parent material at depth), siltstone/mudstone; and colluvium (rarely - associated with pans).

The carbonate ‘parent material’ (secondary) is comprised of an underlying hardpan or soft carbonate horizon, the aforementioned most likely being underlain by basic igneous rock (such as diabase), although this rock type was not encountered anywhere on the surface or in the soil profiles.

The ferricrete ‘parent material’ (secondary) is relic and reflects an ancient topographical/climatic regime (previously fluctuating water-table and iron rich environment). Such material generally overlies relatively impermeable sandstone rock at depth.
The parent material types encountered are indicated on Map 2a (Soil Mapping Units). However, the parent material was not indicated in cases where it was not able to be determined by the author, the aforementioned areas probably being chert or sandstone derived.

8.1.6 REGIONAL SOILS
(Refer to Figures 8.1.6(a) and 8.1.6(b))

The regional soil boundaries are indicated in Figure 8.1.6(b) (Regional Soil Setting). The aforementioned figure was clipped from the unpublished 1: 250 000 Land Type Map Series of the Republic of South Africa - Sheet 2326 Ellisras (1995). Information regarding the soils occurring in the Land Type units was extracted from the published Memoir 19 (Agricultural Research Council, February 2005) that accompanies the aforementioned Land Type map.

Both the Broad Soil Patterns indicated on Figure 8.1.6(b), as well as the average soil form distribution (and quoted percentages) for the Land Types are approximate for the 1: 250 000 sheet as a whole, the aforementioned due to the fact that Land Type maps are based on broad reconnaissance soil surveys only. Thus, the information provided in the current section should be regarded as generalised reconnaissance level information only.

Detailed soil distribution patterns, profile descriptions, and soil physical/chemical information were derived from our soil survey of the Operational Area; and are presented on Map 2a (Soil Mapping Units) and are discussed in the various sub-sections (8.2.1 - 8.2.12) of Section 8.2 (SOILS BASELINE) of the current document.

According to Memoir 19, the Study Area lies within the Ellisras-Limpopo Plain, which is a flat to gently undulating region.

Memoir 19 further reports the information that follows, this information frequently having been adapted from the original form, into a form that best suits the purposes of the current report.

The Memoir reports the underlying ‘geology’ within the Plain to consist of an Aeolian sand mantle of the Quaternary System, along with shale and sandstone of the Karoo Sequence, as well as granite and gabbro of the Bushveld Complex.

Deep, red, apedal loamy-sands to sandy-loams are dominant on the sands of the Quaternary System. These soils belong mainly to the Hutton form and are less weathered than those that lie further to the east, where the rainfall is higher. The shale and sandstone areas result in the formation of moderately deep to deep, yellow apedal eutrophic loamy-sands with the dominant soil form being Clovelly. Some areas of rock outcrops and shallow lithosols of the Mispah form also occur.

The northern fringe of the Waterberg mountain range (sandstone of the Kransberg Subgroup) occurs to the south of the Study Area, and this may influence the soils in small isolated sections the Study Area to a certain limited extent, the aforementioned where this parent material type is present as a result of colluvial action. In raised (relative to the surrounds) topographical positions, this parent material type will give rise to shallow, stony soils of the Mispah and Glenrosa forms.

The symbols utilised to describe slope shape, terrain type and terrain unit in the Land Type inventory descriptions i) to iii) are discussed hereafter.
Slope Shape:

Slope Shape is described as follows: X (concave); Y (convex); and Z (straight).

Terrain Type:

Percentage level land is estimated (with the aid of a slope wedge) in terms of four classes:
A - >80% of the area has slopes less than 8%;
B - 50 - 80% of the area has slopes less than 8%;
C - 20 - 50% of the area has slopes less than 8%;
D - <20% of the area has slopes less than 8%.

Local relief is an estimate of the difference (m) over the Land Type between the highest (unit 1) and lowest (unit 5) points in the landscape. It is expressed in terms of six classes as follows:
Class 1 0-30m; Class 2 30-90m; Class 3 90-150m; Class 4 150-300m; Class 5 300-900m; and Class 6 >900m.

Using the criteria given above, a symbol (e.g. A2) indicating the nature of the terrain type is given in the inventory of each Land Type.

Terrain Unit:

The Terrain Units are described as follows:
1 represents a crest; 2 a scarp; 3 a midslope; 4 a footslope; and 5 a valley-bottom; while 3⁽¹⁾ indicates a second phase midslope and 3⁽²⁾ a third phase midslope.
Whether a terrain unit is a footslope or a midslope depends on its position (a midslope lies immediately below a crest or scarp) and, to an extent, upon the steepness of the slope. In contrast with a midslope, a scarp is steeper than 100% (45 degrees) and usually steeper than about 70 degrees.

The various Terrain Units are indicated in the schematic diagrams below.

*Figure 8.1.6(a): Terrain Units*
The Land Types occurring in the LCPP Study Area are discussed hereafter.

i) **Red-Yellow Apedal, Freely Draining Soils**

**Map Unit: Ae (red, high base status, >300mm deep, no dunes)**

Map Unit Ae refers to yellow and red soils without water tables and belonging to one or more of the following soil forms (in the current area): Hutton, Griffin and Clovelly. The Map Unit refers to land that does not qualify as a plinthic catena and in which one or more of the red and yellow apedal soil forms occupy ≥ 40% of the area. According to the Map Unit definition for Ae, yellow soils occupy <10 % of the area, while high base status eutrophic soils occupy a larger area than mesotrophic soils.

**Land Type: Ae253a**

Parent material: Shale, sandstone and coal from the Karoo Sequence. Gabbro and anorthosite of the Villa Nora Gabbro. Biotite granite of the Lebowa Granite Suite. Note: not all of these parent material types may be relevant to the Study Area.

Terrain: Type: A2.

For Terrain Unit: 4 (95% of the area):
Slope: Grade: 0 - 2 %; Length: 1000 - 5000m; Shape: Z.

For Terrain Unit: 5 (5% of the area):
Slope: Grade: 1 - 3 %; Length: 50 - 100m; Shape: Z-X.

Soils:

- Hutton or Shortlands forms: Relative Abundance of these soil forms in the Land Type Unit: 77.1%; Depth: 50-90cm; Clay: A 20-30%, B 20-50%; Texture B: medium sandy-clay-loam to clay;

- Hutton form: 9.5%; Depth: 50-120cm; Clay: A 4-8%, B 8-14%; Texture B: medium-coarse sand to sandy-loam;

- Avalon form: 5.4%; Depth: 60-90cm; Clay: A 15-30%, B 30-45%; Texture B: medium sandy-clay-loam to clay;

- Mispah form: 4.8%; Depth: 5-20cm; Clay: A 10-20%; Texture A: medium sandy-loam;

- Glencoe and Westleigh forms: 2.9%; Depth: 50-70cm; Clay: A 15-25%, B 30-40%; Texture B: medium sandy-clay-loam to sandy-clay; and

- Pans: Arcadia form: 0.5%; Depth: 50-120cm; Clay: A 45-60%; Texture A: clay.

**Land Type: Ae337a**

Parent material: Gabbro and Anorthosite of the Villa Nora Gabbro.
Terrain: Type: A1.

For Terrain Unit: 4 (90% of the area):
Slope: Grade: 0 - 2%; Length: 500 - 4000m; Shape: Z.

For Terrain Unit: 5 (10% of the area):
Slope: Grade: 1 - 3%; Length: 25 - 50m; Shape: Z-X.

Soils:

- Hutton form: Relative Abundance of these soil forms in the Land Type Unit: 31.5%; Depth: 60-120cm; Clay: A 15-20%, B 20-30%; Texture B: medium sandy-clay-loam;

- Hutton form: 18.2%; Depth: 50-100cm; Clay: A 20-30%, B 35-55%; Texture B: sandy-clay to clay;

- Shortlands form: 18.0%; Depth: 35-60cm; Clay: A 40-50%, B 55-65%; Texture B: clay;

- Arcadia form: 15.8%; Depth: 30-80cm; Clay: A 45-60%; Texture A: clay;

- Swartland and Glenrosa forms: 9.0%; Depth: 40-80cm; Clay: A 15-35%, B 40-50%; Texture B: sandy-clay to clay;

- Oakleaf form: 3.0%; Depth: 100-120cm; Clay: A 20-30%; B 20-30%; Texture B: medium sandy-clay-loam;

- Valsrivier form: 2.7%; Depth: >120cm; Clay: A 25-35%; B 25-35%; Texture B: fine/medium sandy-clay-loam; and

- Avalon form: 1.8%; Depth: 50-80cm; Clay: A 25-35%, B 35-45%; Texture B: sandy-clay-loam to sandy-clay.

ii) Red-Yellow Apedal, Freely Draining Soils

Map Unit: Ah (red and yellow, high base status [usually <15% clay])

Map Unit Ah refers to red and yellow soils without water tables and belonging to one or more of the following soil forms (in the current area): Hutton, Griffin and Clovelly. The Map Unit refers to land that does not qualify as a plinthic catena and in which one or more of the red and yellow apedal soil forms occupy ≥ 40% of the area.

According to the Map Unit definition for Ah, red and yellow soils each occupy >10% of the area, while high base status eutrophic soils occupy a larger area than mesotrophic soils.

Land Type: Ah85a

Parent material: Karoo Sequence sandstone and siltstone of the Clarens Formation as well as undifferentiated shale, mudstone and coal.

Terrain: Type: A2.
For Terrain Unit: 1 (5% of the area):
Slope: Grade: 1 - 2%; Length: 200 - 600m; Shape: Y.

For Terrain Unit: 3 (30% of the area):
Slope: Grade: 1 - 3%; Length: 500 - 3000m; Shape: Z.

For Terrain Unit: 4 (60% of the area):
Slope: Grade: 0 - 1%; Length: 3000 - 8000m; Shape: Z.

For Terrain Unit: 5 (5% of the area):
Slope: Grade: 1 - 2%; Length: 50 - 250m; Shape: X.

Soils:

- Hutton form: Relative Abundance of these soil forms in the Land Type Unit: 43.5%; Depth: >120cm; Clay: A 2-5%, B 4-12%; Texture: fine/medium sand to loamy-sand;

- Clovelly form: 28.9%; Depth: >120cm; Clay: A 2-7%, B 4-12%; Texture B: fine/medium sand to loamy-sand;

- Hutton form: 9.8%; Depth: >120cm; Clay: A 2-4%, B 4-8%; Texture B: coarse sand to loamy-sand;

- Fernwood form: 3.9%; Depth: >120cm; Clay: A 1-3%, B 2-6%; Texture B: fine/medium sand;

- Avalon form: 3.7%; Depth: 30-100cm; Clay: A 4-8%, B 8-12%; Texture B: medium loamy-sand to sandy-loam;

- Clovelly form: 3.4%; Depth: >120cm; Clay: A 6-10%, B 6-15%; Texture B: coarse sand to loamy-sand;

- Oakleaf form: 2.3%; Depth: 80-120cm; Clay: A 10-15%, B 12-30%; Texture B: medium sandy-loam to sandy-clay-loam;

- Valsrivier, Katspruit and Longlands forms: 1.6%; Depth: 20-80cm; Clay: A 8-12; B 15-40%; Texture B: fine/medium sandy-loam to sandy-clay;

- Hutton form: 1.2%; Depth: >120cm; Clay: A 10-15%; B 18-25%; Texture B: medium sandy-loam to sandy-clay-loam;

- Mispah form: 1.1%; Depth: 50-150cm; Clay: A 5-15%; Texture A: fine/medium sand to sandy-loam; and

- Stream Beds: 0.8%.
iii) Plinthic Catena: Upland Duplex and Margalitic Soils Rare
Map Unit: Bc (eutrophic, red soils widespread)

Map Unit Bc refers to land where plinthic soils must cover more than 10% of the area. Upland duplex and margalitic soils are absent or occupy <10% of the area. The valley bottom is occupied by one or other gley soil. According to the Map Unit definition for Bc: high base status eutrophic soils predominate over mesotrophic soils; while red soils (mainly Hutton and Bainsvlei forms) occupy > one third of the area.

Land Type: Bc45a

Parent material: Sandstone and conglomerate of the Kransberg Sub-Group, Waterberg Group as well as undifferentiated shale, sandstone, mudstone and coal of the Karoo Sequence.

Terrain: Type: A4.

For Terrain Unit: 1 (1% of the area):
Slope: Grade: 0 - 15 %; Length: 50 - 150m; Shape: Y.

For Terrain Unit: 3 (2% of the area):
Slope: Grade: 6 - 35 %; Length: 200 - 500m; Shape: X-Z.

For Terrain Unit: 4 (92% of the area):
Slope: Grade: 1 - 3 %; Length: 800 - 3500m; Shape: Z.

For Terrain Unit: 5 (5% of the area):
Slope: Grade: 1 - 3 %; Length: 25 - 200m; Shape: X.

Soils:

- Rock: Abundance in the Land Type Unit: 1.3%;

- Mispah and Glenrosa forms: Relative Abundance of these soil forms in the Land Type Unit: 1.7%; Depth: 5-15cm; Clay: A 4-12%; Texture A: coarse sand to loamy-sand;

- Hutton form: 48.3%; Depth: 80-120cm; Clay: A 10-18%, B 20-30%; Texture B: medium sandy-clay-loam;

- Hutton form: 17.5%; Depth: 50-120cm; Clay: A 2-6%, B 8-14%; Texture B: medium/coarse sand to sandy-loam;

- Avalon form: 12.0%; Depth: 70-120cm; Clay: A 6-15%, B 15-25%; Texture B: medium sandy-loam to sandy-clay-loam;

- Mispah form: 7.4%; Depth: 10-35cm; Clay: A 6-12%; Texture A: coarse sand to sandy-loam;
- Bainsvlei form: 7.4%; Depth: 90-120cm; Clay: A 25-30%; B 35-45%; Texture B: sandy-clay;

- Oakleaf form: 3.3%; Depth: 70-120cm; Clay: A 3-8; B 6-10%; Texture B: coarse sand to loamy-sand;

- Valsrivier form: 1.0%; Depth: >120cm; Clay: A 20-30%; B 30-40%; Texture B: sandy-clay-loam to sandy-clay; and

- Sterkspruit and Westleigh forms: 0.2%; Depth: 25-40cm; Clay: A 15-40%, B 35-45%; Texture A: sandy-clay.

**Land Type: Bc44c**

Parent material: Sandstone and conglomerate of the Kransberg Sub-Group, Waterberg Group as well as undifferentiated shale, sandstone, mudstone and coal of the Karoo Sequence.

This small Land Type polygon falls just outside (south) of the Project Area, so is not outlined in detail.

**iv) Glenrosa and/or Mispah Forms (other soils may occur)**

*Map Unit: Fa* (‘lime rare or absent in the entire landscape-including upland and valley-bottom soils’)

Map Unit Fa is intended to accommodate pedologically young landscapes that are not predominantly rock and not predominantly alluvial or aeolian and in which the dominant soil-forming processes have been rock weathering, the formation of orthic topsoil horizons and, commonly, clay illuviation, giving rise typically to lithocutanic horizons. The soil forms that epitomise these processes are Glenrosa and Mispah. However, exposed rock and soils belonging in almost any of the other 39 soil forms may be found in these land types, provided these other soils do not qualify the land for inclusion in another map unit. According to the Map Unit definition: Fa refers to land in which lime in the soil is not encountered regularly in any part of the landscape.

**Land Type: Fa295a**

Parent material: Biotite granite of the Lebowa Granite Suite, Bushveld Complex.

Terrain: Type: A3.

For Terrain Unit: 1 (10% of the area):
Slope: Grade: 1 - 2 %; Length: 200 - 800m; Shape: Y.

For Terrain Unit: 4 (86% of the area):
Slope: Grade: 1 - 2 %; Length: 500 - 3000m; Shape: Z.

For Terrain Unit: 5 (4% of the area):
Slope: Grade: 1 - 3 %; Length: 50 - 200m; Shape: Z-X.

Soils:
- Rock: Abundance in the Land Type Unit: 4.8%;
- Mispah form: Relative Abundance of these soil forms in the Land Type Unit: 34.1%; Depth: 5-15cm; Clay: A 8-20%; Texture A: loamy-coarse-sand to sandy-loam;
- Hutton and Clovelly forms: 19.2%; Depth: 20-80cm; Clay: A 10-16%, B 18-25%; Texture B: coarse sandy-loam to sandy-clay-loam;
- Glenrosa form: 18.7%; Depth: 30-45cm; Clay: A 8-20%; Texture A: loamy-coarse-sand to sandy-loam;
- Clovelly and Glencoe forms: 15.9%; Depth: 20-70cm; Clay: A 2-6%, B 4-12%; Texture B: coarse sand to loamy-sand;
- Avalon form: 5.7%; Depth: 70-100cm; Clay: A 10-20%, B 15-25%; Texture B: coarse sandy-loam to sandy-clay-loam; and
- Oakleaf form: 1.6%; Depth: >120cm; Clay: A 15-25%; B 20-30%; Texture B: coarse sandy-clay-loam.

v) Glenrosa and/or Mispah Forms (other soils may occur)
Map Unit: Fc (‘lime generally present in the entire landscape-including upland and valley-bottom soils’)

Map Unit Fc is also intended to accommodate pedologically young landscapes that are not predominantly rock and not predominantly alluvial or aeolian and in which the dominant soil-forming processes have been rock weathering, the formation of orthic topsoil horizons and, commonly, clay illuviation, giving rise typically to lithocutanic horizons. The soil forms that epitomise these processes are Glenrosa and Mispah. However, exposed rock and soils belonging in almost any of the other 39 soil forms may be found in these land types, provided these other soils do not qualify the land for inclusion in another map unit.

According to the Map Unit definition: Fc refers to land where lime occurs regularly (there need not be much of it and it need not occur in every soil present) in upland and valley-bottom soils. Occasionally landscapes are encountered without lime but with accumulations of soluble salts in the soil; these have been included in Fb or Fc as the case may be.

Land Type: Fc478a

Parent material: Undifferentiated shale, sandstone, mudstone and coal of the Karoo Sequence.

Terrain: Type: A3.

For Terrain Unit: 1 (15% of the area):
Slope: Grade: 1 - 5 %; Length: 450 - 1400m; Shape: Y-Z.

For Terrain Unit: 3 (15% of the area):
Slope: Grade: 6 - 30 %; Length: 100 - 300m; Shape: Z.
For Terrain Unit: 4 (65% of the area):
Slope: Grade: 1 - 2 %; Length: 500 - 5000m; Shape: Z.

For Terrain Unit: 5 (5% of the area):
Slope: Grade: 1 - 3 %; Length: 20 - 100m; Shape: X.

Soils:

- Rock: Abundance in the Land Type Unit: 15.0%;
- Mispah form: Relative Abundance of these soil forms in the Land Type Unit: 42.0%; Depth: 10-30cm; Clay: A 2-8%; Texture A: medium/coarse sand to loamy-sand;
- Glenrosa form: 18.0%; Depth: 10-40cm; Clay: A 6-15%, B 18-25%; Texture A: medium/coarse sand to loamy-sand;
- Hutton form: 2.6%; Depth: 15-40cm; Clay: A 4-10%, B 6-12%; Texture B: coarse sand to loamy-sand;
- Hutton form: 9.8%; Depth: >120cm; Clay: A 10-20%, B 25-45%; Texture B: medium sandy-clay-loam to sandy-clay;
- Avalon form: 8.3%; Depth: 90-120cm; Clay: A 10-20%, B 25-45%; Texture B: medium sandy-clay-loam to sandy-clay; and
- Oakleaf form: 4.5%; Depth: 80-120cm; Clay: A 8-12%; B 10-20%; Texture B: loamy medium/coarse sandy to sandy-loam.

Figure 8.1.6(b) indicates that only the Ae253a and Fa295a Land Type units occur within the proposed LCPP Operational Area.
Figure 8.1.6(b): Regional Soil Setting

Red Earth cc
8.1.7 REGIONAL LAND CAPABILITY
(Refer to Figure 8.1.1)

The land capability of the Study Area as a whole may be roughly inferred by an interpretation of the land use indicated on Figure 8.1.1 (Location and Topography of Study Area) as follows:

- cultivated areas (majority arable, lesser amount grazing, and very rarely wetland capability class);
- grassland areas (majority grazing, lesser amount arable, occasionally non-grazing wilderness, and rarely wetland capability class);
- ephemeral pans and water courses (wetland capability class); and
- hilly bush / grassland areas (majority non-grazing - i.e. wilderness capability class, occasionally grazing capability class);

as per the Chamber of Mines capability class classification.

Within the Operational Area the soil survey indicated the following percentages of the various Chamber of Mines capability classes: arable 30.07%, grazing 46.76%, wilderness 20.07%, and wetland 2.94%; while man-made features occupy 0.16% of the area.

Despite the arable soils that occur in many areas, such areas will not be able to be cultivated without the provision of irrigation, the aforementioned due to the arid to semi-arid prevailing climate in the area.

8.1.8 REGIONAL LAND USE
(Refer to Figure 8.1.1)

The regional land use is evident in Figure 8.1.1 (Location and Topography of Study Area).

The land use both within and immediately adjacent to LCPP is dominated by game ranching/farming and eco-tourism, and to a lesser extent cattle ranching. Thus occasional-rare farm related structures also exist including homesteads, residences, hunting accommodation, labour accommodation, farm sheds, workshops, boreholes, windmills, reservoirs, water tanks, and water/feeding troughs. Occasional lands are also spread out throughout the area, the aforementioned probably producing dryland hay and other types of livestock feed on a small scale.

The LCPP Project Area is located within the Central Bushveld Bioregion. Mucina and Rutherford (2006), indicate the natural vegetation within the LCPP Project Area as savannas of the Roodeberg Bushveld vegetation type (approximately eastern two-thirds of Project Area), with the section to the west being Limpopo Sweet Bushveld (approximately western third of Project Area). The former vegetation type is comprised of plains and slightly undulating hills with short, dense, open woodland; while the latter vegetation type is comprised of short, open woodland. Disturbed areas are dominated by thickets of Blue Thorn (Acacia erubescens), Black Thorn (Acacia mellifera) and Sickle Bush (Dichrostachys cinerea). These vegetation types are listed as Least Threatened, which implies that they are not threatened due to major habitat loss. The northern fringe of the Waterberg Mountain Bushveld occurs south (outside) of the site.
The arid to semi-arid climate as well as the lack of irrigation water minimises the potential for intensive crop production. Thus, the planting of moderate to low profit commercial agricultural crops are likely to be extremely limited. However, high profit drip irrigated crops such as citrus are likely to be feasible / present, provided that irrigation water is available. One small citrus orchard exists adjacent to the farmhouse on the farm Weltevreden 482 JQ (portion 1).

The historical and current ranching / agricultural activities within the Project Area are discussed in Section 8.4.4 (HISTORICAL AGRICULTURAL PRODUCTION) of this report.

Exxaro’s Grootegeluk Coal Mine lies to the west of the town of Lephalale, and is currently the only operating coal mine in the Waterberg Coalfield. Numerous other mining companies currently own prospecting rights in the Waterberg Coalfield, with these potential projects being in various stages of planning.
8.2 SOILS BASELINE

8.2.1 SURVEY METHODS AND DATA COLLECTION

(Refer to Map 1)

The fieldwork component (300m-grid auger survey) was carried out between 23 April and 10 May 2017 by B.B. McLeroth of Red Earth cc. Given time constraints due to the imminent commencement of the hunting season, the following persons assisted the author with the soil survey fieldwork exercise: Diana Rietz (Phd Soil Science), Bonginkosi Vilakazi (M.Sc Soil Science) and Anele Mkila (B.Sc Soil Science).

An intensive systematic grid soil survey was undertaken, with auger sampling points 300m (one auger per 9.00ha) apart throughout the proposed Operational Area only (2743.59ha), a total of three-hundred-and-twenty-two augers being conducted at pre-determined positions in the survey area as a whole. Auger points were occasionally shifted off the pre-determined grid, to be conducted in more meaningful positions or to avoid man-made obstacles. Upon completion of the soil survey fieldwork exercise, seven modal (typical representative) soil auger points were augered; photographed and sampled (for agricultural analysis).

Distribution of the auger sample points examined with a 100mm bucket soil auger is indicated on Map 1 (Soil Sampling Points).

During the course of the soil survey fieldwork exercise, the land capability, present land use, wetlands, sensitive landscapes, and location of sites of archaeological and cultural interest were recorded. Furthermore, man-made features and structures were also classified and recorded. Many such features may not have been identified given the broad 300m soil survey grid intensity utilised.

Auger sampling was conducted to a maximum depth of 1.8m, or less (vast majority) if a depth limiting material (for the soil auger) was encountered at lesser depth. Such limiting horizons include hard rock, weathering rock, hard plinthic B-horizon, hardpan carbonate horizon, soft carbonate horizon, soft plinthic B-horizon, G-horizon, unconsolidated material with signs of wetness, and unspecified material with signs of wetness.

‘Recorded soil variables’ include the following:

‘Recorded per profile’: soil form/series, effective rooting depth, surface features, compaction, topsoil organic carbon, depth limiting material, parent material, ground roughness and remarks.

‘Recorded per horizon’: name/depth of horizons, clay content, sand grade, Munsell colour (standardized soil colour charts from Munsell Colour Company, Inc., Baltimore 18, Md., USA), structure, wetness hazard and cultivation factors.

This information is either summarized in the soil code (for each distinct polygon) on Map 2a (Soil Mapping Units), or alternatively discussed in Section 8.2.3 (SOIL TYPES AND SUITABILITY FOR AGRICULTURE AND ‘TOPSOIL’).
Soils were classified as per the Soil Classification Working Group, 1991 (Taxonomic System for South Africa). The aforementioned soil types may be correlated to international systems if so required.

### 8.2.2 THE SOIL MAP
(Refer to Map 2a and Table 8.2.2)

Soil-mapping units are indicated on Map 2a (Soil Mapping Units), and are summarized in terms of soil form in Table 8.2.2 (Summary of Soil Form).

The different soil types identified were grouped together into soil-mapping units on the basis of soil form, effective rooting depth (ERD) for rehabilitation (stripping depth) and cropping, surface features, and parent material.

Effective rooting depth (ERD) and ameliorated effective rooting depth (AERD) are actually measures of effective rooting volume (ERV). This is the total soil depth (TSD) less the volume (converted into depth) of the profile occupied by coarse (>2mm) fragments. The difference between ERD and AERD is that these indices reflect the ERV up until the first and final depth limiting horizons respectively. Thus the AERD is the most important determining index for the ultimate potential of a soil. Only ERD was recorded in the current Study Area.

Perched soil water-table depth, location of precipitated surface (day-lighting surface efflorescence) or sub-surface ‘salts’ associated with pollution plumes, and overburden/underburden ‘waste’ (large variety of materials) or ‘non-waste’ type/depth/location (where present) are normally also recorded. However, none of the aforementioned was encountered since the current Study Area is a green fields site.

Each soil-mapping unit has a unique code, which describes these factors.
### Table 8.2.2: Summary of Soil Form

<table>
<thead>
<tr>
<th>Broad Soil Group</th>
<th>Map Notation</th>
<th>Soil Form (South African Taxonomic System)</th>
<th>Soil Horizons</th>
<th>Count</th>
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#### Man-Made Summary

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#### TOTAL (SOILS AND MAN-MADE)

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8.2.3 SOIL TYPES AND SUITABILITY FOR AGRICULTURE AND ‘TOPSOIL’
(Refer to Map 2a; and Table 8.2.2)

The leaching status of soils is based on S-value (cmol (+) kg⁻¹ clay = leaching status). These classes vary as follows:
- dystrophic (S-value <5 = low base status = highly leached, i.e. soil suffered marked leaching);
- mesotrophic (S-value 5-15 = medium base status = moderately leached); and
- eutrophic (S-value >15 = high base status = poorly leached, i.e. little or no leaching).

Note for calcareous soils (S-value is undefined, but very high = extremely high base status = extremely poorly leached, i.e. no leaching). A calcareous soil has sufficient calcium carbonate or calcium-magnesium carbonate to effervesce visibly when treated with cold dilute (10 %) hydrochloric acid.

S-value for the eleven analysed samples in the Operational area varies as follows:
- B-horizons: 16.0 - 23.3 (eutrophic);
- A-horizons: most soils 20.1 - 36.5 (eutrophic); shallow soils (Glenrosa form) 12.0 (mesotrophic); and
- A-horizon: carbonate soils (Brandvlei form) 349.9 (highly calcareous = eutrophic).

The majority of soils in the area are poorly leached (eutrophic); given the interaction of the low to moderate base reserve of the dominant parent material types (sandstone, grit, chert, ferricrete, siltstone and mudstone), as well as low effective rainfall (interaction of the low mean annual precipitation, the high mean annual evaporation, and the hot mean annual temperature) in the area, whereby the leaching potential is insufficient to remove the majority of the base cations (calcium-carbonate and calcium-magnesium carbonate) from the soil profile.

The carbonate broad soil group soils of the Augrabies, Addo, Prieska and Montagu forms display a calcareous neocarbonate B-horizon (and frequently the A-horizon also), while the A-horizon of the Brandvlei and Coega forms is generally (not always) calcareous. These soils are extremely poorly leached (or not leached at all) due to the base rich parent material from which they are derived (calcrete, which is probably underlain by basic igneous rock such as diabase).

Limited other areas of calcareous soils occur as follows:
- A number of the hydromorphic broad soil group G- (and/or A-) horizons of the Katspruit form, the aforementioned as a result of the accumulation of bases in low-lying areas;
- A number of the pedocutanic broad soil group lower subsoils; and
- A number of the shallow broad soil group topsoils, and particularly those displaying bleached colours.

The majority of the sandstone and grit derived soils display 10 - 30% quartz gravel in the profile, while those derived from an underlying chert stone/gravel layer are also gravelly.

The soils encountered in the Operational Area were divided into seven broad groups.

(i) Red apedal soils (Hutton and Lichtenburg forms) [509.64 ha; 18.58 %]

Location / Slope Position: occur in five distinct locations in midslope positions;
Parent Material: acid sedimentary rocks: generally sandstone, frequently ferricrete that in turn overlies sandstone at depth, rarely grit, and very rarely an underlying chert stone layer. These soils have formed on siliceous parent material types/phases which have a moderately-low content of weatherable minerals and thus a low clay-forming potential. Calcrete occasionally occurs at depth (Plooyburg and Kimberley forms) underlying a red apedal B-horizon subsoil, the overlying soil reflecting the sandstone parent material that occurs in an upslope position.

Effective Rooting Depth: generally 60 - 120cm, occasionally 40 - 50cm, rarely 20 - 30cm;

Depth Limiting Horizon: dominantly weathering or hard rock, frequently hard plinthite that in turn overlies sandstone at depth, and rarely calcrete;

Colour: ‘red’ (hue 5YR or 2.5YR) colours; uniform in colour. The iron mineral hematite imparts the red pigment and is indicative of well drained oxidizing conditions.

Structure: A-horizon: weak blocky or occasionally apedal; B-horizon: weak blocky and rarely apedal. The clay mineral suites of the red apedal soils display far greater proportions of non-swelling 1:1 types than swelling 2:1 types, the relative proportions varying slightly between the different auger points and horizons (hence the variability in structural development); and

Texture: sandy-loam to sandy-clay-loam (clay content approximately 10 - 26%).

(ii) **Yellow-brown apedal soils** (Clovelly and Glencoe forms) [882.51 ha; 32.17 %]

Location / Slope Position: widespread in midslope to lower midslope positions; generally occurring between the pedocutanic/shallow soils on the one hand, and the red apedal soils on the other;

Parent Material: acid sedimentary rocks: generally sandstone or grit, frequently ferricrete that in turn overlies sandstone at depth, or occasionally an underlying chert stone layer. These soils have formed on siliceous parent material types/phases which have a low content of weatherable minerals and thus a low- to very-low clay-forming potential. Calcrete rarely occurs at depth (Molopo form) underlying a yellow-brown apedal B-horizon subsoil, the overlying soil reflecting the sandstone parent material that occurs in an upslope position.

Effective Rooting Depth: generally 30 - 60cm, occasionally 70 - 100cm, rarely 110 - 180cm;

Depth Limiting Horizon: weathering or hard rock, or ferricrete (hard plinthite) that in turn overlies sandstone at depth, occasionally an underlying chert stone layer, and rarely calcrete;

Colour: ‘yellow-brown’ (hue 7.5YR, 10YR, and occasionally 5YR) colours; uniform in colour. The iron mineral goethite imparts the yellow pigment and is also indicative of oxidizing conditions. The yellow-brown apedal soils have developed on parent material types which have a lower ferrous iron reserve (all parent materials bar ferricrete) than their red counterparts, as well as in areas with a higher average moisture status (slightly
concave). A large number of areas (strong-brown or occasionally reddish-yellow colour) have both goethite (dominant) and hematite present in the profile.

Structure: A- and B-horizons: weak blocky or apedal. The clay mineral suites display a far greater proportion of non-swelling 1:1 types;

Texture: loamy-sand to sandy-loam textures (clay content approximately 5 - 16%).

(iii) **Neocutanic soils** (Tukulu form) [11.07 ha; 0.40 %]

General: these soils are essentially yellow-brown apedal soils, the only differences (in the current area) being that they are non-uniform in colour due to the presence of cutans and channel infillings (occasionally slightly mottled), and their colour is bleached (hue 10YR) in the dry state. These recent soils of colluvial accumulation are not yet advanced in terms of their pedogenesis. Two small polygons of these soils occur, one in a slightly concave drainage area and one in a footslope area adjacent to the hydromorphic soils. These soils are slightly poorly drained in the current area, the effective rooting depth ranging from 50 - 100cm.

(iv) **Pedocutanic (i.e. structured ) soils** (Swartland, Sepane and Bonheim forms) [492.48 ha; 17.95 %]

Location / Slope Position: majority occur in one large central area in midslope (upper to lower) positions (Swartland form), and three small isolated pockets occur in concave drainage areas or footslope positions (Sepane form);

Parent Material: unknown intermediate rocks or underlying chert stone layer, occasionally ferricrete, rarely siltstone/mudstone, and rarely colluvium. These soils have generally formed on a parent material type/phase that has a moderate content of weatherable minerals;

Effective Rooting Depth: 40 - 100cm;

Depth Limiting Horizon: dominantly weathering or hard rock, or occasionally hard plinthite (Swartland and rarely Bonheim forms); or rarely unconsolidated material with signs of wetness (Sepane form);

Colour: ‘red’ (hue 5YR or 2.5YR), ‘brown’ (hue 7.5YR, 5YR, or 10YR), or ‘bleached’ (hue 10YR) colours; non-uniform in colour due to the presence of cutans (clay skins) on most ped surfaces, and particularly so for the soils displaying ‘bleached’, and less so for the soils displaying ‘brown’ colours;

Structure: A-horizon: weak or moderate blocky, B-horizon: moderate blocky; and

Texture: clay to sandy-clay-loam textures (clay content approximately 55 - 30%); both the presence of 2:1 clays and the high clay contents have given rise to the pedality (structure) of these soils.

(v) **Carbonate soils** (Plooysburg, Kimberley and Molopo forms [42.25 ha; 1.54 %]; and Augrabies, Addo, Prieska, Montagu, Brandvlei and Coega forms [119.67 ha; 4.36 %]; Total [161.92 ha; 5.90 %]
Location / Slope Position: a number of patches occur in crest/scarp or midslope positions, both such areas probably being underlain by basic igneous rock at depth. Alternatively a number of patches occur in footslope positions due to the accumulation of bases in low-lying areas;

Parent Material:
- Calcareous profiles (Augrabies, Addo, Prieska, Montagu, Brandvlei and Coega forms): calcrete, in turn probably underlain by basic igneous rock (such as diabase) at depth.
- Non-calcareous profiles (Plooysburg, Kimberley and Molopo forms): calcrete at depth. The non-calcareous overlying red apedal or yellow-brown apedal material will in these cases have migrated downslope from sandstone/grit/chert parent material areas;

Effective Rooting Depth: generally 50 - 120cm, rarely 10 - 30cm;

Depth Limiting Horizon: calcrete (i.e. hardpan carbonate horizon, or soft carbonate horizon);

Colour:
Calcareous profiles: generally ‘bleached’ or ‘brown’ (hue 10YR or 7.5YR) colours.
Non-calcareous profiles: ‘red’ (hue 5YR) or ‘yellow’ (hue 7.5YR or 10YR) colours;

Structure: A- and B-horizons: weak blocky or apedal; and

Texture: loamy-sand to sandy-loam textures (clay content approximately 5 - 16%).

(vi) **Shallow soils (i.e. lithosols)** (Glenrosa, Mispah and Dresden forms) [617.15 ha; 22.49 %]

Location / Slope Position: widespread numerous patches in upper midslope, ‘crest’ (barely discernible), and footslope positions; or frequently in areas where the slope increases above 2 degrees (to 4 degrees);

Parent Material: acid sedimentary rocks: generally sandstone or grit, frequently an underlying chert stone layer, frequently ferricrete that in turn overlies sandstone at depth; and one patch of siltstone/mudstone. The majority of these soils have formed on siliceous parent material types/phases which have a low content of weatherable minerals and thus a low- to very-low clay-forming potential, the exception being mudstone/siltstone that has a moderate clay forming potential;

Effective Rooting Depth: generally 10 - 30cm, although plant roots may grow deeper in the spaces between the stone/gravel layer. The surface is frequently stony or rocky;

Depth Limiting Horizon: the majority overlie a lithocutanic B-horizon (actually a dense stone/gravel layer, or weathering rock); or occasionally hard rock or ferricrete (hard plinthite that in turn overlies sandstone at depth);

Colour: generally ‘brown’ (hue 10YR or 7.5YR) or more ‘bleached’ (hue 10YR) colours, occasionally ‘red’ (hue 5YR) or ‘yellow’ (hue 7.5YR or 10YR) colours. The
‘brown’ and more ‘bleached’ colours are associated with lateral drainage of moisture after rainfall events, the aforementioned due to the relatively impermeable underlying rock or ferricrete;

Structure: A-horizon: generally weak blocky or occasionally apedal; and

Texture: loamy-sand to sandy-loam textures (clay content approximately 5 - 16%).

(vii) Neocutanic soils (Tukulu form) [11.07 ha; 0.40 %]

General: these soils are essentially yellow-brown apedal soils, the only differences (in the current area) being that they are non-uniform in colour due to the presence of cutans and channel infillings (occasionally slightly mottled), and their colour is bleached (hue 10YR) in the dry state. These recent soils of colluvial accumulation are not yet advanced in terms of their pedogenesis. Two small polygons of these soils occur, one in a slightly concave drainage area and one in a footslope area adjacent to the hydromorphic soils. These soils are slightly poorly drained in the current area, the effective rooting depth ranging from 50 - 100cm.

(viii) Hydromorphic soils (Westleigh and Katspruit forms [59.43 ha; 2.17 %] and Pans [4.97 ha; 0.18 %]; Total [64.40 ha; 2.35 %])

Location / Slope Position:
Westleigh form: concave bottomland ‘vlei’ or drainage areas (ephemeral).
Katspruit form: pan and pan surrounds (ephemeral);

Such soils have formed due to either a fluctuating water table (Westleigh form: soft plinthic B - alternating cycles of oxidation and reduction accompanied by an accumulation of iron and manganese oxides - seasonal ephemeral wetland), or a semi-permanent water table (Katspruit: G-horizon - continuous reduction and marked clay illuviation - permanent ephemeral wetland).

Parent Material:
Westleigh form: sandstone, ferricrete, chert stoneline, or siltstone/mudstone in one area.
Katspruit form: colluvium overlying ferricrete or sandstone (or overlying siltstone/mudstone in one area);

Effective Rooting Depth: 10 - 30cm;

Depth Limiting Horizon: soft plinthic B-horizon or G-horizon;

Colour:
Westleigh form: ‘brown’ or more ‘bleached’ (hue 10YR and 7.5YR) colours. These colours reflect reducing conditions due to waterlogging.
Katspruit form: ‘bleached’ (hue 10YR) colours;

Structure:
Westleigh form: apedal or weak blocky A- and B-horizons.
Katspruit form: moderate blocky or crumb A-horizon, and massive G-horizon;
Texture: sandy-loam to clay textures (clay content approximately 15 - 55%). The Westleigh form generally displays sandy-loam to sandy-clay-loam textures, while the Katspruit form displays sandy-clay to clay textures. Both the presence of a proportion of 2:1 clays and the generally moderate to high clay contents of the Katspruit form, have given rise to the pedality (structure) of these soils.

The district road (3.95 ha; 0.14 %) and three man-made ponds (0.47 ha; 0.02 %) in terrestrial (non-wetland) areas comprise the balance of the total survey area (2743.59 ha; 100.00 %); the aforementioned being indicated in Table 8.2.2 (Summary of Soil Form) and Table 8.4 (Summary of Present Land Use) respectively.

8.2.4 SOIL WATER-TABLE
(Refer to Map 2a)

Map 2a (Soil Mapping Units) normally indicates the distribution of perched soil water-tables (or moisture) in augered depth; making use of the terms ‘moist depth’, ‘moist’, ‘wet’, or ‘very wet’; including the depth at which the moisture associated with a perched water-table commences. Moist soil profiles were not encountered in the current survey area due to both the low effective rainfall in the area, as well as the time of year that the survey was conducted.

Natural perched soil water-tables will generally occur in summer after rainfall events, where there is a relatively impermeable horizon (G-horizon, soft plinthic B, unconsolidated wet material, hard plinthic B, hardpan carbonate horizon, or hard rock) below the A, B or E-horizon. However, vertic A-horizons and pedocutanic B-horizons will also result in waterlogging at or near the surface, after heavy or prolonged rainfall events. This is because these subsoil types generally display a slow (when dry) to very slow (when moist) [for vertic topsoils], to slow-moderate [frequently for pedocutanic subsoils] permeability.

As a general rule in undisturbed areas (where there is no seepage/runoff/discharge of water as a result of the activities of man), natural perched soil water-tables (when they occur after heavy rains) disappear altogether in the dry season (winter), except in the most low-lying positions.

Anthropogenic moisture or wetland conditions may occur in the soils downslope of man-made features in developed, mining or smelting related areas during the operational and closure phases of a project. In such cases, the anthropogenic moisture is derived from runoff/seepage from infrastructure; or seepage/overflow from poorly sealed (or non-sealed) water containment facilities and waste sites. No such sites occur in the current green fields survey area.
8.2.5 SOIL ANALYTICAL DATA
(Refer to Table 8.2.5)

Table 8.2.5 (Soil Analytical Data) shows the agricultural analysis analytical data for the seven topsoil (A-horizon) and four subsoil (B-horizon) samples collected from seven modal (typical) soil augers.

The analytical determinations were conducted in the laboratories of the Institute for Soil, Climate and Water (ISCW) [part of the Agricultural Research Council] in Pretoria. The ISCW data was obtained from the following ISCW reports entitled GROND 201718 5543:
- Majority of the data (also including exchangeable cations in ppm): two reports dated 30/6/2017; and
- CEC and saturation extract soluble cations: one report dated 14/7/2017.

The ISCW data was transferred to our Table 8.2.5.

The following physical and chemical variables were analysed (or calculated from the data provided): texture seven fractions (also includes clay %), exchangeable cations (cmol (+) kg⁻¹ soil and ppm), S-value (cmol (+) kg⁻¹ clay), cation exchange capacity (cmol (+) kg⁻¹ soil, and clay), base saturation (%), exchangeable sodium percentage (%), electrical conductivity, pH (H₂O), saturation extract soluble cations (cmol (+) kg⁻¹ soil), organic carbon (Walkley Black %), phosphorus (Bray 1 ppm), and saturation % (ml of water used to saturate 100g of soil).

The interpretation of this data is discussed in the following sections of the current report:
8.2.3 (SOIL TYPES AND SUITABILITY FOR AGRICULTURE AND ‘TOPSOIL’);
8.2.6 (SOIL ANALYTICAL CHARACTERISTIC AND SOIL FERTILITY); and
8.2.7 (EROSION HAZARD AND SLOPE).
### Table 8.2: Soil Analytical Data

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### Exchangeable Cations

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<th>ppm = mg/kg</th>
<th>Mg cmol(+)/kg soil</th>
<th>ppm = mg/kg</th>
<th>K cmol(+)/kg soil</th>
<th>ppm = mg/kg</th>
<th>Na cmol(+)/kg soil</th>
<th>ppm = mg/kg</th>
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### Exchangeable Cations at pH 7

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<th>ppm = mg/kg</th>
<th>BASE SATURATION</th>
<th>ESP</th>
<th>EC</th>
<th>Eh Redox Potential mV</th>
<th>pH (H2O)</th>
<th>ORGANIC CARBON %</th>
<th>TOTAL N (Digest) %</th>
<th>P (Bray 1 method) ppm = mg/kg</th>
<th>SATURATION %</th>
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<td>2.9</td>
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<td>0.9</td>
<td>0.010</td>
<td>1.2</td>
<td>0.027</td>
<td>3.3</td>
<td>0.037</td>
<td>4.5</td>
</tr>
<tr>
<td>K</td>
<td>0.034</td>
<td>13.3</td>
<td>0.024</td>
<td>9.4</td>
<td>0.014</td>
<td>5.9</td>
<td>0.015</td>
<td>5.9</td>
<td>0.048</td>
<td>18.8</td>
<td>0.024</td>
<td>9.4</td>
</tr>
<tr>
<td>Na</td>
<td>0.008</td>
<td>1.8</td>
<td>0.011</td>
<td>2.5</td>
<td>0.004</td>
<td>0.9</td>
<td>0.005</td>
<td>1.1</td>
<td>0.006</td>
<td>1.4</td>
<td>0.016</td>
<td>3.7</td>
</tr>
</tbody>
</table>

### Soil Form

<table>
<thead>
<tr>
<th>SOIL CODE &amp; FAMILY</th>
<th>DEGREE OF LEACHING</th>
<th>PARENT MATERIAL</th>
<th>PRESENT LAND USE</th>
<th>BROAD SOIL GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hutton</td>
<td>Glencoe</td>
<td>Swartland</td>
<td>Bush and Bare Surface (Grasses mostly gone). Larger growth forms of trees than on other soil types. Usually severely-highly eroded (soil surface capping).</td>
</tr>
<tr>
<td>Ho 3200 Ventersdorp (luvic)</td>
<td>Eutrophic (marginally)</td>
<td>Euromorphic (marginally)</td>
<td>Stoneline (Chert predominantly, &amp; numerous other fragments) Possibly weathered from Conglomerates.</td>
<td></td>
</tr>
<tr>
<td>Gl 1306 Draaihoek (non-luvic)</td>
<td>Eutrophic</td>
<td>Ferricrete overlying Sandstone</td>
<td>Bush and frequent Grasses. Usually slightly eroded (least eroded of all broad soil groups)</td>
<td></td>
</tr>
<tr>
<td>Sw 1221 Mynini (luvic)</td>
<td>Eutrophic</td>
<td>Eutrophic (marginally)</td>
<td>Bush and frequent Grasses. Usually moderately eroded</td>
<td></td>
</tr>
<tr>
<td>Auger CE96</td>
<td>Auger BS102</td>
<td>Auger AV82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMPLE REFERENCE</td>
<td>Auger BG88</td>
<td>Auger BS96SE (south-east of grid point)</td>
<td>Auger BV92</td>
<td>Auger BU98SE (south-east of grid point)</td>
</tr>
<tr>
<td>------------------</td>
<td>------------</td>
<td>------------------------------------------</td>
<td>------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>HORIZON (DEPTH)</td>
<td>Orthic A (0-10cm)</td>
<td>Orthic A (0-10cm)</td>
<td>Orthic A (0-10cm)</td>
<td>Orthic A (0-10cm)</td>
</tr>
<tr>
<td></td>
<td>M380</td>
<td>M381</td>
<td>M382</td>
<td>M378</td>
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<td>LAB REFERENCE (ISCW) Report G RonD 2017/8 554</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Pipette method %</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>Coarse</td>
<td>2.0-0.50mm</td>
<td>29.8</td>
<td>27.6</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>0.50-0.25mm</td>
<td>12.6</td>
<td>15.7</td>
</tr>
<tr>
<td></td>
<td>Fine</td>
<td>0.25-0.10mm</td>
<td>17.5</td>
<td>20.5</td>
</tr>
<tr>
<td></td>
<td>Very Fine</td>
<td>0.10-0.05mm</td>
<td>10.6</td>
<td>10.6</td>
</tr>
<tr>
<td>Silt</td>
<td>Coarse</td>
<td>0.05-0.02mm</td>
<td>4.9</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>Fine</td>
<td>0.02-0.002mm</td>
<td>5.6</td>
<td>3.2</td>
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<tr>
<td></td>
<td>Clay</td>
<td>&lt;0.002mm</td>
<td>15.5</td>
<td>10.2</td>
</tr>
<tr>
<td>Texture</td>
<td>Co SaLm</td>
<td>96.5</td>
<td>Co SaLm</td>
<td>97.0</td>
</tr>
<tr>
<td>EXCHANGEABLE CAT</td>
<td>Ammonium Acetate method</td>
<td></td>
<td></td>
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<tr>
<td>Ca</td>
<td>cmol/kg soil</td>
<td>ppm = mg/kg</td>
<td>1.1841</td>
<td>237</td>
</tr>
<tr>
<td>Mg</td>
<td>cmol/kg soil</td>
<td>ppm = mg/kg</td>
<td>0.4778</td>
<td>58</td>
</tr>
<tr>
<td>K</td>
<td>cmol/kg soil</td>
<td>ppm = mg/kg</td>
<td>0.2027</td>
<td>79</td>
</tr>
<tr>
<td>Na</td>
<td>cmol/kg soil</td>
<td>ppm = mg/kg</td>
<td>0.0399</td>
<td>9</td>
</tr>
<tr>
<td>S-VALUE</td>
<td>cmol/kg soil</td>
<td>ppm = mg/kg</td>
<td>1.904</td>
<td>349</td>
</tr>
<tr>
<td>CEC at pH7</td>
<td>cmol/kg soil</td>
<td>ppm = mg/kg</td>
<td>5.506</td>
<td>35.5</td>
</tr>
<tr>
<td>BASE SATURATION</td>
<td>%</td>
<td>3.4</td>
<td>37.4</td>
<td>212.5</td>
</tr>
<tr>
<td>ESP</td>
<td>%</td>
<td>0.72</td>
<td>0.75</td>
<td>0.91</td>
</tr>
<tr>
<td>EC</td>
<td></td>
<td>1</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>pH (H2O)</td>
<td></td>
<td>5.78</td>
<td>6.14</td>
<td>8.26</td>
</tr>
<tr>
<td>ORGANIC CARBON</td>
<td>%</td>
<td>0.43</td>
<td>0.60</td>
<td>2.57</td>
</tr>
<tr>
<td>TOTAL N (Digest)</td>
<td>ppm = mg/kg</td>
<td>11.75</td>
<td>14.29</td>
<td>6.97</td>
</tr>
<tr>
<td>SATURATION %</td>
<td>ml water to saturate 100g soil</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>SATURATION EXTRACT SOLUBLE CATIONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>cmol/kg soil</td>
<td>ppm = mg/kg</td>
<td>0.003</td>
<td>0.6</td>
</tr>
<tr>
<td>Mg</td>
<td>cmol/kg soil</td>
<td>ppm = mg/kg</td>
<td>0.005</td>
<td>0.6</td>
</tr>
<tr>
<td>K</td>
<td>cmol/kg soil</td>
<td>ppm = mg/kg</td>
<td>0.009</td>
<td>3.5</td>
</tr>
<tr>
<td>Na</td>
<td>cmol/kg soil</td>
<td>ppm = mg/kg</td>
<td>0.006</td>
<td>1.4</td>
</tr>
<tr>
<td>SOIL FORM</td>
<td>Glenerosa</td>
<td>Dresden</td>
<td>Brandvlei</td>
<td>Westleigh</td>
</tr>
<tr>
<td>SOIL CODE &amp; FAMILY</td>
<td>Gp 2111 Overberg</td>
<td>Dr 2000 Hilldrop</td>
<td>Br 1000 Groetloof</td>
<td>We 2000 Marretts (lircic)</td>
</tr>
<tr>
<td>DEGREE OF LEACHING</td>
<td>Mesotrophic</td>
<td>Eutrophic</td>
<td>Eutrophic (highly calcareous)</td>
<td>Eutrophic</td>
</tr>
<tr>
<td>PARENT MATERIAL</td>
<td>Stoneline (Chert predominantly, &amp; numerous other fragments). Possibly weathered from Conglomerates.</td>
<td>Ferricrete overlying Sandstone</td>
<td>Calcrete (probably overlying Base Rich Igneous material)</td>
<td>Sandstone and Ferricrete</td>
</tr>
<tr>
<td>PRESENT LAND USE</td>
<td>Shrubby vegetation and Bare Surface (Grasses mostly gone). Usually severely eroded</td>
<td>Shrubby vegetation and rare Grasses. Usually highly eroded Bush and frequent rare Grasses. Usually frequent Avarica (Sherpia busk some areas), stony/rocky surface, saline. Usually moderately-slightly eroded</td>
<td>Bottomland (‘vlei’) wetland. Savannahs (open ‘wetland’) (frequent Grasses, frequently with Sedges). Slightly eroded</td>
<td></td>
</tr>
<tr>
<td>BROAD SOIL GROUP</td>
<td>SHALLOW</td>
<td>SHALLOW</td>
<td>CARBONATE</td>
<td>HYDROMORPHIC</td>
</tr>
</tbody>
</table>

**Table 8.25: Soil Analytical Data (continued)**

- **PARTICLE SIZE**
- **Na**
- **K**
- **Ca**
- **Mg**
- **Total N**
- **Exchangeable Cations**
- **Organic Carbon**
- **pH**
- **Total N (Digest)**
- **Saturation**
- **SOIL FORM**
- **SOIL CODE & FAMILY**
- **Degree of Leaching**
- **Parent Material**
- **Present Land Use**
- **Broad Soil Group**
8.2.6 SOIL ANALYTICAL CHARACTERISTICS AND SOIL FERTILITY
(Refer to Table 8.2.5)

i) Soil texture

Soil texture is considered to be a permanent property of soils and as such it is particularly important in determining soil behaviour. Many soil properties are dependent on the proportions of sand, silt and clay, including *inter-alia* nutrient and water holding ability, permeability, porosity, erodibility, and susceptibility to compaction.

**Survey Area**

Based on the soil analytical data presented in Table 8.2.5 (Soil Analytical Data) alone, the following trends are evident:

The neocutanic, yellow-brown apedal, shallow, carbonate, red apedal, and hydromorphic (Westleigh form only) broad soil groups generally have low to moderate clay contents (5 - 25%), low to moderate silt contents (8 - 16%), and high sand contents (61 - 83%). The aforementioned soils are generally listed from lowest (neocutanic) to higher (hydromorphic) clay content.

The exceptions are the hydromorphic (Katspruit and extremely rarely Rensburg forms) and pedocutanic broad soil groups that have moderate to high clay contents (38 - 53%), low to moderate silt contents (11 - 17%), and moderate to high sand contents (33 - 47%).

Sand grade is coarse for all samples, except the carbonate broad soil group (Brandvlei form) which is medium to fine.

However, the soil survey obviously showed a slightly larger variation in the measured variables (both within and between soil forms) than those mentioned above for the determined modal samples in Table 8.2.5. Thus, the following represent the overall texture range as determined in-field in the Operational Area:

- Yellow-brown apedal, Neocutanic, Shallow, and Carbonate soils (broad soil groups): loamy-sand to sandy-loam textures (clay content approximately 5 - 16%),
- Red apedal soils: sandy-loam to sandy-clay-loam (clay content approximately 10 - 26%),
- Pedocutanic soils: clay to sandy-clay-loam textures (clay content approximately 55 - 30%), and
- Hydromorphic soils: sandy-loam to clay textures (clay content approximately 15 - 55%).

ii) Soil pH (reaction)

Soil pH is the degree of acidity of a soil. Descriptive terms commonly associated with certain ranges in soil pH (van der Watt, 1995) measured in distilled water are:
Extremely acid (< 4.5), very strongly acid (4.5 - 5.0), strongly acid (5.1 - 5.5),
medium acid (5.6 - 6.0), slightly acid (6.1 - 6.5), neutral (6.6 - 7.3),
mildly alkaline (7.4 - 7.8), moderately alkaline (7.9 - 8.4), strongly alkaline (8.5 - 9.0) and
very strongly alkaline (> 9.0).

An optimum pH is assumed to be between about 6 to 7 (the range in which most
nutrients are most available, and the average range preferred by most crops).

The soil pH has a direct influence on plant growth in a number of ways:

- Through the direct effect of the hydrogen ion concentration on nutrient uptake;
- Indirectly through the effect on trace nutrient availability; and by the
- Mobilizing of toxic ions such as aluminium and manganese, which restrict plant growth.

Survey Area

The pH of the analysed topsoil and subsoil (collectively) samples vary as follows:

- Yellow-brown apedal (Glencoe form) and Shallow (Glenrosa form): 5.53 - 5.89 (medium acid); i.e. slightly too acid;
- Shallow (Dresden form), Hydromorphic (Westleigh form), Pedocutanic (Swartland form), and Red apedal (Hutton form): 6.02 - 6.37 (slightly acid); i.e. ideal; and
- Carbonate (Brandvlei form): 8.26 (moderately alkaline); i.e. too alkaline.

The former two bullets cater for soils that are derived from less base rich (more acid)
parent material types in the survey area (i.e. sandstone, ferricrete, and chert; and
possibly also siltstone and mudstone).
The latter bullet caters for soils that are derived from the most base rich parent material
types in the survey area (i.e. calcrete, which is probably underlain by a base rich
igneous parent material type such as diabase).

The Chamber of Mines arable definition requires a soil pH value of between 4.0 and
8.4. Thus according to this definition, all of the soils are arable in terms of their pH, the
carbonate soils being only marginally so.

iii) Saturated extract

Saturated extracts are used to determine the amounts of easily water-soluble elements,
especially the amounts of Ca (calcium), Mg (magnesium) and Na (sodium) to determine
the salinity and sodicity of the soil.

Background

Electrical conductivity (EC: measured in millisiemens/metre: mS/m) is a measure of the
ability of a soil saturation extract to conduct electricity and is a measure of the
concentration of salts in solution. For example low salinity irrigation waters have values
less than 25mS/m and high salinity irrigation waters have values greater than 75mS/m.

Highly saline (high soluble salt content of which sodium forms a modest proportion
[usually exchangeable sodium percentage or ESP <15]) soils will result in the reduction
of plant growth, caused by the diversion of plant energy from normal physiological
processes to that involved in the acquisition of water under highly stressed conditions.
The sodium adsorption ratio (SAR) measures soil sodicity and is a measure of the
gility of a solution (e.g. saturation extract of irrigation water with regards to sodium
content). At high levels of exchangeable sodium, certain clay minerals, when saturated
with sodium, swell markedly. With the swelling and dispersion of a sodic soil, pore
spaces become blocked and infiltration rates and permeability are greatly reduced. The
critical SAR for poorly drained grey soils is 6, for slowly draining black swelling clays
is 10 and for well drained soils and recent sands 15. The exchangeable sodium
percentage (ESP) [percentage of the cation exchange capacity (CEC) that is occupied
by sodium] is also an indicator of soil sodicity. The cation exchange capacity of a soil is
the sum total of exchangeable cations that a soil can adsorb. A sodic (low soluble salt
content and a high exchangeable sodium percentage [usually ESP >15] soil has
sufficient adsorbed sodium to have caused significant de-flocculation.

The Chamber of Mines specifies that for a soil to be defined as arable (or to be utilized
as ‘topsoil’), that it must have an EC of less than 400mS/m at 25°C and an ESP of less
than 15 throughout the upper 0.75m of soil.

Survey Area

The EC of the analysed samples varies from approximately 100-200 for the majority of
samples, to up to approximately 500 for the pedocutanic (Swartland form) sample, and
up to approximately 900 for the carbonate (Brandvlei form) sample. Thus the majority
of the samples are non-saline as per The Chamber of Mines definition, bar the
pedocutanic (Swartland form, and probably also many of the Sepane forms) and
carbonate (Brandvlei form, and probably also many examples of the non-analysed
Augrabies, Addo, Prieska, Montagu, and Coega forms) soils which are saline.

The ESP of the analysed samples varies from 0.26 to 1.12 % for the majority of
analysed samples, and 2.50 to 6.06 % for the hydromorphic (Westleigh form) samples.
Thus all of the soils are non-sodic as per The Chamber of Mines definition.

iv) Organic carbon, nitrogen and phosphorus

Organic matter (indicated by the amount of organic carbon) is of vital importance in
soil. It improves the structural condition of both coarse- and fine-textured soils and
improves the water holding capacity, especially of sandy soils. It therefore greatly
reduces the erodibility of soil. Organic matter supplies greater than 99 % of total soil
nitrogen (N) and 33 - 67 % of total soil phosphorus (P). Humus, the active fraction of
soil organic matter has a very high CEC (between 150 and 300 cmol(+)/kg) and can
adsorb up to about 6 times its own weight in water. The C: N (carbon: nitrogen) ratio of
humus is often about 10: 1 to 12: 1.

Survey Area

Topsoil organic carbon percentages may be categorised into classes as follows: l = low
(<0.3 % organic carbon), lm = low to medium (0.3 - 0.6 %), m = medium (0.6 - 1.0 %),
mh = medium to high (1.0 - 1.4 %), h = high (1.4 - <1.8 %), vh = very high (>1.8 %),
and ultra high (>10.0%).
The organic carbon percentage of the analysed samples varies from 0.27 % (low) to 0.86 % (medium) for the majority of analysed samples, and is 2.57 % (very high) for the carbonate (Brandvlei form) sample. Total N is generally likely to follow the same trend as organic carbon, with the highest amount being found in the topsoil with the highest organic carbon percentage. The topsoil C: N ratios generally exhibit a larger range than in the subsoil, reflecting the more stable condition of the organic matter at depth.

v) Exchangeable cations

It is normal practice to determine what are known as the ‘exchangeable bases’ i.e., Ca (calcium), Mg (magnesium), K (potassium) and Na (sodium) because they include three of the major plant nutrients, and Na because it indicates the possible sodicity of the soil, especially in circumstances where saturated paste data are not available. Lack of organic matter and clay minerals (which provide exchange sites that serve as nutrient stores) result in the soil having a low ability to retain and supply nutrients for plant growth. The maximum potential of a soil to retain nutrients in an exchangeable form is assessed by measuring the cation exchange capacity (CEC).

The base saturation (%) is then calculated as: (sum of the four bases / CEC) x 100.

In general the amounts of exchangeable cations normally follow the same trend as outlined for pH, texture and saturated paste data. For most soils cations follow the typical trend Ca > Mg > K > Na.

Survey Area

The aforementioned trend was the case for only three (B-horizons of the Hutton, Swartland and Westleigh forms) of the eleven samples. For the remaining eight samples: K > Mg.

vi) Soil fertility

The comments that follow are based on the laboratory data discussed above and thus reflect the fertility of the soils as currently exists in the field, with the soils in-situ. It does not take into account any changes that may occur as a result of stripping, stockpiling and compaction, or the rehabilitation methods or purposes for which the soil may be used. It would be imperative that if any of the soils are to be used for rehabilitation purposes; their fertility status is re-analyzed at that time prior to their use, that recommendations concerning possible ameliorative actions can be given, depending on the species to be planted. In addition different crops have different soil fertility requirements and so the discussion here can be of a general nature only, rather than specific to a particular crop.

The following points are relevant to soil fertility:

- pH

The pH of the analysed topsoil and subsoil (collectively) samples vary as follows:
- Yellow-brown apedal (Glencoe form) and Shallow (Glenrosa form): 5.53 - 5.89 (medium acid): i.e. slightly too acid;
- Shallow (Dresden form), Hydromorphic (Westleigh form), Pedocutanic (Swartland form), and Red apedal (Hutton form): 6.02 - 6.37 (slightly acid): i.e. ideal; and
- Carbonate (Brandvlei form): 8.26 (moderately alkaline): i.e. much too alkaline.

- EC

The EC of the analysed samples varies from approximately 100-200 for the majority of samples, to up to approximately 500 for the pedocutanic (Swartland form) sample, and up to approximately 900 for the carbonate (Brandvlei form) sample. Thus the majority of the samples are non-saline as per The Chamber of Mines definition, bar the pedocutanic (Swartland form, and probably also many of the Sepane forms) and carbonate (Brandvlei form, and probably also many examples of the non-analysed Augrabies, Addo, Prieska, Montagu, and Coega forms) soils which are saline.

- ESP

The ESP of the analysed samples varies from 0.26 to 1.12 % for the majority of samples, and 2.50 to 6.06 % for the hydromorphic (Westleigh form) topsoil and subsoil samples. Thus all of the soils are non-sodic as per The Chamber of Mines definition.

- Total N

Total N of the analysed samples is likely to be low to medium for the majority of analysed samples, and very high for the carbonate (Brandvlei form) sample.

- K, Mg and P

In terms of fertility for maize, the optimal levels of nutrients (exchangeable cations) are: K (120 ppm optimal - 100 ppm acceptable), Mg (60 ppm) and P (34 ppm).

Levels of K for the eleven samples range from 79 (moderately deficient) to 310 (far more than adequate) ppm. Deficiencies (79 - 96 ppm: moderately - very slightly deficient) are present for the following samples: red apedal subsoil, yellow-brown apedal topsoil and subsoil, and shallow (Glenrosa form) topsoil.

Levels of Mg for the eleven samples range from 55 (very slightly deficient) to 273 (far more than adequate) ppm. Very slight deficiencies (55 - 58 ppm) are present for the following samples: red apedal topsoil, and shallow (Glenrosa form) topsoil.

Levels of P are seriously deficient (1.04 - 14.29 ppm) for all of the topsoil and subsoil samples.

Levels of Ca should be in the range of at least 300 to 400 ppm. Levels of Ca for the eleven samples range from 138 (highly deficient) to 589 (more than adequate) ppm for most samples; from 935 to 1308 ppm (both more than adequate) for the pedocutanic topsoil and subsoil respectively; and 3407 ppm (excessive) for the carbonate (Brandvlei form) topsoil sample. Deficiencies (138 - 237 ppm: highly - moderately deficient) are present for the following samples: yellow-brown apedal topsoil and subsoil, and shallow (Glenrosa form) topsoil.
In the case of the subsoils, nutrient deficiencies are of no consequence unless the material is to be utilized for rehabilitation purposes, at which stage the deficiencies should be ameliorated.

In terms of fertility for improved or natural pasture there are no accepted data for the elemental concentrations required in the soil to ensure optimum yields. Most of the available data is based on leaf analysis from various field experiments. The Guidelines for the Rehabilitation of Land Disturbed by Surface Coal Mining in South Africa (1981) suggest that optimal concentrations for P, K and Mg are 36, 120 and 50 ppm, respectively.

8.2.7 EROSION HAZARD AND SLOPE
(Refer to Tables 8.2.5 and 8.2.7; and Figure 8.2.7)

It is necessary to determine the maximum critical slope (at which unacceptable soil erosion will begin to occur) for a site to be regarded as arable. To this end, minimum erosion slopes were calculated (for eleven samples, collected from seven modal soil augers) from the soil erodibility nomograph of Wischmeier, Johnson and Cross (1971) [Figure 8.2.7], based on the soil analytical data (Table 8.2.5) gathered during the soil survey. The results are presented in Table 8.2.7 (Data Used and Results Obtained from the Soil Erodibility Nomograph).

The nomograph uses the following five soil parameters, which have been shown by research to have a major effect in determining erodibility:

i) Mass percentage of the fraction between limiting diameters of 0.1 and 0.002mm (very fine sand plus silt) of the topsoil.

ii) Mass percentage of the fraction between 0.1 and 2.0mm diameter (residue of sand fraction – fine, medium and coarse) of the topsoil.

iii) Organic matter content of the topsoil, obtained by multiplying the organic carbon content (in grams per 100g soil, Walkley Black method) by a factor of 1.724.

iv) Numerical index of soil structure.

v) Numerical index of soil permeability of the soil profile as a whole.

Topsoil and subsoil permeability’s for the shallow, yellow-brown apedal, neocutanic, and carbonate soils in the survey area are generally rapid (>3600mm/hour); those for the red apedal topsoils and subsoils are rapid (>3600mm/hour) to moderate-rapid (360 - 3600mm/hour); while those for the hydromorphic and pedocutanic topsoils and subsoils are generally slow-moderate (3.6 - 36mm/hour), or occasionally moderate (36 - 360mm/hour) for the topsoils.

Despite the prevailing topsoil permeability’s in the area, the permeability classes refer to the permeability of the profile as a whole, which is determined by the controlling soil layer (horizon). Thus profiles overlying horizons of slow permeability (e.g. hard rock, hard plinthite, hardpan carbonate, a pedocutanic horizon, or a gleyed horizon), or luvic soils (with relatively permeable sandy topsoils overlying less permeable higher clay subsoils) are likely to reach field capacity relatively quickly, and particularly so when the soil depth is limited and the storm is heavy or of long duration. A luvic soil displays markedly higher clay content in the B-
horizon relative to the overlying A- or E-horizon. Other controlling soil horizons include slowly (0.36 - 3.6mm/hour) [once moist] permeable vertic A-horizons (extremely rare in survey area), and prismacutanic B-horizons (not present in survey area).

Therefore, the permeability classes utilised for the nomograph exercise for in-situ soils cater for the worst scenario (heavy storm of long duration on a shallow example of the soil type).

Both soil structure and soil permeability have a large influence on the soil erodibility factor (K) and thus the maximum slope for a site to be regarded as arable. The soil permeability index is the most subjective of the five parameters and is difficult to decide upon.

Figure 8.2.7 (The Soil Erodibility Nomograph of Wischmeier, Johnson and Cross [1971]) shows the nomograph, that has been redrawn (by the author) to include finer sub-divisional graph lines for greater ease of calculating K. Table 8.2.7 (Data Used and Results Obtained from the Soil Erodibility Nomograph) is a summary of the data used (extracted from our soil analytical data and field notes of the site) and the results obtained.

**Figure 8.2.7: The Soil Erodibility Nomograph of Wischmeier, Johnson and Cross (1971)**

The x-axis in the diagram refers to increasing organic carbon percentages and increasing percentages of sand (in the left hand ‘graph’); and increasing grades of soil structure and increasing permeability (in the right hand ‘graph’).
# Table 8.2.7: Data Used and Results Obtained from the Soil Erodibility Nomograph

<table>
<thead>
<tr>
<th>SOIL SAMPLE</th>
<th>MASS % OF: vf sand &amp; silt</th>
<th>sand residue (organic carbon x 1.724)</th>
<th>SOIL STRUCTURE (type and size)</th>
<th>SOIL PERMEABILITY BASED ON CONTROLLING SOIL HORIZON (profile as a whole)</th>
<th>DESCRIPTION</th>
<th>SOIL ERODIBILITY FACTOR K (From nomograph)</th>
<th>MAXIMUM CRITICAL SLOPE FOR ARABLE (IN-SITU), REHABILITATION, AND COMPACTED SEAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUGER CE96</td>
<td>Hutton</td>
<td>Orthic A</td>
<td>19.8</td>
<td>64.6</td>
<td>0.8</td>
<td>Blocky</td>
<td>2.0</td>
</tr>
<tr>
<td>Red apedal B</td>
<td></td>
<td></td>
<td>20.4</td>
<td>51.3</td>
<td>0.7</td>
<td>Coarse granular</td>
<td>4.0</td>
</tr>
<tr>
<td>AUGER BS102</td>
<td>Glencoe</td>
<td>Orthic A</td>
<td>21.3</td>
<td>71.3</td>
<td>0.7</td>
<td>Blocky</td>
<td>4.0</td>
</tr>
<tr>
<td>Yellow-brown</td>
<td></td>
<td></td>
<td>21.2</td>
<td>67.1</td>
<td>0.5</td>
<td>Blocky</td>
<td>4.0</td>
</tr>
<tr>
<td>AUGER AY82</td>
<td>Swartland</td>
<td>Orthic A</td>
<td>24.4</td>
<td>39.8</td>
<td>1.5</td>
<td>Blocky</td>
<td>4.0</td>
</tr>
<tr>
<td>Pedocutanic B</td>
<td></td>
<td></td>
<td>15.6</td>
<td>28.3</td>
<td>1.2</td>
<td>Blocky</td>
<td>4.0</td>
</tr>
<tr>
<td>AUGER BG88</td>
<td>Glenrosa</td>
<td>Orthic A</td>
<td>21.1</td>
<td>59.9</td>
<td>0.7</td>
<td>Blocky</td>
<td>4.0</td>
</tr>
<tr>
<td>AUGER BS96SE</td>
<td>Dresden</td>
<td>Orthic A</td>
<td>23.0</td>
<td>63.8</td>
<td>1.0</td>
<td>Blocky</td>
<td>4.0</td>
</tr>
<tr>
<td>AUGER BY92</td>
<td>Brandvlei</td>
<td>Orthic A</td>
<td>29.7</td>
<td>61.7</td>
<td>4.4</td>
<td>Fine granular</td>
<td>2.0</td>
</tr>
<tr>
<td>AUGER BU98SE</td>
<td>Westleigh</td>
<td>Orthic A</td>
<td>23.9</td>
<td>57.5</td>
<td>0.8</td>
<td>Coarse granular</td>
<td>3.0</td>
</tr>
<tr>
<td>Soft Plinthic B</td>
<td></td>
<td></td>
<td>16.2</td>
<td>55.1</td>
<td>0.7</td>
<td>Coarse granular</td>
<td>3.0</td>
</tr>
</tbody>
</table>
Table 8.2.7 shows the soil erodibility factor (K) to increase, and the maximum slope for a site to be classed as arable to decrease with the following:

i) Increasing very fine sand plus silt,
ii) Decreasing organic matter percentage,
iii) Increasing structure index, and
iv) Decreasing permeability.

We regard the minimum slope for an unacceptable erosion hazard to exist, as the maximum slope for the site to be regarded as arable in terms of The Chamber of Mines land use capability (refer to Section 8.3 - LAND CAPABILITY BASELINE). The specification that the product of percent slope and the K factor must not exceed 2.0 for land to be classed as arable, was the basis of calculating the maximum slope for arable in Table 8.2.7. Once the value of 2.0 is exceeded, an unacceptable erosion hazard exists and conservation measures are required.

Note that percentage slope refers to the percentage grade, where 45 degrees (one metre vertical rise in one metre horizontal distance) is equal to a percentage grade of 100%, where percentage grade is equal to vertical distance divided by horizontal distance multiplied by one hundred.

In-Situ (undisturbed) soils

The following critical erosion slopes have been selected from our data in Table 8.2.7 to represent the topsoils (A-horizons) of the various broad soil groups that occur in the area:

- **Red apedal and Yellow-brown apedal soils (also applicable to Neocutanic soils, and Carbonate [Py, Ky and Mp soil forms only] soils):**
  
  Two samples: 7.2 degrees and 6.9 degrees: Average 7.0 degrees (12.3% percentage grade).
  Less-steep than for Scotney’s ‘Ferrallitic soils’ (8.5 degrees).

- **Pedocutanic soils (also applicable to Hydromorphic soils):**
  
  Two samples: 5.9 degrees and 6.5 degrees: Average 6.2 degrees (10.8% percentage grade).
  More-steep than for Scotney’s ‘Non-Ferrallitic soils with a clay increase B-horizon’ (5.7 degrees).

- **Shallow soils:**
  
  Two samples: 5.2 degrees and 4.4 degrees: Average 4.8 degrees (8.4% percentage grade).
  Slightly more-steep than for Scotney’s ‘Duplex soils’ (4.5 degrees), for the lack of a more relevant comparison.

  The subsoil values are not normally considered (not exposed) for the determination of the arable capability class.
Scotney et al. (1987) makes use of the following critical arable slopes:

- Ferrallitic (highly weathered) soils : < 15.0 % (8.5 degrees),
- Non-Ferrallitic soils without a ‘clay increase B-horizon’ : < 12.0 % (6.8 degrees),
- Non-Ferrallitic soils with a ‘clay increase B-horizon’ : < 10.0 % (5.7 degrees),
- Duplex soils : < 8.0 % (4.5 degrees).

The critical erosion slopes determined in Table 8.2.7 are either less-steep (red apedal and yellow-brown apedal), more-steep (pedocutanic and hydromorphic), and slightly more-steep (shallow soils) than those of Scotney et al. (1987) for equivalent soils.

**Unacceptable levels of soil erosion will begin to occur in bare (without grass cover) areas, where the slope exceeds that specified for the respective broad soil groups.**

To provide for a buffer against soil erosion in cultivated areas, the aforementioned selected slopes were also chosen as the maximum permissible slope for an area to be accepted into the arable capability class.

After completion of the soil survey exercise, slope in the Operational Area was determined to vary as follows for natural areas:

- Midslopes (and concave ‘valley-bottom’ areas): almost level (0.5 - 1 degree): vast majority;
- Midslopes (and concave ‘valley-bottom’ areas): very gently sloping (1 - 2 degrees): occasionally; and
- Midslopes (and concave ‘valley-bottom’ areas): gently sloping (2 - 4 degrees): rarely.

Despite the fact that the determined critical erosion slopes are steeper than the prevailing slopes in the area, soil erosion is severe to moderate in the majority of the Operational Area as a result of the degradation/removal of the majority of the grass cover due to overstocking/overgrazing in the past.

Slope was not a limiting factor in the survey area with regard to the determination of the arable capability class since the soils which were deep enough to qualify as arable (≥75cm) occurred in areas where the slope was less than 7.0 degrees [critical erosion slope selected to represent the potentially arable red apedal and yellow-brown apedal soils]. Steeper sections (none in survey area) would generally display soils of lesser depth, and thus would already classify as grazing or non-grazing areas.

It should be noted that the Department of Agriculture stipulates that conservation measures should be implemented on slopes of over 2.0 % (1.1 degrees) on disturbed (where the original grass cover has been removed) sites. These measures involve practices such as building contour banks, re-grassing and cultivating on the contour, etc. The maximum allowable slope for annual cropping is 12 % (6.8 degrees).
Critical erosion slopes are next presented for a number of different Rehabilitation Scenarios.

(i) Rehabilitated ‘topsoiled’ areas overlying building rubble, removed features, and opencast areas [not intentionally compacted]  
[i.e. rehabilitated ‘topsoiled’ areas overlying the footprints of all demolished/removed man-made features not included in Point ii)]

This scenario applies to the rehabilitation of the footprints of all of the sites of the demolished/removed/levelled man-made facilities/features upon closure: e.g. infrastructure / buildings, roads, ‘non-waste’ prepared surfaces/piles/banks, excavations; re-graded opencast areas; non-carbonaceous rock dumps that remain in perpetuity; and the sites of removed rock dumps (or piles of material) / removed overburden or underburden ‘waste’ layers / removed ‘topsoil’ stockpiles.

Topsoil (A-horizon) material should ideally be placed at the top of the rehabilitated ‘topsoil’ sequence. This horizon has the greatest organic matter percentage and is thus more fertile and less erodible (usually, depending on very fine sand and silt contents) than the subsoil (B-horizon). However, in practice topsoil (A-horizon) and subsoil (B-horizon) mixing is likely, despite the fact that it would be desirable to strip and ‘topsoil’ these reserves separately (A-horizons replaced at the surface).

Given that the permeability of the levelled rubble/removed features is defined as slow (3.6 - 36mm/hour) due to unintentional compaction; then the removed feature becomes the controlling horizon in the nomograph exercise.

The following critical erosion slopes have been selected from our data (Table 8.2.7) to represent the various broad soil groups that are recommended for rehabilitation ‘topsoiling’ purposes.

Rehabilitated areas must be re-graded (re-sloped) to ensure that these recommended calculated slopes are not exceeded:

- **Red apedal and Yellow-brown apedal soils:**  
  Also applicable to the Neocutanic soils, and Carbonate (Py, Ky and Mp soil forms only) soils.

  Topsoils: two samples: 5.4 and 4.7 degrees;  
  Subsoils: two samples: 5.9 and 4.8 degrees;  
  Average of A- and B-horizons: **5.2 degrees** (9.2 % percentage grade)  
  [non-vegetated, but slightly steeper (undetermined) after re-vegetation].

- **Pedocutanic soils:**

  Topsoils: one sample: 5.2 degrees;  
  Subsoils: one sample: 7.1 degrees;  
  Average of A- and B-horizon: **6.2 degrees** (10.8 % percentage grade)  
  [non-vegetated, but slightly steeper (undetermined) after re-vegetation].

  The final selected slope is **5.2 degrees** (9.2 % percentage grade) for all ‘topsoil’ types, the soils in the first bullet being preferred.
Suitable broad soil groups for rehabilitation ‘topsoiling’ purposes (surface placement) are as follows (descending order of suitability) [types i - iii preferred):

i) Red apedal, very high suitability,

ii) Yellow-brown apedal (and Neocutanic), high suitability,

iii) Carbonate (Py, Ky, and Mp soil forms only), high suitability, and

iv) Pedocutanic (‘red’ colours only), moderate-low suitability.

The following broad soil groups are not recommended for surface placement, but may be utilised further down in the rehabilitated profile:

i) Carbonate (Ag, Ad, Pr, Mu, Br, Cg soil forms only), very low to unsuitable (saline), and

ii) Shallow, Hydromorphic, and Pedocutanic (‘grey’ colours), very low to unsuitable (Shallow-gravelly/rocky; Hydromorphic and Pedocutanic-bleached).

The A-horizons should ideally be replaced at the surface, the B-horizon material only contributing to the required ‘topsoiling’ depth (as determined by the pre-mining land capability class).

In rehabilitated infrastructure and opencast areas, the pre-disturbance/pre-mining grade (slope), slope shape, contours and drainage density (not necessarily pattern) should be implemented where possible, at all times bearing in mind the calculated critical erosion slopes for the various broad soil groups which occur. This will be done by surface re-grading. Concave (rather than convex) slopes should be maximized wherever possible, while the creation of undulating ‘basin and ridge’ topography with frequent blind hollows should be avoided. In rehabilitated infrastructure/opencast areas, the negative impact of drainage systems approximating their original course is that the re-established drainage systems may incise their beds into the ‘wastes’/rubble/overburden rock/spoil over time (unless these drainage systems are constructed of concrete in such areas). The consequences of this possible deepening of drainage systems is firstly that the ‘clean’ water flowing over rehabilitated areas may become contaminated, and secondly that some (unknown volume) of this water will infiltrate into the polluted zone (rubble from infrastructure, or pit) itself.

Erosion control measures such as intercept drains, contour bank canals, grassed waterways and toe berms should be implemented where necessary.
(ii) Rehabilitated ‘topsoiled’ areas; overlying a compacted-'remoulded’ ‘seal’ layer; overlying a potentially-polluting rehabilitated feature

[i.e. the ‘seal’ layer should ideally overlie rehabilitated pollution control/return water/process water dams, evaporation ponds, slurry/tailings dams, and potentially polluting dumps (e.g. carbonaceous discard dumps and ash dump) at the time that these features become redundant and are rehabilitated. The seal layer should also underlie these features at the time of their construction, and also including the dirty water gullies/drainage canals]

In the case of the aforementioned features, where the objective is to limit the infiltration of rainwater to avoid contamination of the groundwater, a layer of compacted '-remoulded’ soil (or an impermeable membrane) is placed immediately overlying the feature during rehabilitation (also underlying these features during construction). In such cases, the permeability of the controlling ‘soil’ horizon (compacted '-remoulded’ soil) will be defined as slow [0.36 - 3.6mm/hour] to very slow (<0.36mm/hour) according to the nomograph, then irrespective of the soil type used as ‘topsoil’ cover material (overlying the compacted layer), the critical erosion slopes will be low for all suitable (for use as ‘topsoil’) soil types.

Given the findings in Table 8.2.7, during rehabilitation these features must be re-graded (re-sloped) before placement of either the compacted '-remoulded’ soil layer, or the overlying ‘topsoil’ layer; to ensure that the following recommended slope is ideally not exceeded:

- Pedocutanic (B-horizon) or Hydromorphic (G- or B-horizons) soils: maximum 5.2 degrees (9.2 % percentage grade)
  [non-vegetated, but slightly steeper (undetermined) after re-vegetation].

- In terms of the overlying non-compacted ‘topsoil’ layer (Red apedal, Yellow-brown apedal, Neocutanic, Carbonate [Py, Ky and Mp soil forms], or Pedocutanic), the determined slope would be the same.

Thus the final selected slope is 5.2 degrees (9.2 % percentage grade) for all ‘topsoil’ types.

The aforementioned slope is impractical since the slope of a ‘topsoiled’ ‘rehabilitated’ potentially polluting carbonaceous discard dump, ash dump or TSF cannot easily be reduced to this extent, while that of a ‘rehabilitated’ pollution control/return water/process water dam can be reduced (unless this feature remains functioning in perpetuity).

Given the erodibility of the soils on steeper slopes, the ‘topsoiling’ of some features may not be feasible. Even if a compacted '-remoulded’ layer was not established overlying the feature, the determined slope would be the same: 5.2 degrees (9.2 % percentage grade) [non-vegetated, but slightly steeper (undetermined) after re-vegetation]. In such cases, the feature must be re-vegetated using phytoremediation and ecological restoration principles.

Although Vertisols (vertic broad soil group) are extremely rare in the area, these soils are the most suitable of all soils for use as compacted ‘seals’, since the vertic A-horizon
naturally displays a slow permeability when moist, and a very slow permeability once compacted. Thus, if possible such soils should be sought. One patch is known to occur in the very small pan that lies to the south of auger point AQ70. Further patches may occur in other of the pans that occur in the Operational Area. However, given the broad auger grid intensity of 300m that was utilised for the soil survey, augering was not conducted in many of the pan areas. The pedocutanic and hydromorphic broad soils groups are also suitable (less so) for use as compacted ‘seals’ in the area.

The natural angle of repose of dumped spoil/rock/tailings/other material is generally approximately 75.4 % or 37.0 degrees. The recommended maximum gradient (Chamber of Mines) for material dumped on level to gently sloping terrain (therefore also rehabilitated ‘topsoiled’ pollution control/return water/process water dams, evaporation ponds, slimes/tailings dams, and potentially polluting dumps) is at least 1v: 3h (33.0 % or 18.4 degrees), the least erosion occurring if the slope angle reduces in the direction of the toe of the pediment (i.e. concave). One of the key findings of extensive surveys and experimental work carried out by the University of the Witwatersrand between 1996 and 2009 was that grass persistence and erosion control were increased, and irrigation decreased, by TSF slope reduction to <16 degrees.

Given the critical erosion slopes calculated in this exercise, slopes of 18.4 degrees (before re-vegetation) appear to be much too steep and would lead to unacceptable levels of soil erosion occurring after rehabilitation. Other considerations suggest the strong desirability of lesser gradients to reduce erosion and permit mechanization of re-vegetation and maintenance operations (agricultural tractors can be operated with most implements up to 20.0 % or 11.3 degrees) [i.e. 1v: 5h].

(iii) Opencast Mining Areas

Two pits are planned to be excavated for the current proposed project.

Opencast areas must be re-graded, ‘topsoiled’, and re-vegetated as per Point (i).

(iv) Underground Mining Areas

Underground mining is not planned for the current proposed project.

Subsided areas must be re-graded, ‘topsoiled’ (where necessary), and re-vegetated as per Point (i).
8.2.8 DRYLAND / IRRIGATED PRODUCTION POTENTIAL
(Refer to Maps 2a, 3a and 4)

DRYLAND

Ranching

The land use both within and immediately adjacent to LCPP is dominated by ranching / game faming and eco-tourism, and to a lesser extent cattle ranching.

The land in the region is suited to environmental tourism or extensive game ranching. Due to the scarcity of naturally occurring surface water for the majority of the year, the natural vegetation is evolved to a low density of grazers and a probable relatively higher density of browsers. Previous cattle ranching and over-stocking (of grazers) have resulted in the currently degraded eroded land. Thus the farmers should completely discontinue burning for a good number of years, while grazer stocking densities must be kept as absolutely low as possible; to give the land a chance to ‘recover’ somewhat.

Cultivation

Climatic information for the area is presented in Section 8.1.4 (METEOROLOGY). Given the low mean annual precipitation (435 mm), the hot climate (average maximum temperatures ranging from 30°C to 36°C), as well as the unpredictable rainfall in the area; dryland production is not recommended due to the very low yields obtained as well as the high associated risk.

The semi-arid climate minimises the potential for intensive dryland crop production. Thus the arable soils as indicated on Map 3a (Pre-Mining Land Capability) are generally not extensively cultivated due to the very low dryland yields obtained. Thus, the planting of moderate to low profit commercial agricultural crops are likely to be extremely limited.

Occasional cultivated lands are spread out in six locations as indicated on Map 4 (Present Land Use), the aforementioned probably producing dryland hay and other types of livestock feed on a small scale.

Cultivated fields should ideally be located on soils of the arable capability class. The yields obtained on grazing capability class soils would be considerably lower than those obtained on the deeper arable soils. However, shallow patches inevitably occur within a land. Scotney et al. (Soil Capability Classification, March 1987) defines many such areas as arable, albeit with decreased production possibilities, an increased hazard of use, and an increased intensity of conservation techniques required.

Generalised dryland yields in the region are presented for the arable soils (usually red apedal broad soil group). These yields are according to those presented in the South African Atlas of Agrohydrology and -Climatology (R.E. Schulze et-al, 1997).

All of the yields mentioned by Schultze et-al refer to dry mass.
• Maize
2 - 3 tonnes/ha, with an inter-seasonal coefficient of variation of approximately 40 - 50 %. The dryland breakeven is considered to be approximately 3 tonnes/ha.

Schultze et-al indicates that the area is **climatically unsuitable** for all other dryland crops, the following yields being indicated:

• Dry Beans
Unsuitable. Patches of <0.5 tonnes/ha, and 0.5 - 0.75 tonnes/ha in the region.
National average is 1.2 tonnes/ha.
Given well drained arable soils, a MAP of <775mm, a rooting depth of 100cm, and clay content (clay 15 - 35 %); the indicated yields must be multiplied by a factor of 1.0 (i.e. unchanged).

• Soybeans
Unsuitable. Patches 1.00 - 1.50 tonnes/ha in the region.
Given well drained arable soils, a MAP of <775mm, a rooting depth of 100cm, and clay content (clay 15 - 35 %); the indicated yields must be multiplied by a factor of 1.0 (i.e. unchanged).

• Groundnuts
Unsuitable. Patches 1.5 - 2.0 tonnes/ha (shelled) in the region.
For soil depths of 0.5m, 0.6m, 0.7m, 0.8m, and 0.9m; the indicated yields must be multiplied by factors of 0.6, 0.7, 0.8, 0.9, and 1.0 respectively in the different areas. Given arable soil depth of 0.9m, yield is thus unchanged.

• Sorghum
Unsuitable <3 tonnes/ha (patches 3 - 4 tonnes/ha in the region).
Given well drained arable soils, a MAP of <775mm, a rooting depth of 100cm, and clay content (clay 15 - 35 %); the indicated yield must be multiplied by a factor of 1.1 (i.e. increase).

• Sunflowers
Unsuitable (patches <1.0 tonne/ha in the region).
Given well drained arable soils, a MAP of <775mm, a rooting depth of 100cm, and clay content (clay 15 - 35 %); the indicated yields must be multiplied by a factor of 1.0 (i.e. unchanged).

• Cotton:
Unsuitable <1.0 tonne/ha (patches 1.0 - 1.5 tonnes/ha in the region).
For arable soil depths of 0.7m, 0.8m, 0.9m, and 1.0m; the indicated yields must be multiplied by factors of 0.8, 0.9, 1.0 and 1.1 respectively in the different areas.
Given arable soil depth of 0.9m, yield is thus unchanged.

• Kikuyu (*Pennisetum clandestinum*), Coast Cross II (more drought resistant than Kikuyu), *Eragrostis curvula*, and Smuts Finger Grass (*Digitaria eriantha*)
Unsuitable <4 tonnes/ha (patches 4 - 6 tonnes/ha in the region).
Given that the soils are eutrophic in the area, the indicated yields must be multiplied by a factor of 0.8 (i.e. reduced).
The aforementioned yields assume that the pH and nutrient status of the soils are optimum (ameliorated) for a particular crop. The yield variations are primarily rainfall dependant.

**IRRIGATED**

Despite the arable soils that occur in many areas, such areas will not be able to be commercially cultivated without the provision of irrigation, the aforementioned due to the semi-arid prevailing climate in the area. Furthermore, there is a scarcity of borehole water for irrigation purposes, as well as the potentially saline water quality in some areas.

High profit drip irrigated crops such as citrus or vegetables are likely to be feasible, provided that irrigation water is available. One small citrus orchard exists adjacent to the farmhouse on the farm Weltevreden 482 JQ (portion 1).

High irrigated yields will only achieved with high levels of expertise and management.

Schulze et-al (1997) indicates the following for the region:
- gross irrigation requirement: median annual based on the ACRU Model: 1800 - 2000mm/annum, with patches of 1100 - 1800mm/annum; and
- hail incidence: less than once per annum.

**8.2.9 IRRIGATION POTENTIAL**

The irrigation potential in the soil survey area is based on the characteristics (already described) of the soils that occur, and generally varies as follows:

- **High**: red apedal soils;
- **Moderate**: yellow-brown apedal, neocutanic, and carbonate (Py, Ky and Mp soil forms only) soils;
- **Low**: pedocutanic soils (‘red’ colours);
- **Unsuitable**: shallow, hydromorphic, pedocutanic (‘bleached’ grey colours), and carbonate (Ag, Ad, Pr, Mu, Br and Cg soil forms) soils.

The trend of high, moderate, low, and unsuitable potential is generally related to:

- Depth of occurrence of the depth limiting horizon (thus effective rooting depth);
- Texture (clay content) of the soil, as this relates to moisture holding capacity (readily and plant available water);
- Permeability of the soil; and
- Salinity and sodicity of the soil.

The allocation of broad soil groups/soil forms to the various potentials is a guideline only, since within a particular broad soil group/soil form, the soils tend to exhibit a large variation in effective rooting depth. Thus the irrigation potential of each polygon of potential cropping soils needs to be evaluated on its own merits.

The lower irrigation potential soils require more complex irrigation scheduling and drainage control, while the lower yields make them unfeasible for irrigation purposes.
Borehole water quality must be carefully evaluated before considering irrigation. The EC of the irrigation water should ideally be lower than 25mS/m (low salinity irrigation water), and definitely not higher than 75mS/m (high salinity irrigation water).

8.2.10 OVERBURDEN/UNDERBURDEN ‘WASTES’ AND ‘NON-WASTES’

‘Wastes’ (mining related) do not occur in the current green fields survey area.

The term ‘wastes’ has been selected (by the author for discussion purposes) to refer to mining/processing/industrial/smelting related raw materials and by-products, that may have an inherently high pollution potential under certain circumstances. These may include materials such as discard, ash, potentially polluting carbonaceous spoil rock (particularly that which has been crushed to a fine grade), ore fines, slag, pellets, slurry/tailings, coke/anthracite/coal, and scrap.

The term ‘non-wastes’ has been selected (by the author for discussion purposes) to refer to other (non-mining or -processing, or -industrial, or -smelting related) materials, that have an inherently low pollution potential. These may include materials such as potentially non-polluting deposited rock, rubble, concrete, stone chips, and soil (when mixed with the aforementioned).

8.2.11 SOIL UTILIZATION (STRIPPING) GUIDE
(Refer to Map 5; and Table 8.2.11)

As the opencast, infrastructure, storage, waste and containment facilities expand, the available ‘topsoil’ reserves must be stripped as per the depths indicated on Map 5 (Soil Utilization [Stripping] Guide), and either utilised to ‘topsoil’ a feature undergoing rehabilitation or stockpiled for later use (rehabilitation purposes). Map 5 summarizes Map 2a (Soil Mapping Units) into broad soil groups, average usable depth, and available volume of existing ‘topsoil’ (suitable A- and B-horizons) material.

Table 8.2.11 (Summary of Soil Utilization [Stripping] Guide) is extracted from Map 5, and summarizes the information for the survey area (Operational Area).

Table 8.2.11 shows that 16,389,904 m³ of usable (high to low-unsuitable suitability) ‘topsoil’ (suitable A- and B-horizons) is present in-situ in the Operational Area.

Suitable broad soil groups for rehabilitation ‘topsoiling’ purposes (surface placement) are as follows (descending order of suitability) [types i - iii preferred]:

i) Red apedal, very high suitability,
ii) Yellow-brown apedal (and Neocutanic), high suitability,
iii) Carbonate (Py, Ky, and Mp soil forms only), high suitability, and
iv) Pedocutanic (‘red’ colours only), moderate-low suitability.

The following broad soil groups are not recommended for surface placement, but may be utilised further down in the rehabilitated profile:
v) Carbonate (Ag, Ad, Pr, Mu, Br, Cg soil forms only), very low to unsuitable (saline), and

vi) Shallow, Hydromorphic, and Pedocutanic (‘grey’ colours), very low to unsuitable (Shallow-gravelly/rocky; Hydromorphic and Structured-bleached).

The following broad soil groups are recommended for sealing purposes overlying/underlying a potentially-polluting rehabilitation feature. The ‘seal’ layer should ideally overlie rehabilitated pollution control/return water/process water dams, evaporation ponds, slurry/tailings dams, and potentially polluting dumps (e.g. carbonaceous discard dumps and ash dump) at the time that these features become redundant and are rehabilitated. The seal layer should also underlie these features at the time of their construction, and also underlie the base of the dirty water gullies/drains/canals.

vii) Hydromorphic (G- and B-horizons) and Pedocutanic (B-horizon), highly suited to this purpose.

All of these ‘topsoils’ must be stripped, stockpiled and utilised for rehabilitation purposes (in the specified manner). However, ‘topsoil’ types i) - iv) are the most suitable, and must be stripped, stockpiled and utilised separately to ‘topsoil’ types v) - vii); the aforementioned being due to their relative surface versus sub-surface placements. The former ‘topsoil’ types must be replaced at the surface, and where available volume allows, on top of the latter ‘topsoil’ types. Furthermore, the A-horizon material should ideally be replaced above the B-horizon material wherever possible.

The ‘topsoil’ types (vii) utilised for sealing purposes (compacted- ‘remoulded’ layer), must thus also be stripped, stockpiled and utilised separately to the other ‘topsoil’ types.

Recommendations regarding the stripping, stockpiling, suitability and utilization of ‘topsoil’ material are further described in sub-sections of this Specialist Study Report.

These ENVIRONMENTAL MANAGEMENT PLAN sub-sections include the following: Section 11 (TECHNICAL DETAILS OF MANAGEMENT MEASURES); and specifically Sub-Section 11.8 (SUITABLE ‘TOPSOILING’ MATERIALS), and Sub-Section 11.9 (SEQUENCE OF REHABILITATED HORIZONS).

The ‘soft’s’ materials (weathering rock = saprolite, soft carbonate horizon, and hardpan carbonate horizon) must be stockpiled separately from the ‘topsoil’ on the one hand and hard overburden rock on the other. This is because the ‘soft’s’ material will probably be accessible to plant roots, when it is replaced as a layer between the underlying rock/spoil/discard/‘wastes’ and the surface ‘usable’ ‘topsoil’. Furthermore, these ‘soft’s’ materials (particularly the hardpan carbonate and soft carbonate horizons, as well as neocarbonate B-horizons) can perform a useful function in that they can be placed as a breaker layer (to intercept the upward capillary movement of acid water from the pit) between the weathered discard materials and the ‘usable’ ‘topsoil’.
### Table 8.2.11: Summary of Soil Utilization (Stripping) Guide

<table>
<thead>
<tr>
<th>Broad Soil Group</th>
<th>Soil Form (South African Taxonomic System)</th>
<th>Map Notation</th>
<th>Soil Depth and Area</th>
<th>Count</th>
<th>Area (ha)</th>
<th>% of total area</th>
<th>Volume (m³)</th>
<th>% of total volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>Mineral Soils (Red apedal, Yellow-brown apedal, and Neocutanic)</td>
<td>Hu, Li; Cv, Gc; Tu</td>
<td>17.26 18.52 11.05 31.06 113.10 296.00 183.74 124.47 140.44 383.76 78.81 4.03 0.37</td>
<td>77</td>
<td>1403.22</td>
<td>51.15</td>
<td>10239695</td>
<td>62.48</td>
</tr>
<tr>
<td>T</td>
<td>Pedocutanic (i.e. Structured)</td>
<td>Sw, Sc, Bo</td>
<td>8.41 4.42 264.75 177.13 36.71 1.07</td>
<td>29</td>
<td>492.48</td>
<td>17.95</td>
<td>3492439</td>
<td>21.31</td>
</tr>
<tr>
<td>B</td>
<td>Carbonate</td>
<td>Py, Ky, Mp, Ag, Ad, Pr, Mu, Br, Cg</td>
<td>4.03 34.51 9.77 20.03 10.81 7.86 1.25 14.75 4.24 43.89 0.76</td>
<td>23</td>
<td>161.92</td>
<td>5.90</td>
<td>1039978</td>
<td>6.35</td>
</tr>
<tr>
<td>S</td>
<td>Shallow (i.e Lithosols)</td>
<td>Ms, Gs, Dr</td>
<td>254.15 313.72 28.76</td>
<td>38</td>
<td>617.15</td>
<td>22.49</td>
<td>1500742</td>
<td>9.16</td>
</tr>
<tr>
<td>H</td>
<td>Hydromorphic (also including Pan areas)</td>
<td>Ka, We (and usually Ka in Pan areas)</td>
<td>1.66 49.32 13.43</td>
<td>48</td>
<td>64.41</td>
<td>2.35</td>
<td>117049</td>
<td>0.71</td>
</tr>
<tr>
<td>Pond District Road</td>
<td>Pond (and man-made earth Wall) constructed in a non-wetland area</td>
<td></td>
<td></td>
<td>3</td>
<td>0.47</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>District Road</td>
<td>District Road (Dirt)</td>
<td></td>
<td></td>
<td>1</td>
<td>3.95</td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL (SOIL UTILIZATION [STRIPPING] GUIDE)</td>
<td></td>
<td></td>
<td></td>
<td>219</td>
<td>2743.59</td>
<td>100.00</td>
<td>16389904</td>
<td>100.00</td>
</tr>
</tbody>
</table>
8.2.12 REHABILITATION TOPSOIL BUDGET
(Refer to Map 5; and Table 8.2.11)

All soil (suitable and unsuitable) stripped must be replaced on the relevant feature during rehabilitation. This is due to Government Regulations (R537 of 21 March 1980), which require that all ‘topsoil’ (as defined – generally suitable A-, B- and C-horizons) removed be replaced on the disturbed surface during rehabilitation.

The unsuitable (for rehabilitation purposes) soil must be replaced below the suitable ‘topsoil’. In the survey area, the unsuitable soil materials include the following: hard rock, weathering rock, hard plinthic B-horizon, neocarbonate B-horizon, hardpan carbonate horizon, soft carbonate horizon, soft plinthic B-horizon, G-horizon, unconsolidated material with signs of wetness, and unspecified material with signs of wetness. These materials can perform a useful function in that they can be placed as a breaker layer (to intercept the upward capillary movement of polluted or acid water) between the rehabilitated feature and the ‘usable’ ‘topsoil’.

(i) Rehabilitation Scenario (building rubble, removed features, and opencast areas) [not intentionally compacted]
[i.e. rehabilitated ‘topsoiled’ areas overlying the footprints of all demolished/removed man-made features not included in scenario (ii)]

This scenario applies to the rehabilitation of the footprints of all of the sites of the demolished/removed/levelled man-made facilities/features upon closure: e.g. infrastructure / buildings, roads, ‘non-waste’ prepared surfaces/piles/banks, excavations; re-graded opencast areas; and the sites of removed rock dumps (or piles of material) / removed overburden or underburden ‘waste’ layers / removed ‘topsoil’ stockpiles.

Ideally, in the rehabilitated scenario, at least the same percentage of arable and grazing land should exist as were present before disturbance. All of the suitable ‘topsoiling’ materials must be utilised for rehabilitation purposes in the top 0.6m (arable), 0.25m (grazing) and 0.15m (wilderness and wetland/riparian). The mixing of suitable (‘usable’ ‘topsoil’) / unsuitable (‘non-usuable’ soil and other) materials in this zone must be avoided.

Although the land capability (Map 3a) and soils (Map 2a) will have been destroyed (wholly or partially) in disturbed areas post-mining, their pre-disturbance status will be clear, given the trends on the periphery. These clearly interpretable pre-disturbance land capabilities and soils will form the basis for the rehabilitation (i.e. ‘topsoiling’ depth) that must take place in these areas. If however the man-made feature is removed, exposing the original in-situ soils, then ‘topsoiling’ will not be required. Opencast areas should preferably be rehabilitated to the pre-mining land capability depth standard. In areas where the aforementioned is not possible, then these areas must be rehabilitated as per the grazing capability class depth standard, which is 0.25m of suitable ‘topsoil’ material.

Based on the volume (16 389 904m³) of available ‘topsoil’ reflected on Map 5 (Soil Utilization [Stripping] Guide) and in Table 8.2.11 (Summary of Soil Utilization [Stripping]
Guide), then the following area would be able to be rehabilitated to the post-mining/disturbance arable capability classes (*albeit* to a lower production potential):

- Arable (*topsoiling* depth: 0.60m) = 2731ha.

However, not all areas will need to be rehabilitated to the arable depth class standard, as determined by the pre-mining/disturbance capability class. Thus, many areas will be ‘topsoiled’ to a lesser depth of 0.25m or 0.15m (Grazing versus Non-Grazing capability class depth standard).

Furthermore, the extent of the impacted (and thus rehabilitated) footprint will obviously occupy a far lesser extent than the entire Operational Area (2743.59ha).

Thus, available ‘topsoil’ is in more than abundant supply. The Red apedal, Yellow-brown apedal, Neocutanic, and Carbonate (Py, Ky and Mp soil forms only) broad soil groups are preferred for rehabilitation ‘topsoiling’ purposes.

(ii) **Rehabilitation Scenario [compacted ‘remoulded’ ‘seal’ layer]**

[i.e. rehabilitated ‘topsoiled’ (non-compacted ‘topsoil’) areas; overlying a compacted - ‘remoulded’ soil ‘seal’ layer; overlying a potentially-polluting rehabilitated feature]

This scenario applies to the rehabilitation of all of the sites of potentially polluting features upon closure. The ‘seal’ layer should ideally overlie rehabilitated pollution control/return water/process water dams, evaporation ponds, slurry/tailings dams, and potentially polluting dumps (e.g. carbonaceous discard dumps and ash dump) at the time that these features become redundant and are rehabilitated. The seal layer should also underlie these features at the time of their construction, and should also underlie the base of the dirty water gullies/drains/canals. Features with a high pollution potential must be overlaid by an impermeable membrane.

Redundant features, the material from which is not required in the process in the future, must be removed from where it is no longer required, and transported to a designated facility or dumping area (including the pit), which must in turn be ‘rehabilitated’. Redundant features/materials will contribute to soil/water pollution since rainwater will percolate through these materials (leading to acid rock drainage, and dissolving pollutants), and thereafter into the underlying/surrounding soils and water-tables.

To limit the infiltration of rain/waste water into/through potential pollution sources, such features must be sealed with a layer of compacted -‘remoulded’ vertic (ideally) soil (immediately overlying the feature).

The compaction of the seal layer to a high level will lead to a layer with a low to very low coefficient of permeability that is effective at limiting infiltration. From the nomograph point of view, the permeability of this controlling horizon should be slow (0.36 - 3.6mm/hour) to very slow (<0.36mm/hour). It should be possible to achieve a slow permeability by using soils of the hydromorphic (G- and B-horizons) and pedocutanic (B-horizon) broad soil groups.

These soils generally have the following textures:
- Pedocutanic soils: clay to sandy-clay-loam textures (clay content approximately 55 - 30%), and
- Hydromorphic soils: sandy-loam to clay textures (clay content approximately 15 - 55%).

The clay to sandy-clay subsoils (clay content approximately 55 - 30%) of the aforementioned soils are suitable materials for utilization as the compacted ‘seal’.

The compacted layer must in turn be ‘topsoiled’ with at least 0.25m (grazing capability class depth standard) [but preferably more - arable depth standard] of soil material (relatively undisturbed and non-compacted). This ‘topsoil’ layer must be ameliorated to optimize soil fertility, and thereafter re-vegetated.

Those of the pollution control/return water dams, slurry dams, evaporation ponds, discard dumps and ash dumps that remain in perpetuity, must be rehabilitated by re-grading (i.e. re-shaping/re-sloping) the side slopes to an acceptable maximum slope (from the soil erosion perspective), ‘topsoiling’, and re-vegetating.

Table 8.2.11 (Summary of Soil Utilization [Stripping] Guide) indicates that the following volumes of suitable ‘topsoil’ material are available for the construction of compacted-‘re-moulded’ seals in the Operational Area:

- **Pedocutanic:** 3 492 439 m³, and
- **Hydromorphic:** 117 049 m³.

Thus, material for sealing purposes is in more than abundant supply. The Pedocutanic B-horizons and Hydromorphic G- and B-horizons must be utilised.
8.3 LAND CAPABILITY BASELINE

8.3.1 LAND CAPABILITY REQUIREMENTS
(Refer to Map 3; and Tables 8.3.1a and 8.3.1b)

Land capability classes were determined using the guidelines outlined in the following document produced by The Chamber of Mines of South Africa / CoalTech: Guidelines for the Rehabilitation of Mined Land (November 2007). The aforementioned guidelines were extracted (unchanged) from the following document produced by The Chamber of Mines of South Africa: Handbook of Guidelines for Environmental Protection - The Rehabilitation of Land Disturbed by Surface Coal Mining in South Africa (volume 3, 1981). A summary of the land capability classes is presented in Table 8.3.1a (Land Capability Requirements).

Table 8.3.1(a): Land Capability Requirements

<table>
<thead>
<tr>
<th>Criteria for Wetland</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Land with organic soils or</td>
</tr>
<tr>
<td>• A horizon that is gleyed throughout more than 50% of its volume and is significantly thick, occurring within 750mm of the surface.</td>
</tr>
<tr>
<td>[Note: The DWAF definition (DWAF, Edition 1, September 2005) has now superseded this definition, and instead considers a wetland to occur if the soil wetness indicator occurs within 500mm of the surface. Exceptions are the Champagne, Rensburg, Katspruit and Willowbrook forms, which may be of any depth. The topsoils of the former two forms are frequently deeper than 500mm]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criteria for Arable Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Land, which does not qualify as a wetland</td>
</tr>
<tr>
<td>• The soil is readily permeable to the roots of common cultivated plants to a depth of 750mm</td>
</tr>
<tr>
<td>• The soil has a pH value of between 4.0 and 8.4</td>
</tr>
<tr>
<td>• The soil has a low salinity and SAR</td>
</tr>
<tr>
<td>• The soil has a permeability of at least 1.5mm per hour in the upper 500 mm of soil</td>
</tr>
<tr>
<td>• The soil has less than 10% (by volume) rocks or pedocrete fragments larger than 100mm in diameter in the upper 750mm</td>
</tr>
<tr>
<td>• Has a slope (in %) and erodibility factor (K) such that their product is &lt;2.0</td>
</tr>
<tr>
<td>• Occurs under a climatic regime, which facilitates crop yields that are at least equal to the current national average for these crops, or is currently being irrigated successfully</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criteria for Grazing Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Land, which does not qualify as wetland or arable land</td>
</tr>
<tr>
<td>• Has soil, or soil-like material, permeable to roots of native plants, that is more than 250mm thick and contains less than 50% by volume of rocks or pedocrete fragments larger than 100mm</td>
</tr>
<tr>
<td>• Supports, or is capable of supporting, a stand of native or introduced grass species, or other forage plants, utilizable by domesticated livestock or game animals on a commercial basis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criteria for Non-Grazing (Wilderness)* Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Land, which does not qualify as wetland, arable land or grazing land.</td>
</tr>
</tbody>
</table>

*Note that the term “Wilderness”, which was in common usage in South Africa due to its erroneous definition in the 1981 Chamber of Mines guidelines, should in the authors opinion no longer be used. The definition of “wilderness” is globally accepted to be land which has not been impacted upon by human development or settled agricultural or industrial activities. The aforementioned is not the case in areas overlaid by ‘wastes’, or underlain by a pollution plume (as indicated by degraded vegetation).
A soil must meet all of the requirements specified in Table 8.3.1a to qualify for the respective Land Capability class.

A further document was utilised to subdivide the wetlands into three classes (permanent/semi-permanent, seasonal and temporary), as well as to identify riparian areas. The aforementioned document is entitled ‘A Practical Field Procedure for Identification and Delineation of Wetlands and Riparian Areas’, and is published by the Department of Water Affairs and Forestry (Edition 1, September 2005). For further information refer to Section 8.3.2 (WETLAND CLASSIFICATION / DELINEATION AND RIPARIAN AREAS) of our current report document.

Table 8.3.1b (Summary of Pre-Mining Land Capability) is extracted from Map 3a (Pre-Mining Land Capability), and summarizes the information for the Operational Area.
Table 8.3.1(b): Summary of Pre-Mining Land Capability

<table>
<thead>
<tr>
<th>Land Capability</th>
<th>Map Notation</th>
<th>Description</th>
<th>Count</th>
<th>Area (ha)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arable</td>
<td>A</td>
<td>Arable [Effective Rooting Depth ERD &gt; 75cm, non-saline, non-sodic, non-rocky]</td>
<td>37</td>
<td>825.10</td>
<td>30.07</td>
</tr>
<tr>
<td></td>
<td>G-A</td>
<td>Grazing transitional Arable [ERD 60-70cm, non-saline, non-sodic, non-rocky]</td>
<td>7</td>
<td>93.93</td>
<td>3.42</td>
</tr>
<tr>
<td>Grazing</td>
<td>G</td>
<td>Grazing [ERD &lt; 75cm, non-saline, non-sodic, non-rocky]</td>
<td>53</td>
<td>941.75</td>
<td>34.33</td>
</tr>
<tr>
<td></td>
<td>Gb</td>
<td>Grazing [ERD usually &gt; 75cm, probably saline]</td>
<td>9</td>
<td>60.77</td>
<td>2.21</td>
</tr>
<tr>
<td></td>
<td>Gc</td>
<td>Grazing [ERD usually &gt; 75cm, surface capping evident]</td>
<td>13</td>
<td>186.37</td>
<td>6.79</td>
</tr>
<tr>
<td>'Non-Grazing'</td>
<td>L</td>
<td>'Non-Grazing' ('Wilderness') [ERD &lt; 25cm, occasionally rocky surface]</td>
<td>42</td>
<td>550.71</td>
<td>20.07</td>
</tr>
<tr>
<td>Wetland</td>
<td>Wp</td>
<td>Wetland (permanent) [ERD &lt; 10cm, generally Katspruit form]</td>
<td>7</td>
<td>13.52</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>Pan</td>
<td>Wetland (seasonal) [ERD 20-30cm; generally Westleigh form, occasionally Sepane and Glenrosa forms]</td>
<td>23</td>
<td>3.96</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>Pan.W</td>
<td>Wetland (seasonal) [ERD 20-30cm; generally Westleigh form, occasionally Sepane and Glenrosa forms]</td>
<td>2</td>
<td>1.02</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>Ws</td>
<td>Wetland (Seasonal) [ERD 20-30cm; generally Westleigh form, occasionally Sepane and Glenrosa forms]</td>
<td>18</td>
<td>55.78</td>
<td>2.03</td>
</tr>
<tr>
<td></td>
<td>Wt</td>
<td>Wetland (Temporary) [ERD 25-50cm; Sepane and Tukulu forms]</td>
<td>4</td>
<td>6.27</td>
<td>0.23</td>
</tr>
<tr>
<td>'Other' (Man-made)</td>
<td>Pond</td>
<td>Pond (and man-made earth Wall) constructed in a non-wetland area</td>
<td>3</td>
<td>0.47</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>District Road</td>
<td>District Road (Dirt)</td>
<td>1</td>
<td>3.95</td>
<td>0.14</td>
</tr>
<tr>
<td>TOTAL (LAND CAPABILITY)</td>
<td></td>
<td></td>
<td>219</td>
<td>2743.60</td>
<td>100.00</td>
</tr>
</tbody>
</table>
8.3.2 WETLAND CLASSIFICATION / DELINEATION AND RIPARIAN AREAS
(Refer to Map 3b; and Tables 8.3.2a and 8.3.2b)

Wetlands and their associated Riparian areas are generally regarded as especially sensitive landscapes under statutory protection, and as such must not be disturbed, polluted, cultivated or overgrazed without a licence. Such areas have a high significance from a preservation point of view, since they perform important hydrological functions, and are major contributors to the bio-diversity of an area.

**Wetlands:**

A wetland is defined by the South African National Water Act 36 of 1998 as follows: Land that is transitional between terrestrial and aquatic systems where the water-table is usually at or near to the surface or the land is periodically covered with shallow water, and which under normal circumstances supports or would support vegetation typically adapted to life in saturated soil.

Given the aforementioned definition, non-wetland areas have in the current report document been referred to as ‘terrestrial’ areas.

The wetland classification process is presented for information purposes.

The wetland delineation procedure is based on the following document: ‘A Practical Field Procedure for Identification and Delineation of Wetlands and Riparian Areas’, published by the Department of Water Affairs and Forestry (DWAF) [Edition 1, September 2005]. This document was in turn largely based on the following document: ‘Wetland and Riparian Habitats: A Practical Procedure for their Identification and Delineation’ (2000), by The Wetland and Riparian Habitat Working Group (Forest Owners Assoc. S.A.). Both of these documents were utilised in the current delineation procedure. Table 8.3.2a (Wetland Indicators and Corresponding Wetland Types) summarizes the major points from the latter document.

The aforementioned documents have superseded the wetland capability class definition of The Chamber of Mines. This is because The Chamber of Mines definition is both too broad (no subdivision for permanent/semi-permanent, seasonal and temporary wetlands), and considers signs of wetness at depths of up to 0.75m, (as opposed to 0.5m, which is the current practice) below the soil surface.

The wetland delineation procedure makes use of four wetland indicators.

i) **Soil form indicator**

For a site to be classified as a wetland in the first place, it must display a soil form indicator. These include any one of a list of soil forms, which are associated with prolonged and frequent saturation, such soils being termed hydromorphic soils.

ii) **Soil wetness indicator**

These morphological ‘signatures’ include grey colours in the soil matrix, and/or mottling within the top 0.5m of the soil surface, these morphological ‘signatures’ having developed in the soil profile as a result of prolonged and frequent saturation. This depth
has been chosen since experience internationally has shown that frequent saturation of the soil within 0.5m of the surface is necessary to support hydrophytes (plants typically found in wet habitats). Exceptions to this rule are the Champagne, Rensburg, Willowbrook and Katspruit soil forms, where it is not necessary for the profile or horizon to qualify as hydromorphic, since the topsoil horizon may be thicker than 0.5m. The topsoils of the aforementioned forms are usually dark in the permanent wetness zone, due to the accumulation of organic matter. In the case of the Champagne form, the organic carbon content is over 10%.

The wetland indicators of soil form and soil wetness factor are of over-riding importance since soil characteristics (soil form and soil wetness indicators) have often developed over hundreds of years. The next two wetland indicators should be used as guidelines only (for reasons which will be explained).

iii) Terrain unit indicator
This practical index identifies valley-bottom units, as well as depressions in crest, midslope and footslope positions, as the most likely sites for wetlands to occur. However, groundwater discharge may also take place through seeps in non-depression areas on mild to steep slopes, these seeps also being classified as wetlands.

iv) Vegetation indicator
Hydrophytes are plant species, which have developed mechanisms to grow, compete, reproduce and persist in anaerobic soil conditions. Obligate hydrophytes are only found in wetlands, while facultative hydrophytes can occur in both wetland and non-wetland areas. Thus vegetation in an untransformed (virgin) state is a helpful field guide in finding the boundary of a wetland. However, it should be borne in mind that the original vegetation might have been transformed or destroyed as a result of previous agricultural, land use, drainage or mining practices.

Once the site has been classified as a wetland, the four Wetland Indicators are used to further subdivide the wetland into one of three types, viz.: permanent/semi-permanent, seasonal or temporary.
**Table 8.3.2(a): Wetland Indictors and Corresponding Wetland Types**

<table>
<thead>
<tr>
<th>WETLAND INDICATOR</th>
<th>WETLAND TYPE</th>
<th>‘Old Chamber of Mines wetland definition cut-off depth’. Now Grazing capability class.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Permanent</td>
<td>Seasonal</td>
</tr>
<tr>
<td>Soil Form</td>
<td>Katspruit, Rensburg, Champagne, Willowbrook (ANY VEGETATION)</td>
<td>Any form, which incorporates wetness at the Form or Family level.</td>
</tr>
<tr>
<td>Soil Wetness Factor</td>
<td>Wetness all year round</td>
<td>Wetness long periods (3-10 months p.a.) at &lt; 50 cm</td>
</tr>
<tr>
<td>Vegetation</td>
<td>Obligate Wetland species accounting for &gt; 50 % of aerial cover</td>
<td>Obligate/Facultative Wetland species accounting for &gt; 50 % of aerial cover</td>
</tr>
<tr>
<td>Slope Position</td>
<td>Valley-bottom mandatory</td>
<td>Typically lower footslope</td>
</tr>
</tbody>
</table>

**VEGETATION DEFINITIONS:**
- Obligate Wetland species – almost always grow in wetland (> 99 % of occurrences)
- Facultative Wetland species – usually grow in wetlands (67 - 99 % of occurrences) but are occasionally encountered in non-wetland areas.
- Facultative species – are equally likely to grow in wetlands (34 – 66 % of occurrences) and non-wetland areas.
- Facultative Dryland species – usually grow in non-wetland areas but sometimes grow in wetlands (1 - 34 % of occurrences)

**NOTE:** The Wetland Indicators of soil form and soil wetness factor are of over-riding importance. This is because the original vegetation may have either been removed or transformed by previous land use, drainage or mining practices.

**Riparian Areas:**

Riparian habitat (as defined by the South African National Water Act 36 of 1998) includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.

DWAF (Edition 1, September 2005) states that riparian areas: are associated with a watercourse; contain distinctly different plant species than adjacent areas, and contain species similar to adjacent areas but exhibiting more vigorous or robust growth forms; and may have alluvial soils.
Survey Area:

The wetlands (thus also riparian areas) encountered within the survey area indicated on Map 3b (Wetlands) [and Map 3a - Pre-Mining Land Capability] and are summarised in Table 8.3.2b (Summary of Wetlands).

Within the Operational Area, the soil survey indicated the following:
23 pans (3.96ha, 0.14% of Operational Area);
2 pans further dammed up by a man-made wall (1.02ha, 0.04%); and
further wetland areas (permanent 13.52ha, 0.49%; seasonal 55.78ha, 2.03%; and temporary 6.27ha, 0.23%).
Thus total wetlands amount to 80.56ha or 2.94% of the Operational Area (2743.59ha).

These wetlands are ephemeral in nature; dissipate a short distance after they commence; are generally underlain by solid rock or hard plinthite (ferricrete) at approximately 40-70cm below the surface; are not connected to streams and thus do not constitute catchment areas; and are commonly occurring features in the surrounding areas in general.
Thus, the loss of these wetland areas due to mining related activities is deemed acceptable by the author.

An ephemeral stream is defined in Appendix III of our report as follows: “A stream or portion of a stream that flows only in direct response to precipitation, and receives little or no water from springs or no long continued supply from snow or other sources, and its channel is at all times above the water table”.

Anthropogenic (i.e. due to the activities of man - seepage/runoff/discharge from man-made features) wetlands were not encountered. However, three man-made ponds occur in terrestrial (non-wetland) areas.

The wetlands in the Operational Area are further described in the following Sections of the current report:
Section 8.4.2 (BROAD VEGETATION COMMUNITIES); Sub-Point g) Hydromorphic (Wetland) Soils; and
Section 8.5 (SENSITIVE LANDSCAPES); Sub-Points: i) Natural Wetland Soils, ii) Natural Wetland Drainage Features, and iii) Wetland/Riparian Vegetation.
### Table 8.3.2(b): Summary of Wetlands

<table>
<thead>
<tr>
<th>Land Capability</th>
<th>Map Notation</th>
<th>Description</th>
<th>Count</th>
<th>Area</th>
<th>ha</th>
<th>%</th>
<th>Area</th>
<th>ha</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetland</td>
<td>Wp</td>
<td>Wetland (Permanent) [ERD &lt; 10cm, generally Katspruit form].</td>
<td>7</td>
<td>13.52</td>
<td>0.49</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pan</td>
<td>Note: Wp (Wetland Permanent); and Pan.W (Pan displaying a man-made wall in order to increase the water storage capacity)</td>
<td>23</td>
<td>3.96</td>
<td>0.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pan.W</td>
<td>Wetland (Seasonal) [ERD 20-30cm; generally Westleigh form, occasionally Sepane and Glenrosa forms]</td>
<td>2</td>
<td>1.02</td>
<td>0.04</td>
<td></td>
<td>80.55</td>
<td>2.94</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ws</td>
<td>Wetland (Seasonal) [ERD 20-30cm; generally Westleigh form, occasionally Sepane and Glenrosa forms]</td>
<td>18</td>
<td>55.78</td>
<td>2.03</td>
<td></td>
<td>80.55</td>
<td>2.94</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wt</td>
<td>Wetland (Temporary) [ERD 40-50cm; Sepane and Tukulu forms]</td>
<td>4</td>
<td>6.27</td>
<td>0.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL (WETLANDS)</td>
<td></td>
<td></td>
<td>54</td>
<td>80.56</td>
<td>2.94</td>
<td></td>
<td>80.55</td>
<td>2.94</td>
<td></td>
</tr>
</tbody>
</table>

| 'Other' (Man-made) | Pond | Pond (and man-made earth Wall) constructed in a terrestrial (non-wetland) area | 3 | 0.47 | 0.02 | 0.47 | 0.02 |
8.4 LAND USE BASELINE
(Refer to Map 4; Table 8.4; and Figure 8.1.1)

The present land use in the Operational Area is presented on Map 4 (Present Land Use), and summarised in Table 8.4 (Summary of Present Land Use).

The regional land use is discussed in Section 8.1.8 (REGIONAL LAND USE), and is evident in Figure 8.1.1 (Location and Topography of Study Area).

The land use both within and immediately adjacent to LCPP is dominated by game ranching/farming and eco-tourism, and to a lesser extent cattle ranching. Thus occasional-rare farm related structures also exist including homesteads, residences, hunting accommodation, labour accommodation, farm sheds, workshops, boreholes, windmills, reservoirs, water tanks, and water/feeding troughs. Occasional lands are also spread out throughout the area, the aforementioned probably producing dryland hay and other types of livestock feed on a small scale.

8.4.1 MAN-MADE FEATURES
(Refer to Map 4; and Tables 8.4 and 8.4.1)

The man-made features and structures within the Operational Area are presented on Map 4 (Present Land Use), and summarised on the corresponding summary Tables 8.4 (Summary of Present Land Use) and 8.4.1 (Summary of Man-Made Structures). The former Table indicates the district dirt road, three ponds, eight farmyards, four cattle kraals, and one citrus orchard; while the latter Table indicates a variety of human/ranching related structures. Both Tables also indicate the number (‘count’) of relevant features/structures.

Map 4 also indicates numerous tracks on the various farms, as well as previously cultivated areas that are concentrated at six locations.
Table 8.4: Summary of Present Land Use

<table>
<thead>
<tr>
<th>Group</th>
<th>Map Notation</th>
<th>Description</th>
<th>Count</th>
<th>Area</th>
<th>ha</th>
<th>%</th>
<th>Area</th>
<th>ha</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terrestrial Natural</td>
<td>Bush</td>
<td>Bush, Savannah, occasional Grassland; and frequent Bare Patches</td>
<td>2</td>
<td>2575.59</td>
<td>93.88</td>
<td>2575.59</td>
<td>93.88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetland Natural</td>
<td>Wp</td>
<td>Riparian vegetation</td>
<td>7</td>
<td>8.47</td>
<td>2.93</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pan</td>
<td>Bare surface, Standing water during rainy season</td>
<td>23</td>
<td>3.96</td>
<td>0.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pan.W</td>
<td>Bare surface, Standing water during rainy season</td>
<td>2</td>
<td>1.02</td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ws</td>
<td>Riparian vegetation</td>
<td>18</td>
<td>55.69</td>
<td>2.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wt</td>
<td>Riparian vegetation</td>
<td>4</td>
<td>6.27</td>
<td>0.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetland in Farming related area</td>
<td>Ws.Farmyard</td>
<td>Seasonal Wetland passing through a Farmyard</td>
<td>1</td>
<td>0.09</td>
<td>0.00</td>
<td>0.09</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terrestrial Farming / Ranching Related Area</td>
<td>Cp</td>
<td>Cultivated Previously (occasionally long ago)</td>
<td>12</td>
<td>79.67</td>
<td>2.90</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Orchard</td>
<td>Citrus</td>
<td>1</td>
<td>0.05</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kraal</td>
<td>Cattle Kraal</td>
<td>4</td>
<td>0.23</td>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Farmyard</td>
<td>Farmyard (bare, trees, or open; high traffic areas)</td>
<td>8</td>
<td>3.09</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Other' (Man-made), Terrestrial</td>
<td>Pond</td>
<td>Pond (and man-made earth Wall) constructed in a non-wetland area</td>
<td>3</td>
<td>0.47</td>
<td>0.02</td>
<td>0.47</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>District Road</td>
<td>District Road (Dirt)</td>
<td>1</td>
<td>3.95</td>
<td>0.14</td>
<td>3.95</td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL (LAND CAPABILITY)</td>
<td></td>
<td></td>
<td>86</td>
<td>2743.60</td>
<td>100.00</td>
<td>2743.60</td>
<td>100.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Refer to the accompanying legend for man-made Structures
Table 8.4.1: Summary of Man-Made Structures

<table>
<thead>
<tr>
<th>Man-Made Structures</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borehole/Pump</td>
<td>1</td>
</tr>
<tr>
<td>Borehole</td>
<td>2</td>
</tr>
<tr>
<td>Chalet</td>
<td>2</td>
</tr>
<tr>
<td>Construction</td>
<td>1</td>
</tr>
<tr>
<td>Dip</td>
<td>2</td>
</tr>
<tr>
<td>Garage</td>
<td>1</td>
</tr>
<tr>
<td>House</td>
<td>11</td>
</tr>
<tr>
<td>House &amp; Braai</td>
<td>2</td>
</tr>
<tr>
<td>IR (i.e. Informal House Ruins)</td>
<td>3</td>
</tr>
<tr>
<td>Lounge/Kitchen</td>
<td>1</td>
</tr>
<tr>
<td>Pool</td>
<td>1</td>
</tr>
<tr>
<td>Reservoir</td>
<td>7</td>
</tr>
<tr>
<td>Reservoir?</td>
<td>2</td>
</tr>
<tr>
<td>Residence</td>
<td>5</td>
</tr>
<tr>
<td>Rondawel</td>
<td>4</td>
</tr>
<tr>
<td>Shed</td>
<td>5</td>
</tr>
<tr>
<td>Silo</td>
<td>2</td>
</tr>
<tr>
<td>Tank</td>
<td>1</td>
</tr>
<tr>
<td>Tank (JoJo)</td>
<td>4</td>
</tr>
<tr>
<td>Tank (JoJo) &amp; Solar</td>
<td>1</td>
</tr>
<tr>
<td>Tower</td>
<td>1</td>
</tr>
<tr>
<td>Trough</td>
<td>5</td>
</tr>
<tr>
<td>Trough.F (i.e. Trough for Feed)</td>
<td>8</td>
</tr>
<tr>
<td>Trough.F (x7) (i.e. Trough for Feed - 7 troughs)</td>
<td>1</td>
</tr>
<tr>
<td>Trough.W (i.e. Trough for Water)</td>
<td>3</td>
</tr>
<tr>
<td>U (i.e. Undifferentiated / Unknown)</td>
<td>16</td>
</tr>
<tr>
<td>Windmill (or WM)</td>
<td>3</td>
</tr>
<tr>
<td>Workshop</td>
<td>1</td>
</tr>
</tbody>
</table>

8.4.2 BROAD VEGETATION COMMUNITIES
(Refer to Map 4; and Table 8.4)

The vegetated areas are presented on Map 4 (Present Land Use), and summarised in Table 8.4.1 (Summary of Present Land Use).

Although degraded or transformed in sections, the vegetated areas include the following:
- Bush (or Savannah) in Terrestrial (non-wetland) areas: 2575.59ha (93.88 % of Operational Area); and
- Wetland/Riparian Vegetation in Wetland areas: 80.47ha (2.93 %); and
- Total Vegetated area: 2656.06ha (96.81 %).

Soil texture in the Operational Area varies as follows:
- Yellow-brown apedal, Neocutanic, Shallow, and Carbonate soils (broad soil groups): loamy-sand to sandy-loam textures (clay content approximately 5 - 16%),
- Red apedal soils: sandy-loam to sandy-clay-loam (clay content approximately 10 - 26%),
- Pedocutanic soils: clay to sandy-clay -loam textures (clay content approximately 55 - 30%), and
- Hydromorphic soils: sandy-loam to clay textures (clay content approximately 15 - 55%).

Within the Operational Area we record the following observations regarding soil form, vegetation occurring, and levels of soil erosion:

a) Red apedal soils – Hutton and Lichtenburg forms.
Bush and frequent Grasses: Usually slightly eroded (least eroded of all the broad soil groups).

b) Yellow-brown apedal soils – Clovelly and Glencoe forms.
Bush (Combretum spp. dominant) and frequent-rare Grasses. Usually moderately eroded.

c) Neocutanic soils – Tukulu form.
Refer to point g).

d) Pedocutanic (i.e. Structured) soils – Swartland and Bonheim forms.
Bush and Bare Surface (Grasses mostly gone). Much larger growth forms (size) of trees than on other soil types, the aforementioned due to the increased clay content (clay to sandy-clay-loam textures = increased moisture holding capacity). These soils are usually severely-highly eroded due to a reduced (relative to the other soils) subsoil infiltration rate (slow to moderate). The majority of these soils are saline. Surface capping is evident in some areas, and particularly so in the north-eastern extent of where these soil forms occur.

e) Shallow soils (i.e. lithosols):
- Glenrosa and Mispah forms:
  Shrubby vegetation and Bare Surface (Grasses mostly gone). Usually severely eroded.
- Dresden form:
  Shrubby vegetation and rare Grasses. Usually highly eroded.

f) Carbonate soils:
Augrabies, Addo, Prieska, Montagu, Brandvlei, and Coega forms [most display saline profiles].
Bush and frequent-rare Grasses. Usually frequent Acacia (and Shepherds bush in some areas); stony/rocky surface; saline. Usually moderately-slightly eroded.

Plooysburg, Kimberley, and Molopo forms [do not display saline profiles].
Vegetation and erosion status more similar to that occurring on the red apedal and yellow-brown apedal soils.

g) Hydromorphic (Wetland) soils – Katspruit and Westleigh forms:

Both the relative proportions of ‘grasses’ to shrubs/trees, as well as the relative size of the growth forms of the various trees in the wetlands of the Operational Area appear to be dependent on the Effective Rooting Depth (ERD) of the soil. The ERD in such areas is limited by either a fluctuating water-table (characterised by the soft-plinthic B-horizon) or a semi-permanent to permanent water-table (characterised by the G-horizon), in these instances.
the depth limiting horizon occurring directly below the topsoil (A-horizon). The Katspruit and Westleigh forms are relevant, the ERD varying from 0-10cm for the former, and 20-40cm for the latter form.

The ERD may alternatively be limited by either a fluctuating or a semi-permanent to permanent water-table that occurs directly below the B-horizon as the third soil horizon (characterised by the unconsolidated material with signs of wetness, or the unspecified material with signs of wetness horizons). Although the Sepane (Pedocutanic broad soil group) and Tukulu forms (Neocutanic broad soil group) are not grouped with the Hydromorphic soils, these soil forms constitute wetlands where the signs of wetness (mottling and bleached colours) occur at ≤50cm below the soil surface.

Vegetation in lower wetland vlei or drainage line areas (i.e. wetland riparian vegetation):
- Katspruit form (ERD 0 - 10cm): bare surface in pan areas, or open ‘grasslands’ (frequently with sedges) in the vleis surrounding a number of these areas;
- Westleigh form (ERD 20 - 30cm): savannah displaying small growth forms of trees in vlei edge areas;
- Westleigh form (ERD 30 - 40cm): savannah or bush displaying medium growth forms of trees in lower drainage line areas;
- Sepane and Tukulu forms (ERD 40 - 50cm): bush displaying large growth forms of trees in lower to middle drainage line areas.
All of the aforementioned areas are usually slightly eroded.

Vegetation in upper non-wetland drainage areas, generally very slightly concave (i.e. also riparian vegetation):
- Sepane and Tukulu forms, also other forms (ERD 60 - >150cm): dense bush displaying large to very large growth forms of trees. The large to very large growth forms in these areas occur where the signs of wetness occur too deeply below the soil surface (>50cm) to be either classifiable as wetlands, or to be encountered with the soil auger (in many cases). However, trees roots are able to access the moisture in such areas, either directly or by capillary action, thereby resulting in the large to very large growth forms of the trees.

8.4.3 HUMAN SETTLEMENT
(Refer to Map 4; and Tables 8.4 and 8.4.1)

Human settlement is indicated on Map 4 (Present Land Use), and is summarized in Tables 8.4 (Summary of Present Land Use) and 8.4.1 (Summary of Man-Made Structures).

Current human settlement within the Operational area is essentially comprised of the following:
- Residences (i.e. main farmhouse) on each of the farms in the Operational Area (except Garibaldi). Associated structures such as sheds, workshops, garages, rondawels, chalets, windmills, boreholes, reservoirs, and water tanks are present in the immediate vicinity of each of these sites; and
- Houses for guests or labour are frequently present in either the immediate vicinity of the residences, or further away from these main settlement sites.
- Each of the residence or house sites is surrounded by an open area described on Map 4 as a ‘farmyard’.
Previous (but contemporary) settlement sites are described as Informal Ruins (‘IR’) on Map 4. These sites include brick and concrete rubble scattered around the relevant areas.

No signs of historical human settlement (e.g. kraal ruins, mud house floors, pottery, or Stone Age chards) were encountered during the course of the soil survey.

8.4.4 HISTORICAL AGRICULTURAL PRODUCTION
(Refer to Map 4; and Tables 8.4 and 8.4.1)

Ranching (game and cattle) and farming related activities within the Operational Area are indicated on Map 4 (Present Land Use), and are summarized in Tables 8.4 (Summary of Present Land Use) and 8.4.1 (Summary of Man-Made Structures).

a. Agriculture

Previous cultivation was identified at six locations, the aforementioned being comprised of twelve distinct fields in terrestrial areas amounting to 79.67ha (2.90 % of Operational Area). The majority of the cultivated areas are located within arable capability class areas of the Hutton form, while others are located in grazing areas of the Clovelly form, and a lesser number in non-grazing (wilderness) areas of the Glenrosa form.

These dryland fields were probably predominantly utilised to produce supplementary feed for livestock in the past.

Ranching/farming related features and structures are discussed in Sections 8.4.1 (MAN-MADE FEATURES) and 8.4.5 (EXISTING STRUCTURES).

Crop production is discussed in Section 8.2.8 (DRYLAND / IRRIGATED PRODUCTION POTENTIAL).

b. Grazing and Browsing

The indigenous bush, savannah, ‘grasslands’ and wetlands were before the settlement of man utilised by wildlife for both grazing (e.g. impala and zebra) and browsing (e.g. kudu, giraffe, elephant and black rhino).

With the arrival of settlers and cattle, the massive reduction in wildlife populations, regular burning to expand the grasslands, overstocking/overgrazing by cattle, reduced grass basal cover and severe to moderate sheet erosion; the natural balance has been completely changed. The degradation of the area has mostly occurred in the last 100 years.

The farms are now utilised for game ranching/farming and eco-tourism, and to a lesser extent cattle ranching.

The farmers should completely discontinue burning for a good number of years, while grazer stocking densities must be kept as absolutely low as possible; to give the land a chance to ‘recover’ somewhat.
8.4.5 EXISTING STRUCTURES
(Refer to Map 4; and Tables 8.4 and 8.4.1)

The existing man-made structures within the Operational Area are presented on Map 4 (Present Land Use), and summarised on the corresponding summary Tables 8.4 (Summary of Present Land Use) and 8.4.1 (Summary of Man-Made Structures).

The former Table indicates the district dirt road, three ponds, eight farmyards, four cattle kraals, and one citrus orchard; while the latter Table indicates a variety of human/ranching related structures. Both Tables also indicate the number (‘count’) of relevant features/structures.

8.4.6 EVIDENCE OF MISUSE
(Refer to Maps 2a and 4)

a. Agriculture

Overgrazing and soil erosion are evident in the vast majority of the surveyed area, the levels of sheet erosion being indicated on Map 2a (Soil Mapping Units).

The levels of overgrazing/soil erosion on the various farms generally appear to be as follows (from most to least eroded): Grootgenoeg Ptn.1 (very highly eroded in many sections), Honingshade (highly eroded), Grootgenoeg Ptn. 0 (moderately-highly), Weltevreden Ptn. 0 (moderately-highly), Botmansdrift (moderately), Weltevreden Ptn. 1 (slightly-moderately), and Garibaldi (slightly). The current levels of grass basal cover are closely correlated with the existing levels of soil erosion.

The levels of grass cover/erosion on the various broad soil groups appear to be as follows (from most eroded to least eroded - related to topsoil permeability, depth to relatively impermeable horizon, organic carbon content, and slope): shallow, pedocutanic, yellow-brown apedal, neocutanic, hydromorphic, carbonate, and red apedal.

Severe soil sheet erosion occurs throughout almost the entirety of the area. At most sites, soil losses of between approximately 5 - 15 cm have occurred throughout approximately 40 - 80 % of the surface area, the only relatively non-eroded areas being those underlying low vegetation such as small bushes and trees. The vast majority of the erosion appears to have occurred in the relatively recent past, the result of the introduction of cattle (mostly now gone), over-grazing, cycles of consecutive years of drought, consequent relatively bare surfaces at the commencement of the rainy season, and then rain drop and sheet erosion during heavy thunderstorms. Consequently grass cover generally occurs in patches in the more protected sites, with larger relatively bare patches in-between.

Soil fertility and nutrient cycling will have been severely affected by the loss on average of over half of the A-horizon, where organic matter (now mostly lost) is mostly concentrated. Organic matter supplies greater than 99 % of total soil nitrogen and 33 - 67 % of total soil phosphorus, while humus, the active fraction of soil organic matter has
a very high CEC (between 150 and 300 cmol(+) kg\(^{-1}\)) and can adsorb up to about 6 times its own weight in water.

Burning must be discontinued in all areas by the ranchers/farmers, since the resultant loss of mulch and organic matter will result in an increase in soil erosion, further disrupt the nutrient cycle and reduce the moisture holding capacity of these already degraded (eroded) topsoils.

Sequences of brush lines of woody material in combination with other obstacles must be laid out along the contour in severely eroded areas to slow and trap runoff. Mowed seeded grass should be laid out underlying the brush lines, in the hope of germination and creating grass cover and habitat.

b. Mining, Processing and Industry

Evidence of misuse from the mining/processing perspective is not currently applicable in the current green fields Study Area.

However, commonly occurring issues associated with existing mining/processing sites in other areas are highlighted in the Sections mentioned in the next paragraph, so that the same mistakes are avoided in the current potential project area.

Mitigation measures for the identified points are addressed in the following sections of the report:
Section 9.2.2 (IMPACT SIGNIFICANCE RATING AND MANAGEMENT MEASURES), and specifically Tables 9.2.2a-d; and
Section 11 (TECHNICAL DETAILS OF MANAGEMENT MEASURES), and specifically Sub-Section 11.10 (POLLUTION).
8.5 SENSITIVE LANDSCAPES
(Refer to Maps 2a, 3a, 3b and 4; and Tables 8.2.2, 8.3.1b, 8.3.2b and 8.4)

The soils within the survey area are indicated on Map 2a (Soil Mapping Units) and are summarized in Section 8.2.2 (Summary of Soil Form). The wetlands within the survey area are described in Section 8.3.2 (WETLAND CLASSIFICATION / DELINEATION AND RIPARIAN AREAS), indicated on Maps 3a (Pre-Mining Land Capability) and 3b (Wetlands), and are summarized in Tables 8.3.1b (Summary of Pre-Mining Land Capability) and 8.3.2b (Summary of Wetlands). The vegetated areas within the survey area are indicated on Map 4 (Present Land Use) and are summarized in Table 8.4 (Summary of Present Land Use). Refer to the aforementioned for further information.

i) Natural Wetland Soils

Wetlands and their associated riparian areas are generally regarded as especially sensitive landscapes under statutory protection, and as such must not be disturbed, polluted, cultivated or overgrazed without a licence. Such areas have a high significance from a preservation point of view, since they perform important hydrological functions, and are major contributors to the bio-diversity of an area.

Within the Operational Area, the soil survey indicated the following: 23 pans (3.96ha, 0.14% of Operational Area); 2 pans further dammed up by a man-made wall (1.02ha, 0.04%); and further wetland areas (permanent 13.52ha, 0.49%; seasonal 55.78ha, 2.03%; and temporary 6.27ha, 0.23%). Thus total wetlands amount to 80.56ha or 2.94% of the Operational Area (2743.59ha). The Westleigh (dominant), Katspruit (sub-dominant), and Rensburg (extremely rare) soil forms of the hydromorphic broad soil group occur in these areas.

ii) Natural Wetland Drainage Features

A limited number of short disconnected slightly concave ephemeral drainage features exist in the Operational area, these features being occupied by the aforementioned natural wetland soils. Drainage gullies, streams and rivers do not exist in the immediate area.

The free (uninterrupted) flow of water (surface and sub-surface) must be promoted in all areas.

iii) Wetland/Riparian Vegetation

The main categories of wetland/riparian vegetation in the Operational Area are described in Section 8.4.2 (BROAD VEGETATION COMMUNITIES). Riparian vegetation must ideally be preserved for the following reasons: represents a major contributor to the bio-diversity in any area; stabilizes drainage areas; limits and slows runoff; traps sediments; and promotes evapotranspiration.

The wetland soils / wetland drainage features / wetland-riparian vegetation occurring within the Operational Area are not deemed to represent fatal flaws by the author for the following reasons:
ephemeral in nature; dissipate a short distance after they commence; are generally underlain by solid rock or hard plinthite (ferricrete) at approximately 40-70cm below the surface; are not connected to streams and thus do not constitute catchment areas; and are commonly occurring features in the surrounding areas in general. Thus, the loss of these wetland areas due to mining related activities is deemed acceptable by the author.

iv) Erodible Soils

Despite the determined erosion slopes in Section 8.2.7 (EROSION HAZARD AND SLOPE; In-Situ [Undisturbed] Soils), soil erosion is a major issue in the natural vegetated areas.

Severe soil sheet erosion occurs throughout almost the entirety of the area. At most sites, soil losses of between approximately 5 - 15 cm have occurred throughout approximately 40 - 80 % of the surface area, the only relatively non-eroded areas being those underlying low vegetation such as small bushes and trees. The vast majority of the erosion appears to have occurred in the relatively recent past, the result of the introduction of cattle (mostly now gone), over-grazing, burning, cycles of consecutive years of drought, consequent relatively bare surfaces at the commencement of the rainy season, and then rain drop and sheet erosion during heavy thunderstorms. Soil fertility and nutrient cycling will have been severely affected by the loss on average of over half of the A-horizon, where organic matter (now mostly lost) is mostly concentrated.

The removal of grass cover leads to raindrop splash erosion by raindrops, whereby the grass cover is not available to break raindrop energy. Thereafter, in the absence of significant grass cover to slow and trap runoff, soil sheet erosion occurs. Furthermore, the loss of mulch and organic matter due to fire or erosion (water and wind) reduces the soils structural condition and moisture holding capacity, thereby making degraded soils far more susceptible to erosion as they are in the current area.

The soils in the study area that are likely to be more sensitive to erosion than others include the following:
- Pedocutanic soils, due to a slow-moderate subsoil permeability; and
- Shallow soils, due to a relatively impermeable (to water) depth limiting horizon within 10 - 30cm below the soil surface, the aforementioned being either hard plinthite (Dresden form) or hard rock (Mispah form).

Thus, both of these broad soil groups are prone to temporary waterlogging in the topsoil after heavy or prolonged rainfall events, and thereafter ensuing surface runoff and erosion.

v) Vegetative Cover

All soils are more susceptible to erosion when the vegetative cover (grass/trees) is removed, or the litter layer is burnt.
Severe overgrazing and fire are the likely causes of the low grass basal cover and thus severe to moderate levels of sheet erosion that occur throughout the majority of the survey area. In eroded areas, grass cover generally occurs in patches in the more protected sites, with larger relatively bare patches in-between.

The farmers should completely discontinue burning for a good number of years, while grazer stocking densities must be kept as absolutely low as possible; to give the land a chance to ‘recover’ somewhat. Rehabilitated areas must be correctly re-graded and re-vegetated from the outset.

vi) Anthropogenic Moisture

Although anthropogenic moisture does not occur in the current green fields site, the potential for the phenomenon is described in Section 11.10 (POLLUTION); Point A: Polluted Water – Limitation/Prevention of Seepage in Waste-Water and Other Disposal Facilities, Sub-Points: i) and ii).

The infiltration / seepage / runoff of ‘dirty’ water may take place in certain sections of mining / raw material / processing / plant / dumping / containment areas during the operational and closure phases of a project.

Measures must be taken to prevent/limit the infiltration of ‘dirty’ water into the soils, and thereafter into the perched soil water-table, perched ‘ground’ water-table and ‘deeper’ groundwater-tables, and ultimately the streams in certain areas.

vii) Paleochannels and Naturally Buried Soils

No such soils were encountered.

Provided that potential future mining /processing/containment procedures are conducted appropriately, then the impact to the soils/land capability/land use will be limited.

8.6 SITES OF CULTURAL AND ARCHAEOLOGICAL INTEREST

(Refer to Map 4 and Table 8.4.1)

Sites of archaeological interest were not encountered in the current area.

Sites of cultural interest are indicated on Map 4 (Present Land Use), and are summarized in Table 8.4.1 (Summary of Man-made Structures) in Section 8.4.1 (MAN-MADE FEATURES) of the current report.

All of these contemporary structures are related to game and cattle ranching, eco-tourism, and farming.

The identified sites will be forwarded to a heritage specialist for further investigation and comment.
9. IMPACT AND RISK ASSESSMENT
(Refer to Tables 9.2.1(a-c), 9.2.2(a-d), 12, and 17)

9.1 IDENTIFICATION AND DESCRIPTION OF TOPOGRAPHICAL IMPACTS

An Environmental Impact Assessment was performed for each of the project life-cycle phases (i.e. construction phase, operational phase, decommissioning and post-closure phase), for all the project related activities, to determine what the impact will be on the environment. The Environmental Impact Assessment is compliant with the NEMA regulations.

Generally, the Impact Assessment method comprises of four parts:

Activity Identification;
Aspect Identification;
Impact Definition; and
Impact Evaluation.

These four parts are systematically addressed in the sections below. Firstly, the Activities deemed to have a potential impact were identified and categorised to identify the Aspect related to each Activity per life cycle phase. Afterwards, the Environmental Impact (Impact Category and Impact Description) associated with the Aspect was defined and finally, evaluated with reference to the Impact Assessment Methodology.

9.1.1 RELEVANT PROJECT ACTIVITIES

Activities as defined by the National Environmental Management Act 107 of 1998, means policies, programmes, processes, plans and projects.

Activities associated with the project deemed to have a potential impact are listed in the top rows of each of the numerous Sub-Tables associated with the following main Tables:

Table 9.2.2(a): Impact Significance and Management Measures (Construction -Phase);
Table 9.2.2(b): Impact Significance and Management Measures (Operational Phase);
Table 9.2.2(c): Impact Significance and Management Measures (Decommissioning and Closure Phase); and
Table 9.2.2(d): Impacts and Management Measures (Post-Closure Phase).

[i.e. This section is comprised of listing the Activities and Aspects identified which could potentially have an impact on the environmental components relevant to our study. The Impact Category (e.g. Soil Distribution, Soil Quality, and Soil Contamination) and Impact... ]
Description (e.g. Soil Contamination due to spillages and blown dust) relevant to the various Activities and Aspects will also be considered.

Separate Activity lists have not been produced within current Section 9.1.1 to limit the duplication of information.

9.1.2 IDENTIFICATION OF ASPECTS PER LIFE CYCLE PHASE

An Environmental Aspect is the mechanisms by which the project activities impact on receptors (e.g. people, economy, infrastructure, institutions and natural environment).

Aspects associated with the above mentioned Activities were identified for each life-cycle phase and are relayed into the top rows of each of the numerous Sub-Tables associated with previously mentioned Tables 9.2.2 (a) – 9.2.2 (d).

[i.e. the Activities and Aspects identified in Section 9.1.1 are entered into the Tables 9.2.2(a)-(d)].

A separate Activity/Aspect/Impact Identification Table has not been produced within current Section 9.1.2 to limit the duplication of information.

9.1.3 IMPACT DESCRIPTION/DEFINITION PER LIFE CYCLE PHASE

Impact Category, Impact Type and Impact Descriptions associated with the above mentioned Aspects were identified for each life-cycle phase; and are relayed in the top rows of each of the numerous Sub-Tables associated with previously mentioned Tables 9.2.2 (a) - 9.2.2 (d).

[i.e. The Impact Category (e.g. Soil Distribution, Soil Quality, and Soil Contamination) and Impact Description (e.g. Soil Contamination due to spillages and blown dust) relevant to the various Activities and Aspects identified in Section 9.1.1 will be entered into Tables 9.2.2(a)-(d) respectively. The Type of Impact (e.g. Direct, Indirect, Cumulative, or Fatal Flaw) may also be entered into Tables 9.2.2(a)-(d)].

A separate Impact Category, Impact Type, and Impact Description Identification Table is not included within current Section 9.1.3 to limit the duplication of information.

Impact Category and Impact Description

Impacts for Soils are considered in four categories namely:

- **Impact Category: Soil Distribution**

  Impact Description: **Loss of Soil Horizons/Depth** due to ‘topsoil’ (suitable A- and B-horizons) stripping (and stockpiling) from the sites of proposed infrastructure during the construction phase of a project; or by soil erosion; or by the covering over of the in-situ soils by ‘waste’ and/or ‘non-waste’ material during the operational phase of a project.
• **Impact Category: Soil Erosion**

  Impact Description: **Soil Erosion** due to excessive final ‘rehabilitated’ slopes.

• **Impact Category: Soil Quality**

  Impact Description: **Loss of Soil Fertility or Soil Compaction.**

  The aforementioned mainly refers to the following:

  - The utilization (mechanized stripping, stockpiling and ‘topsoiling’ activities) or trafficking of machinery when the soils are too moist (or wet), resulting in soil compaction;
  
  - ‘Topsoil’ stockpiles that are too high (higher than 1.5m) or areas covered over by ‘wastes’ and/or ‘non-wastes’ resulting in soil compaction, the loss of soil fertility, and the loss of the reproductive seed-bank; and
  
  - ‘Topsoil’ stockpiles or man-made ‘soil’ slopes that are too steep and/or non-vegetated, resulting in soil erosion.

• **Impact Category: Soil Contamination**

  Impact Description: **Contamination (Pollution)** of soil due to spillages or dumping of discard, ash, raw materials, ore, product or ‘wastes’ during transport or during the operational phase; or due to the settling of blown dust or plant/industry/smelter fallout; or due to spillage/leakage/seepage of contaminated ‘dirty’ water from pipes, canals, sumps and dams; or due to the seepage and infiltration of contaminated ‘dirty’ water from waste disposal facilities (discard dumps, slurry dams, and ash dumps), plant areas, dams, spread ‘waste’ layers, raw materials, ore or product.

  This impact largely relates to the Downward/Lateral infiltration of pollutants/salts/hydrocarbons from contaminated surface materials, ‘waste’ layers (man-made layers) or ‘dirty’ water reticulation, into (infiltration), or onto (wind-blown) the underlying or surrounding *in-situ* soil horizons or water-tables; or Upward capillary movement into uncontaminated *in-situ* soil horizons or rehabilitation ‘topsoil’ material.

  Impacts are also relevant to Land Capability and Land Use as follows:

• **Impact Category: Land Capability**

  Impact Description: **Change in Land Capability** due to reduced soil depth (‘rehabilitation’ ‘topsoiling’ depth) and/or an increased slope; as compared with the pre-disturbance state.

• **Impact Category: Land Use**

  Impact Description: **Change in Land Use** (post-disturbance state); as compared with the pre-disturbance state.
However, given that the Soils, Land Capability and Land Use are inter-related and inter-
dependant on each other, not all Impact Categories (particularly Land Capability and Land
Use) were mentioned in all cases to avoid duplication. The Land Capability and Land Use
obviously changes in the majority of instances where the soil has been impacted, these
changes being due to the various previously mentioned Soils Impact Categories.

For example, the Impact Category Soil Distribution (soil stripping) will change both the Land
Capability and Land Use, while Soil Erosion will affect land use (reduced grass basal cover).
Thus the Impact Categories were often considered collectively.

**Impact Type**

Impact Types include the following:

- **Direct Impacts**
  Occur directly on the site of the relevant Aspect.

- **Indirect Impacts**
  Occur either in the immediate surrounds or further away from the relevant Aspect.

- **Cumulative Impacts**
  A cumulative impact is defined in GNR 543 (EIA Regulations of 18 June 2010) as:
  “[a] ‘cumulative impact’ in relation to an activity, means the impact of an activity that in
  itself may not be significant, but may become significant when added to the existing and
  potential impacts eventuating from similar or diverse activities or undertakings in the
  area.”

- **Fatal Flaw**
  This is a very significant adverse impact which cannot be avoided or mitigated.

Direct impacts ideally require quantitative assessment as opposed to Indirect and Cumulative
Impacts that are described qualitatively. In addition, an indication of any fatal flaws are also
considered and provided in Tables 9.2.2 (a) – 9.2.2 (c) [where applicable].

A description of the method utilised to quantify Impacts (particularly Direct Impacts) is
provided in Chapter 10 (QUANTIFICATION OF IMPACTS) of this report.
9.2 EVALUATION OF IMPACTS

9.2.1 IMPACT RATING METHODOLOGY

This section is comprised of the impact rating methodology by means of the following Tables: Table 9.2.1(a). Key Elements in the Evaluation of Impact Significance, Table 9.2.1(b). Characteristics to be Used in Impact Descriptions, and Table 9.2.1(c). Method for Rating the Significance of Impacts.

Table 9.2.1(a): Key Elements in the Evaluation of Impact Significance

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Questions applied to the test of Significance</th>
</tr>
</thead>
</table>
| **Consequence**                 | An impact or effect can be described as the change in an environmental parameter, which results from a particular project activity or intervention. Here the term consequence refers to:  
  • The sensitivity of the receiving environment, including its capacity to accommodate the kinds of changes the project may bring about  
  • The type of change and the key characteristics of the change (these are magnitude, extent and duration)  
  • The importance of the change (the level of public concern/ value attached to environment by the stakeholders and the change effected by the project)  
  The following should be considered in the determination of impact consequence:  
  • Standards and Guidelines (e.g. pollution and emissions thresholds)  
  • Scientific evidence and professional judgment  
  • Points of reference from comparable cases  
  • Levels of stakeholder concern                                                                 | Will there be a change in the biophysical environment?  
  Is the change of consequence (of any importance)? |
| Probability                     | Likelihood/ Chances of an impact occurring                                                            | Is the change likely to occur?                                                                                     |
| **Effectiveness of the**        | Significance of the impact needs to be determined both without management measures and with management measures.  
  The significance of the unmanaged impact needs to be determined so there is an appreciation of what could occur in the absence of management measures and of the effectiveness of the proposed management measures. | Will the management measures reduce impact to an acceptable level?                                                      |
| Management Measures**           |                                                                                                        |                                                                                                              |
| **Uncertainty/ Confidence**     | Uncertainty in impact prediction and the effectiveness of the proposed management measures. Sources of uncertainty in impact prediction include:  
  • Scientific uncertainty – limited understanding of an ecosystem or affected stakeholder and the processes that govern change  
  • Data uncertainty – restrictions introduced by incomplete, contradictory or incomparable information, or by insufficient measurement techniques  
  • Policy uncertainty – unclear or disputed objectives, standards or guidelines | What is the degree of confidence in the significance ascribed to the impact? |
|                                |                                                                                                        |                                                                                                              |
Table 9.2.1(b): Characteristics to be used in Impact Description

<table>
<thead>
<tr>
<th>Characteristics used to describe Consequence</th>
<th>Sub-Components</th>
<th>Terms used to describe the Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td></td>
<td>Biophysical, social or economic</td>
</tr>
<tr>
<td><strong>Nature</strong></td>
<td></td>
<td>Direct or Indirect or Cumulative</td>
</tr>
<tr>
<td><strong>Status</strong></td>
<td></td>
<td>Positive (a Benefit), Negative (a Cost) or Neutral</td>
</tr>
<tr>
<td><strong>Phase of Project</strong></td>
<td></td>
<td>During the Pre-Construction (if applicable), Construction, Operational, Decommissioning / Post Closure</td>
</tr>
<tr>
<td><strong>Timing</strong></td>
<td></td>
<td>Immediate, Delayed</td>
</tr>
<tr>
<td><strong>Magnitude</strong></td>
<td>Sensitivity of the Receiving environment/ receptors</td>
<td>High, Medium or Low Sensitivity Low capacity to accommodate the change (impact)/ tolerant of the proposed change</td>
</tr>
<tr>
<td></td>
<td>Severity/ Intensity (degree of change measured against thresholds and/ or professional judgment)</td>
<td>Gravity/ seriousness of the impact Intensity / Influence / Power/ Strength</td>
</tr>
<tr>
<td></td>
<td>Level of Stakeholder concern</td>
<td>High, Medium or Low levels of concern All or some stakeholders are concerned about the change</td>
</tr>
<tr>
<td><strong>Spatial Extent</strong></td>
<td></td>
<td>Area/ Volume covered, Distribution, Population Site/ Local, Regional, National or International</td>
</tr>
<tr>
<td><strong>Duration (and Reversibility)</strong></td>
<td></td>
<td>Short term, Long term Intermittent, Continuous Reversible, Irreversibility Temporary, Permanent</td>
</tr>
<tr>
<td><strong>Confidence</strong></td>
<td></td>
<td>High, Medium, Low</td>
</tr>
</tbody>
</table>

The Impact Significance Rating system is presented in Table 9.2.1(c) and involves four parts:

- **Part A**: Define impact consequence using the three primary impact characteristics of magnitude, spatial scale/ population and duration;
- **Part B**: Use the matrix to determine a rating for impact consequence based on the definition identified in Part A;
- **Part C**: Use the matrix to determine the impact significance rating, which is a function of the impact consequence rating (from Part B) and the probability of occurrence; and
- **Part D**: Define the Confidence level.
### Table 9.2.1(c): Method for Rating the Significance of Impacts

**PART A: DEFINING CONSEQUENCES OF MAGNITUDE, DURATION AND SPATIAL SCALE**
(Use these definitions to define the consequence in Part B) + denotes a positive impact

<table>
<thead>
<tr>
<th>Impact Characteristics</th>
<th>Definition</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major</td>
<td>Major</td>
<td>Substantial deterioration or harm to receptors; receiving environment has an inherent value to stakeholders; receptors of impact are of conservation importance; or identified threshold often exceeded</td>
</tr>
<tr>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate/ measurable deterioration of harm to receptors; receiving environment moderately sensitive; or identified threshold occasionally exceeded</td>
</tr>
<tr>
<td>Minor</td>
<td>Minor</td>
<td>Minor deterioration (nuisance or minor deterioration) or harm to receptors; change to receiving environment not measurable; or identified threshold never exceeded</td>
</tr>
<tr>
<td>Minor +</td>
<td>Minor +</td>
<td>Minor improvement; change not measurable; or threshold never exceeded</td>
</tr>
<tr>
<td>Moderate +</td>
<td>Moderate +</td>
<td>Moderate improvement; within or better than the threshold; or no observed reaction</td>
</tr>
<tr>
<td>Major +</td>
<td>Major +</td>
<td>Substantial improvement; within or better than the threshold; or favourable publicity</td>
</tr>
</tbody>
</table>

### SPATIAL SCALE

<table>
<thead>
<tr>
<th>Site or Local</th>
<th>Regional</th>
<th>National/ International</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site specific or confined to the immediate project area</td>
<td>May be defined in various ways e.g. cadastral, catchment, topographic</td>
<td>Nationally or beyond</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DURATION</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short term</td>
<td>Quickly reversible. Less than two years</td>
</tr>
<tr>
<td>Medium term</td>
<td>Reversible over time. Life of the project</td>
</tr>
<tr>
<td>Long term</td>
<td>Permanent. Beyond closure</td>
</tr>
</tbody>
</table>

### PART B: DETERMINING CONSEQUENCE RATING
(Rate consequence based on definition of magnitude, spatial extent and duration)

<table>
<thead>
<tr>
<th>SPATIAL SCALE</th>
<th>MAGNITUDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site or Local</td>
<td>Medium</td>
</tr>
<tr>
<td>Regional</td>
<td>Low</td>
</tr>
<tr>
<td>National/ International</td>
<td>Low</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minor</th>
<th>DURATION</th>
<th>MAGNITUDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long term</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Medium term</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Short term</td>
<td>Low</td>
<td>Medium</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Moderate</th>
<th>DURATION</th>
<th>MAGNITUDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long term</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Medium term</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Short term</td>
<td>Low</td>
<td>Medium</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Major</th>
<th>DURATION</th>
<th>MAGNITUDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long term</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Medium term</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Short term</td>
<td>Medium</td>
<td>Medium</td>
</tr>
</tbody>
</table>

### PART C: DETERMINING SIGNIFICANCE RATING
(Rate significance based on consequence and probability)

<table>
<thead>
<tr>
<th>CONSEQUENCE</th>
<th>LOW</th>
<th>MEDIUM</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROBABILITY</td>
<td>of exposure to</td>
<td>impacts</td>
<td></td>
</tr>
<tr>
<td>Definite</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Possible</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Unlikely</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
</tr>
</tbody>
</table>

### PART D: CONFIDENCE LEVEL

<table>
<thead>
<tr>
<th>HIGH</th>
<th>MEDIUM</th>
<th>LOW</th>
</tr>
</thead>
</table>
9.2.2 IMPACT SIGNIFICANCE RATING AND MANAGEMENT MEASURES

This section is comprised of the following comprehensive Tables:
Table 9.2.2(a). Impact Significance and Management Measures (Construction Phase),
Table 9.2.2(b). Impact Significance and Management Measures (Operational Phase),
Table 9.2.2(c). Impact Significance and Management Measures (Decommissioning / Closure Phase), and
Table 9.2.2(d). Impacts and Management Measures (Post-Closure Phase).

Impact Significance Rating / Management Measures Tables were compiled for all three life cycle phases (Construction, Operational, and Decommissioning and Closure) of the Project. This was done for the activities deemed to have a potential impact with reference to the aspects identified. The aforementioned Tables include the following information: Activity Area, Activity, Aspect, Impact Category, Type of Impact, Impact Description, Impact Significance Rating Before Management (Measures), Mitigation Measures, Time Period for Implementation, and Impact Significance Rating After Management (Measures).

Impact Significance Rating / Management Measures Tables relevant to the Construction Phase are relayed in Table 9.2.2(a), to the Operational Phase in Table 9.2.2 (b) and finally to the Decommissioning and Closure Phase in Table 9.2.2 (c).

Impacts and Management Measures relevant to the Post-Closure Phase are relayed in Table 9.2.2(d). The aforementioned Table includes the following information: Impact Category, Mitigation Measures, and Time Period for Implementation only. The Mitigation Measures described are equally applicable to all of the previously identified Activity Areas, Activities, and Aspects.

A discussion with regards to the quantification of the impacts is provided in Chapter 10 (QUANTIFICATION OF IMPACTS) of this report. In addition, Chapter 11 (TECHNICAL DETAILS OF MANAGEMENT MEASURES) of this report is also relevant.

Furthermore, Section 8.4.6 (EVIDENCE OF MISUSE) is also relevant and must be referred to.
Table 9.2.2(a): Impact Significance and Management Measures (Construction Phase)

**ACTIVITY AREAS:** Mining, Coal Handling and Processing Plant Area (CHPP), Mine Infrastructure Area (MIA), Heavy Duty Vehicle Area (HDV)

**ACTIVITIES (AND ASPECTS):**
Electrical Distribution: ‘Clean’: 11/33 kV Switching station, Internal power lines (ASPECTS - All Potential Processes and Procedures)

**IMPACT CATEGORY:** Soil Distribution - TYPE OF IMPACT: Direct - IMPACT DESCRIPTION:
1. Soil Distribution: Loss of soil distribution (depth and horizons) at foundation sites.

<table>
<thead>
<tr>
<th>Impact AFTER Management</th>
<th>Magnitude</th>
<th>Duration</th>
<th>Scale</th>
<th>Consequence</th>
<th>Probability</th>
<th>SIGNIFICANCE</th>
<th>+/-</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minor</td>
<td>Medium</td>
<td>Site</td>
<td>Low</td>
<td>Possible</td>
<td>Low</td>
<td>-</td>
<td>High</td>
</tr>
</tbody>
</table>

**Management Measures**

**Measures 1: Soil Distribution:**
Minimal excavation of foundation holes for fence poles, pylon supports and pylon platforms; Place excavated soil in a small pile in the vicinity for rehabilitation ‘topsoiling’ in the Decommissioning/Closure phase; Avoid unnecessary disturbance of the underlying/surrounding in-situ soils at the site. Do not scalp off or poison the grass cover along fence and power line routes as this will lead to soil erosion; Utilise steel (not wooden) poles for fences and power lines; No grazing or burning allowed

**Time Period for Implementation**
During development process; Biannually (soil erosion and vegetative monitoring: spring before- and autumn after-the rains)

**Compliance with Standards**
Chamber of Mines Guidelines and Author’s interpretation
ACTIVITY AREAS: Mining, Coal Handling and Processing Plant Area (CHPP), Mine Infrastructure Area (MIA), Heavy Duty Vehicle Area (HDV)

ACTIVITIES (AND ASPECTS):

‘Clean’ Infrastructure / Features:

‘Dirty’ Infrastructure / Features:
Buildings and Structures: ‘Dirty’: Entrance/ exit and 2 x weighbridges, Solid waste sorting facility, General workshop, Chemical store, Hazardous material store, Electrical workshop, Welding shop, Light duty vehicle (LDV)/ heavy duty vehicle (HDV) workshop, LDV/ HDV wash bay, LDV/ HDV fuel storage and refuelling, Oil discard tanks, HDV tyre storage, HDV tyre change assembly station, HDV tyre change hard stand (ASPECTS - All Potential Processes and Procedures).
Electrical Distribution: ‘Dirty’: Substation and miniature substations (11 kV), Uninterrupted power supply (UPS) generators (ASPECTS - All Potential Processes and Procedures).
Road Network: ‘Dirty’ and ‘Clean’: Access roads (R518), Internal roads (road width = 7.4 m, road reserve = 15 m).

IMPACT CATEGORY: Soil Distribution, Soil Erosion, Soil Quality, Land Use, Land Capability - TYPE OF IMPACT: Direct and Indirect - IMPACT DESCRIPTION:
1. Soil Contamination of the Surrounding in-situ soil areas as a result of ‘dirty’ rainwater run-off and blown dust from the excavation/construction in the Infrastructure areas.
2. Soil Distribution: Loss of soil distribution (depth/horizons) during excavation.
3. Soil Erosion due to bare surface (stripped vegetation).
4. Soil Quality reduction (increased compaction, reduced organic carbon % and decreased nutrient levels) during ‘topsoil’ stripping exercise; due to machinery handling of ‘topsoil’ material or burying of in-situ soils.
5. Land Use: Existing land use destroyed.

<table>
<thead>
<tr>
<th>Impact Management</th>
<th>Magnitude</th>
<th>Duration</th>
<th>Scale</th>
<th>Consequence</th>
<th>Probability</th>
<th>SIGNIFICANCE</th>
<th>+/-</th>
<th>Confidence</th>
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<tr>
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<td>Local</td>
<td>Medium</td>
<td>Definite</td>
<td>Medium</td>
<td>-</td>
<td>High</td>
</tr>
<tr>
<td>‘DIRTY’</td>
<td>Major</td>
<td>Long</td>
<td>Cadastral</td>
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<td>Definite</td>
<td>High</td>
<td>-</td>
<td>High</td>
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<tr>
<td>Management Measures</td>
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</tbody>
</table>

Management Measures

Time Period for Implementation
Compliance with Standards
### Measures 1: Soil Contamination:

Institute all possible measures (e.g. **construct numerous concrete slabs**, secondary drains, and berms) to encourage the run-off of ‘dirty’ water and rain water into drains, rather than allowing trapped water to infiltrate/leach through the ‘waste’/‘non-waste’ layers that may be present in the future, and thereafter into the buried *in-situ* soils (underlying a number of these areas) and water-tables.

The base of relatively potentially highly polluting features (e.g. discard dump and other – determined by the mine) must be well sealed with an impermeable membrane that overlies a compacted-‘re-moulded’ soil ‘seal’ layer. Provide under drainage. The soil ‘seal’ layer must ideally be comprised of pedocutanic (B-horizons) or hydromorphic (G- or B-horizons), the aforementioned soils probably displaying a slow permeability once compacted. Although vertic soil material is far more suited for this purpose, very little occurs in the Operational Area.

Construct and maintain optimum functioning (attend to leaks, clear blockages, remove vegetation and remove siltation) of ‘clean’ (re-directs ‘clean’ water around potential pollution sources) and ‘dirty’ (intercepts ‘dirty’ water from polluted areas) storm water intercept canals/drains/berms, upslope/downslope (respectively) of the various infrastructure areas (potentially polluting features). The associated soil berm must lie adjacent (entire length on the downslope side) to the canals/drains.

Compact the soil base and downslope (not upslope) side-walls of the drains to achieve a relatively impermeable compacted-‘re-moulded’ soil seal’ layer.

### Measures 2: Soil Distribution:

**‘Dirty’ Infrastructure/Features:**
Strip the soils ahead of construction operations as per the depths indicated on Map 5 (Soil Utilization [Stripping] Guide).

**‘Clean’ Infrastructure/Features:**
Minimal ‘topsoil’ stripping for foundations/slabs only. Thus during rehabilitation, the pre-disturbance soil distribution / land capability will easily be regained after removing the foundations / slabs (exposing the *in-situ* soils), with minimal ‘topsoiling’ required.

Do not remove vegetation or strip soil material earlier than is required. Either deposit the stripped ‘topsoil’ in ‘topsoil’ berms in the vicinity of where the soil was stripped (to be utilised for rehabilitation ‘topsoiling’ purposes during the decommissioning / closure phase), or alternatively transport the ‘topsoil’ to the ‘topsoil’ stockpile for later use.

The ‘topsoil’ berms and stockpile must be sited at locations where the ‘topsoil’ is unlikely to become contaminated by either dust erosion (related to the prevailing wind direction) or ‘dirty’ run-off (thus
preferably in an upslope position).

In the case of the 'clean' access and internal roads, and canals/drainage; the stripped 'topsoil' must lie adjacent to the feature (entire length in an upslope position) in the form of a re-vegetated 'topsoil' berm. In the case of 'dirty' haul roads, the stripped 'topsoil' must be stored in the 'topsoil stockpile.'

**Measures 3: Soil Erosion:**

Soil Erosion may be reduced by reducing 'topsoil' berm side-slopes to < 5.2 degrees/ 9.2% percentage grade.
Re-vegetate (locally indigenous grasses) the 'topsoil' berms. Functional surface cover (basal) to be achieved by both natural means as well as by intervention. Thus, Mature Seeded 'Grass' must first be mown from elsewhere on the property and then spread out on the berms during the rainy season. Thereafter manually/mechanically re-vegetate (with self-sustaining locally indigenous 'grasses') in problematic areas, as well as in those areas where the spread seeded 'grass' did not germinate/create cover.
No grazing or burning allowed.

**Measures 4: Soil Quality (compaction and fertility):**

Machinery - utilize tracked vehicles for 'topsoil' handling during the dry season (ideally, but often impractical) to minimise soil compaction of stripped 'topsoil'.
Utilise live topsoil (and compost if available) to replenish soil micro-flora before re-vegetation of the 'topsoil' berms (and other areas). Sample and analyse the 'topsoil'. Fertilize (slow release ameliorants) the 'topsoil' immediately after re-vegetation, and once every 3 - 4 years thereafter.

**Measures 5: Land Use:**

Do not remove vegetation or strip soil material earlier than is required; Re-vegetate the 'topsoil' berms and as many other areas as possible.
Refer to Decommissioning/Closure phase Impacts/Measures for further details.

**Measures 6: Land Capability:**

Do not remove vegetation or strip soil material earlier than is required; Re-vegetate the 'topsoil' berms and as many other areas as possible.
Refer to Decommissioning/Closure phase Impacts/Measures for further details.

<table>
<thead>
<tr>
<th>Impact Management</th>
<th>'CLEAN'</th>
<th>Moderate</th>
<th>Medium Term</th>
<th>Site</th>
<th>Medium</th>
<th>Definite-Probable</th>
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<th>-</th>
<th>High</th>
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</thead>
<tbody>
<tr>
<td>'DIRTY'</td>
<td>Major</td>
<td>Long Term</td>
<td>Cadastral</td>
<td>High</td>
<td></td>
<td>Definite</td>
<td>High</td>
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<td>High</td>
</tr>
</tbody>
</table>
**ACTIVITY AREAS:** Mining, Coal Handling and Processing Plant Area (CHPP), Mine Infrastructure Area (MIA), Heavy Duty Vehicle Area (HDV)

**ACTIVITIES (AND ASPECTS):**
Water Supply Network: ‘Dirty’: Water treatment works (reverse osmosis package plant), Waste water treatment works (closed system package plant), Sludge and solids collection and disposal, Pollution control dams/ storm-water retention ponds (combined), Raw water dam (ASPECTS - All Potential Processes and Procedures)

**IMPACT CATEGORY:** Soil Distribution, Soil Erosion, Soil Quality, Land Use, Land Capability - TYPE OF IMPACT: Direct - IMPACT DESCRIPTION:
1. Soil Contamination not likely during the Construction phase.
2. Soil Distribution: Loss of soil distribution (depth/horizons) during excavation.
3. Soil Erosion due to excessive soil dam and berm side slopes, and bare surface (stripped vegetation).
4. Soil Quality reduction (increased compaction, reduced organic carbon % and decreased nutrient levels) during 'topsoil' stripping exercise; due to machinery handling of 'topsoil' material; and intentional compaction of dam side-slopes and drain base/downslope wall.
5. Land Use: Existing land use destroyed.

<table>
<thead>
<tr>
<th>Impact BEFORE Management</th>
<th>Magnitude</th>
<th>Duration</th>
<th>Scale</th>
<th>Consequence</th>
<th>Probability</th>
<th>SIGNIFICANCE</th>
<th>+/-</th>
<th>Confidence</th>
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<tbody>
<tr>
<td>Management Measures</td>
<td>Major</td>
<td>Long Term</td>
<td>Local</td>
<td>High</td>
<td>Definite</td>
<td>High</td>
<td>-</td>
<td>High</td>
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</table>

**Measures 1: Soil Contamination:**
The base and walls of the 'Dam Features' must be well sealed with an impermeable membrane that overlies a compacted-'re-moulded' soil 'seal' layer. Provide under drainage. The soil 'seal' layer must ideally be comprised of pedocutanic (B-horizons) or hydromorphic (G- or B-horizons), the aforementioned soils probably displaying a slow permeability once compacted. Although vertic soil material is far more suited for this purpose, very little occurs in the Operational Area. A non-compacted 'topsoil' layer comprised of Red apedal (Hu and Li soil forms), Yellow-brown apedal (Cv and Gc forms) or Carbonate (Py, Ky and Mp forms) soils must be present on the surface for 'topsoiling' and re-vegetation purposes.

Construct and maintain optimum functioning (attend to leaks, clear blockages, remove vegetation and remove siltation) of 'clean' (re-directs 'clean' water around potential pollution sources) and 'dirty' (intercepts 'dirty' water from polluted areas) storm water intercept canals/drains/berms, upslope/downslope (respectively) of each dam (potentially polluting features). The associated soil berm must lie adjacent (entire length on the downslope side) to the drains.

Compact the soil base and downslope (not upslope) side-walls of the drains to achieve a relatively impermeable compacted-'re-moulded' soil seal' layer.

<table>
<thead>
<tr>
<th>Time Period for Implementation</th>
<th>Compliance with Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>During construction/development process</td>
<td>Chamber of Mines Guidelines and Author’s interpretation</td>
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</tbody>
</table>

**Measures 2: Soil Distribution:**

<table>
<thead>
<tr>
<th>Time Period for Implementation</th>
<th>Compliance with Standards</th>
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</thead>
<tbody>
<tr>
<td>During construction/development process</td>
<td>Chamber of Mines Guidelines</td>
</tr>
</tbody>
</table>
Excavate *in-situ* 'topsoil’ to the required depth during development; Transport excess stripped soil to the 'topsoil' stockpile.

### Measures 3: Soil Erosion:

Soil Erosion may be reduced by reducing soil dam side-slopes to < 5.2 degrees/ 9.2 % percentage grade where necessary.

- Re-vegetate (locally indigenous grasses) the dam side-slopes and 'topsoil’ berms. Functional surface cover (basal) to be achieved by both natural means as well as by intervention. Thus, Mature Seeded 'Grass' must first be mown from elsewhere on the property and then spread out on the soil dam side-slopes and berms during the rainy season. Thereafter manually/mechanically re-vegetate (with self-sustaining locally indigenous 'grasses') in problematic areas, as well as in those areas where the spread seeded 'grass' did not germinate/create cover.
- No grazing or burning allowed.

### Measures 4: Soil Quality (compaction and fertility)

- Machinery - utilize tracked vehicles for 'topsoil' handling during the dry season (ideally, but often impractical) to minimise soil compaction of stripped 'topsoil'. Import pedocutanic or hydromorphic soil utilised for dam construction and compact in the moist state to maximise compaction and create a compacted-'re-moulded' seal layer;
- Utilise live topsoil (and compost if available) to replenish soil micro-flora before re-vegetation of the dam side-slopes and adjacent (to the drains) 'topsoil’ berms. Sample and analyse the ‘topsoil’. Fertilize (slow release ameliorants) the 'topsoil' immediately after re-vegetation, and once every 3 - 4 years thereafter.

### Measures 5. Land Use:

- Do not remove vegetation or strip soil material earlier than is required; Re-vegetate dam wall side-slopes (where applicable) and 'topsoil’ berms
- Refer to Decommissioning/Closure phase Impacts/Measures for further details.

### Measures 6: Land Capability:

- Do not remove vegetation or strip soil material earlier than is required; Re-vegetate dam wall side-slopes (where applicable) and 'topsoil’ berms
- Refer to Decommissioning/Closure phase Impacts/Measures for further details.

<table>
<thead>
<tr>
<th>Impact</th>
<th>AFTER Management</th>
<th>Moderate</th>
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<th>Medium</th>
<th>Possible</th>
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</table>

Chamber of Mines Guidelines and Author’s interpretation
ACTIVITY AREAS: Mining, Coal Handling and Processing Plant Area (CHPP), Mine Infrastructure Area (MIA), Heavy Duty Vehicle Area (HDV)

ACTIVITIES (AND ASPECTS):

IMPACT CATEGORY: Soil Distribution, Soil Erosion, Soil Quality, Land Use, Land Capability - TYPE OF IMPACT: Direct - IMPACT DESCRIPTION:
1. Soil Contamination not likely during the Construction phase.
2. Soil Distribution: Loss of soil distribution (depth/horizons) during excavation.
3. Soil Erosion due to excessive soil berm side slopes, and bare surface (stripped vegetation).
4. Soil Quality reduction (increased compaction, reduced organic carbon % and decreased nutrient levels) during 'topsoil' stripping exercise; due to machinery handling of 'topsoil' material.
5. Land Use: Existing land use destroyed.

<table>
<thead>
<tr>
<th>Impact BEFORE Management</th>
<th>Magnitude</th>
<th>Duration</th>
<th>Scale</th>
<th>Consequence</th>
<th>Probability</th>
<th>SIGNIFICANCE</th>
<th>+/-</th>
<th>Confidence</th>
</tr>
</thead>
</table>

Management Measures

Measures 1: Soil Contamination:
Future 'Dirty' polluted areas: Construct canals/drains from concrete to prevent seepage of 'dirty' water.
Future 'Clean' non-polluted areas: Construct an earth canal/drain; Compact the soil base and side-walls of the canal/drain to achieve a relatively impermeable compacted-'re-moulded' soil seal layer.

Time Period for Implementation
During development process
Compliance with Standards
Chamber of Mines Guidelines

Measures 2: Soil Distribution:
Excavate in-situ 'topsoil' to the required depth during development of canals/drains;
Establish a 'topsoil' berm from excavated soil material adjacent to the canals/drains (entire length on the downslope side)

Time Period for Implementation
During development process
Compliance with Standards
Chamber of Mines Guidelines

Measures 3: Soil Erosion:
Soil Erosion may be reduced by reducing soil berm side-slopes to < 5.2 degrees/ 9.2 % percentage grade where necessary.
Re-vegetate (locally indigenous grasses) the 'topsoil' berms. Functional surface cover (basal) to be achieved by both natural means as well as by intervention. Thus, Mature Seeded 'Grass' must first be mown from elsewhere on the property and then spread out on the soil berms during the rainy season. Thereafter manually/mechanically re-vegetate (with self-sustaining locally indigenous

Time Period for Implementation
During development process
Compliance with Standards
Chamber of Mines Guidelines and Author's interpretation
‘grasses’) in problematic areas, as well as in those areas where the spread seeded ‘grass’ did not germinate/create cover.
No grazing or burning allowed.

**Measures 4: Soil Quality (compaction and fertility)**

Machinery - utilize tracked vehicles for ‘topsoil’ handling during the dry season (ideally, but often impractical) (ideally – not practical) to minimise compaction;
Utilise live topsoil (and compost if available) to replenish soil micro-flora before re-vegetation of the adjacent (to the canals/drains) ‘topsoil’ berms. Sample and analyse the ‘topsoil’. Fertilize (slow release ameliorants) the ‘topsoil’ immediately after re-vegetation, and once every 3 - 4 years thereafter.

<table>
<thead>
<tr>
<th>Impact AFTER Management</th>
<th>Moderate</th>
<th>Long Term</th>
<th>Site</th>
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<tr>
<td>Measured</td>
<td>During development process</td>
<td>Chamber of Mines Guidelines and Author’s interpretation</td>
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<td>Chamber of Mines Guidelines</td>
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<td>Chamber of Mines Guidelines</td>
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</tbody>
</table>
ACTIVITY AREA: Mining

ACTIVITIES (AND ASPECTS):
Mining: Box cut, Open pit (ASPECTS - All Potential Processes and Procedures)

IMPACT CATEGORY: Soil Contamination, Soil Distribution, Soil Erosion, Soil Quality, Land Use, Land Capability - TYPE OF IMPACT: Direct and Indirect - IMPACT DESCRIPTION:
1. Soil Contamination of the Surrounding in-situ soil areas as a result of ‘dirty’ rainwater run-off and blown dust from the excavation of the Opencast area.
2. Soil Distribution: Loss of soil distribution (depth and horizons) in stripped areas.
3. Soil Erosion due to excessive slopes, uneven terrain, and bare surface (stripped vegetation).
4. Soil Quality reduction (increased compaction, reduced organic carbon % and decreased nutrient levels) during 'topsoil' stripping exercise; due to machinery handling of 'topsoil' material.
5. Land Use: Existing land use destroyed.

<table>
<thead>
<tr>
<th>Impact BEFORE Management</th>
<th>Magnitude</th>
<th>Duration</th>
<th>Scale</th>
<th>Consequence</th>
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<td>Definite</td>
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</table>

Management Measures  

Refer to all Mitigation Measures in the Decommissioning/Closure phase for more detailed information.

Measures 1a: Soil Contamination:

Construct a vegetated berm from 'softs' or soil material around the outer boundary of the opencast (rock dumps/open void) footprint area,

Construct ‘clean’ (re-direct ‘clean’ water around potential pollution sources) and ‘dirty’ (intercept ‘dirty’ water from polluted areas) storm water intercept canals/drainage/berms upslope and downslope of the Opencast Areas respectively.

The spraying of water for dust suppression will be beneficial during mechanical operations.

Wash residual ‘wastes’ from elsewhere off the machinery before utilising the machinery for transportation of ‘topsoil’ or rehabilitation ‘topsoiling’ purposes.

Haul trucks and vehicle traffic must obey speed limits to reduce the amount of blown dust.

Measures 2: Soil Distribution:

During construction/development process (construct ‘softs’ berm, and ‘dirty’/‘clean’ water canals/drainage/berms),

Daily where necessary (spraying of water when operating machinery and haul trucks),

Continuously (speed limits)

Chamber of Mines Guidelines
Strip the soils ahead of opencast operations as per the depths indicated on Map 5 (Soil Utilization [Stripping] Guide). Do not remove vegetation or strip soil material earlier than is required. Either deposit the stripped 'topsoil' on a backfilled area that is undergoing rehabilitation, or alternatively transport the 'topsoil' to the 'topsoil' stockpile for later use.

### Measures 3. Soil Erosion:
Do not remove vegetation or strip soil material earlier than is required. Refer to Decommissioning/Closure phase Impacts/Measures for further details.

### Measures 4. Soil Quality:
Machinery - utilize tracked vehicles for 'topsoil' handling during the dry season (ideally, but often impractical since mining operations are ongoing throughout the year) to minimise compaction. Refer to Decommissioning/Closure phase Impacts/Measures for further details.

### Measures 5. Land Use:
Do not remove vegetation or strip soil material earlier than is required. Re-vegetate rehabilitated areas. Refer to Decommissioning/Closure phase Impacts/Measures for further details.

### Measures 6: Land Capability:
Do not remove vegetation or strip soil material earlier than is required. Re-vegetate rehabilitated areas. Refer to Decommissioning/Closure phase Impacts/Measures for further details.

<table>
<thead>
<tr>
<th>Impact Management</th>
<th>Major</th>
<th>Long Term</th>
<th>Site</th>
<th>High</th>
<th>Definite</th>
<th>High</th>
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<th>High</th>
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</thead>
</table>

Chamber of Mines Guidelines
**ACTIVITY AREAS:** Mining (mainly). Also Coal Handling and Processing Plant Area (CHPP), Mine Infrastructure Area (MIA), Heavy Duty Vehicle Area (HDV)

**ACTIVITIES (AND ASPECTS):**
Residue Stockpiles and Deposits: 'Clean': Topsoil stockpile (in Mining Area); and Soil berm 'stockpiles' (in other areas)

**ASPECTS - All Potential Processes and Procedures**

**IMPACT CATEGORY:** Soil Distribution, Soil Erosion, Soil Quality, Land Use, and Land Capability - TYPE OF IMPACT: Direct - IMPACT DESCRIPTION:
1. Soil Contamination: Not likely during the Construction phase.
2. Soil Distribution: Burying of existing in-situ soils by the stockpile.
3. Soil Erosion of the stockpile due to excessive side-slopes (>5.2 degrees, 9.2 % percentage grade), lack of vegetative (grass) basal cover, and possible absence of a downslope soil berm to intercept run-off.
4. Soil Quality reduction (below and within stockpile): (increased compaction, reduced organic carbon % and decreased nutrient levels, and reduction of reproductive seed-bank in the pile) due to excessive stockpile heights (>2.5m) and expected long periods of storage.
5. Land Use: Existing land use covered over by the stockpile.

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Duration</th>
<th>Scale</th>
<th>Consequence</th>
<th>Probability</th>
<th>SIGNIFICANCE</th>
<th>+/-</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>Major Term</td>
<td>Site</td>
<td>Medium</td>
<td>Medium</td>
<td>Definite</td>
<td>Medium</td>
<td>High</td>
</tr>
</tbody>
</table>

**Management Measures**

**Measures 1: Soil Contamination:**

The 'topsoil' stockpile must not be allowed to become contaminated; by means of the implementation of the following measures:

Do not deposit 'waste' (coal fines, discard or other) materials on the 'clean' 'topsoil' stockpiles.

Spray water for dust suppression where necessary when working with machinery.

The spraying of water for dust suppression in other developed areas (as recommended) will limit dust pollution (coal dust) of the 'topsoil' stockpiles.

The spraying of water for dust suppression will not be required on the pile since the stockpiled topsoils that will be re-vegetated are only slightly prone to wind erosion.

Haul trucks and vehicle traffic must obey speed limits to reduce the amount of blown dust.

Construct and maintain optimum functioning (attend to leaks, clear blockages, remove vegetation and remove siltation) of the 'clean' (re-direct 'clean' water around potential pollution sources) and 'dirty' (intercept 'dirty' water from polluted areas) storm water intercept canals/drains/berms, upslope/downslope (respectively) of potentially polluting features. The aforementioned will limit 'clean' and 'dirty' water run-off and seepage derived from elsewhere from entering the stockpile.

<table>
<thead>
<tr>
<th>Time Period for Implementation</th>
<th>Compliance with Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily when necessary (wash machinery utilised for transportation and spreading of 'topsoil' material),</td>
<td>Chamber of Mines Guidelines</td>
</tr>
<tr>
<td>Daily where necessary (spraying of water when operating machinery and haul trucks),</td>
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<tr>
<td>Continuously (speed limits),</td>
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</tr>
<tr>
<td>Quarterly (drainage features-‘dirty’/‘clean’ drains/canals/berms-monitor and maintain-repair leaks, clear blockages, remove vegetation, remove siltation, dredging),</td>
<td></td>
</tr>
<tr>
<td>Annually (contamination monitoring).</td>
<td></td>
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</tbody>
</table>
areas.

Wash residual ‘wastes’ from elsewhere off the machinery before utilising the machinery for transportation of ‘topsoil’.

The ‘topsoil’ berms and stockpile must be sited at locations where the ‘topsoil’ is unlikely to become contaminated by either dust erosion (related to the prevailing wind direction) or ‘dirty’ run-off (thus preferably in an upslope position).

<table>
<thead>
<tr>
<th>Measures 2. Soil Distribution:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit the surface area of the footprint, to preserve the existing in-situ soils underlying the site.</td>
<td>During construction/development process</td>
</tr>
<tr>
<td>Avoid unnecessary disturbance of any underlying/surrounding in-situ soils that may already be present at the ‘topsoil’ stockpile sites.</td>
<td>Chamber of Mines Guidelines</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measures 3: Soil Erosion:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Side-slopes ideally &lt; 5.2 degrees, 9.2 % percentage grade [non-vegetated maximum slope, but slightly steeper (undetermined) after re-vegetation].</td>
<td></td>
</tr>
<tr>
<td>Functional surface cover (basal, canopy) to be achieved by both natural means as well as by intervention. Thus, Mature Seeded ‘Grass’ must first be mown from elsewhere on the property and then spread out on the bare ‘topsoil’ stockpiles during the rainy season. Thereafter manually/mechanically re-vegetate (with self-sustaining locally indigenous ‘grasses’) in problematic areas, as well as in those areas where the spread seeded ‘grass’ did not germinate/create cover. No grazing or burning allowed.</td>
<td></td>
</tr>
<tr>
<td>Construct a soil berm surrounding the stockpile. That on the upslope sides will divert dirty water run-off, while that down slope will prevent siltation of the surrounds.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measures 4: Soil Quality (compaction and fertility):</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Topsoil’ stockpiles should ideally not exceed a maximum depth of 1.5 – 2.5m, as greater depths than this can lead to the following: anaerobic conditions developing in the pile; a reduction in soil fertility; the accelerated loss of the reproductive seed-bank; and compaction.</td>
<td></td>
</tr>
<tr>
<td>Sample and analyse the ‘topsoil’. Fertilize (slow release ameliorants) the ‘topsoil’ stockpile immediately after establishment, and once every 3 - 4 years thereafter in spring to maintain soil fertility and vegetative (‘grass’) basal cover, thereby limiting soil erosion and continually refreshing the reproductive seed-bank. Do not fertilise the soils in areas displaying healthy existing locally indigenous ‘grass’ cover.</td>
<td></td>
</tr>
<tr>
<td>Machinery - to limit compaction, machinery for stripping/stockpiling/rehabilitation purposes should ideally be tracked (not wheeled), and should operate during the dry winter months only.</td>
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</tbody>
</table>

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</thead>
<tbody>
<tr>
<td>Immediately after establishment of ‘topsoil’ stockpile, and once every 3-4 years thereafter (fertility monitoring; sample and fertilise)</td>
<td>Chamber of Mines Guidelines</td>
</tr>
</tbody>
</table>

Chamber of Mines Guidelines and Author’s interpretation
**Measures 5: Land Use:**
Re-vegetate the stockpile.  
Immediately after establishment  
Chamber of Mines Guidelines

**Measures 6: Land Capability:**
Re-vegetate the stockpile.  
Immediately after establishment  
Chamber of Mines Guidelines

**General Information:**
Available 'topsoil' reserves must be stripped as per the depths indicated on Map 5 (Soil Utilization [Stripping] Guide) during the construction and operational phases (varies for different features).  
The organisation must plan not to stockpile the soils wherever it can, but rather utilize the stripped 'topsoil' material immediately in an area that is being rehabilitated (e.g. 'moving' opencast area).  
Provision should also be made for limited stockpiling of excess 'topsoil' material for use in repair work during the post-closure phase.

<table>
<thead>
<tr>
<th>Impact AFTER Management</th>
<th>Moderate</th>
<th>Medium Term</th>
<th>Site</th>
<th>Medium</th>
<th>Definite</th>
<th>Medium</th>
<th>-</th>
<th>High</th>
</tr>
</thead>
</table>

Chamber of Mines Guidelines
Table 9.2.2(b): Impact Significance and Management Measures (Operational Phase)

<table>
<thead>
<tr>
<th>ACTIVITY AREAS: Mining, Coal Handling and Processing Plant Area (CHPP), Mine Infrastructure Area (MIA), Heavy Duty Vehicle Area (HDV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTIVITIES (AND ASPECTS)</td>
</tr>
<tr>
<td>Buildings and Structures: ‘Clean’: Fencing (ASPECTS - All Potential Processes and Procedures); Electrical Distribution: ‘Clean’: 11/33 kV Switching station, Internal power lines (ASPECTS - All Potential Processes and Procedures)</td>
</tr>
<tr>
<td>IMPACT CATEGORY: Soil Erosion - TYPE OF IMPACT: Direct - IMPACT DESCRIPTION: 1. Soil Erosion due to possible poor vegetative (grass) basal cover</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Duration</th>
<th>Scale</th>
<th>Consequence</th>
<th>Probability</th>
<th>SIGNIFICANCE</th>
<th>+/-</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact BEFORE Management</td>
<td>Minor</td>
<td>Medium Term</td>
<td>Site</td>
<td>Low</td>
<td>Possible</td>
<td>Low</td>
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</tr>
<tr>
<td>Management Measures</td>
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<tr>
<td>Measures 1: Soil Erosion:</td>
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<tr>
<td>Monitor and maintain vegetative (grass) basal cover and soil erosion in the vicinity of the foundation holes; Mature seeded grass may be mown from elsewhere and then spread out in eroded areas displaying poor grass cover; Do not scalp off or poison the grass cover along fence and power line routes; Utilise steel (not wooden) poles for fences and power lines; Do not fertilise the soils in these areas; No grazing or burning allowed.</td>
<td>Time Period for Implementation</td>
<td>Compliance with Standards</td>
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<tr>
<td>Impact AFTER Management</td>
<td>Minor</td>
<td>Medium Term</td>
<td>Site</td>
<td>Low</td>
<td>Unlikely</td>
<td>Low</td>
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</tbody>
</table>

Chamber of Mines Guidelines and Author’s interpretation
ACTIVITY AREAS: Mining, Coal Handling and Processing Plant Area (CHPP), Mine Infrastructure Area (MIA), Heavy Duty Vehicle Area (HDV)

ACTIVITIES (AND ASPECTS):
Road Network: 'Dirty' and 'Clean': Access roads (R518), Internal roads (road width = 7.4 m, road reserve = 15 m) (ASPECTS - All Potential Processes and Procedures)

IMPACT CATEGORY: Soil Erosion, Soil Contamination  - TYPE OF IMPACT: Direct and Indirect - IMPACT DESCRIPTION:
1. Soil Erosion due to possible poor vegetative (grass) basal cover of surrounding soils and soil berms, or 'waste' or 'non-waste' bare surfaces or berms.
2. Soil Contamination of Underlying/Surrounding in-situ soils due to accidental spillages (coal dust, discard, carbonaceous rock, raw materials, chemicals, vehicle oil/fuel leaks), exhaust fumes and blown dust; and subsequent infiltration into the soils and run-off into the drainage areas.

<table>
<thead>
<tr>
<th>Impact BEFORE Management</th>
<th>Magnitude</th>
<th>Duration</th>
<th>Scale</th>
<th>Consequence</th>
<th>Probability</th>
<th>SIGNIFICANCE</th>
<th>+/-</th>
<th>Confidence</th>
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<td></td>
<td>Moderate</td>
<td>Medium</td>
<td>Local</td>
<td>Medium</td>
<td>Definite</td>
<td>Medium</td>
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<td>High</td>
</tr>
</tbody>
</table>

Management Measures

Measures 1: Soil Erosion:
Monitor and maintain vegetative (grass) basal cover in the surrounds; Sample/fertilize the 'topsoil' berms once every 3 - 4 years in spring to maintain vegetative basal cover, thereby limiting soil erosion; No grazing or burning allowed.
Maintain local drainage features (direct/contain 'dirty' water runoff and keep 'clean' water away); Maintain optimum functioning (remove siltation and vegetation) of the 'dirty' water run-off intercept drains/berms to the PCD's, as well as the 'clean' water diversion drains/berms. The aforementioned will limit 'dirty' and 'clean' run-off water derived from elsewhere from impacting these areas.

Measures 2: Soil Contamination:
Report, monitor and clean up accidental spillages immediately; Sweep roads/verges periodically. Spray water for dust suppression; Speed limits; Monitor dust.

<table>
<thead>
<tr>
<th>Impact AFTER Management</th>
<th>Magnitude</th>
<th>Duration</th>
<th>Site</th>
<th>Consequence</th>
<th>Probability</th>
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<th>Confidence</th>
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<tbody>
<tr>
<td></td>
<td>Moderate</td>
<td>Medium</td>
<td>Site</td>
<td>Medium</td>
<td>Possible</td>
<td>Medium</td>
<td>-</td>
<td>Medium</td>
</tr>
</tbody>
</table>
**ACTIVITY AREAS:** Coal Handling and Processing Plant Area (CHPP), Mine Infrastructure Area (MIA), Heavy Duty Vehicle Area (HDV)

**ACTIVITIES (AND ASPECTS):**
Plant Facilities: ‘Clean’: Plant motor control centre (MCC) control room, Transformer bays, Plant coal laboratory, Plant geology grade control, Plant office building (ASPECTS - All Potential Processes and Procedures)

**IMPACT CATEGORY:** Soil Erosion, Soil Contamination
- **TYPE OF IMPACT:** Direct
- **IMPACT DESCRIPTION:**
  1. Soil Erosion due to possible poor vegetative (lawn) basal cover of surrounds.
  2. Soil Contamination of Underlying/Surrounding *in-situ* soils due to accidental spillages (oils or chemicals) on the soil surface and subsequent infiltration into the soils and run-off into the drainage systems (both unlikely)

<table>
<thead>
<tr>
<th>Impact BEFORE Management</th>
<th>Magnitude</th>
<th>Duration</th>
<th>Scale</th>
<th>Consequence</th>
<th>Probability</th>
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<th>Confidence</th>
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<tbody>
<tr>
<td></td>
<td>Moderate</td>
<td>Long Term</td>
<td>Local</td>
<td>Medium</td>
<td>Possible</td>
<td>Medium</td>
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<td>High</td>
</tr>
</tbody>
</table>

**Management Measures**

**Measures 1: Soil Erosion:**
Monitor and maintain vegetative (lawn) basal cover in the vicinity and surrounds; Fertilise lawn soils annually upon commencement of the rainy season

**Measures 2: Soil Contamination:**
Monitor accidental oil/chemical spillages, and blown coal dust; Clean up spills and sweep up coal dust immediately; Discuss further during Induction Training.
Maintain optimum functioning (remove siltation and vegetation) of the 'dirty' water run-off intercept drains/berms to the PCD’s, as well as the 'clean' water diversion drains/berms. The aforementioned will limit 'dirty' and 'clean' run-off water derived from elsewhere from entering these areas.

<table>
<thead>
<tr>
<th>Impact AFTER Management</th>
<th>Magnitude</th>
<th>Duration</th>
<th>Scale</th>
<th>Consequence</th>
<th>Probability</th>
<th>SIGNIFICANCE</th>
<th>+/−</th>
<th>Confidence</th>
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<tbody>
<tr>
<td></td>
<td>Minor</td>
<td>Medium</td>
<td>Site</td>
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<td>Possible</td>
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</tbody>
</table>

**Time Period for Implementation**
- Biannually (soil erosion and vegetative monitoring: spring before- and autumn after- the rains),
- Annually upon commencement of the rainy season (soil quality-fertilise lawn)

**Compliance with Standards**
- Chamber of Mines Guidelines

- Immediately/daily (spills-various facility staff),
- Quarterly (drainage features-'dirty'/'clean' drains/canals/berms-monitor and maintain-repair leaks, clear blockages, remove vegetation, remove siltation, dredging)

**Chamber of Mines Guidelines**
**ACTIVITY AREAS:** Coal Handling and Processing Plant Area (CHPP), Mine Infrastructure Area (MIA), Heavy Duty Vehicle Area (HDV)

**ACTIVITIES (AND ASPECTS):**  
Plant Facilities: 'Dirty': Run of Mine pad, Single stage wash beneficiation, Primary crusher, Conveyors, Plant workshop (ASPECTS - All Potential Processes and Procedures)  
Buildings and Structures: 'Dirty': Entrance/exit and 2 x weighbridges, Solid waste sorting facility, General workshop, Chemical store, Hazardous material store, Electrical workshop, Welding shop, Light duty vehicle (LDV)/heavy duty vehicle (HDV) workshop, LDV/HDV wash bay, LDV/HDV fuel storage and refuelling, Oil discard tanks, HDV tyre storage, HDV tyre change assembly station, HDV tyre change hard stand (ASPECTS - All Potential Processes and Procedures)  
Residue Stockpiles and Deposits: 'Dirty': ROM/raw material stockpile, Waste tip (ASPECTS - All Potential Processes and Procedures)  
Electrical Distribution: 'Dirty': Substation and miniature substations (11 kV), Uninterrupted power supply (UPS) generators (ASPECTS - All Potential Processes and Procedures)

**IMPACT CATEGORY:** Soil Contamination, 'Waste'/'Non-Waste' Erosion, Soil Quality, Land Use, Land Capability  - **TYPE OF IMPACT:** Direct and Indirect  - **IMPACT DESCRIPTION:**  
1. Soil Contamination of Buried Underlying/Surrounding *in-situ* soils due to the infiltration/leaching of 'dirty' water and rain water through the accumulated 'waste'/'non-waste' materials layer, raw materials stockpiles, product stockpiles, conveyor spillages, or other spilled materials (e.g. oils/fuels/chemicals) into the soils and run-off into the drainage systems, as well as the contamination of downwind soils due to the settling of blown dust.  
2. 'Waste'/'Non-Waste' Erosion of the Local/Surrounding bare (devoid of vegetation)surfaces due to the run-off of waste-water and rainfall.

<table>
<thead>
<tr>
<th>Impact BEFORE Management</th>
<th>Magnitude</th>
<th>Duration</th>
<th>Scale</th>
<th>Consequence</th>
<th>Probability</th>
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<tr>
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<td>High</td>
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</tbody>
</table>

**Management Measures**

**Measures 1a: Soil Contamination:**

Continually scrape up and remove daily generated/spilled ‘wastes’/‘non-wastes’ or fines/dust layers that accumulates overlying the concrete pads or *in-situ* soils, and dispose of on the discard dump, in the opencast void, or a designated ‘waste’ storage facility; or re-process as applicable.; Re-use or sell off unwanted materials (e.g. scrap from a salvage yard) as soon as possible.

Spray water for dust suppression; Tarpaulin cover over haul truck bin where necessary to limit dust; Obey speed limits.

**Measures 2a: Land Capability:**

Continuously (monitoring and maintenance), Continuously (scrape up, consolidate, remove, and dump generated daily ‘waste’/‘non-waste’ material), Immediately (clean up spillages), Weekly, or immediately after a spill (clean up, clean concrete pads), Ongoing (maintenance of roofed areas and pads), Continuously (speed limits and tarpaulin haul truck bin cover where necessary), Daily where necessary (spraying of water when operating machinery and haul trucks),

Chamber of Mines Guidelines and Author’s interpretation
### Measures 1b: Soil Contamination:

Monitor and maintain optimum functioning (remove siltation and vegetation) of the earth ‘clean’ water diversion drain surrounding the upslope sections of the relevant ‘Infrastructure’ areas, together with the drains adjacent soil berm (entire length on the downslope side); as well as the earth ‘dirty’ water intercept drain/berm surrounding the downslope sections of the relevant ‘Infrastructure’ areas.

The aforementioned will limit ‘clean’ water run-off from entering the 'Infrastructure' areas, as well as intercept ‘dirty’ water seepage and run-off derived from the 'Infrastructure' areas respectively.

Institute all possible measures (e.g. additional concrete slabs, secondary drains, and berms) to encourage the run-off of ‘dirty’ water and rain water into drains, rather than allowing trapped water to infiltrate/leach through the ‘waste’/‘non-waste’ layers, and thereafter into the buried in-situ soils (underlying a number of these areas) and water-tables.

| **Quarterly (drainage features-‘dirty’/’clean’ drains/canals/berms-monitor and maintain, repair leaks, clear blockages, remove vegetation, remove siltation, dredging).** | Chamber of Mines Guidelines and Author’s interpretation |

### Measures 1c: Soil Contamination: Further Measures:

#### i) Raw Materials – Product Stockpiles:

- Sweep up accumulated raw material layers off the concrete pad (if present) periodically when necessary; Construct concrete pads if they do not already exist.
- Do not spray excessive volumes of water (that drains through the pile) onto the coal stockpiles as this may lead to ‘acid rock drainage’ to the underlying layers; Cover the coal (and other potentially polluting) stockpiles with a portable impermeable sheet during the rainy season (where necessary) for the same reason.

| When necessary-monthly (sweep), Daily (spray water) | Chamber of Mines Guidelines and Author’s interpretation |

#### ii) Conveyors:

- Sweep up spilled material periodically.
- Spray water onto the raw materials that are to be transported by conveyor before these materials are deposited on the conveyor, the aforementioned for dust suppression.
- Monitor soil erosion and Maintain local drainage features (direct/contain ‘dirty’ water runoff and keep ‘clean’ water away).
- Maintain vegetative (grass) basal cover in the surrounding areas

| Monthly (sweep up spilled materials), Continuously (spray water for dust suppression), Quarterly (drainage features-monitor and maintain), Biannually (monitor soil erosion and vegetative cover - spring before- and autumn after- the rains) | Chamber of Mines Guidelines and Author’s interpretation |

#### iii) Fuel-Oil-Chemical Sites, and Salvage Yard:

- Maintain the sloped concrete pads and sumps at the fuel-oil tank/vehicle filling and maintenance/hazardous chemical sites, and salvage yard; Clean concrete pads and sumps inside/underlying these structures/features periodically; Monitor, clean up and report accidental spillages immediately; Maintain the roofed area and concrete pads to prevent the ingress of rainfall or run-off;
- Spray water for dust suppression when necessary.

| Immediately (clean up spillages), Weekly, or immediately after a spill (clean concrete pads and sumps), Monthly (scrape up accumulated ‘waste’ or ‘non-waste’ fines materials), When necessary (spray water), Ongoing (maintenance of roofed area and pads, and re-use or selling of unwanted materials) | Chamber of Mines Guidelines and Author’s interpretation |
### iv) Fumes and Fallout

Monitor emissions and dust, both in the plant and downwind areas;
Ongoing implementation of appropriate pollution reducing measures that are currently in place;
Ongoing maintenance of equipment and processes that are designed to reduce emissions and dust;
Clean up and dispose of accumulated ‘waste’ material layers (particularly fines);
Spray water to limit blown dust in ‘safe’ ‘non-heat’/‘non-electrical’ areas only!!

Continuously (monitor emissions and dust, implement appropriate measures, equipment/process maintenance);
Periodically at intervals on a daily basis (spray water in ‘safe’ ‘non-heat’/‘non-electrical’ areas only!!)

Author’s interpretation

### Measures 2: ‘Waste’/‘Non-Waste’ Erosion, Soil Quality, Land Use, and Land Capability:

Given that the existing *in-situ* soils were either stripped/removed/buried during the Construction phase, the land use / land capability will remain Industrial (buildings, facilities and features: mostly non-vegetated) during the Operational phase. Thus during the Operational phase, soil distribution, soil erosion, and soil quality cannot be ameliorated directly in the majority of the aforementioned sites, except where soils/vegetation is present on the surface. However, the erosion of surface ‘waste’/’non-waste’ can be controlled to a certain extent by the implementation of Measures 1b. Furthermore, refer to Measures 1a, 1b, and 1c above.

As per Measures 1a – 1c

Chamber of Mines Guidelines and Author’s interpretation

<table>
<thead>
<tr>
<th>Impact</th>
<th>Major</th>
<th>Long Term</th>
<th>Local</th>
<th>High</th>
<th>Definitely Probable</th>
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<tbody>
<tr>
<td>Management</td>
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</tbody>
</table>
ACTIVITY AREAS: Mining, Coal Handling and Processing Plant Area (CHPP)

ACTIVITIES (AND ASPECTS):
Residue Stockpiles and Deposits: ‘Dirty’: Discard dump, Overburden stockpile (ASPECTS - All Potential Processes and Procedures)

IMPACT CATEGORY: Soil Contamination - TYPE OF IMPACT: Direct and Indirect - IMPACT DESCRIPTION:
1. Soil Contamination of Buried Underlying/Surrounding in-situ soils due to the infiltration/leaching of ‘dirty’ water and rain water through the ‘dirty’ (carbonaceous) Residue Stockpiles and Deposits, and assorted ‘dirty’ Infrastructure; leading to sulphates, Acid Rock Drainage (ARD), hydrocarbons and other contaminants draining into the soils and running-off into the drainage areas; as well as contamination of the downwind (majority to the south-west) soils due to the settling of blown carbonaceous dust.

<table>
<thead>
<tr>
<th>Impact BEFORE Management</th>
<th>Magnitude</th>
<th>Duration</th>
<th>Scale</th>
<th>Consequence</th>
<th>Probability</th>
<th>SIGNIFICANCE</th>
<th>*/-</th>
<th>Confidence</th>
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<tbody>
<tr>
<td>Time Period for Implementation</td>
<td>Compliance with Standards</td>
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<tr>
<td>Measures 1a: Soil Contamination:</td>
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<tr>
<td>Scrape up, consolidate in the relevant dump, or process any layers that may have spilled, accumulated or been spread out both within or surrounding these sites;</td>
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<tr>
<td>Transport and dump carbonaceous discard (from discard dump), overburden rock (from overburden rock dump), and scraped up ‘waste’ fines (spilled and dust) into the opencast void on an ongoing basis. Carbonaceous materials must be dumped at the bottom of the opencast void, and overlaid by non-carbonaceous materials, before the sulphide minerals (e.g. pyrite) are given the opportunity to oxidise through exposure to air and water, thereby minimising the potential for ARD;</td>
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<tr>
<td>Institute all possible measures to encourage the run-off of ‘dirty’ water and rain water into drains, rather than allowing trapped water to infiltrate into the buried in-situ soils (underlying these areas) and water-tables; Monitor soil contamination on an ongoing basis via the downslope boreholes.</td>
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<td>Spray water for dust suppression; Obey speed limits.</td>
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<tr>
<td>Measures 1b: Soil Contamination:</td>
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<tr>
<td>Monitor and maintain optimum functioning (remove siltation and vegetation) of the earth ‘clean’ water diversion drain surrounding the upslope sections of each of the dumps, together with its adjacent soil berm (entire length on the downslope side); as well as the earth ‘dirty’ water</td>
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<tr>
<td>Quarterly (drainage features-‘dirty’/‘clean’ drains/canals/berms-monitor and maintain-repair leaks, clear blockages, remove vegetation, remove siltation, dredging).</td>
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</table>
intercept drain/berm (to the PCD's) surrounding the downslope sections of each of the 'dirty' dumps.
The aforementioned will limit 'clean' water run-off from entering these areas, as well as intercept 'dirty' water run-off derived from these areas respectively.

Maintain the soil fertility and vegetative cover on the adjacent (to the drains) or surrounding berms.

<table>
<thead>
<tr>
<th>Impact AFTER Management</th>
<th>Moderate</th>
<th>Medium Term</th>
<th>Local</th>
<th>Medium</th>
<th>Definite</th>
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**ACTIVITY AREAS:** Coal Handling and Processing Plant Area (CHPP), Mine Infrastructure Area (MIA), Heavy Duty Vehicle Area (HDV)

**ACTIVITIES (AND ASPECTS):**
Water Supply Network: ‘Dirty’: Water treatment works (reverse osmosis package plant), Waste water treatment works (closed system package plant), Sludge and solids collection and disposal, Pollution control dams/ storm-water retention ponds (combined), Raw water dam (ASPECTS - All Potential Processes and Procedures)

**IMPACT CATEGORY:** Soil Contamination, Soil Erosion, Soil Quality - TYPE OF IMPACT: Direct, Indirect and Cumulative - IMPACT DESCRIPTION:
1a. Soil Contamination of the Underlying/Surrounding in-situ soils due to seepage of ‘dirty’ water below the base of- or through the walls of- the dams; as a result of being either poorly sealed (impermeable membrane liner) or poorly compacted (compacted-‘remoulded’ soils) bases/walls.
1b. Soil Contamination of the ‘topsoiled’ (some instances) dam walls due to the dumping of ‘dirty’ sludge materials derived from the dredging of the base of the dams.
1c. Soil Contamination of the Underlying/Surrounding in-situ soils due to seepage of leaked/spilled ‘dirty’ water or sludge from piping; or a shortage of, or poor maintenance of piping bund walls.
1d. Soil Contamination due to spillages of transported sediments from trucks.
2. Soil Erosion of the ‘topsoiled’ (some instances) dam walls or piping bund walls due to possible excessive side-slopes (>5.2 degrees, 9.2 % percentage grade), or alternatively possible poor vegetative (grass) basal cover.
3. Soil Quality reduction of the ‘topsoiled’ (some instances) dam walls or piping bund walls due to possible non-fertilisation.

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<th>Impact Management BEFORE</th>
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**Management Measures**

**Measures 1: Soil Contamination:**

1a). Correct construction procedures are likely to have prevented leakage.
Monitor seepage from the dams/water treatment works and maintain these features.
Monitor and maintain optimum functioning (remove siltation and vegetation) of the earth ‘dirty’ water intercept drain downslope of each dam, together with its adjacent soil berm (entire length on the downslope side). Monitor soil contamination on an ongoing basis via the downslope boreholes.

1b). Dredged material from the PCD dams and drains must either be disposed of in the residual portion of the discard dump (for materials with a high pollution potential) or the opencast void [as applicable], but not dumped on the dam/drain/bund walls or in surrounding areas.
Dried up sewage sludge material must be scraped up periodically and utilised as a ‘topsoil’ fertiliser in Opencast areas that are being rehabilitated on an ongoing basis during the Operational and Closure phases.

1c). Clean up ‘dirty’ water and sludge from pipeline leaks and spills immediately.

**Time Period for Implementation**

Quarterly (dams-monitor and maintain),
Quarterly (drainage features-‘dirty’/‘clean’ drains/canals/berms-monitor and maintain-repair leaks, clear blockages, remove vegetation, remove siltation, dredging)
Annually (dredging PCD,s where necessary),
Annually in spring (scrape up sewage sludge and utilise as a ‘topsoil’ fertiliser)

**Compliance with Standards**

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Chamber of Mines Guidelines and Author’s interpretation
Chamber of Mines Guidelines
Monitor, maintain, and repair pipelines and bund walls where necessary.

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<th>1d). Clean up sludge/solids spilled from haul trucks immediately.</th>
<th>sludge). Daily (monitor for piping leaks –may also be indicated by a drop in sludge pressure), immediately (repair piping leaks)</th>
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**Measures 2: Soil Erosion:**

Monitor soil erosion, and monitor and maintain the vegetative cover of the ‘topsoil’ dam walls and piping bund walls. Soil Erosion may be reduced by reducing side-slopes to < 5.2 degrees (9.2 % percentage grade) where necessary. Mature seeded grass may be mown from elsewhere and then spread out on areas that display a poor grass basal cover; No grazing or burning allowed.

Biannually (soil erosion and vegetative monitoring: spring before- and autumn after- the rains)

**Measures 3: Soil Quality:**

Sample/Fertilize the ‘topsoil’ dam walls and piping bund walls once every 3 -4 years in spring to maintain soil fertility and vegetative (grass) basal cover, thereby limiting soil erosion and continually refreshing the reproductive seed-bank.

Once every 3-4 years (fertility monitoring: sample and fertilise)

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Chamber of Mines Guidelines and Author’s interpretation

Chamber of Mines Guidelines

Chamber of Mines Guidelines
**ACTIVITY AREAS:** Mining, Coal Handling and Processing Plant Area (CHPP), Mine Infrastructure Area (MIA), Heavy Duty Vehicle Area (HDV)

**ACTIVITIES (AND ASPECTS):**
Water Supply Network: 'Dirty' and 'Clean': 'dirty' water intercept berms/drainage berms/canals, 'clean' water diversion berms/drainage berms/canals, Pipelines, Pump stations, Storage tanks (ASPECTS - All Potential Processes and Procedures)

**IMPACT CATEGORY:** Soil Contamination, Soil Erosion, Soil Quality - TYPE OF IMPACT: Direct and Indirect - IMPACT DESCRIPTION:
1a. Soil Contamination due to seepage of 'dirty' (in some instances) water below possibly poorly compacted/sealed existing canals/drainage berms, or due to possible siltation/vegetative growth in canals/drainage berms.
1b. Soil Contamination of the Underlying/Surrounding *in-situ* soils due to seepage of dirty water from pipelines/pump stations/storage tanks, or seepage of leaked/spilled oil/fuel from the pump motors (if mechanical).
2a. Soil Erosion of the adjacent (to canals/drainage berms) 'topsoil' berms due to either possible excessive side-slopes (>5.2 degrees, 9.2 % percentage grade), or alternatively possible poor vegetative (grass) basal cover.
2b. Soil Erosion of Underlying/Surrounding *in-situ* soils due to possible leakage of water from pipelines/pump stations/storage tanks.
3. Soil Quality reduction due to possible non-fertilisation or vegetation maintenance of the 'topsoil' berms.

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<th>Impact BEFORE Management</th>
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**Management Measures**

**Measures 1a: Soil Contamination (canals, drains, berms):**
Monitor and maintain optimum functioning (remove siltation and vegetation) of the 'dirty' water run-off intercept drains/berms to the PCD's, as well as the 'clean' water diversion drains/berms. The aforementioned will limit 'dirty' and 'clean' run-off water. Promote water flow in the canals/drainage berms to limit seepage below those that may be poorly sealed. Dredged material from the canals/drains must be disposed of in the discard dump (high pollution potential), but not dumped on the canal/drain walls or in surrounding areas.

**Measures 1b: Soil Contamination (pipelines, pump stations, storage tanks):**
Clean up oil/fuel spillages below pumps in pump station immediately; Clean concrete pad below pumps in pump station periodically, to collect up minor oil/fuel leakage; Ongoing maintenance of equipment.

**Measures 2: Soil Erosion:**
Canal and Drain Berms:

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