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A SPECIALIST REPORT ON THE SOILS, AGRICULTURAL POTENTIAL AND LAND CAPABILITY FOR THE PROPOSED GLENCORE KROONDAL MINE RESIDUE EXPANSION PROJECT, NORTHWEST PROVINCE

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Declaration

I, Barend Johannes Henning, declare that -

- I act as the independent specialist;
- I will perform the work relating to the project in an objective manner, even if this results in views and findings that are not favourable to the project proponent;
- 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 project, including knowledge of the National Environmental Management Act, 1998 (Act No. 107 of 1998; 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 will consider, to the extent possible, the matters listed in Regulation 8;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the project proponent 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 project; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority or project proponent;
- All the particulars furnished by me in this document are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

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SIGNATURE OF SPECIALIST

Notations and terms

Aerobic: Having molecular oxygen (O_2) present.

Agricultural means land zoned for agricultural use.

Anthropogenic: Of human creation

Arable means land that can produce crops requiring tillage; land so located and constituted that production of cultivated crops is economical and practical.

Alluvium (from the Latin, alluvius, from alluere, "to wash against") is loose, unconsolidated (not cemented together into a solid rock) soil or sediments, which has been eroded, reshaped by water in some form, and redeposited in a non-marine setting. Alluvium is typically made up of a variety of materials, including fine particles of silt and clay and larger particles of sand and gravel. When this loose alluvial material is deposited or cemented into a lithological unit, or lithified, it would be called an alluvial deposit.

Base status: A qualitative expression of base saturation. See base saturation percentage.

Black turf: Soils included by this lay-term are the more structured and darker soils such as the Bonheim, Rensburg, Arcadia, Milkwood, Mayo, Sterkspruit, and Swartland soil forms.

Biota: Living things; plants, animals, bacteria

Bottomland: The lowlands along streams and rivers, on alluvial (river deposited) soil.

Calcareous: Containing calcium carbonate.

Catena: A sequence of soils of similar age, derived from similar parent material, and occurring under similar macroclimatic conditions, but having different characteristics due to variation in relief and drainage.

Carbonate can refer both to carbonate minerals and carbonate rock (which is made of chiefly carbonate minerals), and both are dominated by the carbonate ion, CO_3^{2-}. Carbonate minerals are extremely varied and ubiquitous in chemically precipitated sedimentary rock. The most common are calcite or calcium carbonate, $CaCO_3$, the chief constituent of limestone (as well as the main component of mollusc shells and coral skeletons); dolomite, a calcium-magnesium carbonate $CaMg(CO_3)_2$; and siderite, or iron(II) carbonate, $FeCO_3$, an important iron ore. Sodium carbonate ("soda" or "natron") and potassium carbonate ("potash") have been used since antiquity for cleaning and preservation, as well as for the manufacture of glass.

Chroma: The relative purity of the spectral colour, which decreases with increasing greyness.

Effective soil depth means the depth of soil material that plant roots can penetrate readily to obtain water and plant nutrients; the depth to a layer that differs sufficiently from the overlying material in physical or chemical properties to prevent or seriously retard the growth of roots.

Erosion: The group of processes whereby soil or rock material is loosened or dissolved and removed from any part of the earth's surface.

Fertilizer: An organic or inorganic material, natural or synthetic, which can supply one or more of the nutrient elements essential for the growth and reproduction of plants.

Fine sand: (1) A soil separate consisting of particles 0,25-0,1mm in diameter. (2) A soil texture class with fine sand plus very fine sand (i.e., 0,25-0,05mm in diameter) more than 60% of the sand fraction.

Fine textured soils: Soils with a texture of sandy clay, silty clay or clay.

Floristic: of flora (plants).

Floodplain: Wetland inundated when a river overtops its banks during flood events resulting in the wetland soils being saturated for extended periods of time.

Gley: Soil material that has developed under anaerobic conditions because of prolonged saturation with water. Grey and sometimes blue or green colours predominate but **mottles** (yellow, red, brown and black) may be present and indicate localised areas of better aeration.

High potential means prime or unique.

Horizon: See soil horizons.

Hydric soil: Soil that in its undrained condition is saturated or flooded long enough during the growing season to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils).

Hue (of colour): The dominant spectral colour (e.g., red).

Land means the total natural environment of the exposed part of the earth's surface, including atmosphere, climate, soils, vegetation and the cultural environment.

Land capability: The ability of land to meet the needs of one or more uses under defined conditions of management.

Land type: A class of land with specified characteristics. In South Africa it has been used as a map unit denoting land, mappable at 1:250,000 scale, over which there is a marked uniformity of climate, terrain form and soil pattern.

Land use: The use to which land is put.

Mottles: Soils with variegated colour patters are described as being mottled, with the "background colour" referred to as the matrix and the spots or blotches of colour referred to as mottles.

Organic soil material: Soil material with a high abundance of undecomposed plant material and humus. According to the Soil Classification Working Group (1991) an organic soil horizon must have at least 10% organic carbon by weight throughout a vertical distance of 200 mm and be saturated for long periods in the year unless drained. According to the Soil Survey Staff (1975) definition, for a soil to be classed as organic it must have >12% organic carbon by weight if it is sandy and >18% if it is clay-rich.

Pedology: The branch of soil science that treats soils as natural phenomena, including their morphological, physical, chemical, mineralogical and biological properties, their genesis, their classification and their geographical distribution.

Perched water table: The upper limit of a zone of saturation in soil, separated by a relatively impermeable unsaturated zone from the main body of groundwater.

Permanent irrigation means the availability for, and regular artificial application of, water to the soil for the benefit of growing crops. Application may be seasonal.

Prime means the best land available, primarily from the national perspective, but with allowance of provincial perspectives; land best suited to, and capable of, consistently producing acceptable yields of a wide range of crops (food, feed, forage, fibre and oilseed), with acceptable expenditure of energy and economic resources and minimal damage to the environment (and is available for these uses).

Seasonally wet soil: Soil which is flooded or waterlogged to the soil surface for extended periods (>1 month) during the wet season but is predominantly dry during the dry season.

Sedges: Grass-like plants belonging to the family Cyperaceae, sometimes referred to as nutgrasses. Papyrus is a member of this family.

Sodic soil: Soil with a low soluble salt content and a high exchangeable sodium percentage (usually EST > 15).

Soil drainage classes describe the soil moisture conditions as determined by the capacity of the soil and the site for removing excess water. The classes range from very well drained, where excess water is removed very quickly, to very poorly drained, where excess water is removed very slowly. Wetlands include all soils in the very poorly drained and poorly drained classes, and some soils in the somewhat poorly drained class. These three classes are roughly equivalent to the permanent, seasonal and temporary classes

Soil family means a defined subdivision of a soil form representing a greater degree of uniformity than the form itself.

Soil form means the highest category in the South African soil classification system; soil forms are defined in terms of kind and sequence of diagnostic horizons; the soil form implies, inter alia, physical and hydrological properties which provide an indication of land-use possibilities and constraints; In the 1991 Edition, titled “Soil Classification: A Taxonomic System for South Africa”, 73 soil forms are recognized.

Soil horizons: Layers of soil that have uniform characteristics and have developed through pedogenic processes; they are bound by air, hard rock or other horizons (i.e., soil material that has different characteristics).

Soil profile: The vertically sectioned sample through the soil mantle, usually consisting of two or three horizons (Soil Classification Working Group, 1991).

Soil saturation: The soil is considered saturated if the water table or **capillary fringe** reaches the soil surface (Soil Survey Staff, 1992).

Swelling clay: Clay minerals such as the smectites that exhibit interlayer swelling when wetted, or clayey soils which, on account of the presence of swelling clay minerals, swell when wetted and shrink with cracking when dried. The latter are also known as heaving soils.

Temporarily wet soil: The soil close to the soil surface (i.e., within 50 cm) is wet for periods > 2 weeks during the wet season in most years. However, it is seldom flooded or saturated at the surface for longer than a month.

Terrain unit classes: Areas of the land surface with homogenous form and slope. Terrain may be seen as being made up of all or some of the following units: crest (1), scarp (2), midslope (3), footslope (4) and valley bottom (5).

Texture, soil: The relative proportions of the various size separate in the soil as described by the classes of soil texture shown in the soil texture chart (see diagram on next page). The pure sand, sand, loamy sand, sandy loam and sandy clay loam classes are further subdivided according to the relative percentages of the coarse, medium and fine sand subseparates.

Topsoil clay content means the average percentage clay-sized material (<0.002 mm) in the uppermost part of the soil; that is, the part ordinarily moved in tillage, or its equivalent in uncultivated soils, ranging in depth from about 100 to 300 mm; frequently designated as the “plough layer” or the “Ap horizon”.

Unique agricultural land means land that is or can be used for producing specific high-value crops. It is usually not prime, but important to agriculture due to a specific combination of location, climate or soil properties that make it highly suited for a specific crop when managed with specific farming or conservation methods. Included is agricultural land of high local importance where it is useful and environmentally sound to encourage continued agricultural production, even if some or most of the land is of mediocre quality for agriculture and is not used for particularly high-value crops.

Vertic, diagnostic A-horizon: A-horizons that have both, a high clay content and a predominance of smectitic clay minerals possess the capacity to shrink and swell markedly in response to moisture changes. Such expansive materials have a characteristic appearance: structure is strongly developed, ped faces are shiny, and consistence is highly plastic when moist and sticky when wet

Water regime: When and for how long the soil is flooded or saturated.

List of abbreviations

Abbreviation	Description
ARC	Agricultural Research Council
CARA	Conservation of Agricultural Resources Act
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
EAP	Environmental Assessment Practitioner
EIA	Environmental Impact Assessment
EMPR	Environmental Management Programme Report
ENPAT	Environmental Potential Atlas
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic Information Systems
GPS	Geographical Positioning System
ISCW	Institute for Soil, Climate and Water
MAE	Mean Annual Evaporation
MAMSL	Meter Above Mean Sea Level
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
NW	Northwest Province
NEMA	National Environmental Management Act
PQ4	Priority Quaternary Catchment
SADC	Southern African Development Community
SANBI	South African National Biodiversity Institute
WHO	World Health Organisation

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1 ASSIGNMENT

Exigo Sustainability was appointed by Glencore Operations South Africa (Pty) Ltd to conduct a soil potential and land capability study as part of the proposed mining expansion project on the Glencore Kroondal Mining Operations properties, Northwest Province. The expansion project includes the infrastructures associated with the proposed Co-Disposal Facilities (CDFs), Pollution Control Dam (PCD), topsoil stockpiles, silt trap, conveyor and access road, and the process water tank and desilting facility.

The main purpose of this study was solely to assess the agricultural potential and value of the soil types on the site and to determine the impact the proposed mining infrastructure will have on the land capability of the soils. This assessment is essential as it will contribute to meeting the requirements of the National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998) in compliance with Gazette No. 43310 Government Notice R320.

The assignment is interpreted as follows: Compile a study on the soil potential of the soil forms of the proposed development site according to guidelines and criteria set by the National Department of Agriculture. The study will include a detailed soil assessment and interpretation of impacts associated with the proposed mining development. To compile this, the following had to be done:

2 INFORMATION SOURCES

The following information sources were obtained:

- All relevant maps through GIS mapping, and information (previous studies and agricultural databases) on the land use, soils, agricultural potential and land capability of the area concerned;
- Requirements regarding the agricultural potential survey and prime or unique agricultural land as requested by the NDA;
- Obtain relevant information of land type, geology and soil types of the area. This includes information on the soil potential, clay percentage, soil depth and soil forms, as classified by the Environmental Potential Atlas of South Africa (Institute for Soil, Climate and Water, Agricultural Research Institute);
- Obtain information of the prevailing land use and agricultural activities being practiced in the larger area of the neighbouring properties;
- Obtain an aerial photograph of the area to help in the interpretation and identification of major soil types and land uses in the study area.

2.1 REGULATIONS GOVERNING THIS REPORT

2.1.1 National Environmental Management Act, 1998 (Act No. 107 of 1998) - Gazette No. 43310 Government Notice R. 320

This report was prepared in terms of the National Environmental Management Act, 1998 (Act No. 107

of 1998) Gazette No. 43310 Government Notice R. 320. – Specialist reports includes a list of requirements to be included in a specialist report:

1. A specialist report or a report prepared in terms of these regulations must contain:

    a. Details of

        i. The specialist who prepared the report; and

        ii. The expertise of that specialist to compile a specialist report, including a curriculum vitae;

    b. A declaration that the specialist is independent in a form as may be specified by the competent authority;

    c. An indication of the scope of, and purpose for which, the report was prepared;

    d. The date and season of the site investigation and the relevance of the season to the outcome of the assessment;

    e. A description of the methodology adopted in preparing the report or carrying out the specialized process;

    f. The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;

    g. An identification of any areas to be avoided, including buffers;

    h. A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;

    i. A description of any assumptions made and any uncertainties or gaps in knowledge;

    j. A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment;

    k. any mitigation measures for inclusion in the EMPr;

    l. any conditions for inclusion in the environmental authorisation;

    m. any monitoring requirements for inclusion in the EMPr or environmental authorisation

    n. a reasoned opinion –

        i. As to whether the proposed activity or portions thereof should be authorised and

        ii. If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr and where applicable, the closure plan;

o. A description of any consultation process that was undertaken while preparing the specialist report;

p. A summary and copies of any comments received during any consultation process and where applicable all responses thereto; and

q. Any other information requested by the competent authority.

2.1.2 Other related legislation

The natural resources of South Africa constitute a national asset, which is essential for the economic welfare of present and future generations. Economic development and national food security depend on the availability of productive and fertile agricultural land and are threatened by the demand for land for residential and industrial development. Urban and rural planning needs to be integrated rather than sectorial and fragmentary. The use of agricultural land for other purposes should therefore be minimised. Currently the retention of productive agricultural land is administrated through the Subdivision of Agricultural Land Act, 1970 (Act No. 70 Of 1970) which controls the subdivision of agricultural land and its use for purposes other than agriculture. Soon the use of these scares resources will be regulated through the Sustainable Utilisation of Agricultural Resources Bill. One of the objects of the new Bill is to provide for the use and preservation of agricultural land, especially “prime and unique agricultural land” by means of prescribe criteria in terms of which agricultural land may be used for purposes other than agriculture, in collaboration with principles as laid down in the Development Facilitation Act, 1995 (Act No. 67 of 1995) and in collaboration with the Land Use Bill, 2001. The prescribe criteria shall relate to the importance of the continued use of those agricultural resources for agricultural purposes in general particularly taking into consideration the use of prime and unique agricultural land or its agricultural importance relative to a particular province or area. Different criteria may be prescribed from time to time and such criteria may differ from province and area.

1. Terms of reference

2.1.3 Objectives

The objectives of this report are as follows:

- Conduct a soil survey on the proposed development site and identify the different soil types / forms present on the site;
- From the soil survey results link the optimal land use and other potential uses and options to the agricultural potential of the soils by classifying the soils into different Agricultural Potential classes according to the requirements set by the Department of Agriculture, South Africa. From these results soils maps and an agricultural potential map will be compiled;

- Discussion of the agricultural potential and land capability in terms of the soils, water availability, grazing capacity, surrounding developments and status of land.
- Identify potential impacts of the development on the soils and provide mitigation measures to manage these impacts.

2.1.4 Limitations and assumptions

- To obtain a comprehensive understanding of the dynamics of the soils of the study area, surveys should ideally be replicated over several seasons and over a few years. However, due to project time constraints such long-term studies are not feasible;
- The large study area did not allow for the finer level of assessment that can be obtained in smaller study areas. Therefore, data collection in this study relied heavily on data from representative, homogenous sections of soils, as well as general observations, aerial photograph analysis, generic data and a desktop analysis.

3 STUDY AREA

3.1 LOCATION AND DESCRIPTION OF ACTIVITY

Kroondal Chrome Mine is currently owned by Glencore Alloys, a subsidiary of Glencore South Africa (Pty) Ltd. The mine is situated 10 km east of Rustenburg on portions of the farm Kroondal 304JQ. Historically, mining at Kroondal has consisted of both opencast and underground mining. Currently, all opencast mining has ceased, and these areas have been rehabilitated. Only underground mining remains. The mine is operating from an approved 2003 Environmental Management Programme (EMP) report.

The current infrastructure for which the mine is as follows:

- Transport, power and water supply networks;
- Telephone lines;
- An explosives magazine;
- Beneficiation plant (crushing, screening circuit, HMS, spiral and stockpile sections);
- Stockpile areas for product;
- Tailings dam and associated Return Water Dam;
- Two waste rock dumps;
- Water management infrastructure including storm water management infrastructure, canals, a process dam (capacity 222 kilolitres), an Erickson dam (capacity 1089 kilolitres) a
- Silt trap (capacity 800 kilolitres) and the main catchment dam (capacity 20000 kilolitres);
- 10 monitoring boreholes;
- 11 water meters;
- Buildings including main office buildings, workshops (engineering, store complex and yard), service department (office, change house and lamp room complex), a salvage yard,
- Garages, toilets, security offices, a lapa, weigh bridge offices and a weighing bridge;
- Fences;
- A diesel storage area (adjacent to the workshop);
- A contractor’s hostel;
- A sewage plant;
- Workers housing;
- 2 Inclines shafts and a few ventilation shafts.

The residu expansion project for the Glencore Kroondal is resented in Figure 2 and includes the infrastructures associated with the proposed Co-Disposal Facilities (Tailings and Waste Rock) (CDF), Pollution Control Dam (PCD), topsoil stockpiles, silt trap, conyeor and access road, and the process water tank and desilting facility.

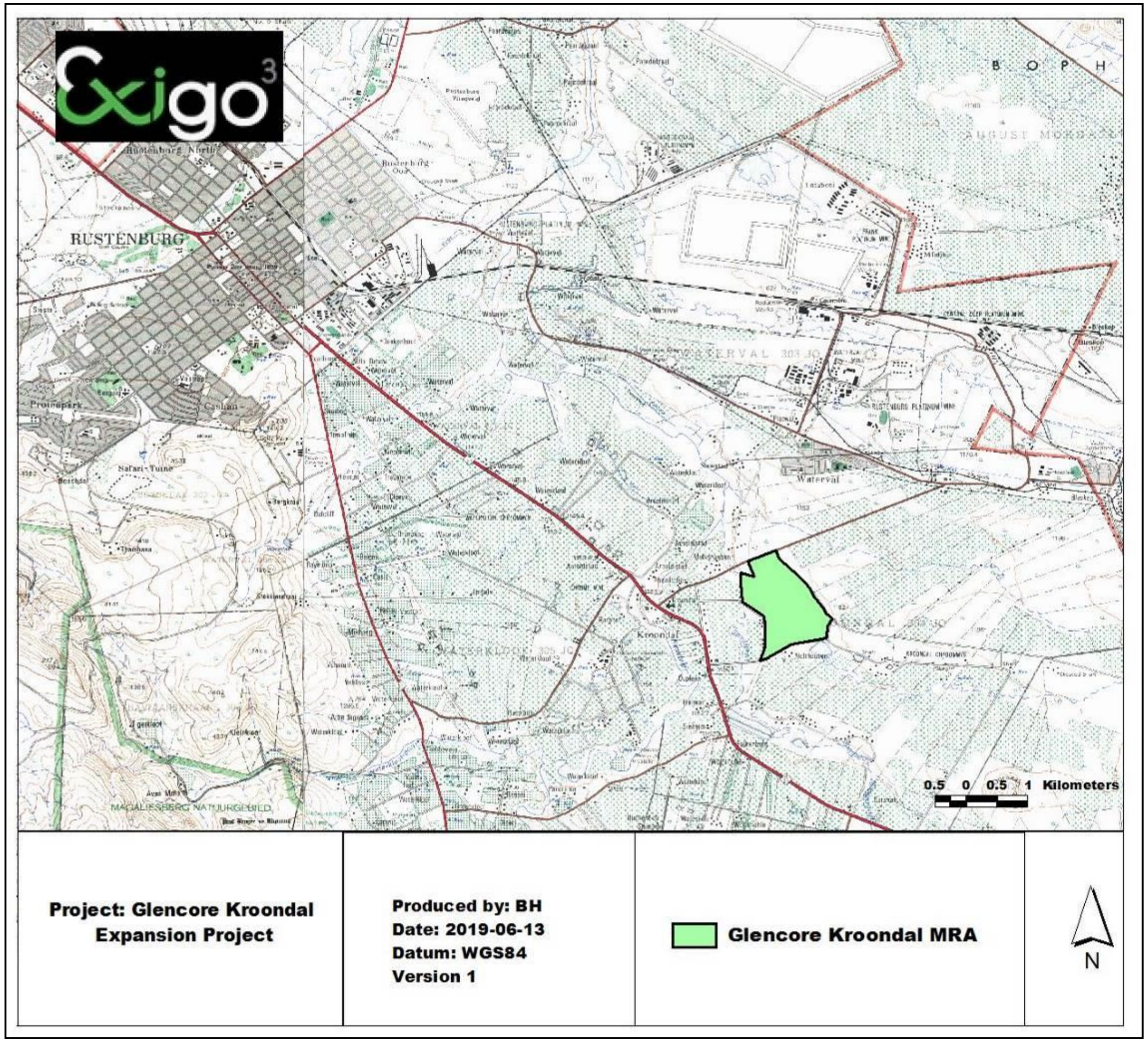

Figure 1. Regional Location Map

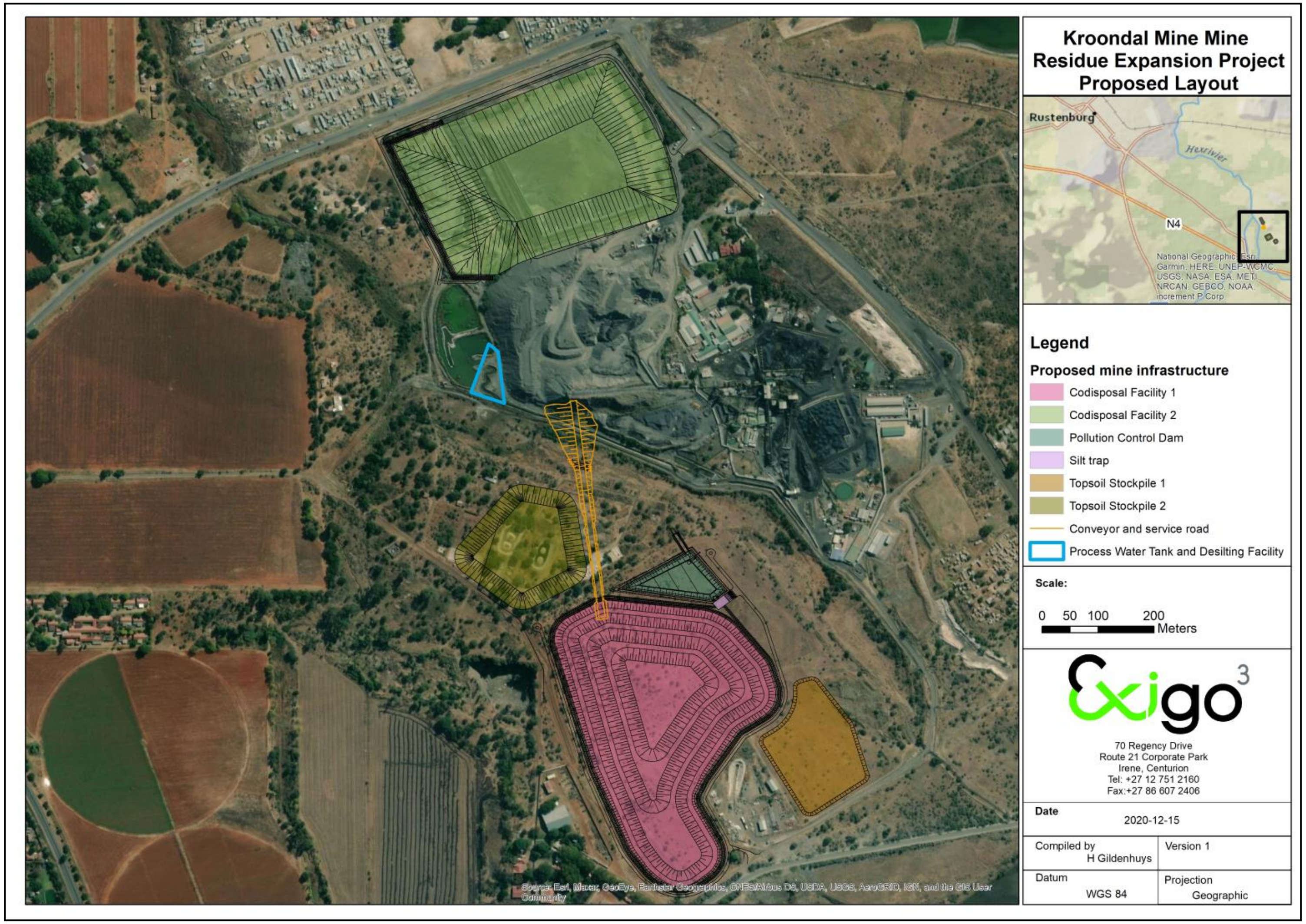

Figure 2. Satellite image showing the project area (Google Pro, 2010) and proposed activities

3.2 CLIMATE

Solar radiation, temperature, and precipitation are the main drivers of crop growth; therefore, agriculture has always been highly dependent on climate patterns and variations. Since the industrial revolution, humans have been changing the global climate by emitting high amounts of greenhouse gases into the atmosphere, resulting in higher global temperatures, affecting hydrological regimes and increasing climatic variability. Climate change is projected to have significant impacts on agricultural conditions, food supply, and food security.

Rustenburg normally receives about 513mm of rain per year, with most rainfall occurring mainly during mid-summer. It receives the lowest rainfall (0mm) in June and the highest (101mm) in January. The precipitation is almost exclusively due to rainfall, showers and thunderstorms with the maximum fall occurring in January. Heavy falls of 125 to 150 mm occasionally fall in a single day.

The average annual S-pan evaporation is approximately 1 700 mm. The highest evaporation occurs in December (approximately 191 mm) and the lowest evaporation in June (approximately 81 mm).

The monthly distribution of average daily maximum temperatures shows that the average midday temperatures for Rustenburg range from 19.3°C in June to 29.4°C in January. The region is the coldest during July when the mercury drops to 1.7°C on average during the night.

The dominant day time wind directions are from the North to the Northeast and from the West Northwest to North Northwest. During night time conditions the predominant wind direction is from the South Southeast to South Southwest. For both the daytime and nighttime conditions, approximately 50% of the measured wind speeds are between 1.54 m/s and 3.09 m/s (EnviroNgaka, 2013).

3.3 GEOLOGY AND SOIL TYPES

Geology is directly related to soil types and plant communities that may occur in a specific area (Van Rooyen & Theron, 1996). A Land type unit is a unique combination of soil pattern, terrain and macroclimate, the classification of which is used to determine the potential agricultural value of soils in an area. The land type units represented within the study area include the Ea3 land type (Land Type Survey Staff, 1987) (ENPAT, 2001). The land type, geology and associated soil type is presented in Table 1 below as classified by the Environmental Potential Atlas, South Africa (ENPAT, 2000).

Table 1. Land types, geology and dominant soil types of the proposed development site

Landtype	Soils	Geology
Ea3	One or more of: vertic, melanic, red structured diagnostic horizons, undifferentiated	Norite, gabbro, pyroxenite and anorthosite of the Bushveld Complex. Occasional dykes of syenite and diabase.

The soils are generally vertic, black clay soils or red clayey soils derived from Norite. The soils are derived from norite and have a moderate (15-35%) to high (>35%) clay content, depending on their position in the landscape.

3.4 TOPOGRAPHY, LANDUSES AND DRAINAGE

The Study Area is situated on slightly undulating plains and a non-perennial tributary of the Sandspruit. Small sections of original vegetation remain intact along rivers and water courses where pioneer plant species are prevalent. Other disturbances because of rubble dumping, littering and the area being used as a pass through by local people are also prevalent in the area. The major land uses of the study area as classified by the Environmental Potential Atlas of South Africa (2000) are vacant / unspecified land.

The study area is in the in the Crocodile (West) and Marico Water Management Area (WMA), and is located mainly in the Quaternary Catchment Area (QCA) A22H. The study area is drained mainly by means of surface run-off (sheetflow) with storm water collecting along roads and footpaths cutting through the area, to drain into the perennial and non-perennial rivers that bisect through the proposed development area.

3.5 LAND USE AND EXISTING INFRASTRUCTURE

The current land-use of the proposed development site is mining with the neighbouring areas being used for mining, small scale subsistence farming, industrial developments and rural developments. The major land use of the study area as classified by the Environmental Potential Atlas of South Africa (2000) is vacant / unspecified land.

3.6 VEGETATION

3.6.1 Biomes

The project area lies within the Savanna Biome. The Savanna Biome is the largest biome in Southern Africa. It is characterized by a grassy ground layer and a distinct upper layer of woody plants (trees and shrubs). The environmental factors delimiting the biome are complex and include altitude, rainfall, geology and soil types, with rainfall being the major delimiting factor. Fire and grazing also keep the grassy layer dominant.

3.6.2 Vegetation types

3.6.2.1 Mucina & Rutherford (2006) Classification

The most recent classification of the area by Mucina & Rutherford shows that the proposed development site is classified as Marikana Thornveld. The Marikana Thornveld vegetation type occurs in the North West and Gauteng Provinces. It occurs on plains from the Rustenburg area in the west, through Marikana and Brits to the Pretoria area in the east. The total mine area falls within this vegetation type.

The Marikana Thornveld vegetation type is considered Endangered. While the national conservation target for this vegetation type is 19%, less than 1% is statutorily conserved. This vegetation type has been transformed (48%), mainly by cultivation and urban or built-up areas. Most agricultural development of this area is in the western regions towards Rustenburg, while in the east industrial development is a greater threat. Alien invasive plants are localised in high densities, especially along drainage lines, in this vegetation type.

The Marikana Thornveld vegetation type is characterised by open *Vachellia karroo* woodland, in valleys and slightly undulating plains and some lowland hills. Shrubs are denser along drainage lines, on termitaria and rocky outcrops or in other habitats protected from fire. Key indicator species of this vegetation type include (dominant species are denoted by (d)):

- Tall tree: *Senegalia burkei;*
- Small trees: *Senegalia caffra (d), Vachellia gerrardii, V. karoo (d), Combretum molle (d), Searsia lancea (d), Ziziphus mucronata (d), Ziziphus mucronata (d), Vachellia nilotica, V. tortilis subsp. heteracantha, Celtis africana, Dombeya rotundifolia, Pappea capensis, Peltophorum africanum, Terminalia sericea;*
- Tall shrubs: *Euclea crispa subsp. crispa (d), Olea europaea subsp. africana (d), Rhus pyroides var. pyroides (d), Diospyros lycoides subsp. guerkei, Ehretia rigida subsp. rigida, Euclea undulata, Grewia flava, Pavetta gardeniifolia;*
- Low shrubs: *Asparagus cooperi (d), Rhynchosia nitens (d), Indigofera zeyheri;*
- Woody climbers: *Clematis brachiata (d), Justicia flava, Helinus integrifolius;*
- Herbaceous climber: *Cyphostemma cirrhosum, Pentarrihum insipidum (d);*
- Graminoids: *Elionurus muticus (d), Eragrostis lehmanniana (d), Setaria sphacelata (d), Themeda triandra (d), Aristida scabrivalvis subsp. scabrivalvis, Fingerhuthia africana, Heteropogon contortus, Hyperthelia dissoluta, Melinis nerviglumis, Barleria macrostegia, Dianthus mooiensis subsp. mooiensis, Ipomoea oblongata, Vernonia oligocephala;*
- Herbs: *Hermannia depressa (d), Ipomoea obscura (d), Barleria macrostegia, Dianthus mooiensis subsp. mooiensis, Ipomoea oblongata, Vernonia oligocephala*; and
- Geophytic herbs: *Ledebouria revoluta, Ornithogalum tenuifolium, Sansevieria aethiopica*

4 GUIDELINES FOR AGRICULTURAL POTENTIAL

4.1 MOISTURE AVAILABILITY

The moisture availability of soils is an aspect which recently has become an important factor to consider when cultivating crops under dry-land conditions. Moisture and water availability will be affected by a temperature increase, regardless of any change in rainfall. Higher temperatures increase the evaporation rate, thus reducing the level of moisture available for plant growth, although other climatic elements are involved. A warming of 1°C, with no change in precipitation, may decrease yields of wheat and maize in the core cropping regions such as the US by about 5%. A very large decrease in moisture availability in the drier regions of the world would be of great concern to the subsistence farmers that farm these lands. Reduced moisture availability would only exacerbate the existing problems of infertile soils, soil erosion and poor crop yields. In the extreme case, a reduction in moisture could lead to desertification. The classes as classified for South Africa are shown in Table 2.

Table 2. Moisture availability classes as derived from seasonal rainfall and evaporation

Moisture availability class	Summer rain season (R/0.25PET)	Winter rain season (R/0.4PET)	Agricultural Potential
1	>34	>34	Conducive to rain-fed arable agriculture
2	27-34	25-34	Conducive to rain-fed arable agriculture
3	**19-26**	**15-24**	**Conducive to rain-fed arable agriculture**
4	12-18	10-14	Marginal for rain-fed arable agriculture
5	6-12	6-9	Conditions too dry for rain-fed arable agriculture
6	<6	<6	Conditions too dry for rain-fed arable agriculture

The soils on the proposed development site are classified as class 3, which suggest that climatic conditions are conducive to rain-fed arable agriculture.

4.2 SOIL CLASSIFICATION OF THE SITE FROM ARC DATABASES

The Agricultural Research Institute uses specific soil characteristics to indicate the suitability of soils for arable agriculture.

These characteristics for the site are as follows:

- Structurally favourable soils: Soils with structure favouring arable land use scarce or absent;
- Soil association: Black and red, strongly structured clayey soils with high base status (association of Vertisols, Phaoezems, Kastanozems and Nitisols. In addition, one or more Leptosols, Calcisols and Cambisols may be present)
- Soil pH: 5.5-7.4;
- Prime agricultural activity for the area: Cattle

Since the classification of the soil characteristics is based on a broad-scale desktop study of the general area, a thorough investigation of the soil types of the proposed development site is necessary for a more accurate classification of the soils. The main aim of the study is to identify the soil types on site and evaluate their specific characteristics to determine the agricultural potential of the soils. The study will thus reduce the scale at which soils for the area was previously.

4.3 NATIONAL ASSESSMENT CRITERIA

4.3.1 Agricultural Potential of soils in South Africa

The essence of identifying high potential agricultural land in South Africa is to retain prime area for agricultural development and to retain as much productive areas as possible for the future. South Africa is dominated by shallow soils which are predominantly sandy. This poses a severe inherent limitation to crop production. The poor quality of the soil is due to the influence of the parent material in which they were formed. According to Laker (2005), South Africa has only 13 % (approximately 14 million ha) arable land, of which only 3 % is high potential. Inferring from the international requirement of about 0.4 ha arable land to feed an individual person, South Africa could produce enough food to feed only 35 million people on the available 14 million hectares of arable land. In line with this goal, the Department of Agriculture has developed a set of criteria to define potential and prime areas for agricultural development in South Africa. Based on Part 1 of the Regulation of Conservation of Agricultural Resources Act 43 of 1983, an agricultural land in the Northwest Province and specifically in the grid square in which the project site falls is considered high potential if the land:

1. Is under permanent irrigation; or
2. Can be classified into one of the following soil forms:
    a. Avalon
    b. Bainsvlei
    c. Bloemdal
    d. Clovelly
    e. Glencoe
    f. Hutton
    g. Oakleaf
    h. Pinedene
    i. Shortlands
    j. Tukulu And

3. The effective soil depth is equal to or greater than 900mm; and
4. Topsoil clay content between 10 and 35%.

High potential here means prime or unique. Prime refers to the best available land, mainly from the national perspective, suited to and capable of consistently producing acceptable yields of a wide range of crops (food, feed, forage, fibre and oilseeds), with acceptable expenditure of energy and economic resources and minimal damage to the environment. Unique agricultural land means land that is or can be used for producing specific high value crops.

Permanent irrigation means the availability for, and regular artificial application of, water to the soil for the benefit of growing crops. The application may be seasonal.

The classification of the National Department of Agriculture indicate that the site lies in a quarter degree grid square (QDS) with HIGH ARABLE POTENTIAL. The soil potential classification of the Department of Agriculture is based on broad-scale mapping (QDS) and the actual field study will refine the classification based on on-site conditions. The aim of this study should therefore be to refine the classification of the site at ground level.

4.3.2 Land capability of soils in South Africa

Scotney et al. (1991) within the concept of land capability defines land capability as ―the extent to which land can meet the needs of one or more uses under defined conditions of management, without permanent damage. Land capability is an expression of the effect of physical factors (e.g., terrain form and soil type), including climate, on the total suitability and potential for use for crops that require regular tillage, for grazing, for forestry and for wildlife without damage. Land capability involves the consideration of (i) the risks of damage from erosion and other causes, (ii) the difficulties in land use caused by physical factors, including climate and (iii) the production potential‖ (Scotney et al., 1991).

The current land capability data set that is used as the national norm indicates that there is little or no soils in South Africa that are not subject to limitations. Most of the country‘s soils have moderate to severe limitations largely due to limited soil depth or moderate erodibility, caused by sandy texture or slopes. It was determined that nowhere in South Africa do best soil and good climate classes coincide (Schoeman et al, 2002).

The land capability classes used for the South African Agricultural Sector are indicated in Table 3, while Table 4 indicate limitations and land use potential for the Land Capability classes.

Table 3. Land capability classes (Schoeman *et al.* 2002)

Land Capability Class	Increased intensity of use									Land Capability Groups
I	W	F	LG	MG	IG	LC	MC	IC	VIC	Arable land
II	W	F	LG	MG	IG	LC	MC	IC	-	
III	W	F	LG	MG	IG	LC	MC	-	-	
IV	W	F	LG	MG	IG	LC	-	-	-	
V	W	-	LG	MG	-	-	-	-	-	Grazing land
VI	W	F	LG	MG	-	-	-	-	-	
VII	W	F	LG	-	-	-	-	-	-	
VIII	W	-	-	-	-	-	-	-	-	Wildlife

W - Wildlife; F - Forestry
LG - Light grazing; MG - Moderate grazing
IG - Intensive grazing; LC - Light cultivation
MC - Moderate cultivation; IC - Intensive cultivation
VIC - Very intensive cultivation

Table 4. Land capability Classes: Limitations & land use

Land Capability Class	Definition	Conservation Need	Use suitability
I	No or few limitations. Very high arable potential. Very low erosion hazard.	Good agronomic practice.	Annual cropping.
II	Slight limitations. High arable potential. Low erosion hazard.	Adequate run-off control.	Annual cropping with special tillage or ley (25%)
III	Moderate limitations. Some erosion hazards.	Special conservation practice and tillage methods.	Rotation of crops and ley (50 %).
IV	Severe limitations. Low arable potential. High erosion hazard.	Intensive conservation practice.	Long term leys (75 %)
V	Watercourse and land with wetness limitations.	Protection and control of water table.	Improved pastures or Wildlife
VI	Limitations preclude cultivation. Suitable for perennial vegetation.	Protection measures for establishment e.g., Sod-seeding	Veld and/or afforestation
VII	Very severe limitations. Suitable only for natural vegetation.	Adequate management for natural vegetation.	Natural veld grazing and afforestation
VIII	Extremely severe limitations. Not suitable for grazing or afforestation.	Total protection from agriculture.	Wildlife

From the databases of Department of Agriculture the site has the following land capability:

Class III: - Moderate Potential Arable land – small sections of valleys and plains

These aspects still need to be confirmed at ground level though.

Criteria for determining land capability of a piece of land are based on soil and land characteristics. These criteria related back to hazards or limitations to land use and are as follows:

- Slope %;

- Clay %;
- Effective rooting depth;
- Permeability;
- Signs of wetness;
- Rockiness;
- Soil surface crusting.

5 METHODS

The assessment of agricultural potential and land capability of the study area was based on a combination of desktop studies to amass general information and then through site visit for status quo assessment, soil sampling and characterization, and the validation of generated information from the desktop studies:

- Definition of parameters of land as stipulated by the Subdivision of Agricultural Land Act, No. 70 of 1970 and the Amended Regulation of Conservation of Agricultural Resources Act No. 43 of 1983;
- Classification of high potential agricultural land in South Africa compiled by the Agricultural Research Council (Schoeman, 2004) for the National Department of Agriculture;
- Long-term climatic data record of the study area, obtained from Weather SA.
- Geophysical features of the site using Geographical Information System;
- Moisture availability class, determined through seasonal rainfall and fraction of the potential evapotranspiration (ARC, 2002);
- Field visit to the project site for general observation, survey of the farm in terms of vegetation, soils, water resources, terrain type and infrastructural profile;
- Previous and current land use of the farm and that of the neighbourhood;
- Other agro-ecological factors prevailing in the area;
- Agricultural potential of the property;
- Possible crop productivity or value of the farm for grazing purposes.

5.1 SOIL SURVEYS

The site surveys were conducted during May 2019. After a thorough investigation of an aerial photograph of the area and visual assessment of the specific sites and areas surrounding the sites, the following was done:

- Field observations were randomly made in the accessible, with specific emphasis on the resource area;
- Slopes were analysed to determine the viability to cultivate crops in specific areas;
- The following soil physical and chemical characteristics were analysed through physical investigation:
    - Soil Depth (soil auger used);
    - Soil clay content (land type memoirs);

   - Soil texture and general structure;
   - Soil samples taken, analysed and interpreted quantitatively, as mass of contaminant per mass of dry weight (DW) of soil (mg/kg), pH values and/or milli-Siemens per meter (µS/cm) for electrical conductivity (EC).

2. Data recorded of surveys included:

   - A description of the soil types and profiles identified on the sites;
   - Specific soil characteristics on the proposed development sites and areas surrounding the sites;
   - Photographs of the soil profiles and associated vegetation were taken and are included as part of the photographic guide.

3. Data processing

   A broad classification of the soil types on the farm was done. A soil map indicates the dominant soil types identified by using a Geographic Positioning System (GPS) to locate sampled points on the topographical map of the farm. Soils were classified according to the Taxonomic Soil Classification System for South Africa, 1991. The following attributes were recorded and taken into consideration at each of the sites where samples were collected:

   - Soil Type;
   - Soil Depth;
   - Soil clay content;
   - Estimated soil texture class and soil structure;
   - Soil chemical analyses;
   - Slope;
   - Moisture availability;
   - Agricultural potential.

   The agricultural potential of the soils was determined by using the specified guidelines stated above. The actual soil depth, clay content, slope, moisture potential and soil form were evaluated to determine the agricultural potential status. The soil characteristics and norms used to determine the agricultural potential of the soils were obtained from the National Department of Agriculture, which created criteria for high potential agricultural land in South Africa (Schoeman, 2004) as stated in previous discussion in the report.

6 RESULTS

The proposed development site show variation in terms of soil characteristics and soil types identified during the survey. The classification of soils on the farm was based on land type description and the Binomial System for South Africa, which classifies soils into forms and families based on the diagnostic horizon of the soil profile (Macvicar, 1991). Exposed soil profile characteristics created by road cuttings in the field were also used in describing the local soil form. In addition, a soil auger was used to assess soil depths and for sampling (if not limited by depth) at pre-determined distances during a walk-over survey on the property. Soil identification and classification of the dominant soil type were done. The soil type and profile identified on the site will be discussed in detail in the following section.

The soils were classified into broad classes according to the dominant soil form and family as follows:

- Vertic, black clayey soils of the Arcadia Soil Form;
- Red apedal soils of the Hutton soil Form;
- Black clayey / alluvial soils of the Rensburg soil forms associated with drainage channels and wetlands;
- Degraded areas where the topsoil has been disturbed and often removed (old mining areas / haul roads – not described in this section under soil forms)

The geological formations and vegetation patterns showed a strong correlation to the major soil units mapped in the study area. The location of the soil forms in the landscape is presented in figure 3, while the land capability map is indicated in figure 4.

6.1 VERTIC, BLACK CLAYEY SOILS OF THE ARCADIA SOIL FORM

Binominal Classification S.A.: Arcadia soil form

Description: These black vertic soils have deep A-horizons (>800mm deep on site) and are high in clay content with swelling-shrinking properties under conditions of water content changes. These expansive materials have a characteristic appearance: structure is strongly developed, ped faces are shiny, and consistence is highly plastic when moist and sticky when wet. The swell-shrink potential is manifested typically by the formation of conspicuous vertical cracks in the dry state and the presence, at some depth, of slickensides (polishedor grooved glide planes produced by internal movement).

Landscape: Plains (Photograph 1)

Depth of soil forms: 400-1200

Texture: Clay

Average Clay Content: 20-40%)

Agricultural Potential: The mainly smectitic nature, with consequent shrinking and swelling properties, of the Arcadia (turf) soils means that there is a narrower moisture range for cultivation than most other agricultural soils. If these swelling clay soils become wet, the pores fill up, they saturate easily and drain slowly, causing anaerobic conditions (especially under irrigation) and a deficit of oxygen in the root zone. If allowed to dry out, however, these soils can crack, damaging roots. Surface crusting is also a potential problem, due to the swelling and sealing nature of the soils, which can lead to decreased infiltration rates. However, these black clay soils are naturally fertile, with high cation exchange capacities and moderately high organic carbon contents. If well managed, they can be productive soils. In summary, the area mostly has soils of low and low to moderate agricultural potential due to insufficient depth with poor permeability.

Land capability: Livestock and / or game grazing are viable due to the slightly higher nutrient and organic content of the topsoil in grassland areas that support a mixture of palatable and unpalatable species.

Photograph 1. Landscape associated with black, vertic clayey soils of the Arcadia soil form

Photograph 2. Vertic, black clayey soils of the Arcadia soil form in the project area

6.2 RED APEDAL SOILS OF THER HUTTON SOIL FORM

Binominal Classification S.A.: Hutton soil form

Description: The Hutton soils found on the site occur in in a small section of the proposed new CDFs, PCD and stockpiles. The Hutton soil form on site is deep and has a medium to high clay content. The Hutton soil forms consist of an orthic A horizon on a red apedal B horizon overlying unspecified material. The red apedal soils B1-horizon has uniform "red" soil colours in both the moist and dry states and has weak structure or is structureless in the moist state. The range of red colors that is a key identification tool in differentiating between a red apedal and yellow-brown apedal is defined by the Soil Classification Working Group Book, 1991. Some of the defining red soil colours identified on the sites are bleached (10R 3/6), while some are bright red. The relatively high magnesium and iron content of the parent rocks from which these soils are derived, impart the strong red colours noted.

Landscape: Plains (Photograph 3)

Depth of soil forms: 600-1200mm+

Texture: Loamclay to sandyclay

Average Clay Content: 15-25%

Agricultural Potential: Moderate potential soils depending on size of land available for sustainable arable agriculture. Soil is often deep with a higher clay content. The red apedal Hutton soil with higher clay content in the topsoil has a high-water holding capacity. The high quality orthic A and red apedal B-horizons make it a suitable soil form for annual crop production (good rooting medium) and use as 'topsoil', having favourable structure (weak blocky to apedal) and consistence (slightly firm to friable). Under the climatic conditions these soils would however not sustain arable crop production. Considering that the amount of land that is needed to economically sustain arable agriculture, the soil type described above cannot be considered as viable for crop production.

Land capability: Livestock and / or game grazing are viable due to the slightly higher nutrient and organic content of the topsoil in grassland areas that support a mixture of palatable and unpalatable species.

Photograph 3. Landscape associated with the red apedal Hutton soils in the project area

Photograph 4. Road cutting indicating the Hutton soil form in the project area

6.3 BLACK OR DARK GREY CLAYEY SOILS ASSOCIATED WITH THE DRAINAGE CHANNELS AND WETLANDS OF THE RENSBURG AND ARCADIA SOIL FORMS

Binominal Classification S.A.: Rensburg and Arcadia soil forms

Description: The soils are generally dark grey to black in the topsoil horizons, and high in transported clays, and show pronounced mottling on gleyed backgrounds in the subsoils. These soils occur within the zone of groundwater influence. The soils are alluvial and are deep (>1,2m) with an orthic A and neocutanic B with signs of wetness in the horisons. Brown A horizon and red-brown B horizon. The soils are slightly sensitive to erosion. The subsoil is more sensitive to erosion and should preferably not be exposed.

Landscape: Bottomlands (drainage channel and wetlands) (Photograph 5)

Depth: >1200mm

Texture: Sandyclay to Clay

Average Clay Content: 20-40%

Agricultural Potential: Zero potential soils, due to the soil wetness these areas are not suitable for crop cultivation under arable conditions.

Land capability: The grazing potential of these low-lying areas is high due to the palatable grasses growing throughout the year on these soils. The only limiting factor may be that livestock movement is limited during the wet season when the clay expands, causing livestock to get stuck in the muddy conditions. Soils are very sensitive and prone to erosion. A specific strategy is needed to prevent damage to these soils considering that overgrazing and trampling has already caused some degradation of the floodplains.

Photograph 5. Valleybottom wetland in the project area

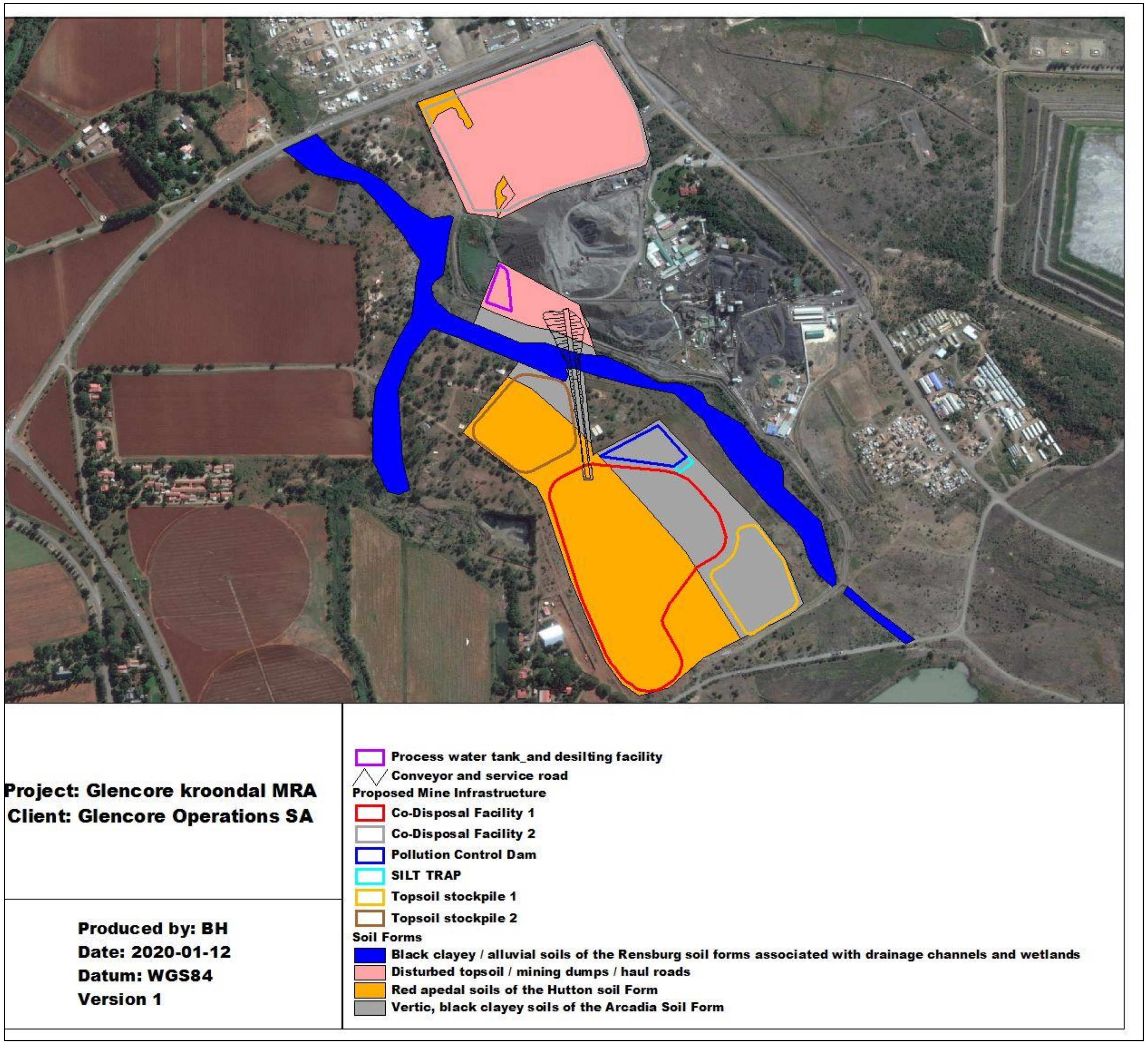

Figure 3. Soil form map for the proposed Glencore Kroondal Mine Residue Expansion site

7 AGRO-ENTERPRISE AND LAND CAPABILITY

Land capability is a system that was developed by the U.S. Department of Agriculture in the 1950s. It separates soils into classes of increasing land use limitations. Criteria used in the original system related only to soil physical properties and not soil fertility. If land capability is to be utilised in the agricultural sector, soil fertility parameters alongside yield data need to be considered. Increasingly this has been the case with the development of soil potential mapping.

7.1 SOIL CHEMICAL ANALYSES (ZIMPANDE RESEARCH COLLABORATIVE, 2021)

Soil samples were taken by Zimpande Research Collaborative (2021) at 5 different locations for the proposed reside expansion facilities as indicated in Figure 4.

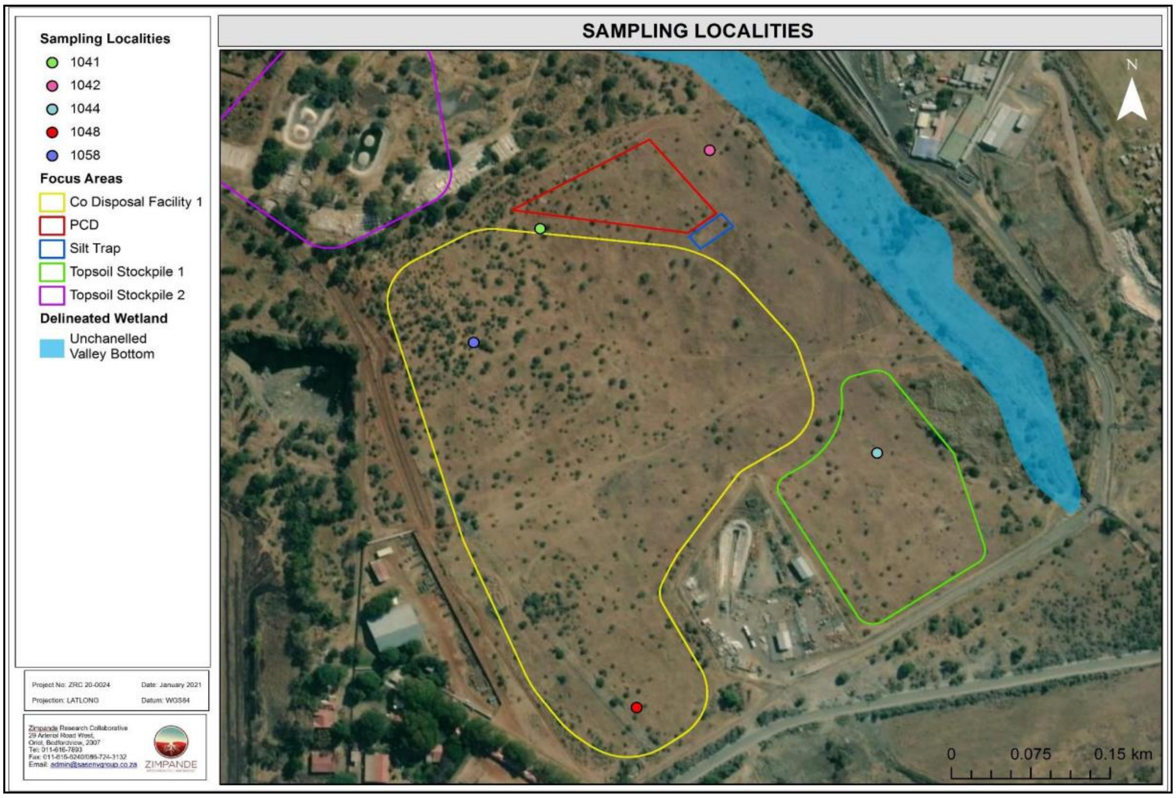

Figure 4. Sample localities associated with the study area (adapted from Zimpande Research Collaborative 2021)

7.1.1 Soil pH

The chemical soil analyses conducted by Zimpande Research Collaborative (2021) indicate that the natural pH of the surrounding soils is slightly acidic. Most of the nutrients which support plant growth are anticipated to be available because the soil pH ranges between 6.2 and 7.3. This indicates that the soils are more suitable for the cultivation of most crops.

7.1.2 Electrical Conductivity

The low EC values indicates that the soils are neither saline nor sodic and thus anticipated to not have a detrimental effect on plant growth at the current time (Zimpande Research Collaborative, 2021).

7.1.3 Metal toxicity

All samples showed low levels of Copper and Zinc. For both Copper and Zinc all samples fell below the detection limit set at 0.040 mg/kg for Copper and 0.100 mg/kg for Zinc. Therefore, these elements are not anticipated to cause toxic conditions for plant growth (Zimpande Research Collaborative, 2021.

7.1.4 Macronutrients

Nitrogen concentration in all the sample was low and not falling within the range of 10-50 mg/kg. The lower nitrate concentration can be attributed to the nitrate ions being highly mobile in the soils and thus more prone to leaching away from the root zone.

High acidity of the soils can be the reason for the low phosphate concentration. This can be rectified by the buildup of phosphates in the soil through additional fertilisation.

The Potassium levels in the soil samples indicated that supplementary potash fertilizers such as wood ash should be added directly as a fertilizer or added to a compost pile to increase the potassium content.

7.1.5 Soil micronutrients

Table 5 below depicts the summary of the physio-chemical parameters associated with the study area.

Table 5. Summary of the measured physio-chemical parameters associated with the study area (Zimpande Research Collaborative, 2021)

Sample Point	Analyses					
	pH Value at 25˚C	Fe (mg/kg)	Al (mg/kg)	K (mg/kg)	Mn (mg/kg)	Mg (mg/kg)
1041	6.1	1.38	0.528	2.1	<0.100	16
1042	6.7	3.95	0.610	<2.0	<0.100	24
1044	6.5	0.436	<0.400	<2.0	<0.100	24
1048	6.3	1.78	0.438	16.6	<0.100	20

The following was concluded:

- The low levels of aluminium concentration may be due to the slightly higher pH values;
- For all samples, Mn concentration fell below the detection limit set at <0.100 mg/kg potentially due to the slightly higher pH value.
- Magnesium (Mg) concentrations of the soil was regarded as low.

7.1.6 Soil texture

The summary of the particle size distribution associated with the study area is presented on Table 6 below and the summary of the physio-chemical parameters associated with the study area is presented on Table 6 below.

Table 6. Summary of the particle size distribution of each sample associated with the study area (Zimpande Research Collaborative, 2021).

Sample Point	Particle Size Distribution			Textural Class
	Sand (%)	Silt (%)	Clay (%)	
1041	67	11	22	Sandy Clay Loam
1042	77	8	12	Loamy Sand
1044	58	12	28	Sandy Clay Loam
1048	67	8	24	Sandy Clay Loam
1052	11	14	75	Clay

The clay % indicate that the soils are suitable for crop cultivation.

7.2 CLIMATIC CONDITIONS

The area is expected to receive an annual total rainfall between 600 and 700mm, of which most fall from October to April. It should, however, be borne in mind that the long-term average annual rainfall of 619 mm is marginal for dryland cultivation, especially when coupled with the intense nature of the precipitation and the variation between rainfall seasons. Without supplementary irrigation, this area should be considered as having a moderate to high risk for rain-fed agriculture.

The project site is thus considered dry which would contribute to moisture stress condition during crop growth and development. The potential of groundwater is relatively low to sustain a high water demanding irrigated cropping, expected at the project site.

7.3 CROP PRODUCTION

The soils of the project site are mostly clayey or sandy clay loam soils (Table 6) derived from Norite / Gabbro with isolated sections of the area representing loamy sand soils. The mainly smectic nature, with consequent shrinking and swelling properties, of the Arcadia (turf) soils means that there is a narrower moisture range for cultivation than most other agricultural soils. If these swelling clay soils become wet, the pores fill up, they saturate easily and drain slowly, causing anaerobic conditions (especially under irrigation) and a deficit of oxygen in the root zone. If allowed to dry out, however, these soils can crack, damaging roots. Surface crusting is also a potential problem, due to the swelling and sealing nature of the soils, which can lead to decreased infiltration rates. However, these black clay soils are naturally fertile, with high cation exchange capacities and moderately high organic carbon contents. If well managed, they can be productive soils. These soils have a high clay content and water holding capacity, although in combination with the climatic conditions (rainfall 620mm annually) render this section of the proposed development site only moderately favourable for effective crop production which could result from high moisture demands by planted crops.

The low-lying bottomlands have sandy-clay or clay soils that are seasonally flooded or have a perched water table. These areas are unsuitable for crop cultivation.

The soil nutrient analysis in combination with the climatic conditions and the nature of the soils render the study area to have a Moderate to Low Potential for effective crop production which could result from high moisture demands by planted crops. In addition, the farm is in an area which is marginal for rain-fed arable crop production. Economically viable farming is thus restrictive to irrigated cropping due the high risk that could be associated with dry-land farming. Higher day temperatures in summer months may hamper soil moisture storage for crop use. At present no irrigation or functional centre pivots occur on the property.

7.4 LIVESTOCK PRODUCTION / WILDLIFE GRAZING

The natural vegetation in the study area has a grazing capacity that varies from medium (clayey soils) to high (seasonally wet soils, deeper loamy soils). The area for the proposed CDFs, PCD and associated infrastructure can support grazing according to the soil nutrient content as follows:

- The red-yellow apedal soils and black clayey soils associated with the study area has a Medium potential for livestock grazing due to the higher nutrient content of the soil supporting a mixture of palatable and unpalatable grasses. Grazing value decreases as the season changes from summer to winter though, with the lowest grazing potential available to livestock at the end of the season.;
- The seasonally wet soils of the study area support palatable grass species and these areas have a Medium to High suitability for livestock or game grazing. These soils have a good water holding capacity and grass species that grow in these areas vary from having a medium to high palatability depending on the seasonal changes.

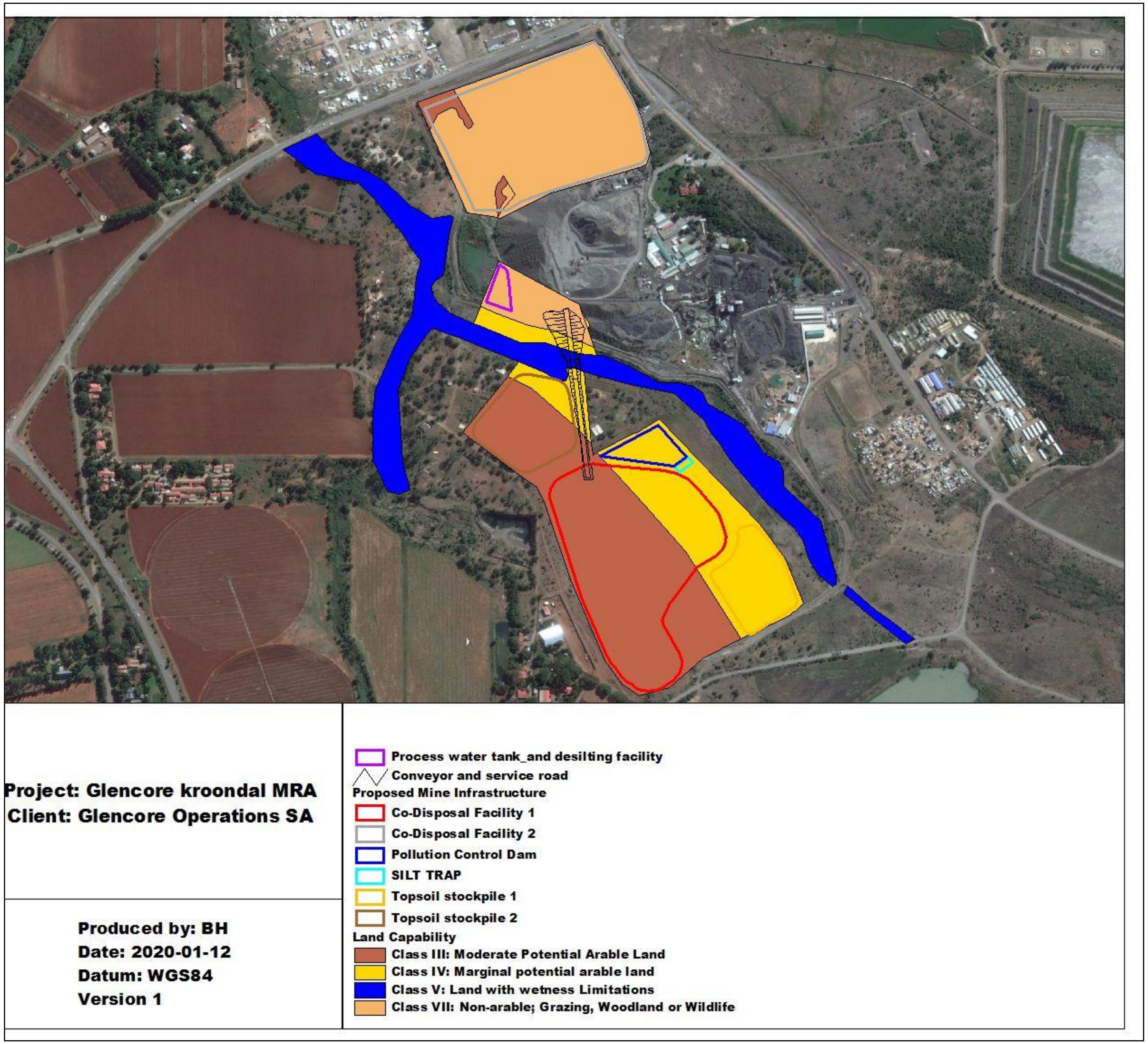

Figure 5. Land capability map of the proposed Glencore Kroondal Mine Residue Expansion site

8 ANTICIPATED SOIL IMPACTS

The objective of this section was to identify impacts and provide a list of actions and potential impacts associated with the various mining phases namely the planning and design phase, construction phase, operational phase, decommission phase and closure phase for the various mining components:

- Co-Disposal Facilities;
- Pollution Control Dam;
- Topsoil stockpiles;
- Silt trap
- Support infrastructure including conveyor and roads.

The impacts associated with the mining development on the soils and land capability will depend on the specific area where the mining activities will take place. The mining activities that will take place along the flatter terrain associated with the valley floors and plains where deeper, clayey soils occur will not have any negative impact on crop production and local food security because of the seasonally wet conditions and small pockets of soils that cannot sustain crop cultivation without irrigation, and any potential impacts (compaction, erosion) on these low-lying areas will be easier to mitigate. The section below described the impacts associated with the mining development on the soils and land capability in more detail.

8.1 PLANNING AND DESIGN PHASE

Planning and design is necessary to ensure that mitigation and impact management can be effectively implemented and minimise impacts in future. The planning and design phase of the mine will involve the following actions:

- Layout avoidance of sensitive soil types associated with wetlands or soils with high erosion / compaction risk;

No specific direct impacts will occur on the soils of the area during this phase.

8.2 CONSTRUCTION PHASE

The development and start-up of the mining operation covers the period when considerable changes take place as the mine infrastructure and facilities are constructed. The most immediate impacts are disruptions and disturbances to soil include stripping of topsoil and exposure of soils due to site clearance for construction of the Co-Disposal Facilities, pollution control dam, topsoil stockpiles, access and haul roads and other mining related infrastructure. This is usually a significant change to the visual appeal of the area.

Exposure of rocks, ore and soils to rainfall and wind may lead to atmospheric contamination by dusts and increased erosion of the site and sedimentation of local water courses. An increase in the movement of construction vehicles will result in an increase in the dust levels in the area. The following impacts will occur during the construction phase of the mine:

- **Soil compaction** occurs when soil particles are pressed together, reducing pore space between them. Heavily compacted soils contain few large pores and have a reduced rate of both water infiltration and drainage from the compacted layer. In addition, the exchange of gases slows down in compacted soils, causing an increase in the likelihood of aeration-related problems. Finally, while soil compaction increases soil strength-the ability of soil to resist being moved by an applied force-a compacted soil also means that roots must exert greater force to penetrate the compacted layer. In the case of mining activities associated with the proposed mining infrastructure during construction, soil compaction will be caused by regular heavy vehicle movement (wheel impact) and laydown areas of stockpiles on soils. If mitigating measures are not implemented the effect of the compaction will negatively affect soil structure of soils on the site.
- **Soil erosion and sedimentation**: Mining activities may further result in widespread soil disturbance and is usually associated with accelerated **soil erosion**, particularly in the study area during the summer months that receives high rainfall. Soil is especially prone to erosion once the topsoil has been stripped, leaving the soil exposed to wind and water erosion. Any soils left exposed throughout the construction phase could lead to significant erosion of the soils in the vicinity of the mining development. Soil, sediments and associated contaminants are transported into streams, rivers and other water bodies, resulting in the loss or alteration of habitats for aquatic organisms, as well as changes in water quality. The hardened surfaces and compacted soils of the development area will also lead to an increase in surface run-off during storm events which will likely be discharged via stormwater outlet points, concentrating flows leaving the development area. Soil erosion also promotes a variety of terrestrial ecological changes associated with disturbed areas, including the establishment of alien invasive plant species, altered plant community species composition and loss of habitat for indigenous fauna and flora.
- **Soil pollution:** Construction work of the magnitude contemplated for the proposed mine will always carry a substantial risk of soil pollution, with large construction vehicles contributing substantially due to oil and fuel spillages. Building waste, batching plants, sewage and domestic waste are also potential contributors to this problem. If not promptly dealt with, spillages or accumulation of waste matter can contaminate the soil and surface or ground water, leading to potential medium/long-term impacts on soil chemical composition.
- **Soil destruction** is a form of soil degradation that involves the destruction of natural soil bodies and all the parameters that led to the formation of the soil. Stripping of the topsoil during construction will remove the fertile layer of the soil. This will result in the loss of the soil carbon content as well as soil micro-organisms that support the soil nutrient cycles.
- **Loss of land capability:** This impact involves the loss of land available for farming and tourism: The area where the mine is proposed is in an area largely used for mining activities. The land in general has a low to moderate capability for crop cultivation and can mostly be utilized as grazing for

livestock. The construction of the mining infrastructure will result in a total loss of the land capability as it currently is and will change the current land use from grazing to industrial land-use. The mining operations will have a negative impact initially and will reduce the percentage of land available for livestock grazing and agricultural activities done. The surface area of the mine to be disturbed is however relatively small and therefore the impact will not be as significant as anticipated.

8.3 OPERATIONAL PHASE

The routine operational phases account for most of the environmental impacts associated with mining and are considered to have the greatest potential to drive environmental change. The extent to which mining operational activities act as drivers of environmental change depends in part on the type, scale, duration and magnitude of the activities, and the sensitivity of the receiving environment.

The removal and storage (stockpiling) of ore in the operational phase is usually the most intensive activity on any mine operation. The process involves exposure of ore bodies, followed by loading and transportation of the ore to the stockpile sites. These activities are characterized by large-scale disturbance due to noise and generation of dust from the movement of vehicles and possible wind-blown dust from stockpiles at the recovery plant.

Typical activities of the operational phase will include:

- Storage of tailings in CDFs;
- Pollution Control Dam;
- Disposal of waste rock on CDFs;
- Transporting of people and equipment;
- Transportation of product off-site;
- Transportation of supplies to the site;
- Handling and storage of hazardous materials and substances;
- Domestic waste generation, storage and disposal;
- o Water storage facilities;
- o Hazardous waste storage and disposal.

A short description of the impacts associated with the operational phase is included below:

- In the case of mining activities associated with the proposed underground mining operation, soil compaction will be caused by regular heavy vehicle movement (wheel impact) and laydown areas of stockpiles and the Co-Disposal Facilities on soils.
- The hardened surfaces and compacted soils of the mining development area will also lead to an increase in surface run-off during storm events which will likely be discharged via stormwater outlet points, concentrating flows leaving the mining area. This can lead to erosion and channel incision in the water courses and change the in-stream habitat. This could result in higher velocity flows with greater erosive energy which can result in channel

incision and gully erosion downstream within the channel and floodplain wetlands. The bare side slopes of the soil stockpiles and steep slopes associated with soil stockpiles will result in erosion of the stockpiles and movement of the eroded sediment into the drainage channels that eventually feed the Sandspruit to the south and north of the proposed development areas, leading to increased sedimentation within the wetlands and possible changes to flow and vegetation. The sediment is likely to deposit out where gradients flatten, generally sites of wetlands.

- During the operational phase heavy machinery and vehicles as well as sewage and domestic waste would be the main contributors to potential soil pollution problems.
- The operation of the proposed mine will result in a total loss of the land capability as it currently is and will change the current land use from grazing to industrial land-use. The mining operations will have a negative impact initially and will reduce the percentage of land available for livestock grazing and agricultural activities done but will partially recover after successful rehabilitation provides good grazing. The mining activities that will reduce the land capability during the operational phase of the mine include the dumping of waste rock on the CDFs and laydown of stockpiles.

8.4 DECOMMISSIONING AND CLOSURE PHASES

The decommissioning phase starts when all the economically exploitable mineral reserves in an area have been extracted. The actions which mark this phase include:

- Cessation of mining;
- Removal of mine infrastructure

The closure phases of the mine involve rehabilitation actions to mitigate impacts caused during the construction and operational phase of the mine. Some of the rehabilitation actions include the following:

- Ripping and rehabilitation of all haul roads;
- Use of topsoil stockpiles for rehabilitation;
- Rehabilitation of the CDFs, PCD and associated infrastructure;
- Seeding of ripped and rehabilitated surfaces;

The major impacts on the soils during these phases are as follows:

- Soil compaction is likely to occur over much of the rehabilitated areas because of the storage and placement of soil and the change in structure following placement. In the case of mining activities associated with the proposed mine during the closure phase, it will be reduced because of rehabilitation activities, although compaction will still be caused by regular heavy vehicle movement during rehabilitation.
- The poor soil cover associated with rehabilitated areas also renders the site more susceptible

to erosion and soil loss. It is probable that these soils will be transferred through the rehabilitated landscape into the draining water courses and receiving water bodies as described earlier. The rehabilitation of the site and decreased surfaces will however still reduce the risk of erosion and sedimentation carried into the rivers during the closure phase, compared to the other phases. Soil compaction is likely to occur over much of the rehabilitated area because of the storage and placement of soil and the change in structure following placement.

- During the closure phase of the mine the risk of spillages are still pertinent, although the impact will mainly be limited to potential spillages from vehicles. The impact will therefore be greatly reduced because of concurrent rehabilitation and removal of potential spillage sources (sewage plant, heavy machinery).
- Although the cleared areas will eventually be revegated, it is not anticipated that grazing areas that was lost to mining will be remediated to such an extent that the land capability will return.

9 QUANTITATIVE IMPACT ASSESSMENT

Table 5 indicate the impacts described above and specific ratings of significance the impact will potentially have on the ecosystem during the proposed mining activities according to the layout plan of the mining development:

Table 7. Quantitative impact assessment for the various mining components and mining phases on the soils and land capability

No	Impact	Activity	Without or With Mitigation	Nature (Negative or Positive Impact)	Probability		Duration		Scale		Magnitude/ Severity		Significance		Mitigation Measures	Mitigation Effect
					Magnitude	Score	Magnitude	Score	Magnitude	Score	Magnitude	Score	Score	Magnitude		
								Planning Phase								
1	Delay of mining onset	Obtaining of IWUL for crossings (wetland soils) and mining layout on sensitive soils	**WOM**	**Negative**	Definite	5	Short term	1	Local	1	High	8	50	Moderate	Apply and obtain IWUL from DWS after liaison with relevant officials and site visit to the area	Can be avoided, managed or mitigated
			WM	**Negative**	Highly Probable	4	Short term	1	Local	1	Medium	6	32	Low		Can be reversed
								Construction Phase								
2	Soil compaction	Heavy machinery and vehicle movement on site	**WOM**	Negative	Definite	5	Permanent	5	Local	1	High	8	70	High	Refer to section 10 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Local	1	Low	2	35	Low		Can be reversed
3	Soil erosion and sedimentation	Topsoil & subsoil stripping, exposure of soils to wind and rain during construction causing erosion and sedimentation in wetlands	**WOM**	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 10 of report	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Local	1	Medium	6	44	Moderate		Can be avoided, managed or mitigated
4	Spillages of harmful substances	Heavy machinery and vehicle movement on site	**WOM**	Negative	Highly Probable	4	Long term	4	Regional	3	Medium	6	52	Moderate	Refer to section 10 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Long term	4	Site	2	Low	2	16	Negligible		Can be reversed
5	Soil destruction and sterilization	Topsoil & subsoil stripping	**WOM**	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 10 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Local	1	High	8	65	High		Can be reversed
6	Loss of land capability	Topsoil & subsoil stripping	**WOM**	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 10 of report	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Local	1	Medium	6	44	Moderate		Can be reversed
								Operational Phase								
7	Soil compaction	Heavy machinery and vehicle movement on site, laydown areas of CDFs and stockpiles	**WOM**	Negative	Definite	5	Permanent	5	Regional	3	High	8	80	High	Refer to section 10 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Site	2	High	8	70	High		Can be avoided, managed or mitigated
8	Soil erosion and sedimentation in wetland / water courses	Increased hardened surfaces around infrastructure, laydown areas of CDFs and stockpiles, road and conveyor crossings	**WOM**	Negative	Definite	5	Permanent	5	Regional	3	High	8	80	High	Refer to section 10 of report	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Site	2	Medium	6	48	Moderate		Can be avoided, managed or mitigated
9	Spillages of harmful substances leading to water pollution in wetlands	Heavy machinery and vehicle movement on site	**WOM**	Negative	Highly Probable	4	Long term	4	Regional	3	Medium	6	52	Moderate	Refer to section 10 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Medium term	3	Site	2	Low	2	14	Negligible		Can be reversed
10	Soil destruction and sterilization	Topsoil & subsoil stripping	**WOM**	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 10 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Local	1	Medium	6	55	Moderate		Can be reversed
11	Loss of land capability	Topsoil & subsoil stripping,	**WOM**	Negative	Definite	5	Permanent	5	Site	2	High	8	75	High	Refer to section 10 of report	May cause irreplaceable loss of resources
			WM	Negative	Highly Probable	4	Long term	4	Local	1	Medium	6	44	Moderate		Can be reversed

No	Impact	Activity	Without or With Mitigation	Nature (Negative or Positive Impact)	Probability		Duration		Scale		Magnitude/ Severity		Significance		Mitigation Measures	Mitigation Effect
					Magnitude	Score	Magnitude	Score	Magnitude	Score	Magnitude	Score	Score	Magnitude		
Closure and Decommissioning Phase																
12	Improvement of eroded soils and compaction	Rehabilitation of mining site	**WOM**	Positive	Highly Probable	4	Long term	4	Local	1	Low	2	28	Low	Refer to section 10 of report	Can be avoided, managed or mitigated
			WM	Positive	Definite	5	Permanent	5	Local	1	Medium	6	60	Moderate		Can be reversed
13	Soil erosion and sedimentation	Demolition of mining infrastructure / Cessation of mining / rehabilitation of mining site	**WOM**	Negative	Highly Probable	4	Long term	4	Regional	3	Medium	6	52	Moderate	Refer to section 10 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Medium term	3	Site	2	Low	2	14	Negligible		Can be avoided, managed or mitigated
14	Soil compaction	Heavy machinery and vehicle movement on site	**WOM**	Negative	Definite	5	Permanent	5	Local	1	Medium	6	60	Moderate	Refer to section 10 of report	May cause irreplaceable loss of resources
			WM	Negative	Definite	5	Long term	4	Local	1	Low	2	35	Low		Can be reversed
15	Spillages of harmful substances	Heavy machinery and vehicle movement on site	**WOM**	Negative	Highly Probable	4	Medium term	3	Regional	3	Medium	6	48	Moderate	Refer to section 10 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Short term	1	Site	2	Low	2	10	Negligible		Can be avoided, managed or mitigated
Post-Closure Phase																
16	Improvement of soil compaction and erosion	Natural processes	**WOM**	Positive	Highly Probable	4	Long term	4	Local	1	Low	2	28	Low	Refer to section 10 of report	Can be avoided, managed or mitigated
			WM	Positive	Definite	5	Permanent	5	Local	1	Medium	6	60	Moderate		Can be reversed
17	Soil erosion and sedimentation	Exposed surfaces / unrehabilitated areas on site post closure / poor monitoring during LoM	**WOM**	Negative	Highly Probable	4	Medium term	3	Site	2	Medium	6	44	Moderate	Refer to section 10 of report	May cause irreplaceable loss of resources
			WM	Negative	Probable	2	Short term	1	Local	1	Low	2	8	Negligible		Can be avoided, managed or mitigated

10 SOILS AND LAND CAPABILITY MANAGEMENT PLAN AND MITIGATION MEASURES FOR THE PROPOSED GLENCORE KROONDAL MINE RESIDUE EXPANSION PROJECT

A management system has been developed to comply with the objectives and principles set out in this document. This system is based on the principle of managing the potential environmental impacts using the best available technology, not entailing excessive cost. In this way, the technology is effective, but does not seriously impair economic stability of the development. Management measures required for the different phases of the mine which relates to biodiversity is presented in Table 8 below.

Table 8. Soils and Land Capability Management Plan to be implemented as part of the Environmental Management Programme Report for the Glencore Kroondal Mine Residue Expansion Project

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
Planning and Design phase									
Pre-mining	Mining through sensitive soils and road crossings across wetlands / water courses	Soils	Delay of mining onset	National Water Act Section 21 C and I	Obtaining of IWUL for crossings and mining through water courses / wetlands	Application forms completed as obtained from DWS	Apply and obtain IWUL from DWS after liaison with relevant officials and site visit to the area	2 years	Environmental Assessment Practitioner (EAP)
Construction Phase									
Support infrastructure, CDFs, PCD, stockpiles and silt trap	Heavy machinery and vehicle movement on site	Soils	Soil compaction	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	• Prevent edge effects • Keep mining development footprint restricted to layout plans • To limit soil loss and compaction	Keep mining development footprint restricted to layout plans	• Soil should be handled when dry during removal and placement to reduce the risk of compaction; • Vegetation (grass and small shrubs) should not be cleared from the site prior to mining activities or construction (except if vegetation requires relocation as determined through an ecology assessment). This material is to be stripped together with topsoil as it will supplement the organic and possibly seed content of the topsoil stockpile depending on the time of soil stripping (whether plants are in seed or not); and • During construction, sensitive soils with high risk of compaction (e.g., clayey soils) must be avoided by construction vehicles and equipment, wherever possible, to reduce potential impacts. Only necessary damage must be caused and, for example, unnecessary driving around in the veld or bulldozing natural habitat must not take place. • Rip and/or scarify all compacted areas. Do not rip and/or scarify areas under wet conditions, as the soil will not loosen. Compacted soil can also be decompacted by "Rotary Decompactors" to effectively aerate soils for vegetation establishment.	Continuous	Contractor / ECO
Support infrastructure, CDFs, PCD, stockpiles and silt trap	Topsoil & subsoil stripping	Soils	Soil erosion and sedimentation	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	• To prevent the loss of soil through the expansion of the WRD • To prevent the loss of topsoil capability during stockpiling • To prevent the contamination of soils due to spillages of reagents • To prevent soil erosion	Management of storm water on site; Minimize time that soil is left exposed after vegetation is cleared that will cause erosion and sedimentation	• When possible, topsoil stripping and excavation activities should be scheduled for the low rainfall season (winter); • Cover disturbed soils as completely as possible, using vegetation or other materials; • Minimize the amount of land disturbance and develop and implement stringent erosion and dust control practices. • Sediment trapping, erosion and storm water control should be addressed by a hydrological engineer in a detailed storm water management plan; • All aspects related to dust and air quality should be addressed by an air quality specialist in a specialist report; • Protect sloping areas and drainage channel banks that are susceptible to erosion and ensure that there is no undue soil erosion resultant from activities within and adjacent to the construction camp and Work Areas; • Repair all erosion damage as soon as possible to allow for sufficient rehabilitation growth; • Gravel roads must be well drained to limit soil erosion;	Continuous	Contractor / ECO
Support infrastructure, CDFs, PCD, stockpiles and silt trap	Heavy machinery & vehicle movement on site	Soils	Spillages	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) Section 11(1)	• To prevent contamination of soil due to the spillages of hydrocarbons and reagents used in the process and during transportation of these substances • To reduce the risk of contamination of soils due to increased fuel deliveries	Active monitoring of potential spillages	• Contamination prevention measures should be addressed in the Environmental Management Programme (EMP) for the proposed development, and this should be implemented and made available and accessible at all times to the contractors and construction crew conducting the works on site for reference; • A spill prevention and emergency spill response plan, as well as dust suppression, and fire prevention plans should also be compiled to guide the construction works; • An emergency response contingency plan should be put in place to address clean-up measures should a spill and/or a leak occur, as well as preventative measures to prevent contamination;	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
							• Burying of any waste including rubble, domestic waste, empty containers on the site should be strictly prohibited and all construction rubble waste must be removed to an approved disposal site; and • Regular monitoring of site activities and machinery must be undertaken to identify spills or leaks; • Ensure that mining related waste or spillage and effluent do not affect the sensitive habitat boundaries and associated buffer zones. • This risk of spillages of reagents and hydrocarbons on the soil during transportation can be reduced with proper maintenance of vehicles. This would include a rigorous and proactive maintenance program • This risk can be further reduced through an adequate program of training of drivers and crews. This would include defensive driver training, basic vehicle maintenance, and emergency control of spills. For the vehicle crews to be adequately able to control any spills at an early stage, the vehicles must be properly equipped with spill containment equipment (booms, sandbags, spades, absorbent pads, etc.). Responsibility for training lies with the transport contractor. Adequate training, maintenance, and equipment of transport crews should be included as a requirement for transport contracts. • All employees will be trained in cleaning up of a spillage. The necessary spill kits containing the correct equipment to clean up spills will be made available at strategic points in the plant area		
Support infrastructure, CDFs, PCD, stockpiles and silt trap	Topsoil & subsoil stripping, opencast mining	Soils and land capability	Soil destruction and sterilization	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	• Prevent edge effects • Keep mining development footprint restricted to layout plans	Keep mining development footprint restricted to layout plans	• No specific mitigation can be applied during the construction phase of the mine to prevent soil destruction, although an important measure should be the correct handling and stockpiling of topsoil as discussed in section 11 of this report.	Continuous	Contractor / ECO
Support infrastructure, CDFs, PCD, stockpiles and silt trap	Topsoil & subsoil stripping, Clearing of vegetation for pipeline construction through wetlands and water courses as well as road crossings	Soils and land capability	Loss of land capability	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	• Prevent edge effects • Keep mining development footprint restricted to layout plans	Keep mining development footprint restricted to layout plans	No specific mitigation can be applied during the construction phase itself to prevent loss of land capability considering that the land use will change to industrial. This, however, does not prevent the mine from ensuring that disturbance and clearing should be confined to the footprint areas of the mine and not over the larger area. This can be done in the following ways: • Corridors should be secured around the mining footprint areas to ensure the current land use (grazing) can continue in a functional way during mining. • Clearly demarcate the entire development footprint prior to initial site clearance and prevent construction personnel from leaving the demarcated area. This could be done through the fencing off the entire development footprint and institute strict access control to the portions of the owner-controlled property that are to remain undisturbed as soon as possible after initial site clearance. The fence should preferably be impermeable (for example a solid wall) to discourage invertebrates and small animals from entering the site. [Normally solid perimeter walls are not recommended to facilitate the movement of invertebrates, but in this case restriction of their movement into the area will be advantageous.] • All development activities should be restricted to specific recommended areas and strict buffer zones should be applied around the sensitive areas. The Environment Control Officer (ECO) should demarcate and control these areas. Unnecessary bulldozing through the veld should be avoided.	Continuous	Contractor / ECO
OPERATIONAL PHASE									
Support infrastructure, CDFs, PCD, stockpiles and silt trap	Heavy machinery and vehicle movement on site, laydown areas of WRDs and stockpiles	Soils	Soil compaction	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• During operation, sensitive soils with high risk of compaction (e.g., clayey soils) must be avoided by construction vehicles and equipment, wherever possible, to reduce potential impacts. Only necessary damage must be caused and, for example, unnecessary driving around in the veld or bulldozing natural habitat must not take place. Vehicles should also stick to haul roads when dumping of waste rock on CDFs and topsoil are done. • Rip and/or scarify all compacted areas on a continuous basis. Do not rip and/or scarify areas under wet conditions, as the soil will not loosen. Compacted soil can also be decompacted by "Rotary Decompactors" to effectively aerate soils for vegetation	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
							establishment. • Refer to mitigation measures needed during the construction phase that are like the mitigation measures for impacts during the operational phase.		
	Laydown areas of WRDs and stockpiles, crushing and stockpiling	Soils	Increased Soil erosion and sedimentation;	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Rehabilitation: revegetate or stabilise all disturbed areas as soon as possible. Indigenous trees can be planted in the buffer zone of the proposed development to enhance the aesthetic value of the site and stabilize soil conditions; • The vegetative (grass) cover on the soil stockpiles (berms) must be continually monitored to maintain a high basal cover. Such maintenance will limit soil erosion by both the mediums of water (runoff) and wind (dust); • Conservation of topsoil should be prioritized on site and done as follows: ○ Topsoil should be handled twice only - once to strip and stockpile, and secondly to replace, level, shape and scarify; ○ Stockpile topsoil separately from subsoil; ○ Stockpile in an area that is protected from storm water runoff and wind; ○ Topsoil stockpile1 should not exceed 2.0 m in height and should be protected by a mulch cover where possible; ○ Topsoil stockpile 2 can be dumped higher but not exceeding 10m to reduce slope length and minimize erosion. ○ Maintain topsoil stockpiles in a weed free condition; ○ Topsoil should not be compacted in any way, nor should any object be placed or stockpiled upon it; ○ Stockpile topsoil for the minimum time period possible i.e., strip just before the relevant activity commences and replace as soon as it is completed. • Refer to mitigation measures needed during the operational phase that are like the mitigation measures for impacts during the construction phase.	Continuous	Contractor / ECO
	Laydown areas of WRDs and stockpiles, materials handling and transportation, crushing and stockpiling	Soils	Spillages of harmful substances to the soils;	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) Section 11(1)	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Vehicle maintenance only done in designated areas – spill trays, sumps to be used and managed according to the correct procedures. • Vehicles and machines must be maintained properly to ensure that oil spillages are kept to a minimum. • Fuel and oil storage facilities should be bunded with adequate storm water management measures. • Operational and Maintenance plan and schedule for management of sewage facilities should be compiled. An emergency plan should be compiled to deal with system failures and should include a down-stream notification procedure • Routine checks should be done on all mechanical instruments for problems such as leaks, overheating, vibration, noise or any other abnormalities. All equipment should be free of obstruction, be properly aligned and be moving at normal speed. Mechanical maintenance must be according to the manufacturer's instructions • Refer to mitigation measures needed during the operational phase that are like the mitigation measures for impacts during the construction phase	Continuous	Contractor / ECO
	Topsoil & subsoil stripping, opencast mining	Soils and land capability	Soil destruction and sterilization	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• The most desired approach during all the mining phases is to continually rehabilitate the soils to the best possible state – considering the current technology and knowledge available as well as the financial means to conduct such rehabilitation. The rehabilitation of soils to pre-mining conditions is basically impossible though. Refer to section 11 of this document for a detailed discussion on the rehabilitation of topsoil after stripping. • Refer to mitigation measures needed during the operational phase that are like the mitigation measures for impacts during the construction phase	Continuous	Contractor / ECO
	Topsoil & subsoil stripping	Soils and land capability	Loss of land capability	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Refer to mitigation measures needed during the operational phase that are like the mitigation measures for impacts during the construction phase • Only a small area of the land should be used for mining at a time. Rehabilitation should take place on a continuous basis where after the land would become partially available again as grazing.	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
DECOMMISSIONING PHASE									
Support infrastructure, CDFs, PCD, stockpiles and silt trap	Demolition of mining infrastructure; Heavy machinery and vehicle movement on site	Soils	Spillages of harmful substances to the soils;	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) Section 11(1)	Refer to Construction Phase objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction and operational phases needed during the decommissioning phase that are similar	Continuous	Contractor / ECO
	Demolition of mining infrastructure, Heavy machinery and vehicle movement on site	Soils	Soil compaction	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction and operational phases needed during the decommissioning phase that are similar	Continuous	Contractor / ECO
	Demolition of mining infrastructure / Cessation of mining /	Soils	Increased Soil erosion and sedimentation;	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction and operational phases needed during the decommissioning phase that are similar	Continuous	Contractor / ECO
					Refer to Construction Phase objectives	Refer to Construction Phase criteria	Refer to mitigation measures for the construction and operational phases needed during the decommissioning phase that are similar	Continuous	Contractor / ECO
CLOSURE PHASE & POST CLOSURE PHASES									
Support infrastructure, CDFs, PCD, stockpiles and silt trap	Rehabilitation	Soils	Improvement of soils and repair of erosion damage through revegetation over time	NEMA Regulation 543 Section 32	• To ensure that the mining areas rehabilitated according to prescriptions • To shape and prepare the rehabilitation areas to blend in with the surrounding environment. • To rehabilitate all disturbed areas to a suitable post closure land use • To manage the social impact of closure on personnel who became redundant due to closure • To keep all the post closure monitoring in place and to ensure that the necessary reporting is done to the authorities and interested and affected parties	Rehabilitate within development footprint to ensure revegetation and rehabilitation impacts are kept within the mining footprint areas	• Plant vegetation species for rehabilitation that will effectively bind the loose material, and which can absorb run-off from the mining areas. • Rehabilitate all the land where infrastructure has been demolished. • Monitor the establishment of the vegetation cover on the rehabilitated sites to the point where it is self-sustaining. • Protect rehabilitation areas until the area is self-sustaining. • Diversion trenches and storm water measures must be maintained • Water management facilities will stay operational and maintained and monitored until such a stage is reached where it is no longer necessary. • The mining areas will be shaped to make it safe. • All the monitoring and reporting on the management and rehabilitation issues to the authorities will continue till closure of the mine is approved.	Continuous	Ecologist / ECO
	Rehabilitation	Soils	Soil compaction	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• During closure, sensitive soils with high risk of compaction (e.g., clayey soils) must be avoided by vehicles wherever possible, to reduce potential impacts. Only necessary damage must be caused and, for example, unnecessary driving around in the veld or bulldozing natural habitat must not take place. • Rip and/or scarify all compacted areas on a continuous basis. Do not rip and/or scarify areas under wet conditions, as the soil will not loosen. Compacted soil can also be decompacted by “Rotary Decompactors” to effectively aerate soils for vegetation establishment. Other soil rehabilitation measures are discussed in section 11. • Soil should be sampled and analysed prior to replacement during rehabilitation. If necessary, and under advisement from a suitably qualified restoration ecologist, supplemental fertilisation may be necessary.	Continuous	Contractor / ECO
	Rehabilitation	Soils	Soil erosion and sedimentation	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Refer to mitigation measures for the other mining phases needed during the closure phase that are relevant	Continuous	Contractor / ECO

Components	Activity	Aspect	Impact	Legal requirements	Objectives	Performance criteria	Mitigation Measures	Time frame	Responsible person
	Rehabilitation	Soils	Spillages of harmful substances to the soils;	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) Section 11(1)	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Refer to mitigation measures for the other mining phases needed during the closure phase that are relevant	Continuous	Contractor / ECO
	Rehabilitation	Soils and land capability	Loss of land capability	CONSERVATION OF AGRICULTURAL RESOURCES ACT 43 OF 1983 NEMA Regulation 543 Section 32	Refer to Construction Phase objectives	Refer to Construction Phase criteria	• Once mining activities have ceased, disturbed areas should be rehabilitated, and the grazing capacity restored as high as possible. The rehabilitation of the soils and revegetation is discussed in section 11 of this report. • Refer to mitigation measures for the other mining phases needed during the closure phase that are relevant	Continuous	Contractor / ECO

11 REHABILITATION MEASURES FOR SOIL STABILISATION AND PROTECTION

Rehabilitation can be defined as the return of disturbed areas to a safe, stable, productive and self-sustaining condition that promotes biodiverse land use. Land rehabilitation techniques can be used to speed up the time required to restore the impacted area back to its original, or better, state. To re-create and maintain a sustainable environment it is important to plan how the areas to be impacted by the Glencore Kroondal Mine Residue Expansion Project will be rehabilitated and revegetated.

11.1 BEST PRACTICES IN REHABILITATION PLANNING AND MANAGEMENT

Use of rehabilitation planning and environmental management that aims for sustainability is encouraged in all aspects of reclamation planning, design and implementation. Environmental Guidelines (DWAF, 2005) aims to guide environmental management during all phases of a project lifecycle.

These Environmental Best Practice Guidelines for; Planning; Construction, Operation and Decommissioning Planning provide a scientific-based, comprehensive and integrated strategies to also perform rehabilitation for developments and therefore mitigate against safety hazards and environmental degradation.

11.2 CLEARED INDIGENOUS PLANT MATERIAL

Where construction or rehabilitation activities are to commence in a specific area, certain indigenous plant material from the construction footprint area could be collected and bagged to be used in re-vegetation or as mulch during rehabilitation. To protect drainage areas and small streams as well as erosion prone areas, brush could be cut and used to *"brush pack"* these problem areas to protect it. This will also restrict movement of animals and humans over sensitive erosion probe areas until pioneer vegetation has established.

11.3 TOPSOIL, STOCKPILES AND BACKFILLING

The way topsoil and stockpiles are created and maintained is important with regards to the implementation of a successful rehabilitation process. Soil management practices must be adhered to to reduce soil loss and to encourage rehabilitation post-construction. The two most important aspects to consider when removing topsoil are the depth of soil to be removed and the conditions of storage.

The topsoil layer (0-25 cm) is important as it contains nutrients, organic material, seed, and communities of micro-organisms, fungi and soil fauna. The biologically active upper layer of soil is fundamental in the development of soils and the sustainability of the entire ecosystem. The correct handling of topsoil is vital in conserving the seed bank and nutrients which occur within this layer thereby ensuring successful rehabilitation.

- Topsoil must only be used for rehabilitation purposes and not for any other use example i.e., construction of roads.
- Previously excavated areas on the site should be backfilled with suitable topsoil, levelled to resemble the surrounding topography and slopes and scarified for re-vegetation/re-seeding.
- On steeper slopes rehabilitation measures may include systems such as soil terracing, berm creation, grass blocks, fascine work, gabion basket work, reno mattresses, retaining block mechanisms, sandbags, boulder and rock placement, stone pitching, and grading.
- Erosion control netting or matting (GeoJute or Bio-Jute) may be utilised on steep slopes to assist with soil retention, weed control and vegetation establishment. The netting material helps protect the soil from wind and water erosion, and the required rehabilitation plant material can be installed by making small incisions for planting. The netting is biodegradable and will eventually break down and form a mulch layer.

11.4 COMPACTION AND REHABILITATION MEASURES

Soil compaction is often an effect of high traffic areas on development sites. It can become a major problem and can be recognized by:

- Excess surface moisture and slow drying soils due to deeper compaction preventing the percolation of water through the soil profile;
- Water runoff due to surface compaction preventing penetration and absorption (ponding of water), especially on banks and sloping surfaces.
- Large clear or sparsely covered areas devoid of a good vegetative cover due to hardened topsoil layers

The problems associated with compaction can be rehabilitated after mining has ceased as follows:

- Rip and/or scarify all disturbed areas, including roads that are no longer in use (preferably before the rainy season). Do not rip and/or scarify areas under wet conditions, as the soil will not loosen.

- Compacted soil can also be decompacted by “Rotary Decompactors” to effectively aerate soils for vegetation establishment.

11.5 EROSION REHABILITATION MEASURES

Water has the gift to sustain life, but also the potential to maim, damage and destroy if not managed correctly. Remedial actions must be established to ensure that potential erosion is addressed with an erosion control strategy towards long-term rehabilitation. It is important to take note of the following generic points regarding erosion risks in the study area:

- Soil loss will be greater during wetter periods. However, the provision of erosion control measures for the through the drier months of the year is equally as important;
- Soil loss from the site is proportionally related to the time the soils are exposed, prior to rehabilitation. The time from commencement of rehabilitation activities to finalization thereof should be limited. Rehabilitation efforts should commence as soon as practical;
- Construction staging and progressive/concurrent rehabilitation is important; and
- The extent of the disturbance that will take place will influence the risk and consequences of erosion on the site.
- Avoid over-wetting, saturation and unnecessary run-off during dust control activities and irrigation.
- Retain natural indigenous grass and shrubs and re-vegetate bare areas as soon as possible.

11.6 RE-VEGETATION

Plant species that have been rescued or removed and relocated to the temporary nursery could be used in replanting rehabilitation areas.

Additional plant material (indigenous trees) as required should be sourced from local indigenous nurseries and specifications regarding plant sizes, heights and the installation process of these plants should be developed by the On-Site ECO and Rehabilitation Specialist. Standard horticultural best practice would apply, with specific reference to the fact that the plant material would have to be in good condition, free from pests and diseases (any such plant would have to be removed from the site), well-formed and well rooted, potting materials are weed free and with sufficient root cover. Groundcovers and sedges are often supplied in trays, and the same standards would apply.

- A grass seed specification for reseeding the rehabilitated areas is included below. Re-grassing should be undertaken (as far as possible) during the summer months, as germination and establishment is best at this time of year. Spring rains are also conducive to good germination results, and as such rehabilitation programmes should take these factors into consideration.

- There are two methods for seeding, hand broadcasting and hydroseeding. The methods utilised will be site specific and the On-Site ECO and Rehabilitation Specialist will determine them.
- In certain areas grass runners may be required, and grass sods where instant cover is necessary.
- A typical grass seed mixture (hand sowing) that could be implemented for rehabilitation activities will include: (specification 4-5kg/ha)
    - *Eragrostis tef* (Tef);
    - *Eragrostis curvula* (Weeping Love Grass);
    - *Digitaria eriantha* (Smutsvinger);
    - *Cynodon* spp. (Bermuda kweek);
    - *Panicum maximum* (Witbuffel);
    - *Chloris gayana* (Rhodes grass);
    - *Paspalum notatum (Bahia Grass)*

12 STATEMENT ON HYDROPEDOLOGYOF THE PROJECT AREA

Hydropedology is the relatively new, interdisciplinary research field which focuses on the interactive relationship between soils and water. Soil physical properties, such as the hydraulic conductivity and porosity, have an important impact on the occurrence and rates of hydrological processes. In turn, hydrological processes play an important role on the formation of soil morphological properties such as colour, mottles, macropores and carbonate accumulations.

The Zimpande Research Collaborative (ZRC) was appointed to undertake a hydropedological assessment as part of the water use licence application for the proposed Glencore Mine Residue Expansion Project on the Glencore Kroondal Mining Operations properties, Northwest Province.

The proposed expansion project is located within proximity to a watercourse, thus it was deemed necessary to investigate the recharge mechanisms of the watercourse and define the hydropedological drivers (if any) of the watercourse project to ensure that the proposed activities do not impact on the hydropedologically important areas in support of the principles of sustainable development and Integrated Environmental Management (Zimpande Research Collaborative, 2021).

The contribution of the soils within the focus areas to the adjacent natural wetlands from a hydropedological perspective can be considered limited due to the reasons which will be elaborated below.

A large portion of the landscape where the proposed development is to occur due to the occurrence of recharge deep soils which contribute to the ground water regime. Shallow responsive soils which are characterised by a limited storage capacity are also common, resulting in the generation of overland flow after rain events. In addition, the remaining areas earmarked for developed have been impacted and have little (If any) hydropedological function since they are associated with mining activities.

Although the hydropedological contribution is limited, other components in the catchment water balance such as groundwater and surface water studies should be considered to ensure that no significant change in the PES of the adjacent natural wetland occurs.

It is for this reason that the specialist recommends that:

- Surface water studies are conducted to determine how much runoff is lost due to the separation of clean and dirty water areas within the catchment of the CVB; and
- Once the volume of runoff recharge lost has been quantified, the water emanating from the clean water trenches should be discharged back into the CVB to compensate for the losses that will occur to ensure that the PES does not occur, provided that the water is of an appropriate quality to do so.

If the above mitigatory measures are implemented, the proposed water use activities will be considered acceptable from a hydropedological process conservation and management perspective.

13 DISCUSSION & CONCLUSION

This study addresses the agricultural potential, land capability and general characteristics of the soils on the site for the development of the Glencore Kroondal Mine Residue Expansion project (CDFs, PCD, stockpiles and associated infrastructure) in the Northwest Province. The results obtained from the study were done after field observations were done to verify the soil potential classified by the Department of Agriculture on a small scale.

Based on Part 1 of the Regulation of Conservation of Agricultural Resources Act 43 of 1983, the proposed area, earmarked for the mining expansion development can be classified as having soil potential that is mostly Moderate. The soil forms identified in the study area and the subsequent land capability is summarised in Table 9.

Table 9. Soil forms, land capability and potential of the proposed mining infrastructure

Soil Forms	Land capability
Vertic, black clayey soils of the Arcadia soil form	Class IV: Marginal potential arable land
Red apedal soils of the Hutton soil Form	Class III: Moderate Potential Arable Land
Disturbed topsoil / mining areas	Class VII: Non-arable; Grazing, Woodland or Wildlife
Black clayey / alluvial soils of the Rensburg / Katspruit soil forms associated with drainage channels	Class V: Watercourse and land with wetness limitations

The density of the vegetation and grazing capacity of the land would allow grazing of the area, especially on the unimpacted sections of land to the south of the already developed Glencore Kroondal Mine. The proposed mining development will cause a slight loss of grazing value of the land, although site specific mitigation needs to be implemented.

The land capability of the site is mostly marginal or moderate potential arable land due to the climatic conditions in combination with the soil chemical status and the soil forms identified in the development footprint areas. The potential impacts associated with the proposed development are soil disturbance (erosion, compaction), loss of land capability, soil destruction and sterilisation and soil pollution (spillages).

The site should subsequently be considered as being limited value grazing land with marginal potential for arable agriculture considering the climatic conditions and often clayey nature (shrink and swell clayey soils) of the soils.

Mitigation measures are provided in the report for the impacts and provided this management and rehabilitation measures stipulated in the report are strictly adhered to, the mining development could be supported.

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